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Infrastructure

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Abstract
Infrastructure materially connects more or less distant places by facilitating various social processes and relations across space. Usually understood in physical terms as the material elements shaping resource flows, infrastructure also refers to the institutions and rules conditioning social practice. Recent geographic research has stressed the social, political and economic dimensions of infrastructure. As objects of empirical analysis, infrastructure discloses broad transformations in the production and management of sociotechnical systems, including the "splintering" of collective services and utilities. Conceptually, infrastructure has provided the foundations for methodological and conceptual innovations surrounding ontologies of flow and mobility, and theorizations of society-nature relations that reframe technological networks as unstable, politicized entities.

Main text
Infrastructure plays a vital role in structuring the relative spatial connectivity of place. Infrastructure systems tend to be immobile, but facilitate numerous mobilities which, at their core, provide the mechanisms and context through which modern life functions. They enable the process of time-space compression and shape the relational networks through which localities are articulated within broader social, economic, political and environmental systems. They expedite technological transformations and socio-spatial change and foster new spatial imaginaries. The Internet, for instance, is celebrated as the backbone of a new era of connectivity and progress. Yet while the 'information age' is premised upon the idea of uninterrupted digital flows and circulation, such discourses render other infrastructure systems mundane and overlook inequalities in access and processes of uneven development.

Infrastructure is usually understood in physical terms. *Technical*, or hard, infrastructures are physical systems comprised of material elements – highways, pipelines, power stations, cables, energy grids, airports, fiber optics, sewers – that mediate resource flows. Transportation, water, energy, trade and telecommunications networks materially connect more or less distant places by facilitating various social processes and relations across space. The development of technical infrastructure systems plays a vital role in the development of territorial units from cities to nation-states. At the same time, by supporting processes of globalization via telecommunications and trade innovations (such as containerization and intermodalism),

technical infrastructure provides an important means to challenge the construction of places as bounded, internally organized, territorial units.

Variations in the density and concentration of technical infrastructures spur distinct patterns of uneven geographical development. Infrastructure systems can invoke distinct environmental and social problems from local events (oil spills, water pollution) to global crises (climate change). However, the transformative potential of engineered systems also provides the potential to realize new spatial fixes. Infrastructure megaprojects, as material and symbolic spaces, have been closely associated with programs of modernization. They often function as a means, and context, for sustainable development while in the wake of the 2008-2009 global financial crisis, infrastructure investment has emerged as a key policy tool to reinvigorate local and national economies.

Infrastructure may also be understood through the production and operation of social relations. *Social*, or soft, infrastructure is comprised by the formal institutions and informal practices employed by various actors (individuals, households etc.) that structure the capacities of people in place. The relative "thickness" of social networks strongly influences the practices and experiences of everyday life. Social infrastructures, e.g. public services or utilities, may be provided by governmental agencies. They may also be forged by a diverse array of actors operating at multiple scales – from small-scale co-operatives to transnational organizations – when the state is unable or unwilling to provide them. Simone (2004) directly ties the concept of infrastructure to people's activities in cities by foregrounding the economic collaborations among marginalized residents in Johannesburg. Examining the case of urban markets, he frames practices of "cooking, reciting, selling, loading and unloading, fighting, praying, relaxing, pounding, and buying … on stages too cramped, too deteriorated, too clogged with waste, history, energy, and sweat to sustain all of them" as providing the concrete acts and context through which the city is reproduced (2004, 426). In this context, people's networks and rules, which are dynamically invoked and reinforced, form the infrastructure conditioning social practice.

Entering the twenty-first century, the nature and focus of geographic inquiry shifted alongside a broader reappraisal of infrastructure studies across the social sciences. Geographic engagement with infrastructure, particularly those in the sphere of transportation geography, has strong roots in the discipline's quantitative turn. Systematic approaches to the mapping and measurement of spatial processes developed through the 1950s and 1960s helped establish geography as a science and enabled geographers to inform public policy and investments decisions. Despite a long-standing interest in social justice issues within geography, infrastructure systems consequently tended to be relegated to the apolitical domain of engineers and technocrats (see Furlong 2010, Graham 2010). Over the past decade, a groundswell of critical analyses – drawing on a diverse amalgam of theoretical frameworks – has focused on examining how infrastructure profoundly shapes the production, experience, governance and transformation of social relations. Work conducted under the rubric of the politics of infrastructure, technonatures, urban metabolism and the sociotechnical city have encouraged a reconsideration of geographic engagements; spurred, in no small part, by a reinvigorated commitment to "[open] up the 'black box' of urban infrastructure to explore the ways in which infrastructures, cities and nation states are produced and transformed *together*" (McFarlane and Rutherford 2008, 364).

In contrast to scholars in other disciplines – for example, science and technology studies, which concentrates on the technological or engineered aspects of infrastructure systems –

geographic scholarship has tended to foreground social, political and economic factors to demonstrate, empirically and conceptually, that infrastructure systems are not isolated, apolitical, static or stable entities. Inequalities in access and mobility produce distinct power relations and articulations of uneven development that position them as central objects of social struggle. Developments like urban growth and shrinkage, or public budgetary crises can challenge traditional forms of infrastructure provision and require new technical or social solutions. Moreover, scholarship influenced by the new mobilities paradigm challenges normative understandings of infrastructure stability by drawing attention to how, at a micro-scale, infrastructure may be characterized by dynamism and change. Seemingly fixed, material objects are constantly being modified and refashioned in subtle ways; streets are repaved, buildings painted, grass mowed.

Post-structural approaches, notably drawing from actor-network theory and cyborg studies, have attempted to conceptually collapse the distinction between the human body and technological networks. Infrastructures are conceived as a series of interconnecting unconscious life-support systems that make urban life possible. For instance, the modern home – with its provisions of light, heat and water and telecommunications networks – provides a normalized yet essential exoskeleton that blurs the distinction between the organic and technological. Shifting scale, the hybrid urbanization embodied within the cyborg city produces urban space as an inseparable fusion of the social and technical. Marxist scholars have engaged such normalization as a mode of fetishism that obfuscates the social relations that underpin the production of infrastructure systems. Scholars utilizing assemblage theory have further problematized notions of agency by focusing analytical attention on sociomaterial interaction. Assemblage theory constructs infrastructure systems as bringing together and organizing multiple human and non-human relationships in a manner that distributes agency beyond the human actants involved. Bennett (2005), for example, interprets the 2003 North American Black Out as a moment of crisis rooted in the specific arrangement of flows, users, commodities, production processes, lifestyles, profit motives and electron streams bundled in the specific infrastructural constellation of the East Coast electric grid.

Splintering urbanism

The form, function and governance of infrastructure networks vary across geographical and historical contexts. Graham and Marvin's (2001) "splintering urbanism" thesis has proved a highly influential analytical framework to conceptualize broad transformations in the production and management of sociotechnical systems. Between 1850 and 1960 urbanization, especially in advanced capitalist countries, ushered in a movement from piecemeal and fragmented infrastructure provision towards an emphasis on the centralized and standardized systems that underpinned the modern networked city. The intersection of modernist aesthetics and technology promoted rationality and order in the production of urban space. Infrastructure systems served as both functional, material networks and symbolic representational spaces that spurred dreams of mobility, modernity and circulation. The modern infrastructural ideal, as a decidedly western construct, was buttressed by an ideological belief in the positive social transformative capacity of networked technologies. The ascension of modern theories and practices of urban planning helped codify new ways of thinking about and shaping cities and their sociotechnical relations. Government support for near-universal access to infrastructure networks across urban, regional and nation space was vital to the extension of the networked technologies that facilitated new forms of mass production and consumption. The Fordist New Deal is commonly accepted to be

the nadir of technological modernism in the United States, with the machine emerging as a motif for both industrial production and social organization.

Across the globe, postwar modernization programs were characterized, and defined, by standardized modern infrastructures; from highways and high-rise residential tower blocks to vast electric, water and sewage grids. However, the ascension of the modern infrastructural ideal fostered a concomitant critique of dehumanizing and alienating impacts of technological modernism. By the early-1970s, social critiques regarding the lived experience of high modernism, perhaps most influentially in the writings and activism of Jane Jacobs, undermined the development of infrastructural networks as idealized technological-engineered systems. As the long postwar capitalist boom subsided, governments struggled to invest the constant inputs of capital and labor required to maintain modern infrastructure networks which consequently became vulnerable to protracted fiscal crises and physical decay into the 1980s.

Processes of political and economic restructuring following the Crisis of Fordism directly impacted the planning, management and governance of infrastructure systems. Planning rationales that legitimized the construction of modern integrated infrastructure systems were undermined by increased technical specialization and a gradual shift in attention from concerns regarding built form and mechanic metaphors to administrative, legal and social issues. Under the auspices of neoliberalism, the logics of infrastructure provision have shifted from the modern ideal of public provision and universal access to collectively distributed services towards the valorization of individual choice and atomized mobility; in a manner that obfuscates the continued reliance on public infrastructures that enables such mobility. In lieu of nationally-scaled spatial fixes, local governance units have taken on increasing responsibility for developing the urban infrastructures necessary to support growth in their own territorial jurisdictions. Infrastructure restructuring, both in terms of material networks and their governance regimes, has provided a lens to uncover both processes of deterritorialization associated with globalization and the rise of the "network society", and the modes of reterritorialization through which new scalar relations are produced.

A key mechanism here is the cleaving, or secession, of infrastructure elements from collective public systems. Publicly managed infrastructures have been increasingly *splintered* through processes of deregulation and privatization (Graham and Marvin 2001). The unbundling of existing infrastructure networks establishes premium network spaces" (e.g. toll roads, privatized express rail links) that are integrated into selective global political economic frameworks through specialized development funds, financial tools and public-private partnerships. Material, political and economic relations foster new topological geographies that tie together a privileged archipelago of elite global nodes reformulated in a manner that constructs and reinforces sociospatial relations. In an era of free-trade, just-in-time production and globalized supply-chain networks, the production of premium infrastructure networks enables localities to create competitive advantages while erecting barriers to entry for their competitors. City-regions that are able to construct world-class infrastructure, develop multimodal transportation centers and lower transportation costs greatly strengthen their competitive position in the international economy. Consequently, several planning scholars now consider strategic investment in infrastructure as presenting a new spatial planning paradigm, with urban infrastructure planning held as a potentially visionary yet pragmatic tool for planners.

Local units of governments have subsequently adjusted how they perceive and utilize their infrastructure assets. As austerity regimes limit the public capital available to invest in public infrastructure, a major trend in local urban policy has been the financialization of

infrastructure networks; either through engaging in public-private partnerships (P3) or selling them off outright. Technical infrastructure has acted as an experimental testing ground for P3 funding arrangements. A common form of P3 arrangement enables governments to lease the operation of such infrastructure to a private company over a limited timeframe for a lump sum payment while retaining ownership of the physical systems. The City of Chicago has exemplified such strategic unbundling through landmark leasing arrangements for the Chicago Skyway and municipal parking meters. A broad global trend is emerging in which the public ownership and local management of technical infrastructure is usurped by supranational governance regimes, whereby infrastructure systems are privately-owned by global companies and regulated by local actors.

Critics of P3 arrangements point to the dangers associated with local governments' reliance on increasingly risky financial arrangements and security-backed speculation. The production, financing and governance of urban infrastructures produced through supranational governance deepens the multifaceted and multiscalar connectivity of place, but in doing so opens local struggles over collective consumption amenities to the disciplinary logic of private capital. Moreover, unbundling has profound implications for class struggle and environmental justice by engendering differential access to infrastructure networks. New articulations of uneven geographic development intensify sociospatial polarization with metropolitan space. Places that are physically bypassed by globally privileged networks suffer from limited material and social connectivity and are often discursively framed as corridors that require traversing, rather than spaces of habitation.

Disruptions, crises and consequences

Investigations into the political production and transformative capacity of infrastructure systems have pointed to a central paradox. While infrastructure systems are essential to our everyday lives, their ubiquity renders them invisible; normalized and taken-for-granted. Oftentimes it is only once systems breakdown, fail or are disrupted that their materialities, roles, geographies and social functions are revealed (see Graham 2010). This is the case both for technical and social infrastructure. Differing infrastructure systems are themselves fused together in complex and interdependent relationships. Consequently, crisis arising at a specific point may quickly cascade through other infrastructures and networked places. Crises can be place based. Natural disasters may strike specific locales, as when Hurricane Katrina hit New Orleans in 2005, or localized fat deposits in city sewers can cripple basic sanitations systems. They may also be distinctly reticulated. The spread of SARS and H1N1 through global air hubs revealed how infrastructure-based crises cascade between places as transnational mobility was disrupted by malign pathogens. Increases in the visibility of infrastructural failures mean infrastructure disruptions – from the challenges of climate change to the threat of Internet worms and identity theft – can become ingrained as a normalized expectation within modern society. Moreover, infrastructure networks have emerged as a mechanism for political insurgency, whether in the form of infrastructural terrorism (most notably in the case of the 9/11 attacks in New York), *Anonymous* attacking governmental websites, or First Nations protestors in Ontario blocking major highways to gain visibility for their cause. Many recent state interventions around infrastructure networks have therefore been marked by a concern with securitization and surveillance.

Infrastructure disruptions are experienced differentially across geographical and social contexts. In advanced capitalist countries, infrastructure tends to be normalized until large-scale crises viscerally insert them into political and economic mechanisms. By contrast, infrastructure

disruptions tend to be foregrounded for precarious social groups whose lack of access or relative disconnectivity leads everyday life to revolve around a constant struggle to obtain adequate water, food, sanitation and mobility. Several scholars have illustrated that the epochal shift between the modern networked city and the unbundling neoliberal city-region has, and continues to, unfurl in uneven geographically and historically unstable patterns. Critics drawing on evidence from cities in the developing world demonstrate that the construction and 'implementation of the modern infrastructural ideal was far from universal. Rather, standardized networks developed unevenly and exhibited significant geographic variations within and across national contexts. Historical analyses also complicate simple narratives of the bundling and unbundling logic of infrastructure networks by disclosing an ambivalent relationship between standardized service provision and increased levels of urban integration and the complex relationship between publicly owned networks and the driving role of private interests in infrastructure construction (see Coutard 2008).

Despite, or even because of, their technical and fiscal vulnerabilities, infrastructures are not only vital in demarcating the practical possibilities of governance regimes, but are also crucial in defining the ideological parameters of political discourse (Gandy 2005). For instance, as splintering urbanism is the product of strategic coalitions within multiscalar governance regimes, unbundling processes are open to social contestation and political intervention. Flexible networks and creative investment strategies can open possibilities for future urban growth and development. As an unstable and multistage process, infrastructure splintering fosters fissures in which new modes of social and spatial justice, as well as collective action, can emerge. Network splintering may cleave off premium network space, but differentiated service provision within public networks enables institutional and financial capacity to better serve marginalized users and urban inhabitants. Contestation over infrastructure production and a rescaled territorial politics of collective provision can animate political movements centered on class struggle at broader spatial scales, as seen in the mobilization of the Los Angeles Bus Riders Union. The struggle between global forces controlling commodified networks and attempts to democratize infrastructure systems will likely form an increasingly central component of urban, national and international politics.

There is considerable scope for conceptual and applied geographic research to probe the limits and possibilities of political movements around a politics of infrastructure, particularly at the interdisciplinary nexus of political economy and ecology, critical urban studies, and security studies. While much of this research may center on major societal shifts and moments of crisis, critics of dominant strands of political (economy) of infrastructure perspectives illustrate significant conceptual and political insights can be revealed by uncovering the everyday adaptability and transformations of infrastructure; including the stressing the role of mediating technologies in influencing infrastructure provision and adaptability. The elaboration of multiple scalar perspectives offers a productive avenue to further examine infrastructure's role in shaping the governance practices, progressive development frameworks, and the spatial processes conditioning contemporary social relations and everyday life (see Furlong 2010, McFarlane and Rutherford 2008).

SEE ALSO: Actor Network Theory; Built Environments; Mobility; Neoliberalism; Socio-Nature; Technology; Topological Relationships; Uneven Development; Urban Political Ecology; Urban Politics

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Key Words

Flows; Governance; Networks, Technology; Urbanization