



Coronavirus icon by dDara from the Noun Project

COVID-19, Networks and Regional Science*

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Like no other disaster in recent memory, the COVID-19 crisis has brought home the importance of networks and connections. How different entities – countries, cities, firms and individuals – are connected has profoundly affected the spread of the virus and continues to determine both its human and economic costs. The very forces that give rise to and disseminate network benefits are now distributing and amplifying the costs of the virus through hub and spoke systems. Not coincidentally, the first known U.S. infected patient was recorded in Snohomish County, Washington,[1] just north of Seattle where the SEA-TAC airport serves as an important Delta Airlines connector (hub) to Asia. Subsequent cases were identified in Los Angeles and Chicago, where LAX and ORD, respectively, are international and major domestic hubs for United Airlines. A *New York Times* animation shows how the virus is believed to have spread through the world's airline network (Wu et al., March 22, 2020).[2]

The largest initial concentrations of infections in the U.S. appeared in densely settled or connected places, such as New York City. Population agglomerations have benefited enormously from network externalities and spillovers associated with high population density[3], but these same proximity-based forces are now likely causing rapid growth in the number of infections. To illustrate, animated maps shows how the virus has spread in Pennsylvania, first in the eastern part from New York City and New Jersey and then via Philadelphia and Pittsburgh towards the center of the state. The Vail ski resort in Colorado, with international visitors had a heavy caseload early on: <https://imgur.com/a/Ci3ZSEI>

Early news media reports highlighted the vulnerability of tightly coupled global supply chains which had origins or component manufacturing located in Wuhan, Hubei Province. Such chains build on and capture network effects and, when they disintegrate, lead to cascading failures; they also illustrate the concept of node centrality (importance) of different actors within them. Apple Inc. lost \$34bn in stock valuation as of mid-February 2020 largely due to pressure on its suppliers located in Hubei[4]. This current experience will likely lead companies to rewire their supply networks, i.e., to rethink how they source components in terms of geographic diversification around the globe.

Decision makers in food industry supply chains are struggling to redirect unused perishable food in the restaurant sector into retailing, by rewiring or reorganizing their transportation and storage networks. Input-output tables that show multiplier effects of new economic activity are now being used to show the opposite effects in terms of economic collapse. When a restaurant shuts down, the local linen supplier loses businesses, farmers are left with unsold perishable product that had been contracted for delivery, and local newspapers no longer receive advertising dollars. And the ripples continue on through reduced purchasing power of the restaurant's laid off workers, and reduced tax payments.

Another example of a critical supply chain is found in the medical sector. Here detailed knowledge of where different firms are located spatially could improve coordination and prioritize production of critically needed medical equipment and drugs. As in food-tracing, RFID-enabled tracking and analysis of big data allow researchers to develop real time models to accelerate transshipment and finetune delivery schedules using tools and innovation from logistics firms such as Walmart and Amazon.[5]

The coronavirus has separated “essential” jobs from those which are not, and jobs that can be carried out at home from those that cannot. It has also raised awareness of what is considered “critical infrastructure,” specifically in a network context. Millions of jobs were lost in an unimaginably short period of time, but labor now is being reallocated into essential jobs, including in the food system.[6] These kinds of shifts can be modelled and better understood for future disaster preparation using network ideas and analytical tools such as network *rewiring*[7]. Likewise, international trade networks are changing as countries restrict exports of food[8] and other essential goods and understanding these changes may help decision-makers to better anticipate and deal with future supply shortages.

The term “contact tracing” has entered the vernacular, as public authorities seek to mitigate the spread of the disease using knowledge of afflicted individuals’ networks.[9] Cell phone companies are providing location data to allow law enforcement agencies to identify not only where the disease may be spilling over but also where illegal social gatherings may be occurring. While highly controversial given the privacy issues involved, all of these examples are relevant to regional scientists, to the extent that they include human behavior tied to geographic space.

Looking ahead, the many natural experiments that are being created by the devastating current crisis could lead to new frontiers of applied regional science research, both in terms of analytical tools and development of theory that bridges concepts from aspatial network science with those of regional science. In addition to the above examples, the virus has upended migration and commuting patterns or networks. Examining these changes may help us not only to better predict future pandemics, but also to mitigate their horrific toll on humans around the world.

[1] Holshue et al. First Case of 2019 Novel Coronavirus in the United States <https://www.nejm.org/doi/full/10.1056/NEJMoa2001191>

[2] Wu, Jin, Weiyi Cai, Derek Watkins, and James, “How the Virus Got Out,” *New York Times*, March 22, 2020, <https://www.nytimes.com/interactive/2020/03/22/world/coronavirus-spread.html>

[3] Goetz, S.J. and Y. Han (2020) “Latent Innovation in Local Economies” *Research Policy*. <https://doi.org/10.1016/j.respol.2019.103909>

[4] Apple’s coronavirus warning just shaved \$34 billion off its stock market value, Julia Horowitz, *CNN Business* <https://www.cnn.com/2020/02/18/investing/premarket-stocks-trading/index.html>

[5] Schmidt, Eric, “A Real Digital Infrastructure at Last,” *Wall Street Journal*, March 27, 2020. <https://www.wsj.com/articles/a-real-digital-infrastructure-at-last-11585313825>

[6] Bender, Ruth and Matthew Dalton, “Coronavirus Pandemic Compels Historic Labor Shift,” *Wall Street Journal*, March 29, 2020. <https://www.wsj.com/articles/coronavirus-pandemic-compels-historic-labor-shift-11585474206>

[7] Han, Y. and S.J. Goetz (2019) “Measuring Network Rewiring Over Time,” *PLOS ONE* 14 (7).

[8] Countries Starting to Hoard Food, Threatening Global Trade, Boomborg, Isis Almeida and Agnieszka de Sousa, March 25, 2020 <https://finance.yahoo.com/news/countries-starting-hoard-food-threatening-233000095.html>

[9] Tau, Byron, “Government Tracking How People Move Around in Coronavirus Pandemic,” *Wall Street Journal*, March 28, 2020, <https://www.wsj.com/articles/government-tracking-how-people-move-around-in-coronavirus-pandemic-11585393202>.

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