Does Data Follow the Flag?

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Abstract

Does data follow the flag? Many authors have argued international conflict, military treaties, and trade agreements impact commerce and trade flows. The internet enables over 15% of global GDP, yet we know little about whether or why international politics impact transnational data flows. This paper analyzes monthly-level changes in the Border Gateway Protocol (BGP) from 2008-2019. This protocol determines how data is routed through the internet and across borders between over 70,000 internet operators, influencing the speed, price, and reliability of data transfer both across and within national boundaries. I demonstrate that while trade agreements generally do not affect cross-border internet interconnection, agreements preventing data localization, one of the key international data issues, increase customer-to-provider data interconnection. While the relationship between international conflict and data flows is inconclusive, new military treaties are positively associated with data flows. Despite the prevailing understanding of the internet as "un-territorial" and resistant to border effects and regulation, the internet's structure does follow the flag.

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1 Introduction

Structure has many meanings in international relations - the structure of alliances, military power, international finance and trade, or prestige. Network structures shape how individuals and states interact in the international system (Kahler, 2009), whether activist groups or international organizations can influence national policies (Hafner-Burton and Montgomery, 2006; Keck and Sikkink, 1998), and who gets what in the global economy (Goldstein, Rivers and Tomz, 2007). The internet - a network of networks - emerged as an information infrastructure composed of agreements between system operators to exchange data. This structure has been massively successful - as of 2017, the digital economy is accountable for 15% of global GDP.[1]

On an average day in 2020 at the Amsterdam Internet Exchange (AMS-IX), 62,465 TB of data transited between 887 internet service operators based in over 40 countries (Grove and de Lange, 2021). Every €1 in turnover at the exchange generates €15 in value for the Dutch economy, meaning that the AMS-IX contributed approximately €300M in 2020 alone.[2] The transnational data exchanges in Amsterdam between network operators are one slice of the internet. How internet service providers exchange data with other networks - by agreeing to interconnect - has significant implications for internet speed, price, and stability. These operators exist within national boundaries but exchange data across them. The internet may be one of the most significant technological advances in recent memory, yet know very little about how its technical structure interacts with politics. The internet is international, and even perhaps "un-territorial," but does data follow the flag?

The internet is considered an ideal case for a privately run system and networked governance (Mueller, Schmidt and Kuerbis, 2013). The Internet Corporation for Assigned Names and Numbers (ICANN), a multi-stakeholder nonprofit organization that split from the US government in 2016, organizes many internet protocols. International organizations such as the International Organization for Standardization (ISO) create security and data practices that nearly every country implements. Many early scholars predicted that the internet would be free from government intervention, disrupt traditional territoriality, and create a new global society with free and open exchange (Daskal, 2015; Froomkin, 1997; Johnson and Post, 1996; Kobrin, 2001; Swire, 1998).

[1] Huawei and Oxford Economics. "Digital Spillover: Measuring the True Impact of the Digital Economy," 2017. https://www.huawei.com/minisite/gci/en/digital-spillover/files/gci_digital_spillover.pdf.

[2] "The Future of the Digital Economy." Pb7 Research and the METISfiles, 2020. https://www.digitalemainport.nl/.

Yet, the open and market-driven vision for the internet frequently confronts the challenges of international politics. For the internet to operate - for networks to network - internet service operators sign agreements to exchange data. These operators exist within countries and regulatory environments. Lessig (1999) argued that the technical structure of internet architectures influences individuals' behaviors. This fundamental insight motivates a robust literature on the internet's effects on politics Farrell (2012). However, we have little insight into politics' impact on the internet or international relations' influence on trans-border data flows.

For over fifty years, economists and political scientists have asked whether bilateral political or military relationships between states impacts their trade (Barbieri and Levy, 1999; Berger et al., 2013; Carter, Wellhausen and Huth, 2019; Davis and Meunier, 2011; Hirschman, 1945; Savage and Deutsch, 1960). In addition to factor endowments and comparative advantage, the "trade follows the flag" argument states that countries can promote commercial interests through direct intervention. On the one hand, conflict may reduce, or alliances may increase, trade beyond what we would expect (Anderton and Carter, 2001; Glick and Taylor, 2010; Gowa and Mansfield, 1993, 2004; Keshk, Pollins and Reuveny, 2004; Long, 2008; Mansfield and Bronson, 1997; Pollins, 1989*b*,*a*; Michaels and Zhi, 2010). On the other, trade agreements remove trade barriers and allow coordination that increases trade (Baier and Bergstrand, 2007; Büthe and Milner, 2008; Dür, Baccini and Elsig, 2014).

Data are routed through bilateral agreements to exchange data either settlement-free (peer-to-peer) or for a settlement (provider-to-customer). Data flows between states just like other goods and services, and how data flows through the internet across the world has significant economic and security implications. Inefficient internet structures in the developing world have led to significant increases in cost and latency, placing a drag on national economies (Chavula et al., 2015, 2017; Gupta et al., 2014). Conversely, efficient internet architectures in countries like the Netherlands are a significant economic comparative advantage (Chakravorti and Chaturvedi, 2020). International conflict may impact data flows as well - centrality within the internet architecture allows countries to weaponize transnational data flows (Farrell and Newman, 2019).

This paper tests two sets of explanations for changes in bilateral internet exchange agreements - international conflict and trade agreements. The doomed Pacific Light Cable Network (PLCN) demonstrated that intelligence risks create incentives for states to exert control over data flows. However, other efforts to weaponize data flows, including the programs revealed by Edward Snowden in 2014, influenced internet interconnection without direct government involvement. Military treaties between states may decrease the risk of weapoinzed data flows the same way that conflict may increase the risk. Additionally, international trade treaties may influence transnational data flows by increasing trade, facilitating e-commerce, creating shared data regulations, or preventing data localization.

The paper continues as follows - first, it explains the internet's technical structure, its significance, and the current understanding of how internet operators make decisions on how to route data. After, it explains how the two main hypotheses in the literature - that conflict reduces trade and bilateral trade agreements increase trade - translate into the digital economy.

The paper's empirical test leverages millions of interconnection agreements between over a hundred thousand internet operators between 2008 and 2019. It tests the effect of trade agreements, military treaties, and conflict on internet interconnection. Trade agreements that prevent data localization are positively and significantly associated provider-to-customer data interconnection, and military treaties is positively associated with both forms of data interconnection between states. Furthermore, while militarized interstate disputes do not impact interconnection, large-scale conflicts measured by UCDP are negatively associated with data flows. Overall, this provides evidence that the loosely organized network of 100,000 internet service operators are influenced by politics and their home country's relationship with their peers.

2 Context: Technical Internet

The internet fills a demand to exchange information that has existed throughout history. Relay stations in the Mongol Empire, the telegraph between Berlin and Paris, and Bell's U.S. Patent 174,465 are all peer-to-peer communication networks that work well as long as the number of nodes is limited. As the network expands the demands on centrally-organized structures increases costs and prevents long-range communication.

The invention of the internet - literally a network of networks - is built on the principle that a distributed structure with a diffuse protocol can defeat the network problems from the telephone. The first long-distance computer communications were between UCLA and Stanford on ARPANET in 1969. The key innovation is the "store and forward" framework - computers route messages along the network so that two nodes without a direct connection could communicate. A set of routing rules, negotiated by each network, determined how information could pass through the system. As the number of "routers" increased, nodes could communicate across long distances by making short hops across the system. Each packet contains information about its source and destination, and the destination assembles the message once it is delivered. The architecture of the internet is a series of connected routers that agree to pass packets to one another.[3]

While communication networks such as national mail delivery are controlled and organized by governments, a series of internet service operators called Autonomous Systems (ASes) structures the internet. An AS refers to a network or group of networks that a common administrator controls. The earliest ASes were universities and research institutions from the original ARPANET. The number of systems increased from fewer than 5,000 in 1998 to over 70,000 in 2020.[4] In 2022, the most common ASes are internet service providers, but there remain universities, corporations, or state organizations.[5]

At the core of the internet are agreements between ASes to share data, exchange, or "peer", across their networks. For computers to communicate outside of their network they can do two things. They can agree to exchange data directly with the customers in other networks, or they can find another network to carry their data to other networks. These are the "peer-to-peer" and "customer-to-provider" agreements that allow data to move between physical locations in digital space. When networks peer they agree to exchange data without charging fees, when they interconnect as customer-to-provider one network agrees to carry data for another for a fee. Typically networks will peer when they are similar sizes and expect data flows to be symmetric, and agree to carry data when one network will depend heavily on another to move data.

Some degree of centralization exists in this process. A series of regional internet registries (RIRs) collects and disseminates information about the identity of each AS that provides internet access. The first of these, the Réseaux IP Européens Network Coordination (RIPE), was founded in 1992 in Amsterdam, and other internet registries created during the 1990s expanded to coordinate internet exchange in each region. Each of the registries runs as non-profit, membership-based organizations of providers. Routing rules, however, are negotiated by individual network operators.

The existing literature on politics and the internet typically focuses on how politics shape platforms and applications such as social media or the mass media. This includes the emerging literature

[3] For a history of the internet, see Abbate (1999).

[4] https://www.cidr-report.org/as2.0/

[5] Network Working Group. "Guidelines for Creation, Selection, and Registration of an Autonomous System (AS)." Internet Engineering Task Force, March 1996. https://datatracker.ietf.org/doc/html/rfc1930.

on models of internet filtering and control (Deibert et al., 2010), how authoritarian regimes use the internet to silence dissent (Lorentzen, 2014; Roberts, 2018), and how censorship affects how individuals interact with online platforms (Pan and Roberts, 2020). Less of this work has examined how politics shapes the internet's structure and development at a fundamental level. The literature on the digital divide tries to understand how politics might present a barrier to internet development Milner (2006). O'Hara and Hall (2021) argues that Europe, China, Silicon Valley, and the United States advocate four different models of the internet. In these cases, the internet is a domestic phenomenon - states can promote or prevent development within their borders. However, the internet has a significant international structure.

3 Internet Infrastructure

3.1 Why Does Internet Structure Matter?

Internet expansion is essential for economic growth (Czernich, Falck, Kretschmer and Woessmann, 2011; Datta and Agarwal, 2004; Koutroumpis, 2009; Roller and Waverman, 2001). Internet access is one of the main outcomes of the United Nations 2015 Sustainable Development Goals and the World Bank's (2016) *World Development Report* argues "The greatest rise of information and communications in history will not be truly revolutionary until it benefits everyone in every part of the world." However, how and when internet service providers agree to exchange data - the structure of the internet - has significant implications for the speed, price, and reliability of internet access, along with important security ramifications. The existing research in network science investigates interconnection development, while an adjacent literature in economics attempts to measure how the quality of internet provision influences welfare and growth. Finally, new globalization research discusses internet structures as a source of power and intelligence.

Routing decisions can degrade an entire region's internet. Gupta et al. (2014) find that 66.8% of African internet traffic travels out of the continent to reach another point in Africa. They explain that local ISPs are either not peering at local exchanges, or the local exchanges do not exist, which causes data to travel further through "circuitous paths." These paths contribute to increased latency, reducing the speed that data can travel.[6] They also increase the cost of internet services because data has to travel through paid interconnection channels instead of local settlement-free peering

[6]Latency is the amount of time that it takes for data to begin transferring after it has been called.

arrangements. For example, if a business in Kenya needs information on a computer in Uganda, the only path may be a service in the Netherlands. The African networks have to pay the broker in the Netherlands and the data has to travel through multiple international submarine cables.

Chavula, Feamster, Bagula and Suleman (2015) demonstrate how circuitous paths, which they argue are due to insufficient interconnection, lead to slower internet latency for academic institutions. Chavula, Phokeer, Formoso and Feamster (2017) argue that due to a lack of interconnection in the region, data often travels faster between Africa and Europe than within Africa. A United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)-sponsored working paper on barriers to internet access in Least Developed Countries (LDCs) found the the presence of an internet exchange point (designed to facilitate greater internet peering) increased the speed of fixed-internet broadband (Vakataki 'Ofa, 2019).

In addition to increasing internet speed, increasing internet peering (one of the two forms of interconnection in this paper) is associated with lower internet prices (Baake and Wichmann, 1999; McKnight and Bailey, 1998). Greater interconnection also gives networks greater reliability, since it reduces the dependence on any one path for data.[7] Both internet speed and pricing are cited as significant barriers to economic advancement in the developing world.

Developing countries pay attention to these internet policy prescriptions, and cite greater interconnection between internet service operators as a key economic goal. Mauritania's *National Strategy of Modernization of Administration and ICTs* (2012-2016) included interconnection as a main priority. The most important part of encouraging interconnection is an internet exchange point "to allow the operators of the countries to interconnect and exchange their Internet traffic "locally" without having to go back to exchange point located in a developed country as is the case today" (p. 66).

Developed states discuss their comparative advantages in terms of the internet's infrastructure. In 2020, the Netherlands had the most IXP traffic (14.3 Tbit/s)[8][9] in Europe. The Netherlands markets itself as the "Digital Gateway to Europe," building the "over a 1000 years the Netherlands

[7] Gonyea, Ben. "What Is Internet Peering and Why Is It Beneficial." Digital Realty, March 27, 2014. https://www.digitalrealty.com/blog/what-is-internet-peering-and-why-is-it-beneficial.; Doerr, Christian, Razvan Gavrila, Fernando Kuipers, and Panagiotis Trimintzios. "Good Practices in Resilient Internet Interconnection." Report/Study. European Network and Information Security Agency, June 2012.; Garnett, Paul. "Connect2Recover: Building Back Better with Broadband." International Telecommunications Union, March 15, 2021.; Ivanov, Ivo. "Another Five Reasons to Peer." APNIC Blog, September 7, 2021. https://blog.apnic.net/2021/09/07/another-five-reasons-to-peer/.

[8] This is approximately 7,000 hours of video or 240,000 hours of music in data per second.

[9] European Internet Exchange Association. "Internet Exchange Points 2020 Report." Amsterdam, 2020. https://www.euro-ix.net/media/filer_public/93/77/937743c9-1996-4586-8daf-f5fcd2640be3/ixp_report_2020_.pdf.

has been the (digital) gateway to the European market."[10] The Amsterdam Internet Exchange, AMS-IX, a not-for-profit organization founded in the early 1990s by a consortium of internet service providers, is a central part of their advantage. In 2020, at its peak traffic AMS-IX exchanges 10 Tbit/s between its members and exchanged a total of 22.8 exabytes of data.[11] AMS-IX is also the center of a global network. In 2020, 30% of internet providers exchanging data AMS-IX were from outside Europe, 49% were from Europe (excl. Netherlands), and 21% were domestic (Grove and de Lange, 2021). As a result, the Netherlands has the lowest average latency in Europe, and data in the Netherlands can reach 80% of Europe within 50 milliseconds.[12]

The Netherlands centrality within the internet architecture yield benefits beyond the direct effect of attracting new business and a faster internet. A 2020 report found that the digital infrastructure in the Netherlands accounted for €460 billion, 60% of GNP, and 3.3 million jobs.[13] The Netherlands robust digital platforms and internet infrastructure also made it the second most prepared country for remote work during the COVID-19 pandemic (Chakravorti and Chaturvedi, 2020). The Netherlands is also a global hub for high speed trading, which relies on fast and stable data exchange. A central position in the internet architecture is a resource in itself - it makes states like the Netherlands a hub for the global digital economy.

While local peering and dense internet interconnection leads to a less expensive, more reliable, and faster internet, do these factors matter for economic growth? Czernich et al. (2011) leverages local changes in broadband internet access to demonstrate that a 10% increase in high-speed internet coverage raises annual per capita growth by 0.9 to 1.5%. Grimes, Ren and Stevens (2012) analyze firm-level productivity to show how businesses benefit from high-speed internet roll-out. Other authors argue that that internet speed independently contributes to economic growth beyond general internet penetration (Crandall, Lehr and Litan, 2007; Lüdering, 2016; Rohman and Bohlin, 2012). An over-reliance on few interconnection pathways increases the risk of internet blackouts due to single faults like submarine cable disruptions due to natural disasters or human error.[14]

While internet structure matters for economic development, it may also provide intelligence advantages over adversaries. A country's reliance on others opens it up to coercion from foreign

[10] Digital Gateway to Europe. "Homepage," 2018. https://www.digitalgateway.eu/.

[11] 5 exabytes is equal in information to every word ever spoken by human beings in all history.

[12] https://netrouting.com/data-centers/amsterdam/

[13] "The Future of the Digital Economy." Pb7 Research and the METISfiles, 2020. https://www.digitalemainport.nl/.

[14] Schumann, Robert, and Michael Kende. "Lifting Barriers to Internet Development in Africa: Suggestions for Improving Connectivity." Internet Society, May 2013.

powers through conditionality, sanction, and changing incentives (Drezner, 2003; Hirschman, 1945), and a state's importance in global networks provides opportunities to shape international rules and regimes (Keohane and Nye, 1977; Slaughter, 2017). Recently, Farrell and Newman (2019) argued that centrality within global networks also provides direct coercive advantages through "panopticon" and "chokepoint" effects - the ability to monitor the overall network and exclude specific actors from it. The authors' argue that the internet represents a "panopticon" opportunity for the United States, which can leverage the internet's structure with intelligence capabilities to monitor adversaries. Global technical structures are why certain countries gain intelligence advantages.

3.2 What Influences the Internet's Structure?

Interconnection in the networks literature is a dependent variable used to understand how ASes interact. At a very basic level, internet interconnection results from demand for access to the computers that can be reached by another network. If a new data center opens in one area, increased demand for data on that server will result in more demand for interconnection with systems that can reach the new system. If a business in one country opens an office in another, they may pay a premium for a data service that can reliably and rapidly deliver data between their two offices.

The Barabasi-Albert model (1999), the most well-known attempt to describe the internet network, characterizes the internet by high levels of preferential attachment and growth. Preferential attachment, also known as "the rich get richer", is the concept that new nodes to the system prefer to join already well-connected nodes (Merton, 1968). Those who subscribe to this view of the internet understand interconnection as hierarchical and characterized by low levels of peering at the local level (Chang, Jamin and Willinger, 2006; Chen et al., 2002; Subramanian et al., 2002). The Barabasi-Albert model has been debated within the networks literature as local data peering became more common (Dhamdhere and Dovrolis, 2010). This paper does not seek to resolve debates regarding the shape of the internet, but whether bilateral state relations impact the individual agreements that make up the structure.

If greater interconnection leads to faster, cheaper, and more reliable internet, then why don't all networks interconnect all the time? First, there may not be sufficient demand for a certain internet pathway. Interconnection agreements have to be negotiated and maintained at exchange points, ISPs must invest in creating peering partnerships, and operators may not have the bandwidth to agree to all interconnection agreements. Internet traffic may be asymmetric - an ASN with a dense network of interconnection agreements would have few reasons to carry traffic for a small ASN with few existing connections, and they may be unable to agree on a price to carry data. Peering (whether paid or unpaid) is "widely considered to be an art rather than science," negotiated through the biases and heuristics of individual network operators trying to determine whether the traffic ratios, backbone capacity, and expected traffic volumes indicate that interconnection will be profitable (Dhamdhere, Dovrolis and Francois, 2010).

There may also be cultural or political barriers to interconnection. Fanou, Francois and Aben (2015) uncovers differences in transit habits depending on the country's official language, monetary region, and business profile of different ISPs. The authors hypothesize that these differences create barriers for firms negotiating peering agreements. In a report for the Internet Society, Schumann and Kende (2013) advise "Advance the harmonisation of cross-border interconnection and licensing regimes at the regional level, including through the regional economic communities (RECs);" and encouraging competition among internet service providers. Another Internet Society report argues that monopolies and differences in licensing regimes reduce interconnection.[15] However, there are no existing studies on whether internet interconnection is impacted by cross-border regulatory harmonization or the removal of national monopolies.

One data flow barrier may be national data regulations or localization rules that govern how (or even whether) data can be exchanged across national boundaries. There is mixed evidence for this in practice. Goldberg, Johnson and Shriver (2019) find significant negative effect for the European Union General Data Protection Regulation (GDPR) for e-commerce sales (which rely heavily on interconnection) and web traffic. However, Zhuo, Huffaker, Claffy and Greenstein (2020) demonstrates that the GDPR is not associated with any change in internet routing. These studies assume that privacy regulations create an additional regulatory burden that imposes costs on internet-dependent businesses. The next section discusses how localization interacts with the internet's structure in detail.

However, evidence that data follows the flag should be surprising given what we have been led to believe about the internet - that it is inherently difficult to regulate and extraterritorial. This argument starts at the technical level - because the internet is vast, the data routing rules are self-organizing and highly decentralized (Feamster, Winick and Rexford, 2004; Hall, Ander-

[15] Internet Society. "Policy Brief: Internet Interconnection," October 30, 2015. https://www.internetsociety.org/policybriefs/internetinterconnection/.

son, Clayton, Ouzounis and Trimintzios, 2011). Swire (1998) and Froomkin (1997) argued that the internet empowered private actors over states. Legal scholars faced a challenge regarding how physical-contextual laws applied to digital spaces. The non-physical and distributed internet architecture is why Johnson and Post (1996) argued that traditional law could not govern the internet. Daskal (2015) argued that data was fundamentally "un-territorial," similar to arguments made by Kobrin (2001). These perspectives suggest that territorially-dependent effects (like conflict or trade agreements between countries), should not impact data transfer.

4 What Could Influence International Internet Interconnection?

Bilateral relationships between states influence trade by increasing or decreasing the transaction costs and risks for businesses (Savage and Deutsch, 1960). This paper considers both economic and security conflict and cooperation. First, that military conflict between states may reduce interconnection, either due to the fears of disrupted economic relations (the historical argument) or due to the fear of weaponized interdependence (an newer argument). Consequently, international treaties that promote military cooperation may result in increased internet interconnection. Second, that international trade treaties will increase interconnection through increased trade generally, or digital trade specifically. Furthermore, treaties that prevent data localization (one of the main points of contention in digital trade today) will increase interconnection directly by reducing risk and compliance costs for firms.

4.1 Security Conflicts and Cooperation

If data is akin to trade, there are various characteristics of bilateral security relationships that may influence the incentives for internet service providers to exchange data. International trade is significantly reduced by conventional wars (Glick and Taylor, 2010; Anderton and Carter, 2001), the fear or expectation of future conflicts (Long, 2008), low level conflict (Keshk, Pollins and Reuveny, 2004), and diplomatic conflicts (Pollins, 1989*b*,*a*; Michaels and Zhi, 2010). International conflict causes states to become less interdependent as well (Kim and Rousseau, 2005). Morrow (1999) argues firms reduce business with countries that present security risks. When states are in conflict they become more focused on relative gains with their adversary, leading to decreases in bilateral trade (Liberman, 1996). However, as Grinberg (2021) notes, states may not be able to produce a good that they trade with an adversary, and so trade may continue even as conflict breaks out.

The reverse may be true as well - if conflict reduces trade, military alliances may also promote it (Gowa and Mansfield, 1993, 2004; Gowa, 1994; Mansfield and Bronson, 1997). Military alliances reduce the fear of security externalities from economic exchange, enforce trade linkages, or create strategic interdependence.

If interstate conflict reduces trade between countries, there may be reduced demand for interconnection and data flows. For example, if a Ukrainian business closed their offices in Moscow after conflict in Crimea in 2014, they may no longer need an internet service that can exchange data between the two countries. An AS may decide to remove their point of presence in an internet exchange (which they must pay to maintain), if they do not anticipate growing demand for data along a route.

The recent literature on weaponized interdependence draws a direct link between technical structures and international competition and provides a security explanation for why conflict might reduce digital interconnection. Farrell and Newman (2019) argue that the United States position within the internet architecture enables a vast intelligence gathering program that provides significant security advantages. If this is the case, countries should seek to reduce the amount of data that they transit through an adversary at the onset of a international conflict. Data interconnections provide the adversary an opportunity to steal data, yet the internet is highly decentralized and the structure is created by a series of independent operators.

Examples suggest that state pressure to reduce interconnection is already occurring - the fear of future conflict is leading the United States to exert control over where internet service providers can route data. In 2017, Facebook and Google proposed investing a minimum of $300 million to build a 120 terabyte per second cable between Los Angeles and Hong Kong. This would have been the second trans-Pacific cable connecting Hong Kong and the United States, but would have had over twelve times the capacity of the Asia America Gateway (AAG). The increased capacity would allow tech companies to expand their presence and increase the efficiency of the global internet infrastructure.[16]

In 2019, the U.S. Justice Department cited national security concerns to oppose the bid.[17] In

[16] Quigley, Brian. "New Undersea Cable Expands Capacity for Google Asia Pacific Customers and Users." Google Cloud Blog (blog), October 12, 2016. https://cloud.google.com/blog/products/gcp/new-undersea-cable-expands-capacity-for-google-apac-customers-and-users/.

[17] Strohm, Chris, and Todd Shields. "Justice Department Opposes Google's Undersea Cable From China." Bloomberg.Com, August 28, 2019. https://www.bloomberg.com/news/articles/2019-08-28/

June, 2020 the Department of Justice recommended that the FCC deny the cable license.[18] The recommendation was based on:

> Concerns that PLCN would advance the PRC government's goal that Hong Kong be the dominant hub in the Asia Pacific region for global information and communications technology and services infrastructure, which would increase the share of U.S. internet, data, and telecommunications traffic to the Asia Pacific region traversing PRC territory and PRC-owned or -controlled infrastructure before reaching its ultimate destinations in other parts of Asia.

There is significant evidence that different forms of trade are affected by conflict, and how the United States approached internet interconenction with China suggests that similar fears may affect the Border Gateway Protocol. At the same time, control over submarine cable landings may not be a strong enough lever to damage China or Hong Kong as a global center of internet data transfer. The Department of Justice approved the PLCN cable section linking the El Segundo, CA and Toucheng, Taiwan in April 2020.[19]

However, direct influence over interconnection is not necessary for the weaponized interdependence mechanism to work. The Snowden leaks demonstrated the power of internet interconnection. A key component of the United States National Security Agency program was "upstream collection," where the government partnered with AS and IXP operators to siphon intelligence data. Many countries carry out similar internet intelligence programs, including the Mastering the Internet program in the United Kingdom, Onyx in Switzerland, SORM in Russia, and the Central Monitoring System in India. Businesses are aware of how their data is routed, and demanded more control over their data in the aftermath of the Snowden leaks.

NTT Communications,[20] carried out a survey of their customers after the Snowden leaks in 2014. 31% of respondents said that they were moving data to "locations where they know it will

justice-department-opposes-google-s-undersea-cable-from-china.; O'Keefe, Kate, Drew FitzGerald, and Jeremy Page. "National Security Concerns Threaten Undersea Data Link Backed by Google, Facebook." Wall Street Journal, August 28, 2019, sec. Politics. https://www.wsj.com/articles/trans-pacific-tensions-threaten-u-s-data-link-to-china-11566991801.

[18] National Security Division (NSD). "Team Telecom Recommends That the FCC Deny Pacific Light Cable Network System's Hong Kong Undersea Cable Connection to the United States." U.S. Department of Justice, June 17, 2020. https://www.justice.gov/opa/pr/team-telecom-recommends-fcc-deny-pacific-light-cable-network-system-s-hong-kong-undersea.

[19] U.S. Department of Justice. "Department of Justice Clears on Google's Application to the Federal Communications Commission to Operate a Portion of the Pacific Light Cable Network System," April 8, 2020. https://www.justice.gov/opa/pr/department-justice-clears-google-s-application-federal-communications-commission-operate.

[20] NTT is one of the largest communications in the world with the sixth largest AS on the internet as of 2022

be safe," 96% of EU and 92% of US respondents stated they wanted a cloud data service located in their own region. Respondents reported that they cared most about whether a cloud provider could provide guarantees over the physical location of data.[21] When conflict breaks out between two states the value of intelligence increases, and this creates risks for data that travels between the two locations.

4.2 Trade Conflicts and Cooperation

Are there trade barriers to data flows and can states reduce them by signing new agreements? Baier and Bergstrand (2007) demonstrate that free trade agreements have a significant and robust effect on interstate trade flows. Büthe and Milner (2008) demonstrate that this effect is due to the commitment mechanisms that preferential trade and international trade agreements provide to investors. Specifically, foreign direct investment (FDI) significantly increases when countries join international trade agreements controlling for a variety of domestic policy preferences. Dür, Baccini and Elsig (2014) build a comprehensive dataset of trade agreement design to show how the effects in the literature are primarily driven by deep trade agreements that provide greater commitment.

The U.S. International Trade Commission found that digital trade provisions have a significant effect on international services trade, but did not address whether trade agreements generally impacted data flows and the internet's structure (Gurevich and Guberman, 2021). There has been little investigation of how the internet's technical structure is impacted by trade agreements, or if any effect is dependent on digital trade provisions.

Trade agreements may spur internet interconnection for several reasons. First, any trade agreement should increase trade between two countries, increasing the demand for internet flows. Furthermore, trade agreements may have provisions that directly affect digital trade. First, trade agreements can have e-commerce clauses, which directly reduce barriers to online trade. Next, trade agreements can contain provisions on the free movement of data, which express intentions to remove internet barriers. Finally, trade agreements may have a provision aimed at limiting or prohibiting data localization requirements, which directly addresses many risks and fears from that internet service operators and digital businesses.

E-commerce and data provisions are part of many trade agreements signed since 2000. E-

[21] NTT Communications. "NSA After-Shocks: How Snowden Has Changed ICT Decision-Makers' Approach to the Cloud," 2014.
https://www.ntt.com/content/dam/nttcom/affiliate/cmn/pdf/resouces/whitepapers/nsa_aftershocks.pdf.

commerce itself is a broad category, defined by the WTO as "the production, distribution, marketing, sale or delivery of goods and services by electronic means."[22] E-commerce trade provisions include rules on electronic signature and authentication (signing contracts digitally), intellectual property protections, mutual recognition of digital certificates, and protecting source code. All United States trade agreements since 2003 have included an e-commerce clause recognizing the importance of digital trade to economic development. Since e-commerce is dependent on robust internet interconnection, reducing barriers to the one may facilitate the expansion of the other.

The WTO *Declaration on Global Electronic Commerce* stated in 1998 that data itself is not subject to tariffs. However, data are subject to national regulations and localization requirements that influences digital commerce. The United States International Trade Commission found that data localization and regulation was the most cited barrier to digital economic growth by business firms.[23]

Data localization laws require digital information to be stored and processed within the country.[24] Localization rules are discussed as a form of "data protectionism."[25] Certain types of data can be subject to data localization, such as health data in Australia, government data in Nigeria, and geospaticial data in South Korea (Chander and Lê, 2015; Ferracane, 2017). Localization rules are separate from rules and regulations regarding personal data privacy and regulation, such as the General Data Protection Regulation (GDPR) in the European Union. Regulations such as GDPR rules govern how data is processed, but do not necessarily require data to be processed in a specific place. Some authors describe this as the difference between "hard" and "soft" localization (Chander, 2020).

Authors posit different mechanisms for why hard or soft data localization may reduce data flows, and, by extension, interconnection agreements. Adapting to hard localization measures is a costly process. A digital business must gain a point of presence in the country to ensure basic services, and it must create new storage facilities in the country. To access data in the new country they need an efficient infrastructure in that country, which may not be possible. Firms have to negotiate new interconnection agreements and design new routing protocols to comply with localization.

[22] Goode, Walter. Dictionary of Trade Policy Terms. 6th ed. World Trade Organization, 2020. https://www.wto.org/english/res_e/publications_e/dictionary_trade_policy_e.htm.

[23] "Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions." United States International Trade Commission, August 2017. https://www.usitc.gov/publications/332/pub4716.pdf.

[24] "Digital Trade in the U.S. and Global Economies, Part 1." United States International Trade Commission, July 2013.

[25] Beattie, Alan. "Data Protectionism: The Growing Menace to Global Business." Financial Times, May 13, 2018. https://www.ft.com/content/6f0f41e4-47de-11e8-8ee8-cae73aab7ccb.

Localization has negative consequences for network performance. If data must be stored locally, it may not be located in the easiest place to reach. For instance, data moving between two points in Indonesia might move the fastest if it used a path through Singapore. It may be faster for all firms in Indonesia to access their data in Singapore, but now data must find paths through the domestic internet.[26] For example, Article 29 from China's draft "Data Security Management Measures" states that when users in China access Chinese websites the data should not be routed outside of China.[27] ASes considering where to route data have to consider the possibility that they will need to adjust if new localization measures take place.

National data regulations do not necessarily require data to be processed in one location. Nevertheless, authors have argued that data and privacy regulation will impact data flows going back to the European Privacy Directive of 1995 (Swire and Litan, 1998). Numerous industry, think-tank, and consulting groups argued that GDPR presented a barrier to data flows.[28] The 2019 *National Trade Estimate* cited GDPR as a significant barrier to trade, specifically due to restrictions on data flows. Agreements like the EU-US Privacy Shield (Schrems II) or APEC Cross-Border Privacy Rules (CBPR) are designed limit the effect of national data regulations on transnational data flows by harmonizing standards.

While some trade agreements discuss data flows, few make binding commitments to regulate data in a specific way, and the most significant effort at harmonizing data regulation (EU–US Privacy Shield) was struck down in 2020. European Union bilateral trade agreements with Canada (2017), Japan (2019), and Singapore (2019), contain a self-standing chapter on digital trade with provisions on issues such as "prohibiting unjustified barriers to data flows, including data localisation requirements and protecting privacy."[29] The U.S.-Korea Free Trade Agreement (USKORUS) states "parties shall endeavor to refrain from imposing or maintaining unnecessary barriers to electronic

[26] Internet Society. "Internet Way of Networking Use Case: Data Localization," September 30, 2020. https://www.internetsociety.org/resources/doc/2020/internet-impact-assessment-toolkit/use-case-data-localization/.

[27] Tai, Katharin, Lorand Laskai, Rogier Creemers, Mingli Shi, Kevin Neville, and Paul Triolo. "Translation: China's New Draft 'Data Security Management Measures.'" New America (blog), May 31, 2019. hhttp://newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinas-new-draft-data-security-management-measures/.

[28] Bauer, Matthias, Fredrik Erixon, Michal Krol, and Hosuk Lee-Makiyama. "The Economic Importance of Getting Data Protection Rioght: Protecting Privacy, Transmitting Data, Moving Commerce." European Centre for International Political Economy, 2013.; Kepes, Rozi, Joshua White, and Aaron Yeater. "The Importance of Cross-Border Data Flows." Analysis Group, 2021.; "Business Without Borders: The Importance of Cross-Border Data Transfers to Global Prosperity." U.S. Chamber of Commerce, 2014.; Mandel, Michael. "Data, Trade and Growth." progressive policy institute, 2014.

[29] European Commission. "Digital Trade," June 21, 2021. https://ec.europa.eu/trade/policy/accessing-markets/goods-and-services/digital-trade/.

information flows."[30]

However, several trade agreements have provisions directly addressing "hard" data localization. The Amended Australia Singapore Free Trade Agreement (SAFTA), which came into effect in December 2017, contains a chapter on Digital Trade. Articles 23 and 24 address "Cross-Border Transfer of Information by Electronic Means" and "location of computing facilities." Article 24 Provision 2 states that "Neither Party shall require a covered person to use or locate computing facilities in that Party's territory as a condition for conducting business in that territory."[31] The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which came into effect for the first six parties in 2018, contains the same data localization provision as SAFTA.[32]

While localization laws have become increasingly common, and are cited as one of the main barriers to data flows, we have no empirical evidence that localization prevention provisions impact the internet's structure.

5 Empirical Approach

5.1 DV: Internet Interconnection

The Center for Applied Internet Data Analysis (CAIDA) at the University of California, San Diego has gathered data about different aspects of the internet architecture since 1998. This paper leverages two CAIDA datasets, *AS Relationships* with peering agreements between systems,[33] and *AS Organizations* that maps autonomous system (AS) numbers to organizations.[34] These independent operators form agreements to exchange data between one another through the Border Gateway Protocol (BGP). This protocol is how requests for information on one system are routed to their destinations.

Data can be exchanged to ways on the internet peer-to-peer or provider-to-customer. In a peer-to-peer agreement two networks exchange data between their two customer networks, thereby reducing the cost of delivery by shortening the distance data must travel and limiting the number

[30] Williams, Brock R, Mark E Manyin, Remy Jurenas, and Michaela D Platzer. "The U.S.-South Korea Free Trade Agreement (KORUS FTA): Provisions and Implementation." CRS Reports, September 16, 2014.

[31] Singapore-Australia Free Trade Agreement, § Chapter 14: Digital Economy (2017). https://www.dfat.gov.au/sites/default/files/SAFTA-chapter-14.pdf.

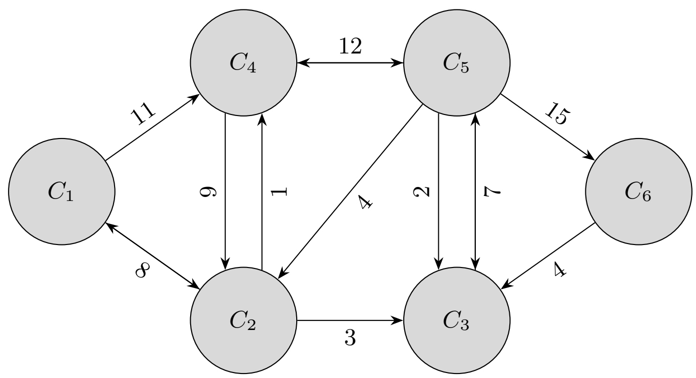
[32] CPTPP also contains other provisions on data flows, including a provision on encouraging cybersecurity cooperation.https://www.mfat.govt.nz/assets/Trade-agreements/TPP/Text-ENGLISH/14.-Electronic-Commerce-Chapter.pdf

[33] https://www.caida.org/data/as-relationships/

[34] https://www.caida.org/data/as-organizations/

of intermediaries. These agreements can either be free or paid. Provider-to-customer agreements are agreements for one network to provide another with access to the internet for fees. Typically network volumes are more asymmetric in provider-to-customer agreements than peer-to-peer. An organization such as CAIDA places monitors throughout the internet to observe routing decisions, which I then project into a network of agreements between providers internationally.

Figure 1: Representation of Transnational Interconnection



The figure demonstrates the network in the main analysis. Each C_i represents one country with internet service providers that have agreements to exchange data in C_{-i}. Double arrow lines represent the number of peer-to-peer agreements between these providers, and a one arrow line represents a provider-to-customer agreements between these providers.

Each of the registered ASes declare a primary country, which can then be projected to the country level, such as in Figure 1. In this network, there are six countries. Within each country there may be interconnection agreements with different organizations, and the arrows represent interconnection agreements between systems in two different countries. Directed arrows represent provider-to-customer agreements. For example, there are eleven ASes in C_1 with customer agreements in C_4, so data is allowed to move between the two countries leveraging any of those eleven agreements between ASes in those two countries. However, those ASes in C_1 must pay those in C_4 to carry their data. The two-sided arrows represent the peer-to-peer agreements. For instance, there are seven peering agreements between ASes in C_5 and C_3.

Data can still move between any of the countries since every country has at least one agreement. However, when two countries do not have any ASes with a direct link data must move farther to reach its destination, and they must pay every interconnection fee on the way. This means greater latency, higher cost, and less efficiency. There are opportunities to cut down on the distance between countries. For instance, an AS in C_6 could agree to peer with an AS in C_2 to cut C_3 out of the system, which they currently both have to pay to exchange data. However, do trade agreements and international conflict between C_2 and C_3 affect whether this actually occurs?

CAIDA has monthly-level data for peering and customer arrangements from January 1998 to the present day. ASN ownership can change ownership over time, so the dataset mapping ASes to organizations is dynamic. CAIDA publishes information about the current ownership of ASes using data from the larger internet registries from January 2004 to the present day. I combine the static snapshots of AS ownership into one dataset with all owners of AS numbers over time.

CAIDA collects a view of internet routing by placing monitors in different countries and probing the internet. The different monitors attempt to contact hosts and record information about how their connection is routed through the network. CAIDA leverages an algorithm to infer the type of agreement that the network operators are engaging in (Luckie, Huffaker, Dhamdhere, Giotsas and claffy, 2013). I use this dataset for two variables - the number of P2P and P2C agreements between two countries (j_i, j_{-i}) in any given month (t).

Figure 2: Interconnection Agreements Between January 2008 and December 2019

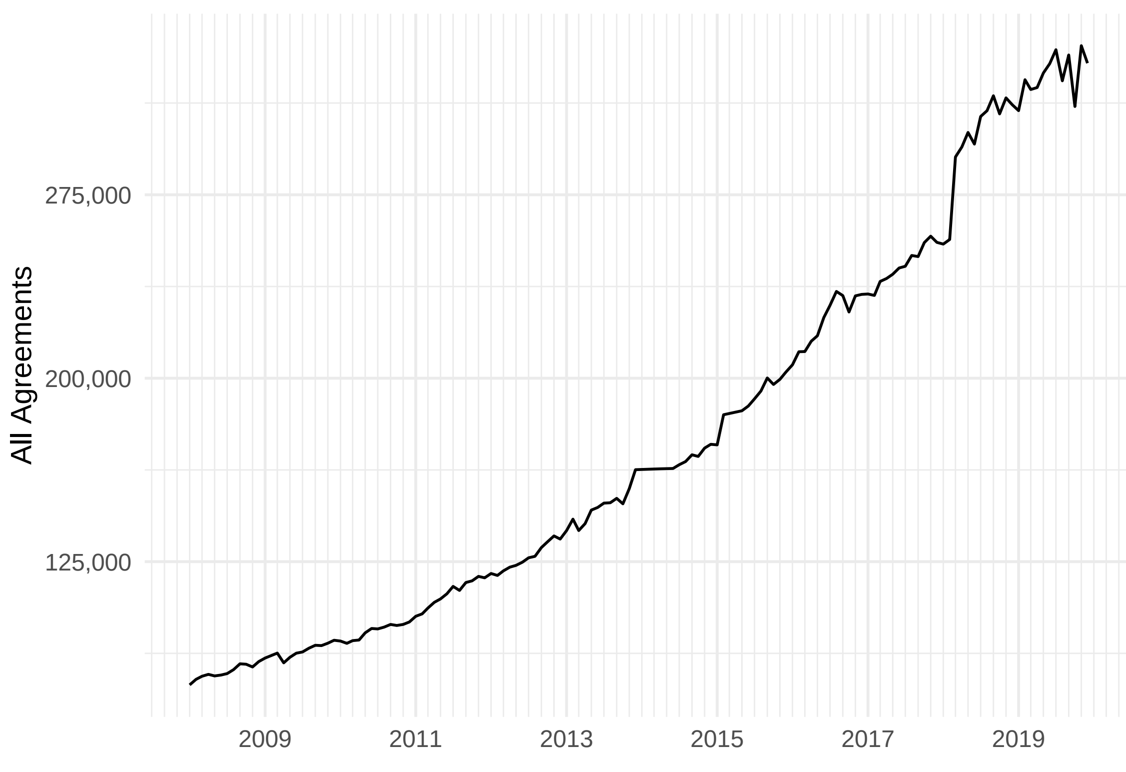


Figure 2 contains the total number of interconnection agreements in the CAIDA dataset. This is the sum of peer-to-peer and customer-to-provider agreements between ASes in two countries.

Unsurprisingly, the number has increased significantly with the increasing number of internet users. For January 1998, the dataset contains 11,546 interconnection agreements, doubling by October, 1998 and again by April, 2001, until the number reached 388,505 in December 2019. The technical collection process, the cleaning process, and potential biases in this data are discussed further in Appendix Section 2.

5.2 IVs: Conflict and Cooperation

Security Cooperation I use the *Alliance Treaty Obligations and Provisions Project (ATOP)* data on military agreements to measure the impact of alliance and treaty formation on interconnection (Leeds et al., 2002). Version 5.0 of the dataset covers all alliances formed between 1815 and December 31, 2015. The dataset contains "formal agreements among independent states to cooperate militarily in the face of potential or realized military conflict." These agreements include non-aggression pacts, but not arms sales or military aid agreements unless they include obligations on military cooperation.

Trade Agreements

I use the *Design of Trade Agreements (DESTA)* dataset Version 2.0 for the preferential trade agreement weights (Dür, Baccini and Elsig, 2014).Since internet interconnection is measured at the month level, I add the month that the agreement entered into force to the DESTA dataset.

The first variable is PRESENCE OF A TRADE AGREEMENT, which includes all agreements in the DESTA dataset (152 agreements affecting 2,161 unique dyads). I then create a variable for PRESENCE OF E-COMMERCE PROVISION, which only includes "trade agreements with provisions addressing the production, distribution, marketing, sale or delivery of goods and services by electronic means." The authors use computerized keywords to identify these provisions following Monteiro and Teh (2017), including terms such as cyber, electronic commerce, telecommunication, and digital. 85 such agreements have gone into force since 2000, including 64 between January 2008 and December 2019. Of the 2,161 dyads with new trade agreements during that period, 1045 entered into a new trade agreement with an e-commerce provision. Additional information about trade agreements with e-commerce components, including whether they address data flows, is in Appendix Section 4.

Third, I create a variable for PRESENCE OF DATA FLOW AGREEMENT, which includes cases where "there is a principle in the agreement that cross-border data flows are free between the parties." These are often in an e-commerce chapter (if it exists). These agreements to not necessarily include specific provisions to address free data flow, but describe a commitment by the parties to increasing data flows. These agreements are worded to address the "soft localization" fears of digitally-dependent firms. This includes 48 agreements into force between January 2008 and December 2019 across 1016 dyads, beginning with the the Nicaragua-Taiwan FTA entering into force in January 2008.

Finally, I create a variable for Presence of agreement preventing data localization. This includes agreements with "provisions aimed at limiting or prohibiting the use of data localization requirements. The provision should be specific (i.e. for all types of data flows) and not a commitment that could cover such barrier in the case of trade in services or investment." These agreements are worded to target the "hard localization" that disrupts data flows, imposes costs on digital firms, and can theoretically decrease internet efficiency between countries. Between January 2008 and December 2019, 6 agreements came into force, affecting 59 dyads.

Conflict

I use two different ways of measuring international conflict. First, I use the Militarized Interstate Disputes (MIDs) dataset 4.02, which covers disputes through December 2014 (Maoz et al., 2019). The dyadic dataset records the first and last dates of conflicts in which both states meet the minimum participation criteria. I code 1 for all months where the conflict is ongoing, and 0 for all months where there is no conflict within a dyad. There are a total of 187 unique disputes in the MIDs dataset between 2008 and 2015 across 146 dyads. Unlike in the UCDP dataset, battle-related casualties do not have to occur for a conflict to be recorded between two sides.

The second data source for conflict is the Uppsala Conflict Data Program (UCDP), which has collected information on armed conflict since 1970 (Harbom, Melander and Wallensteen, 2008). I leverage the UCDP Dyadic Dataset Version 21.1, which covers organized violence through 2020 (Pettersson et al., 2021). I measure whether a conflict is occurring within a dyad using the date that 25 battle-related casualties occurred in a year, given that the two sides were not in a dispute in the prior year. Conflicts end based on the UCDP conflict resolution dataset. The dyadic version of the UCDP dataset includes information about the primary parties of the conflict, along with any other sides with troops actively supporting the primary parties. I consider all parties supporting either side as a dyad engaged in conflict. There are 32 dyads which entered into a conflict under this definition since January 2008. This includes conflict a total of 12 conflicts in Syria, Sudan, Congo, Libya, Ukraine, Georgia, Somalia, and Eritrea. Additional information regarding conflict can be found in Appendix Section 5.

5.3 Methods

The general approach for this paper is the gravity model, which is a common econometric tool in the study of trade (Anderson, 2011; Carter and Poast, 2020), migration (Karemera, Oguledo and Davis, 2000), and online commerce (Cowgill and Dorobantu, 2014). In the canonical gravity model, the imports between country a and country b are a function of the size of the two country's economies and a term to capture the cost of trading between the two countries. This cost is often measured as distance, but can also be border walls, similarities in regulatory regimes, or rivalry. Instead of measuring trade flows, I model the number of interconnection agreements between ISPs in two countries as a function of their changing bilateral relationship. While the gravity model typically models imports from a to b, this analysis relies on the more general model of the total volume of trade between a and b.

There are 155 countries in this analysis, each of which are responsible for determining interconnection and internet policy within an internet protocol (IP) space. This results in 11,935 unique dyads over 186 months from January 2008 through December 2019. Of all dyads at risk, 8,600 (72%) never feature an interconnection agreement.

The presence of zero-values for trade is a widely recognized challenge for gravity models. The gravity approach models trade values as logarithms, which are undefined for zero, and drops all zero values for the dependent variable. There are several issues with this - zero may have a substantive importance in itself, and changes between a positive value and zero may be especially important. Santos Silva and Tenreyro (2006) argues that one solution is to model the raw trade values as count data with a Poisson distribution generalized to non-integer data. This is the solution adopted in the main analysis for the paper, and additional results with linear models can be found in Appendix Section 6.

Similar to Carter and Poast (2020), this paper uses a high-dimensional fixed effect approach with fixed effects for both countries, the dyads, and months. This specification controls for all time-invariant country-level factors that may unilaterally effect internet interconnection, along with time-invariant dyadic level factors that may effect the amount of data moving between two countries. These fixed effect captures many of the factors in the traditional gravity model, such as the GDP of the individual states, or distance between two countries or whether they share a border. The month fixed effects account for any time-varying factors that will effect all countries, such as new technologies that facilitate internet peering or a general trend towards greater internet interconnection.

6 Results

The results for the effect of trade on internet interconnection are in Table 1, and the results for the effect of security cooperation and conflict on internet interconnection can be found in Table 2. Overall, the results demonstrate a positive effect for the impact of trade agreements on interconnection and negative effect for conflict on interconnection.[35]

Table 1: Effect of Trade Agreements on Interconnection

Dependent Variable:	**P2C Agreements**			
Trade Agreement:	All	E-commerce Chapter	Free Data Movement Provisions	Localization Prevented
Coefficient	0.045	-0.006	-0.011	0.222***
	(0.064)	(0.045)	(0.045)	(0.063)
Observations	608,028	608,028	608,028	608,028
Dependent Variable:	**P2P Agreements**			
Trade Agreement:	All	E-commerce Chapter	Free Data Movement Provisions	Localization Prevented
Coefficient	0.243*	0.086	0.084	0.099
	(0.095)	(0.087)	(0.087)	(0.086)
Observations	721,188	721,188	721,188	721,188
Fixed-effects				
Dyad	Yes	Yes	Yes	Yes
Month	Yes	Yes	Yes	Yes

Clustered (Dyad) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05*

Two countries signing a trade agreement for the first time, regardless of whether the agreement contains specific provisions on e-commerce or free data movement, is not associated with increase in the number of provider-to-customer interconnection agreements between the two countries (Table 1). However, trade agreements overall are significantly and positively associated the number of peer-to-peer interconnection agreements. The coefficient represents a 27.5% increase in settlement-free interconnection.

[35] The results in this section are still preliminary and may change in subsequent versions. This is due to the mapping between autonomous systems and countries, which I am still revising and represents a significant challenge. For example, an AS can declare their location as "Asia-Pacific" or "European Union." There is a country that each AS operates in, but this information has to be gathered separately.

The next two columns of the table test the association between agreements with e-commerce provisions and wording indicating that data flows between states should be free. In both cases, the relationship between agreements and interconnection is indistinguishable from zero. However, signing a trade agreement with a provision preventing hard localization is associated with a statistically reliable 27.0% increase in the total number of provider-to-customer agreements between internet service providers in the party states.

Recall that there are two types of data exchange agreements that internet service providers can enter into - provider-to-customer (P2C) and peer-to-peer (P2P). The P2C agreements tend to be more asymmetric in their data flows, with the customer demanding data from the provider and agreeing to pay a settlement fee. Conversely, P2P agreements occur when there is equal demand for data transiting from both of the systems and exchange typically occurs without any fees. Both of these types of agreements indicate that there is greater demand for data flows between the two locations.[36]

Table 2: Effects of Security Cooperation and Conflict on Interconnection

Dependent Variable:	**P2C Agreements**		
Conflict:	UCDP (2008-2019)	MID (2008-2014)	ATOP (2008-2018)
Coefficient	-0.086***	-0.002	0.189**
	(0.025)	(0.031)	(0.067)
Observations	608,028	277,830	539,242
Dependent Variable:	**P2P Agreements**		
Conflict:	UCDP (2008-2015)	MID (2008-2014)	ATOP (2008-2018)
Coefficient	-0.177***	0.002	0.717***
	(0.052)	(0.030)	(0.181)
Observations	721,188	234,576	606,806
Fixed-effects			
Dyad	Yes	Yes	Yes
Month	Yes	Yes	Yes

Clustered (Dyad) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05*

[36]Future versions of this paper will address why provider-to-customer agreements appear to be affected by rules preventing localization. One argument might be that you trust another system more to carry your data when you know that localization will be more difficult. However, I do not know why the coefficient for the relationship between P2P agreements is positive for all trade agreements and null for P2C agreements. At the moment I do not have a great theory for why we might expect heterogeneous results between the P2P and P2C agreements.

The results for conflict and interconnection are contained in Table 2. Rivalry covers all dyads through December 2015, MIDs cover all dyads through December 2014, and UCDP covers all dyads through the entire period (January 2008 through December 2019). Conflict as measured by UCDP is both more intense and less frequent than conflict measured by MIDs. An active conflict in UCDP is associated with significant and negative effects on both provider-to-customer agreements (-8.2%) and peer-to-peer agreements (-16.2%). However, there does not appear to be any relationship between the onset of a militarized interstate dispute and interconnection in either form.

The final column in Table 2 addresses the relationship between new security agreements and data exchange agreements. New agreements came into effect between 291 dyads between 2008 and 2019. An alliance between two states is associated with a positive and significant increases in both provider-to-customer (20.8%) and peer-to-peer (104.8%) data exchange agreements. This is in line with authors who argue that military alliances promote trade and integration between states (Gowa and Mansfield, 1993, 2004; Gowa, 1994; Mansfield and Bronson, 1997). Because data flows can weaponized for intelligence advantages (Farrell and Newman, 2019), formal alliances reduce the risk to data along with the potential disruptions due to conflict.

7 Contributions

The internet is a distributed system sustained by tens of thousands of operators who choose where and when to exchange data, but these operators exist within national boundaries. While globalization may lessen the power of the state, distributed global networks also create demand for government coordination (Drezner, 2008). This paper outlined two characteristics of bilateral relationships that may either promote or prevent individual network operators from engaging in interconnection with their counterparts across national boundaries. Data is central to intelligence operations, and the internet's structure allows potential adversaries to collect information that may provide security advantages. Armed conflict may make these risks especially salient and new treaties may dampen these fears. At the same time, barriers to digital trade, such as data localization laws and differences in regulatory regimes, could prevent greater digital integration. Reducing these barriers may induce operators to interconnect, helping to unlock the internet's potential as a transformative economic technology.

This paper provides evidence that data does follow the flag. However, the commercial peace, which relies on trade following the flag, has not been addressed within this paper. If conflict reduces data interconnection between countries firms may lobby against conflict. As the literature on digital interdependence develops to consider more forms of conflict and cooperation between states (treaties on cybercrime, cybersecurity cooperation and conflict, international standards) the suite of policies firms might lobby on may increase. Nye (2016) argues that interdependence and globalization create "entanglement" with regards to cyberattacks - the attackers avoid exploiting an adversary system because they are unable to control the consequences. Suppose conflict reduces a country's ability to access a stable, fast, and affordable internet. In that case, a state engaging in conflict may reflect its willingness to suffer extreme costs, resist domestic economic interests, or find economic alternatives.

This paper also provides new findings regarding how private businesses react to changes in bilateral relationships at the micro-level. Previous studies focused on yearly trade or firm-level data, while this study measures data exchange agreements and bilateral commercial exchanges at the monthly level. This granular view is possible due to the ongoing technical interconnection measurements collected by computer science research groups.

Most trade negotiations today include provisions on the digital economy, and trade negotiators worldwide consider including data localization prevention provisions in new agreements. This paper demonstrates one significant benefit for including these provisions - countries that commit to not enforcing localization promote interconnection between their countries, which lowers the cost of moving data both to one another and the internet broadly.

This paper demonstrates the influence of trade agreements for interconnection and, by extension, the price, speed, and reliability of internet infrastructures for all parties in the agreement. The analysis shows how provisions preventing data localization are especially important for peer-to-peer interconnection, which is a key driver of improved internet infrastructure. A trade agreement with a provision preventing localization is associated with a 48.3% increase in peer-to-peer agreements between internet service operators in two countries. (Zhuo et al., 2020) found no detectable effect of GDPR (which has a localization element) on interconnection, while others argue that localization places strains on the digital economy (Bauer et al., 2014). However, this analysis instead demonstrates the benefits of *preventing* localization between states, rather than the costs of doing so.

Another potential implication of this study is who lobbies for trade clauses preventing data localization. On one hand, all businesses and individuals benefit from a more efficient internet architecture. However, these benefits may fall disproportionately to technology firms, content delivery networks, e-commerce firms, or financial firms engaging in high-speed trading. Alternatively, authors have argued that data localization is a form of protectionism (Fan and Gupta, 2018), and so some domestic firms may have significant incentives to lobby against provisions limiting localization. Certain technology firms may benefit directly from localization, while others may benefit from a healthier internet, spurring lobbying between industries over trade policy (Bailey, Goldstein and Weingast, 1997; Grossman and Helpman, 1994; Kim, 2017).

The global internet interconnection structure has significant implications for economic growth and how individuals and businesses experience the internet. However, it is not simply a result of network operators making efficient decisions about distributing data across networks, or of underlying demand for data exchange across systems. This "un-territorial" view of the internet infrastructure sidestepped geopolitics and its influence on network operators. The global internet structure is also a function of politics - how countries interact significantly influences how their internet service providers behave. In the ongoing discussion around how social factors influence technology, this paper shows how the international system shapes technologies and how politics shapes technical systems.

References

Abbate, Janet. 1999. *Inventing the Internet*. Inside Technology Cambridge, Mass: MIT Press.

Anderson, James E. 2011. "The Gravity Model." *Annual Review of Economics* 3(1):133–160.

Anderton, Charles H. and John R. Carter. 2001. "The Impact of War on Trade: An Interrupted Times-Series Study." *Journal of Peace Research* 38(4):445–457.

Baake, Pio and Thorsten Wichmann. 1999. "On the Economics of Internet Peering." *NETNOMICS* 1(1):89–105.

Baier, Scott and Jeffrey Bergstrand. 2007. "Do Free Trade Agreements Actually Increase Members' International Trade?" *Journal of International Economics* 71(1):72–95.

Bailey, Michael A., Judith Goldstein and Barry R. Weingast. 1997. "The Institutional Roots of American Trade Policy: Politics, Coalitions, and International Trade." *World Politics* 49(3):309–338.

Barabási, Albert-László and Réka Albert. 1999. "Emergence of Scaling in Random Networks." *Science* 286(5439):509–512.

Barbieri, Katherine and Jack S. Levy. 1999. "Sleeping with the Enemy: The Impact of War on Trade." *Journal of Peace Research* 36(4):463–479.

Bauer, Matthias, Hosuk Lee-Makiyama, Erik van der Marel and Bert Verschelde. 2014. The Costs of Data Localisation: Friendly Fire on Economic Recovery. Technical report European Center for International Political Economy.

Berger, Daniel, William Easterly, Nathan Nunn and Shanker Satyanath. 2013. "Commercial Imperialism? Political Influence and Trade during the Cold War." *American Economic Review* 103(2):863–896.

Büthe, Tim and Helen V. Milner. 2008. "The Politics of Foreign Direct Investment into Developing Countries: Increasing FDI through International Trade Agreements?" *American Journal of Political Science* 52(4):741–762.

Carter, David B. and Paul Poast. 2020. "Barriers to Trade: How Border Walls Affect Trade Relations." *International Organization* 74(1):165–185.

Carter, David B, Rachel L Wellhausen and Paul K Huth. 2019. "International Law, Territorial Disputes, and Foreign Direct Investment." *International Studies Quarterly* 63(1):58–71.

Chakravorti, Bhaskar and Ravi Shankar Chaturvedi. 2020. "Which Countries Were (And Weren't) Ready for Remote Work?" *Harvard Business Review* .

Chander, Anupam. 2020. "Is Data Localization a Solution for Schrems II?" *Journal of International Economic Law* 23(3):15.

Chander, Anupam and Uyên Lê. 2015. "Data Nationalism." *Emory Law Journal* 64(3):677.

Chang, H., S. Jamin and W. Willinger. 2006. To Peer or Not to Peer: Modeling the Evolution of the Internet's AS-Level Topology. In *Proceedings IEEE INFOCOM 2006. 25TH IEEE International Conference on Computer Communications*. pp. 1–12.

Chavula, Josiah, Amreesh Phokeer, Agustin Formoso and Nick Feamster. 2017. Insight into Africa's country-level latencies. In *2017 IEEE AFRICON: Science, Technology and Innovation for Africa, AFRICON 2017*. Institute of Electrical and Electronics Engineers Inc. pp. 938–944.

Chavula, Josiah, Nick Feamster, Antoine Bagula and Hussein Suleman. 2015. Quantifying the Effects of Circuitous Routes on the Latency of Intra-Africa Internet Traffic: A Study of Research and Education Networks. In *E-Infrastructure and e-Services for Developing Countries*, ed. Amos Nungu, Bjorn Pehrson and Julianne Sansa-Otim. Vol. 147 Cham: Springer International Publishing pp. 64–73.

Chen, Qian, Hyunseok Chang, R. Govindan and S. Jamin. 2002. The Origin of Power Laws in Internet Topologies Revisited. In *Proceedings.Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies*. Vol. 2 pp. 608–617 vol.2.

Cowgill, Bo and Cosmina Dorobantu. 2014. "Worldwide Gravity in Online Commerce.".

Crandall, Robert, William Lehr and Robert Litan. 2007. The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data. Technical Report 6 The Brookings Instituion Washington, D.C: .

Czernich, Nina, Oliver Falck, Tobias Kretschmer and Ludger Woessmann. 2011. "Broadband Infrastructure and Economic Growth*." *The Economic Journal* 121(552):505–532.

Daskal, Jennifer. 2015. "The Un-Territoriality of Data." *Yale Law Journal* 125(2).

Datta, Anusua and Sumit Agarwal. 2004. "Telecommunications and Economic Growth: A Panel Data Approach." *Applied Economics* 36(15):1649–1654.

Davis, Christina L. and Sophie Meunier. 2011. "Business as Usual? Economic Responses to Political Tensions: BUSINESS AS USUAL?" *American Journal of Political Science* 55(3):628–646.

Deibert, Ronald, John Palfrey, Rafal Rohozinski and Jonathan Zittrain, eds. 2010. *Access Controlled: The Shaping of Power, Rights, and Rule in Cyberspace*. Information Revolution and Global Politics Cambridge, Mass: MIT Press.

Dhamdhere, Amogh and Constantine Dovrolis. 2010. The Internet Is Flat: Modeling the Transition from a Transit Hierarchy to a Peering Mesh. In *Proceedings of the 6th International COnference*. Co-NEXT '10 New York, NY, USA: Association for Computing Machinery pp. 1–12.

Dhamdhere, Amogh, Constantine Dovrolis and Pierre Francois. 2010. A Value-Based Framework for Internet Peering Agreements. In *2010 22nd International Teletraffic Congress (lTC 22)*. pp. 1–8.

Drezner, Daniel W. 2003. "The Hidden Hand of Economic Coercion." *International Organization* 57(3):643–659.

Drezner, Daniel W. 2008. *All Politics Is Global: Explaining International Regulatory Regimes*. Princeton: Princeton Univ. Press.

Dür, Andreas, Leonardo Baccini and Manfred Elsig. 2014. "The Design of International Trade Agreements: Introducing a New Dataset." *The Review of International Organizations* 9(3):353–375.

Fan, Ziyang and Anil K. Gupta. 2018. "The Dangers of Digital Protectionism." *Harvard Business Review* .

Fanou, Rodérick, Pierre Francois and Emile Aben. 2015. On the Diversity of Interdomain Routing in Africa. In *Passive and Active Measurement*, ed. Jelena Mirkovic and Yong Liu. Lecture Notes in Computer Science Cham: Springer International Publishing pp. 41–54.

Farrell, Henry. 2012. "The Consequences of the Internet for Politics." *Annual Review of Political Science* 15:35–52.

Farrell, Henry and Abraham L. Newman. 2019. "Weaponized Interdependence: How Global Economic Networks Shape State Coercion." *International Security* 44(1):42–79.

Feamster, Nick, Jared Winick and Jennifer Rexford. 2004. A Model of BGP Routing for Network Engineering. In *SIGMETRICS '04/Performance '04*. p. 12.

Ferracane, Martha. 2017. Restrictions to Cross-Border Data Flows: A Taxonomy. Technical report European Center for International Political Economy.

Froomkin, A. Michael. 1997. The Internet as a Source of Regulatory Arbitrage. SSRN Scholarly Paper ID 2718515 Social Science Research Network Rochester, NY: .

Glick, Reuven and Alan Taylor. 2010. "Collateral Damage: Trade Disruption and the Economic Impact of War." *The Review of Economics and Statistics* 92(1):102–127.

Goldberg, Samuel, Garrett Johnson and Scott Shriver. 2019. Regulating Privacy Online: An Economic Evaluation of the GDPR. SSRN Scholarly Paper ID 3421731 Social Science Research Network Rochester, NY: .

Goldstein, Judith, Douglas Rivers and Michael Tomz. 2007. "Institutions in International Relations: Understanding the Effects of the GATT and the WTO on World Trade." *International Organization* (61).

Gowa, Joanne. 1994. *Allies, Adversaries, and International Trade*. Princeton Paperbacks Princeton, NJ: Princeton Univ. Press.

Gowa, Joanne and Edward D. Mansfield. 1993. "Power Politics and International Trade." *The American Political Science Review* 87(2):408–420.

Gowa, Joanne and Edward D. Mansfield. 2004. "Alliances, Imperfect Markets, and Major-Power Trade." *International Organization* 58(4):775–805.

Grimes, Arthur, Cleo Ren and Philip Stevens. 2012. "The Need for Speed: Impacts of Internet Connectivity on Firm Productivity." *Journal of Productivity Analysis* 37(2):187–201.

Grinberg, Mariya. 2021. "Wartime Commercial Policy and Trade between Enemies." *International Security* 46(1):9–52.

Grossman, Gene M. and Elhanan Helpman. 1994. "Protection for Sale." *The American Economic Review* 84(4):833–850.

Grove, Stijn and Judith de Lange. 2021. 2021 State of the Dutch Data Hub. Technical report Digital Gateway to Europe.

Gupta, Arpit, Matt Calder, Nick Feamster, Marshini Chetty, Enrico Calandro and Ethan Katz-Bassett. 2014. Peering at the Internet's Frontier: A First Look at ISP Interconnectivity in Africa. In *Passive and Active Measurement*, ed. Michalis Faloutsos and Aleksandar Kuzmanovic. Lecture Notes in Computer Science Cham: Springer International Publishing pp. 204–213.

Gurevich, Tamara and David Guberman. 2021. Economic Impact of Trade Agreements Implemented under Trade Authorities Procedures, 2021 Report. Technical Report 5199 United States International Trade Commission.

Hafner-Burton, Emilie M. and Alexander H. Montgomery. 2006. "Power Positions: International Organizations, Social Networks, and Conflict." *Journal of Conflict Resolution* 50(1):3–27.

Hall, Chris, Ross Anderson, Richard Clayton, Evangelos Ouzounis and Panagiotis Trimintzios. 2011. Resilience of the Internet Interconnection Ecosystem. Report/Study European Network and Information Security Agency.

Harbom, Lotta, Erik Melander and Peter Wallensteen. 2008. "Dyadic Dimensions of Armed Conflict, 1946-2007." *Journal of Peace Research* 45(5):697–710.

Hirschman, Albert O. 1945. *National Power and the Structure of Foreign Trade*. Berkeley :: University of California Press.

Johnson, David R. and David Post. 1996. "Law and Borders: The Rise of Law in Cyberspace." *Stanford Law Review* 48(5):1367–1402.

Kahler, Miles, ed. 2009. *Networked Politics: Agency, Power, and Governance*. Cornell Studies in Political Economy Ithaca: Cornell University Press.

Karemera, David, Victor Iwuagwu Oguledo and Bobby Davis. 2000. "A Gravity Model Analysis of International Migration to North America." *Applied Economics* 32(13):1745–1755.

Keck, Margaret E. and Kathryn Sikkink. 1998. *Activists beyond Borders: Advocacy Networks in International Politics*. Ithaca, N.Y: Cornell University Press.

Keohane, Robert Owen and Joseph S. Nye. 1977. *Power and Interdependence: World Politics in Transition*. Boston: Little, Brown.

Keshk, Omar M. G., Brian M. Pollins and Rafael Reuveny. 2004. "Trade Still Follows the Flag: The Primacy of Politics in a Simultaneous Model of Interdependence and Armed Conflict." *The Journal of Politics* 66(4):1155–1179.

Kim, Hyung Min and David L. Rousseau. 2005. "The Classical Liberals Were Half Right (or Half Wrong): New Tests of the 'Liberal Peace', 1960-88." *Journal of Peace Research* 42(5):523–543.

Kim, In Song. 2017. "Political Cleavages within Industry: Firm-level Lobbying for Trade Liberalization." *American Political Science Review* 111(1):1–20.

Kobrin, Stephen J. 2001. "Territoriality and the Governance of Cyberspace." *Journal of International Business Studies* 32(4):687–704.

Koutroumpis, Pantelis. 2009. "The Economic Impact of Broadband on Growth: A Simultaneous Approach." *Telecommunications Policy* 33(9):471–485.

Leeds, Brett Ashley, Jeffrey M. Ritter, Sara McLaughlin Mitchell and Andrew G. Long. 2002. "Alliance Treaty Obligations and Provisions, 1815-1944." *International Interactions* 28:237–260.

Lessig, Lawrence. 1999. *Code and Other Laws of Cyberspace*. New York: Basic Books.

Liberman, Peter. 1996. "Trading with the Enemy: Security and Relative Economic Gains." *International Security* 21(1):147–175.

Long, Andrew G. 2008. "Bilateral Trade in the Shadow of Armed Conflict." *International Studies Quarterly* 52(1):81–101.

Lorentzen, Peter. 2014. "China's Strategic Censorship." *American Journal of Political Science* 58(2):402–414.

Luckie, Matthew, Bradley Huffaker, Amogh Dhamdhere, Vasileios Giotsas and kc claffy. 2013. AS Relationships, Customer Cones, and Validation. In *Proceedings of the 2013 Conference on Internet Measurement Conference*. Barcelona Spain: ACM pp. 243–256.

Lüdering, Jochen. 2016. Low Latency Internet and Economic Growth: A Simultaneous Approach. In *27th European Regional Conference of the International Telecommunications Society*. Cambridge, United Kingdom: p. 20.

Mansfield, Edward D. and Rachel Bronson. 1997. "Alliances, Preferential Trading Arrangements, and International Trade." *The American Political Science Review* 91(1):94–107.

Maoz, Zeev, Paul L. Johnson, Jasper Kaplan, Fiona Ogunkoya and Aaron Shreve. 2019. "The Dyadic Militarized Interstate Disputes (MIDs) Dataset Version 3.0: Logic, Characteristics, and Comparisons to Alternative Datasets." *Journal of Conflict Resolution* 6(3):811–835.

McKnight, Lee W. and Joseph P. Bailey. 1998. *Internet Economics*. MIT Press.

Merton, Robert K. 1968. "The Matthew Effect in Science." *Science* 159(3819).

Michaels, Guy and Xiaojia Zhi. 2010. "Freedom Fries." *American Economic Journal: Applied Economics* 2(3):256–281.

Milner, Helen V. 2006. "The Digital Divide: The Role of Political Institutions in Technology Diffusion." *Comparative Political Studies* .

Monteiro, José-Antonio and Robert Teh. 2017. Provisions on Electronic Commerce in Regional Trade Agreements. WTO Staff Working Paper ERSD-2017-11 World Trade Organization Geneva: .

Morrow, James D. 1999. "How Could Trade Affect Conflict?" *Journal of Peace Research* 36(4):481–489.

Mueller, Milton, Andreas Schmidt and Brenden Kuerbis. 2013. "Internet Security and Networked Governance in International Relations." *International Studies Review* 15(1):86–104.

Nye, Joseph. 2016. "Deterrence and Dissuasion in Cyberspace." *International Security* 41(3):44–71.

O'Hara, Kieron and Wendy Hall. 2021. *Four Internets: Data, Geopolitics, and the Governance of Cyberspace*. New York, NY, United States of America: Oxford University Press.

Pan, Jennifer and Margaret E. Roberts. 2020. "Censorship's Effect on Incidental Exposure to Information: Evidence From Wikipedia." *SAGE Open* 10(1):2158244019894068.

Pettersson, Therese, Shawn Davis, Amber Deniz, Garoun Engstrom, Nanar Hawach, Stina Hogladh, Margareta Sollenberg and Magnus Oberg. 2021. "Organized Violence 1989-2020, with a Special Emphasis on Syria." *Journal of Peace Research* 58(4).

Pollins, Brian M. 1989*a*. "Conflict, Cooperation, and Commerce: The Effect of International Political Interactions on Bilateral Trade Flows." *American Journal of Political Science* 33(3):737–761.

Pollins, Brian M. 1989*b*. "Does Trade Still Follow the Flag?" *American Political Science Review* 83(2):465–480.

Roberts, Margaret E. 2018. *Censored: Distraction and Diversion inside China's Great Firewall*. Princeton, New Jersey: Princeton University Press.

Rohman, Ibrahim Kholilul and Erik Bohlin. 2012. "Does Broadband Speed Really Matter as a Driver of Economic Growth? Investigating OECD Countries." *International Journal of Management and Network Economics* 2(4):336–356.

Roller, Lars-Hendrik and Leonard Waverman. 2001. "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach." *American Economic Review* 91(4):909–923.

Santos Silva, J. M. C. and Silvana Tenreyro. 2006. "The Log of Gravity." *The Review of Economics and Statistics* 88(4):641–658.

Savage, I. Richard and Karl W. Deutsch. 1960. "A Statistical Model of the Gross Analysis of Transaction Flows." *Econometrica* 28(3):551–572.

Schumann, Robert and Michael Kende. 2013. Lifting Barriers to Internet Development in Africa: Suggestions for Improving Connectivity. Technical Report 35729-502d1 Internet Society.

Slaughter, Anne-Marie. 2017. *The Chessboard and the Web: Strategies of Connection in a Networked World*. The Henry L. Stimson Lectures Series New Haven: Yale University Press.

Subramanian, L., S. Agarwal, J. Rexford and R.H. Katz. 2002. Characterizing the Internet Hierarchy from Multiple Vantage Points. In *Proceedings.Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies*. Vol. 2 pp. 618–627 vol.2.

Swire, Peter P. 1998. "Of Elephants, Mice, and Privacy: International Choice of Law and the Internet." *University of Pennsylvania Law Review* 253:1975–2005.

Swire, Peter P. and Robert E. Litan. 1998. *None of Your Business: World Data Flows, Electronic Commerce, and the European Privacy Directive*. Washington, D.C: Brookings Institution Press.

The World Bank. 2016. *World Development Report 2016: Digital Dividends*. Washington, DC: World Bank.

Vakataki 'Ofa, Siope. 2019. Estimating the Effects of Internet Exchange Points on Fixed-broadband Speed and Latency. Technical report United Nations ESCAP.

Zhuo, Ran, Bradley Huffaker, KC Claffy and Shane Greenstein. 2020. "The Impact of the General Data Protection Regulation on Internet Interconnection.".