OPEN FOR FEEDBACK

What are the links between data infrastructure and trade competitiveness?

Open Data Institute

Contents

About

This report has been researched and produced by the Open Data Institute, and published in 2019.

Lead author: Lawrence Kay

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Terms

Data-enabled: a product that has been developed with digitised information or relies on it to function.

Open standards for data: reusable agreements that make it easier for people and organisations to publish, access, share and use better quality data.[1]

Data infrastructure: datasets, identifiers and registers; the standards and technologies used to curate and provide access to those data assets; and the guidance and policies that inform the use and management of them.[2]

Identifiers: labels used to refer to an object being discussed or exchanged, such as products, companies or people.[3]

Business climate: the conditions in which companies are established, managed, and shut down, subject to the rule of law, regulation, and political stability.[4]

Local content stipulations: requirements by a government that domestic firms use domestic suppliers.[5]

Market access: the ease with which producers in one country can access and sell to consumers in another country.

Non-tariff barriers: charges, standards, quantitative restrictions, contingent protection, and other measures that companies are asked to comply with when selling goods and services from one country into another.[6]

Open data: data that is available to everyone to access, use and share.[7]

Personal data: information relating to natural persons who can be identified or who are identifiable, directly from the information in question; or who can be indirectly identified from that information in combination with other information.[8]

Registers: datasets that provide consistent, accurate and up to date lists of information across a variety of activities.[9]

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[1] Open Data Institute (2018) 'Open Standards for Data', https://standards.theodi.org
[2] Open Data Institute (2019) 'Open Data and Data Infrastructure', https://docs.google.com/document/d/1tAeidONKZEkpCf9Jkwe4amWZKbQHTMiHJb8rW7PV7Fs
[3] Open Data Institute (2014) 'White paper: Enhancing open data with identifiers', https://theodi.org/article/white-paper-enhancing-open-data-with-identifiers
[4] European Bank for Reconstruction and Development (n.d.), 'Investment climate and governance', https://www.ebrd.com/what-we-do/sectors-and-topics/investment-climate-governance.html
[5] OECD (n.d.) 'Local content requirements impact the global economy', https://www.oecd.org/trade/topics/local-content-requirements
[6] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit', https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y, p63
[7] Open Data Institute (2017) 'What is 'open data' and why should we care?', https://theodi.org/article/what-is-open-data-and-why-should-we-care/
[8] Information Commissioner's Office (2019) 'What is Personal Data?', https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/key-definitions/what-is-personal-data/
[9] Open Data Institute (2018) 'Registers: making lists we can trust', https://docs.google.com/document/d/1CvSfa1Ahp5ZqqGmkZ1irdVYeFHCCNO6tY5VaFchFk6g/edit

Tariffs: duties on products imported from one country into another.[10]

Trade competitiveness: a country's advantage or disadvantage in selling its products in international markets.[11]

Transaction costs: the costs involved in market exchange, such as through discovering market prices and the costs of writing and enforcing contracts.[12]

[10] World Trade Organization (n.d.) 'Tariffs', https://www.wto.org/english/tratop_e/tariffs_e/tariffs_e.htm
[11] Organisation for Economic Co-operation and Development (2014) 'Glossary of Statistical Terms', https://stats.oecd.org/glossary/detail.asp?ID=399
[12] Ibid.

Executive summary

Data could drive global economic growth for decades to come, but little is known about how countries can turn their use of it into trade competitiveness. Up to two billion people might now be using cloud computing to store digital information, while greater access to public and private data across the world could create as much as $3tn in annual value for the global economy.[13,14,15] But what can countries do to capture that value through the data-enabled goods and services that they sell abroad?

This report discusses how data infrastructure might be built for trade competitiveness. Countries can approach the construction of data infrastructure with a variety of objectives. The discussion here explores what policymakers might consider as they seek to boost the exports of domestic companies that are using data to create and maintain goods and services. The report broaches the key questions of how easy it is for domestic producers of data-enabled goods and services to find potential buyers abroad; the incentives that such companies have in developing new products; their level of access to production factors[16], such as data; how many support services, such as research and data science, are available to them as they seek to grow and sell abroad; and how trade promotion schemes might help.

Some countries are already trying to gain an advantage in data-enabled technology in the hope that it will lead to long-term trade competitiveness. The United States (US) has established itself as a leader in the collection, analysis, and use of data in digital services such as those offered by Amazon, Facebook, and Google. But countries such as Germany are rapidly trying to catch up in the use of data-enabled technology in the transport sector, while countries as diverse as Japan and Kenya are developing national strategies for the exploitation of data through artificial intelligence.[17] [18] Canada is spending C$3bn in its Ontario province alone to help it better compete in internationally competitive digital services.[19]

Trust in the use of data may have become a point of trade competitiveness in data-enabled goods and services in recent years. The European Union's (EU's) General Data Protection Regulation (GDPR) is partly about showing that EU countries have high-quality data-use standards, and can exchange data in a trustworthy manner. The United Nations Conference on Trade and Development has recommended that countries around the world seek to establish data-exchange relationships with their trading partners that are based on being open about data collection and why data is being collected; and allowing data subjects to access and

[13] HM Government (2013) 'Shakespeare Review: An Independent Review of Public Sector Information', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/198752/13-744-shakespeare-review-of-public-sector-information.pdf p8

[14] McKinsey (2013) 'Open data: Unlocking innovation and performance with liquid information', https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/open-data-unlocking-innovation-and-performance-with-liquid-information

[15] Cisco Systems (2016) '1.2 Cross-Border Data Flows, Digital Innovation, and Economic Growth' http://reports.weforum.org/global-information-technology-report-2016/1-2-cross-border-data-flows-digital-innovation-and-economic-growth

[16] Investopedia (2019), 'Factors of production', https://www.investopedia.com/terms/f/factors-production.asp

[17] Oxford Insights (2018), 'European data economies trade project: Background research and mapping', https://docs.google.com/document/d/127K62i_FgtqQWQrynpPJCegjLNyZnEPguREmyD4naJ0/edit, p18;

[18] Nesta, 'Mapping AI governance', https://www.nesta.org.uk/data-visualisation-and-interactive/mapping-ai-governance/

[19] Ontario Government (2019), 'Seizing Global Opportunities: Ontario's Innovation Agenda', https://www.ontario.ca/page/seizing-global-opportunities-ontarios-innovation-agenda

correct data about them.[20] Those nations or groups of countries that establish reputations for good data infrastructure in the years to come may find that they benefit from more international data exchange and hence access to better data.

In recent years, countries have tried to benefit more from data-enabled exchange, aided by trade agreements that enable cross-border data flows. The Comprehensive and Progressive Agreement for Trans-Pacific Partnership between 11 countries on either side of the Pacific, for example, includes stipulations about cross-border data flows that favour international commerce.[21] With such agreements, countries will be better able to find opportunities for specialisation, although such benefits may be impeded in the future by moves across the world for personal data to be stored in the country in which it was collected – and only physically accessible in that country. Domestic storage of personal data is supported by large majorities of people in Indonesia, China, India, Mexico and Poland.[22]

Some countries are already fostering competition and entrepreneurialism in data-enabled sectors as a way to produce competitive products. Australia, for example, has put data exploitation at the centre of its economic strategy and has recognised that companies become more competitive abroad if they are subject to the pressure of competition at home.[23] But this is in the face of seemingly dominant positions in markets for social media and other digital services, held by large US companies such as Facebook. There are ongoing discussions about such issues in the EU, the US, and the United Kingdom (UK), and it is possible that the countries which are most able to increase competition in data-enabled sectors – perhaps through data-portability schemes – could enjoy a future competitive advantage.[24]

If countries are to produce data-enabled goods and services that are competitive abroad, domestic companies need access to data. Australia's 2015 Public Data Policy Statement, for example, encouraged public organisations to open data so that it could be used by entrepreneurs as they develop new goods and services.[25] Citymapper, an urban transport service that uses data to help travellers to optimise their routes, grew out of Transport for London publishing realtime timetable and location data from across its network as open data, and the service has since spread to cities around the world.[26]

Countries that have physical infrastructure that allows easy creation and exporting of data-enabled goods and services could have a competitive advantage. Data centres, for example, allow companies to securely store and analyse information that is highly sensitive to operations in the financial and healthcare sectors. Giving access to them through a wide variety of cloud computing services can allow companies to keep costs down. But the costs of building data centres across the world can differ substantially and therefore affect competitiveness

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[20] UNCTAD (2016), 'Data Protection Regulations and International Data Flows: Implications for Trade and Development', p56, https://unctad.org/en/PublicationsLibrary/dtlstict2016d1_en.pdf
[21] Lexology (2019), 'The CPTPP Enters into Force: What Does it Mean for Global Trade?', https://www.lexology.com/library/detail.aspx?g=9941ebd7-a3f8-4630-bc65-c483931f81ba
[22] CIGI and Ipsos (2014), '83% of Global Internet Users Believe Affordable Access to the Internet Should be a Basic Human Right', https://www.cigionline.org/sites/default/files/documents/internet-survey-2014-factum.pdf
[23] Australian Government (2018) 'Australia 2030: Prosperity through Innovation', https://www.industry.gov.au/data-and-publications/australia-2030-prosperity-through-innovation, p4
[24] Kay L (2019), 'How to pit a small regulator against big tech?', https://medium.com/@lawrencebernardkay_13612/how-to-pit-a-small-regulator-against-big-tech-3f1b000f99be
[25] Australian Government (2015), 'Australian Government Public Data Policy Statement', https://www.pmc.gov.au/sites/default/files/publications/aust_govt_public_data_policy_statement_1.pdf
[26] https://citymapper.com/london

– perhaps varying by as much as $60.9m in Brazil, $51.2m in Chile, and $43m in the US.[27]

There are many complementary services and skills that help companies to produce data-enabled products, and hence make them competitive in international markets. This might mean access to a variety of data platforms that help companies to collate and analyse data, or being able to employ data scientists with the right domain experience. It could also mean being able to work with research organisations like university departments as they seek to develop frontier technology that could be commercialised – something which Hong Kong is positioning itself for as it establishes research centres on healthcare, artificial intelligence and robotics.[28] [29]

As companies develop data-enabled products, governments can play their traditional trade promotion role. There is currently little focus of such efforts on data-enabled sectors, with the UK–Australia FinTech Bridge[30] being probably the leading example: it seeks to increase market access and regulatory coordination between the two countries, particularly for the companies that have emerged alongside the UK's open banking initiative and have business models built on trustworthy access to high-quality data. Many countries have schemes for promoting digital trade, and these could be expanded to promote their data infrastructure in years to come.

Developing some of these features while building data infrastructure could help many countries to raise their trade competitiveness. Doing so might help countries around the world to grow firms that can more readily compete with the large digital firms that already exist, perhaps developing services that become popular through trustworthy data use. But this is a young research area for trade policymakers, and so far all that is really known is that poor data standards or constricted data flows in countries such as Brazil might be costing the country as much as 4% of its annual investment; and China and Indonesia as much as 1.5% of their exports.[31]

[27] US Chamber of Commerce (2014) 'Business Without Borders: The Importance of Cross-border Data Transfers to Global Prosperity', https://www.uschamber.com/report/business-without-borders-importance-cross-border-data-transfers-global-prosperity
[28] Future Cities Catapult (2017) 'City Data Sharing Toolkit', https://futurecities.catapult.org.uk/project/city-data-sharing-toolkit/
[29] World Economic Forum (2019) 'This is China's plan to eclipse Silicon Valley', https://www.weforum.org/agenda/2019/02/this-is-china-s-plan-to-eclipse-silicon-valley/
[30] Australian Government (2019) 'UK-Australia FinTech Bridge', https://treasury.gov.au/fintech/uk-australia-fintech-bridge
[31] World Bank Group (2016) 'World Development Report 2016: Digital Dividends', http://www.worldbank.org/en/publication/wdr2016, p301

Introduction

Data could drive global economic growth for decades to come, but what that means for how countries should trade data-enabled goods and services is unclear. The rise of large digital companies like Google and Alibaba has shown that selling goods and services, collecting data about their users, and creating better products thereafter can be a tremendously competitive business model. But it is hard to unpick whether that means countries that want to maximise their competitiveness should have strong data-protection laws; allow easy flow of data across borders; or concentrate on only a few data-enabled activities, now that developed countries have moved so far ahead.

Data infrastructure offers policymakers a framework for understanding how the treatment and sharing of data might affect trade competitiveness. In the past two years organisations such as the Organisation for Economic Co-operation and Development (OECD) and the European Centre for International Political Economy have pioneered analysis of the use of data in international trade, discussing rules on data collection and cross-border exchange. The discussion here builds on these efforts by considering all aspects of data infrastructure, and how they might be understood in trade-competitiveness terms.

Data infrastructure is the equivalent of infrastructure for transportation and utilities. It consists of datasets, identifiers and registers, the standards and technologies used to curate and provide access to those data assets, and the guidance and policies that inform the use and management of them.[32] There are organisations that govern data infrastructure and groups involved in contributing to or maintaining it. In the same way that good transport infrastructure makes it easier to move around, meet people, and run businesses, high-quality data infrastructure allows more exploitation of data for economic and social benefits.

Data infrastructure improves exploitation of data's unique features. Some types of data can be made excludable in that owners can prevent others from using it through security measures and intellectual property rights – described in the Open Data Institute theory of change as 'data hoarding'.[33] This is similar to how an oil company can prevent others from using its oil field, but it is not rivalrous and can be used by more than one person without being depleted. As digitised information – bits – in the form of data is a modern phenomenon, the world's leading economies and data producers are only at the beginning of understanding how best to collect data and produce economic growth through better goods and services built on data.

A country's trade competitiveness is its ability to sell its goods and services abroad.[34] Trade competitiveness is a 'behind the border' notion, meaning that it considers the domestic conditions for innovation and optimisation in goods and services and how they enable countries to raise the value they get from their exports.

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[32] Dodds L and Wells P (2019), 'Data Infrastructure', https://www.stateofopendata.od4d.net/chapters/issues/data-infrastructure.html

[33] Open Data Institute (2018), Theory of change, https://theodi.org/about-the-odi/our-vision-and-manifesto/our-theory-of-change/

[34] A standard definition of export competitiveness, popularised by the OECD, is the degree to which, under open market conditions, a country can produce goods and services that meet the test of foreign competition while simultaneously maintaining and expanding domestic real income. See World Bank (2012), 'Trade Competitiveness Diagnostic Toolkit', https://openknowledge.worldbank.org/handle/10986/2248

[35] Data infrastructure is also often a domestic consideration, as it has so far involved more national rather than international coordination of laws, standards, ethics, and skills for the collection and manipulation of data, not least as some data is only collected and used at the local or national levels.

Estimates of cross-border flows of data and their values have increased substantially in recent years.[36,37] The International Monetary Fund has identified the use of data as one of five issues that need to be better understood if measurements of digital trade can be improved on, and the estimates are wide: up to 2 billion people might now be using cloud computing to store digital information, up from around 1.1 billion in 2014; and annual per capita growth in OECD countries between 1996 and 2007 is thought to have risen by 0.9–1.5 percentage points with every 10 percentage-point increase in broadband reach.[38,39,40] But the range of these and other estimates for the effects of data on economic growth has been so wide that organisations such as the US Chamber of Commerce doubt their usefulness.[41,42]

Cross-border data use has accelerated because the World Wide Web spread the internet quickly and in unlikely ways, greatly expanding international trade. The web was invented by Sir Tim Berners-Lee – co-founder of the Open Data Institute – with an ethos of openness that is also at the heart of free trade.[43] It gave billions of people around the world an almost free platform on which to exchange ideas, goods, and services, creating enormous wealth gains.

The nature of modern international commerce means that data infrastructure questions arise quickly. When data is being transferred from a consumer to a company, it might happen through identifiers and registers in one country but with standards and technology used to curate and provide access to those data assets from another country. A third country might become involved through its guidance and policies being used for the management of data assets. And above these national considerations, international bodies like the EU could have a role. Consumers can therefore be affected by decisions about the governance and policies surrounding data made in any one, or all of the three possible countries.[44]

The rest of the discussion explores the links between data infrastructure and trade competitiveness in several steps. The next section raises issues of data

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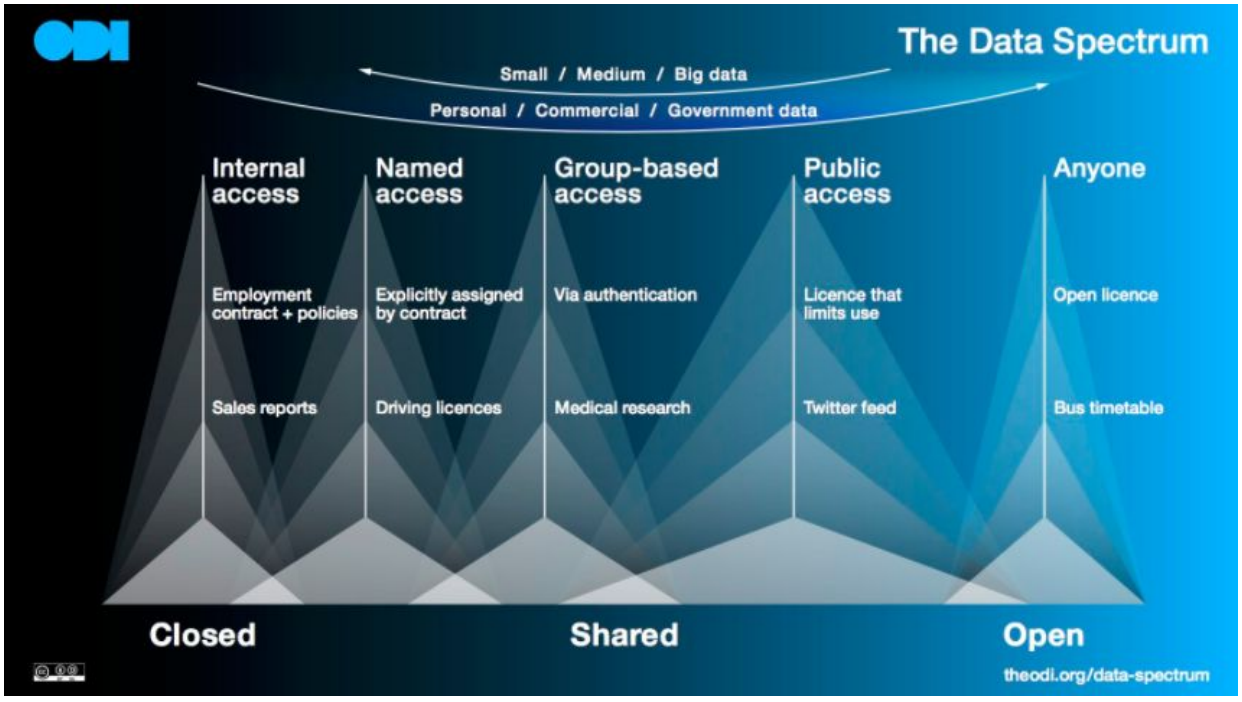
[35] Ibid
[36] Cisco Systems (2016) '1.2 Cross-Border Data Flows, Digital Innovation, and Economic Growth' http://reports.weforum.org/global-information-technology-report-2016/1-2-cross-border-data-flows-digital-innovation-and-economic-growth/
[37] World Economic Forum (2019) 'Trade and Cross-Border Data Flows', https://www.oecd-ilibrary.org/trade/trade-and-cross-border-data-flows_b2023a47-en
[38] International Monetary Fund (2018) 'Towards a Handbook on Measuring Digital Trade: status update', https://unstats.un.org/unsd/nationalaccount/aeg/2018/M12_3f_Digital_Trade_OECD.pdf
[39] Cisco Systems (2016) '1.2 Cross-Border Data Flows, Digital Innovation, and Economic Growth' http://reports.weforum.org/global-information-technology-report-2016/1-2-cross-border-data-flows-digital-innovation-and-economic-growth
[40] Center for Economic Studies (2009) 'Broadband Infrastructure and Economic Growth', https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1468-0297.2011.02420
[41] The difficulty in estimating data flows may mean that policymakers are underestimating their importance. Unlike for digital services, the receipt of an amount of data is not recorded in official statistics as payments are only made for the digital service received. The value of the data is captured in the service, but the fact that data is not explicitly recorded in trade statistics may mean that policy-makers are insufficiently focused on the data aspects of trade agreements, and impediments to the flow of data across borders. European Centre for Political Economy (2013) 'The Economic Importance of Getting Data Protection Right: Protecting Privacy, Transmitting Data, Moving Commerce', https://www.uschamber.com/economic-importance-getting-data-protection-right
[42] European Centre for Political Economy (2014) 'Data, Trade and Growth', https://www.progressivepolicy.org/slider/data-trade-and-growth/
[43] World Economic Forum (2015) 'The Case for Trade and Competitiveness', https://www.weforum.org/reports/case-trade-and-competitiveness
[44] World Economic Forum (2019) 'Trade and Cross-Border Data Flows, https://www.oecd-ilibrary.org/trade/trade-and-cross-border-data-flows_b2023a47-en

openness, the nature of data, and restrictions on its cross-border exchange in recent years. The sections thereafter define data infrastructure, and delineate its parts according to the classic elements of assessing trade competitiveness: market access; incentives for trade and investment; factor conditions; intermediate inputs and backbone services; and trade promotion. Considering these issues could help policymakers around the world to consider how they might start incorporating data infrastructure considerations into their trade competitiveness strategies.

Data openness and international trade

Data can be plotted on a spectrum of how open it is for others to use. The Data Spectrum below shows that access to a dataset can be closed to anyone but those in a specified group of people, such as the staff of a company; more open when access is granted to further groups; and highly accessible or open to anyone around the world when certain licences are used.

Figure 1: The Data Spectrum



Personal data can be found at both ends of the spectrum and believing that it is never open data is a common misperception.[45] There are everyday examples of personal data that is openly available, such as data about elected representatives, and judgements often need to be made over whether such data is also sensitive and could cause serious harm to an organisation or person if it is released. Sharing personal data has long motivated data protection laws around the world, and the EU's Digital Single Market strategy has distinguished non-personal data – such as on transport timetables – from personal data in an attempt to simplify research.[46]

The economic benefits of open data have been documented by several studies. [47] A report in 2011 for the European Commission found that with easier access to and

[45] Open Data Institute (2019) Anonymisation and open data: An introduction to managing the risk of re-identification, https://docs.google.com/document/d/1CoXniaTnQL_4ZyQuji9_MA_YCEElQjx4z1SEdB08c2M

[46] European Commission (2019) 'Free flow of non-personal data' https://ec.europa.eu/digital-single-market/en/free-flow-non-personal-data; Eur-Lex (2018) 'Regulation (EU) 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union' https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1546942605408&uri=CELEX:32018R1807

[47] Tennison J (2016) 'The Economic Impact of Open Data: What Do We Already Know?' https://www.huffingtonpost.co.uk/jeni-tennison/economic-impact-of-open-data_b_8434234.html?

use of public sector information, its value to the EU economy could be as high as 1.7% of GDP.[48] In Britain the value of such data has been estimated at around £7bn, while greater access to public and private data across the world could create as much as $3tn in annual value for the global economy.[49]

'Big data' is a mix of personal and non-personal data.[50] The excitement about large amounts of data is often about what can be discovered about human behaviour under different conditions. For example, combining non-personal data about the weather with personal data about the characteristics of people and where they take holidays could enable better personalised holiday offerings. But determining if data is about personal characteristics can be a delicate task – is train timetable data about an inanimate vehicle, or a link to other things that are known about the people on it?

Data access can provoke national security concerns. Whether in the form of raw data or data used in products and services, cyber attacks for stealing digitised information in the form of intellectual property have caused estimated annual losses of around $12bn for countries such as the US.[51] Identity theft creates consumer mistrust and introduces friction into data sharing and digital services. In 2017 a personal-data breach at the financial services company, Equifax, affected about 143 million US consumers, and this is regularly cited as a reason by consumers for not using online financial services.[52] A recent Open Data Institute report on anonymisation described how the use of Strava, a fitness tracking app, by American and British military personnel had revealed the location of their military bases.[53]

Discussion of cross-border data flows in digital goods and services and its sensitivity is now several decades long. In 1980 the OECD warned against the misuse of large databases and noted that misalignment between countries' regulatory regimes on data could impede cross-border working.[54] In 1981 the Council of Europe called for data privacy laws and considered the restrictions that countries might place on the export of data for processing elsewhere.

The value of data to international commerce means that restricting the flow of data can suppress economic activity. Enacted or proposed regulatory restrictions on data flows could be costing Brazil as much as 4% of its annual investment; and China and Indonesia as much as 1.5%of their exports.[55] The Digital Trade Restrictiveness Index finds China the world's most restrictive for digital trade,

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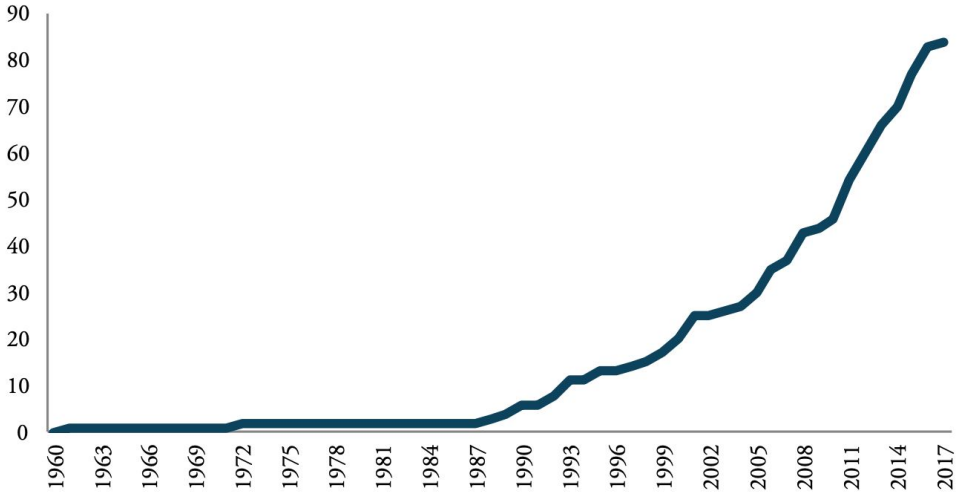
[48] Vickery G (2011) 'Review of Recent Studies on PSI- Re-Use and Related Market Developments' http://ec.europa.eu/newsroom/document.cfm?doc_id=1093, p3
[49] HM Government (2013) 'Shakespeare Review: An Independent Review of Public Sector Information' https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/198752/13-744-shakespeare-review-of-public-sector-information.pdf, p8; McKinsey (2013) 'Open data: Unlocking innovation and performance with liquid information' https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Open%20data%20Unlocking%20innovation%20and%20performance%20with%20liquid%20information/MGI_Open_data_FullReport_Oct2013.ashx
[50] Open Data Institute (2018) 'What is 'open data' and why should we care?' https://theodi.org/article/what-is-open-data-and-why-should-we-care/
[51] CSIS (2018) 'Economic Impact of Cybercrime— No Slowing Down', https://www.mcafee.com/enterprise/en-us/assets/reports/restricted/rp-economic-impact-cybercrime.pdf, p17
[52]Ibid, p18, 19
[53] Open Data Institute (2018) 'Anonymisation: Case Studies' https://docs.google.com/document/d/1KeFx3fuECT_j3hpH4Fyk3smTw4VYPQjgEp2EMLcXxRU/, p10
[54] The E15 Initiative (2015) Information Goes Global: Protecting Privacy, Security and the New Economy in a World of Cross-border Data Flows, p3
[55] World Bank Group (2016) 'World Development Report 2016: Digital Dividends', http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf, p301

followed by Indonesia in second place, and Brazil in sixth place, with each country eschewing the benefits that would come from liberalisation.[56]

Restraints on data flows come in several forms. The European Centre for International Political Economy has undertaken a taxonomy of restrictions on cross-border data flows that suggests there has been a significant increase in restrictions in recent decades.[57] The centre's taxonomy is delineated by whether there are local storage and processing requirements or bans on data transfer; and restrictions that are conditional on the country receiving it or the data controller and data processor that is managing it.

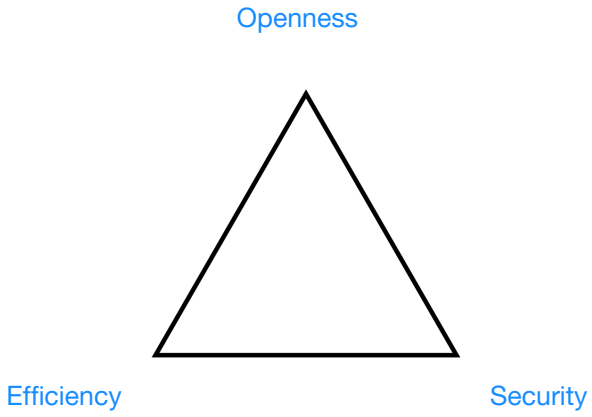
Figure 2: cumulative number of restrictions on cross-border data flows (1960–2017)[58]



The benefits of openness, questions of efficiency, and demands for personal and national security puts policymakers in what might be an iron triangle.[59] An 'iron triangle' represents the relationship between three performance criteria. With a high level of open sharing of data, economic learning and management efficiency are high but so are concerns about security. When data sharing is restricted, gains from its use will likely be reduced, and efficiency might be lower, but security concerns fall. Picking a point within the triangle is likely to be a process of long deliberation for many countries, alongside coordination with their trading partners.

[56] European Centre for International Political Economy (2018) 'Digital Trade Restrictiveness Index', http://ecipe.org/wp-content/uploads/2018/05/DTRI_FINAL.pdf, p21
[57] The E15 Initiative (2016) 'Data Moving Across Borders: The Future of Digital Trade Policy', http://e15initiative.org/publications/data-moving-across-borders-the-future-of-digital-trade-policy/, p5; European Centre for International Political Economy (2018) 'Restrictions on Cross-Border Data Flows: A Taxonomy', https://ecipe.org/wp-content/uploads/2017/11/Restrictions-on-cross-border-data-flows-a-taxonomy-final1.pdf
[58] European Centre for International Political Economy (2018) Restrictions on Cross-Border Data Flows: A Taxonomy, https://ecipe.org/wp-content/uploads/2017/11/Restrictions-on-cross-border-data-flows-a-taxonomy-final1.pdf, p2. The data refer to 64 economies. In addition to the 28 member states of the EU, the analysis covers the following countries: Argentina, Australia, Canada, Chile, China, Colombia, Costa Rica, Ecuador, Hong Kong, Iceland, India, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, New Zealand, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Russian Federation, Singapore, South Africa, Switzerland, Taiwan, Thailand, Turkey, United States and Vietnam.
[59] Mitchell AD and Hepburn J (2017) 'Don't Fence me in: reforming trade and investment law to better facilitate cross-border data transfer' https://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1128&context=yjolt, p219

Figure 3: iron triangle of international data access and exchange[60]



[60] ibid, p219

Data infrastructure and international trade competitiveness

Data infrastructure

Building data infrastructure could offer a way to balance some of the trade-offs in international data exchange. The way that data is collected, stored, and used often makes it difficult for innovators to access, impeding the possibilities for 'combinatorial innovation' – different innovations working together – for economic and social ends.[61] But using elements of data infrastructure could allow countries to find a balance between restricting and enabling access to data, which may provide competitive advantage in the future. Data infrastructure consists of:

- data assets such as datasets, identifiers and registers
- the standards and technologies used to curate and provide access to those data assets
- the guidance and policies that inform the use and management of data assets and the data infrastructure itself
- the organisations that govern the data infrastructure
- the communities involved in contributing to or maintaining it, and those who are affected by decisions that are made using it.

Registers are datasets that provide consistent, accurate and up-to-date lists of information across a variety of activities.[62] They typically have basic information about a dataset, and examples include lists of countries and government departments, companies and food types.[63] For example, the Harmonized Commodity Description and Coding System for classifying products helps companies and countries around the world to identify products, helping them to work from a common understanding of the types of goods being traded.

When standards for data are open, policymakers can enjoy lower coordination costs. Data standards can be created for technical, economic and policy reasons, such as the Open Contracting Data Standard, which is helping to create transparency around public spending in Paraguay and Nigeria.[64] Another example is the General Transit Feed Specification, a commonly used means for collecting and sharing data on transit systems, that is particularly used in transport applications and other services in cities around the world. Making an agreement reusable reduces the need for negotiation over how data will be used, increasing the amount of data available to data users and improving usability.[65]

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[61] Dodds L and Wells P (2019) 'Open Data and Data Infrastructure' https://docs.google.com/document/d/1tAeidONKZEkpCf9Jkwe4amWZKbQHTMiHJb8rW7PV7Fs/

[62] Open Data Institute (2018) 'Registers: making lists we can trust', forthcoming

[63] Gov.uk, 'Government registers collection' https://www.registers.service.gov.uk/registers; Companies House, 'Search the register' https://beta.companieshouse.gov.uk/; Food Standards Agency, 'Register: Food Types' https://data.food.gov.uk/codes/_foodtype

[64] Open Data Institute (2018) 'Exploring the development and impact of open standards for data' https://docs.google.com/document/d/1Sab5YMVj4PVqLjZD35hX8FTnMeeP6gLGG0xszuRMlaM/; Open Contracting 'Impact stories' https://www.open-contracting.org/impact-stories/

[65] Open Data Institute (2018) 'Open standards for data guidebook', http://standards.theodi.org/

There is still some way to go before data standards, identifiers, and registers are open and accepted enough to link countries in data-enabled trade.[66] Many low- and middle-income countries lack the means to use data and build competitive data-enabled services provided by firms from high- and upper-middle-income countries, such as the US, the UK and China. The Web Foundation, in a review of low- and middle-income countries, has shown that progress on introducing appropriate safeguards and regulation is mixed.[67]

Attitudes to data ethics and data governance are affecting trade competitiveness in ways that are currently difficult to judge. Data ethics is a branch of ethics that evaluates data practices with the potential to adversely affect people and society – in data collection, sharing and use.[68] Invoking ethics and privacy considerations in the international exchange of data may be a question of protectionism, but some have argued that data-privacy regulation may not even be a legitimate topic for economists to consider.[69]

Restricting data exchanges due to privacy-violation concerns can be an element of a classic trade problem: incomplete contracts. An incomplete contract is an agreement for exchange that does not cover all of the possible actions by the parties involved, and therefore affects the nature of the agreement that the parties are willing to enter.[70] This is relevant to data transfers, because there are numerous examples of companies using data about consumers in ways that the consumers did not expect. Restrictions on cross-border data exchange may suffer from the same problem, in that some countries are restricting access to data about their citizens because they do not have sufficient control over how that data will be used abroad. If this is the case, it may explain why agreements for data exchange tend to be for only simple products and services.[71]

Countries which cannot credibly commit to international data-exchange agreements could become less integrated in digital-trade flows. The ability of a country to enforce contracts – for an agreement between companies to be followed, or for a legal system to force a reneging company to follow the contract – has long been seen as central to economic growth.[72] Sensitivity with regard to personal data might mean that in data-enabled international trade, countries with weak legal regimes will suffer from lower innovation, investment and firm dynamism.[73]

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[66] Open Data Institute and Thomson Reuters (2014) 'Creating value with identifiers in an Open Data World' https://innovation.thomsonreuters.com/en/labs/data-identifiers.html
[67] World Wide Web Foundation (2017) 'A Smart Web for a More Equal Future' http://webfoundation.org/docs/2017/07/PersonalData_Report_WF.pdf
[68] Open Data Institute (2017) 'Ethical Data Handling' https://www.scribd.com/document/358778144/ODI-Ethical-Data-Handling-2017-09-13
[69] Goldfarb A and Trefler D (2017) 'AI and International Trade', https://www.nber.org/chapters/c14012.pdf, p28
[70] Hart O (2017) 'Incomplete Contracts and Control' https://scholar.harvard.edu/files/hart/files/incomplete_contracts_and_control.pdf
[71] The 2016 World Development Report suggested that the effects of the internet on international trade and economic growth are highest in data-intensive but simple products that do not need complicated contracts, and the OECD has suggested that some simple contracts for data trade are so established and trusted - such as those for peer networks - that new ones are agreed with little more than a handshake. Organisation for Economic Co-operation and Development (2013) 'Internet Traffic Exchange: Market Developments and Policy Challenges' https://www.oecd-ilibrary.org/science-and-technology/internet-traffic-exchange_5k918gpt130q-en;jsessionid=V7KHmPZCMfoQYWGqbtoy0dGl.ip-10-240-5-34
[72] Doing Business (n.d.) 'Enforcing Contracts' http://www.doingbusiness.org/en/data/exploretopics/enforcing-contracts/why-matters
[73] World Bank (2003) 'Do More Transparent Governments Govern Better?' http://documents.worldbank.org/curated/en/568401468741328131/109509322_20041117183019/additional/multi0page.pdf; International Monetary Fund (2014) 'Judicial System Reform in Italy— A Key to Growth' https://www.imf.org/external/pubs/ft/wp/2014/wp1432.pdf

The rapid development of data-enabled technology means that some sector-specific data infrastructure is emerging. In the same way that countries can reach an appropriate balance between openness and efficiency for data exchange relative to the nature of the data being used, sectors such as healthcare and agriculture can do the same. Examples include open banking initiatives in the UK and Mexico, which have created industry bodies for coordinating technology use and judging consumer appetite for the use of personal data.[74]

Trade competitiveness

Data infrastructure enables a country to become more internationally competitive in producing data-enabled goods and services. Access to and exploitation of data could drive economic dynamism for years to come. Countries around the world have some strategic choices to make about: whether they want to share data with others; the reputation they want for how they use data; whether they will develop labour skills for working with it; if they are going to keep data confined to a small number of large firms, or have it accessible to entrepreneurs; and much else besides.

The World Bank's Trade Competitiveness Diagnostic Toolkit is an authoritative way to analyse trade competitiveness.[75] The toolkit has a diagnostic framework, and a three-step process for guiding national policymakers who want to understand how well exports are competing in foreign markets; what might be affecting performance and how the export of goods and services could deliver more value. The resulting analysis can be used across countries, for example, to help Russia understand whether it exports more than natural resources and why it might not; and Bangladesh to see if its success in the export of garments could suggest ways for it to be more competitive in other sectors.

The toolkit framework is used here to consider how data infrastructure might affect trade competitiveness. An advantage of using the toolkit is that it has been comprehensively tested in many low- and middle-income countries – such as Brazil, Georgia, and across South Asia. This opens the possibility that more can be learned about the effects of data infrastructure on poverty, and allows easier comparisons across countries using the World Bank's data across a familiar framework.[76] Competitiveness diagnostics for developed countries use essentially the same framework – each seeks to answer primary questions about macro incentives, backbone services and transaction costs, and government and market failures – but with more information available allowing deeper investigation of some issues.

[74] Reuters (2018) 'Mexico financial technology law passes final hurdle in Congress' https://uk.reuters.com/article/us-mexico-fintech/mexico-financial-technology-law-passes-final-hurdle-in-congress-idUKKCN1GD6KX

[75] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit', https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y

[76] World Bank (2013) 'Brazilian Exports Climbing Down a Competitiveness Cliff', http://documents.worldbank.org/curated/en/777771468017074102/pdf/wps6302.pdf; World Bank (2015) 'Survival Is for the Fittest Export Survival Patterns in Georgia', http://documents.worldbank.org/curated/en/649521468249871277/pdf/WPS7161.pdf; World Bank (2017) 'South Asia's Turn Policies to Boost Competitiveness and Create the Next Export Powerhouse' https://openknowledge.worldbank.org/bitstream/handle/10986/25094/9781464809736.pdf; World Bank, 'TCdata360', https://tcdata360.worldbank.org/

Macro incentives

Macro incentives are the first diagnostic question that the toolkit raises for data infrastructure.[77] In classic trade terms, macro incentives are about tariffs, exchange rates, taxes, labour markets, product and factor markets, property rights, regulation, and how easy it is to establish and close down an enterprise. Some of these, such as property rights and the regulation of large data-enabled companies such as Google, are at the centre of discussions about data infrastructure in many countries.

Debates over data ownership – property rights – have been ongoing for years, and using data rights may be the most economically efficient way to resolve the question. In the 1970s, Richard Posner, a law and economics academic at the University of Chicago, argued that it was inefficient to treat public information about a person as owned by that person – as doing so would lead to substantial bureaucracy in establishing, say, whether a photographer could use the image of many people in a public place without asking for their permission first.[78] Acknowledging that data subjects have rights over data about them – which might also be about lots of other people – and that data users have responsibilities to those data subjects, might be a better way, although this raises the question of legal regimes and incomplete contracts mentioned above.[79]

Factor inputs are the resources that companies use to create products and services. Data is a factor input, but not in the same way as other factor inputs. It is non-rivalrous (supply is not affected by use) but with some business models – such as Amazon's – companies collect consumer data to greatly increase their ability to target new consumers and offer better services, sometimes leading to a dominant position in the market. That raises questions about competition and access to data as a factor input for the creation and improvement of goods and services. Increasing the ease of porting data between companies – perhaps directed by consumers as they switch from one digital service to another, and using open application programming interfaces (APIs) – could be a way to increase domestic competition and raise export competitiveness.[80]

Backbone services and transaction costs

The second diagnostic question that the toolkit raises for data infrastructure is around 'backbone services' and 'transaction costs'.[81] Difficulties faced regarding developing and trading goods and services - domestically or across borders - are described as 'transaction costs'.

Reducing transaction costs can make production significantly cheaper, thereby increasing the price competitiveness of a product in a foreign market. For example, easy access to intellectual property lawyers or experts on consumer

[77] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit' https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y, p4
[78] Posner RA (1977) 'The Right of Privacy', https://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=2803&context=journal_articles
[79] Open Data Institute (2018) 'No one owns data: we need to strengthen our rights' https://theodi.org/article/no-one-owns-data-we-need-to-strengthen-our-rights/
[80] Digital Competition Expert Panel (2019) 'Unlocking digital competition: Report of the Digital Competition Expert Panel' https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/785547/unlocking_digital_competition_furman_review_web.pdf
[81] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit' https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y, p4

demand in another country, can make it simpler for a firm to judge whether and how to sell into that country; and being able to rely on a trade agreement that has established commercial rules for working with a company in another jurisdiction can have a similar effect.

Access to data science skills is a well-known example of a backbone data infrastructure service. If a company has been collecting data for years – for example on the productivity of its farms – and wants to use it to make better planting and sales decisions, it may need the expertise of a data scientist to help analyse the data, perhaps also developing a software application to help staff make decisions with the data. The data scientists will be better able to deliver those improvements if they are operating in a clear legal framework for data use, and have had industry-standard training that allows experts to quickly start working together. There are a range of other data skills and career paths.[82]

Government and market failures

The third diagnostic question that the toolkit raises for data infrastructure is around policies for overcoming government and market failures. For data policy these tend to involve coordination issues like open standards, which help to connect companies and share market information through shared language, common technology formats, and use guidance – that might not have been possible without them.[83]

Special economic zones might be a future development for data standards. Such zones are a common attempt by governments around the world to locate, say, high-technology companies in one place to take advantage of some local skills, collaborate, and create 'knowledge externalities' – positive spillover of new and innovative knowledge that benefit entrepreneurs. And given that special economic zones are often a way to improve a small part of a country's business environment – like Shenzen in China or the Subic Bay Freeport Zone in the Philippines – they could be used to store data and determine access to it in countries with weak legal regimes.

The sections below use the toolkit to consider data infrastructure with several classic aspects of trade competitiveness. These are: market access; incentives for trade and investment; factor conditions; intermediate inputs and backbone services; and trade promotion.

Market access

Market access is the ease with which a company in one country can sell to a consumer in another. Tariffs and non-tariff barriers affect the ease of access, and are raised by charges, indirect barriers, standards, quantitative restrictions, and contingent protection; or lowered by trade agreements and market coordination measures.[84] Together, these affect the cost of entering an international market – the

[82] Data Skills Framework 2019 by Open Data Institute
https://theodi.org/article/open-data-skills-framework/
[83] Open Standards for Data, 'Types of open standards for data',
https://standards.theodi.org/introduction/types-of-open-standards-for-data/
[84] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit',
https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y, p63

amount a company has to pay to get its product to a consumer – and the risk of doing so.[85]

Digital platforms have created substantial international markets, improving producers' access to international consumers. Amazon connects producers and consumers across many countries, while 'gig economy' sites such as Upwork link freelancers with new clients locally and internationally, in ways that were unheard of a few decades ago. Such platforms have used their 'two-sided' role to increase the efficiency with which market participants can connect with each other, often helping to reduce price dispersion.[86]

Data standards make it easier for companies to benefit from 'network effects'.[87] A 'network effect' is the effect that an additional user of a product or service has on the value of that product or service. Network effects were most famously apparent in the spread of telephone networks, when the value of telephones to each user increased as more people owned telephones and joined the network. Facebook has connected millions of people, making it more valuable to existing and new users, and has created tools for developers that allows them to link more services and people – and related data – to the network.

Trade agreements are a way of increasing market access through coordination.[88] They are the result of discussions between two or more countries about how they might reduce tariffs and restrictions on the sale of goods in their respective markets, but also about reducing trade frictions through the mutual recognition of standards. For example, the North American Free Trade Agreement sought to align some of the labour environmental production standards between Canada, Mexico, and the US, helping to boost trade between the countries from $290bn when the agreement was signed in 1993 to $1.1tn in 2016.[89]

Some recent trade agreements have included stipulations against a new type of non-tariff barrier: data localisation.[90] Non-tariff barriers raise the costs for a firm selling into a country, but without requiring direct payment of tariffs, and include requirements by countries such as China and Russia that data collected about their citizens must be stored in their countries. This mandates the data-collecting firms to maintain separate data storage and perhaps lose the benefits of being able to use some cloud services, analyse the information elsewhere and share it efficiently with commercial partners across the world.[91] The Comprehensive and Progressive

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[85] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit' https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y,

[86] Brynjolfsson B, Hui X, and Liu M (2018) 'Does Machine Translation Affect International Trade: Evidence from a Large Digital Platform', http://ide.mit.edu/sites/default/files/publications/Machine_Translation_NBER.pdf, p4

[87] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit', https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y, p136

[88] Grossman GM (2016) 'The Purpose of Trade Agreements', https://www.nber.org/papers/w22070.pdf, p2

[89] Council on Foreign Relations (2018) 'NAFTA's Economic Impact' https://www.cfr.org/backgrounder/naftas-economic-impact

[90] The OECD has categorised data storage requirements. They can run from no requirements; to a requirement for data storage with no stipulation with regard to the flow of data; to the additions of requiring data to be processed in the jurisdiction or that it be used in all circumstances in the jurisdiction. See Organisation for Economic Co-operation and Development (2019) 'Trade and Cross-Border Data Flows', https://www.oecd-ilibrary.org/trade/trade-and-cross-border-data-flows_b2023a47-en, p23

[91] Data localisation requirements can be imposed on non-personal data forms as well, as with the United States Copyright Act of 1976, which stipulates that work created by the US government is in the public domain when it is used domestically, but is subject to copyright protection abroad. See Wikipedia, 'Copyright status of works by the federal government of the United States' https://en.wikipedia.org/wiki/Copyright_status_of_works_by_the_federal_government_of_the_United_States

Agreement for Trans-Pacific Partnership between 11 countries on either side of the Pacific prohibits data localisation measures.'[92]

Data-localisation requirements may act in the same way that local content stipulations do.[93] A requirement for a company to use a local supplier during production reduces the range and possible quality of inputs and services available, and is likely to push up costs and inhibit the quality of the final product. Depending on the nature of a data-localisation requirement, it may stipulate that a company has to store data in a local facility that perhaps is less secure than an international facility, or that may use inferior technology than its international equivalent.

Data-localisation requirements affect a range of sectors. The ease of data flow – including personal data – affects a broad range of sectors from mining, consumer products and manufacturing, to healthcare retail.[94] Small firms are the most affected in some instances – such as those running communication services – as they are not so able to tailor their practices to specific countries compared to big firms. But it does not impact only on small firms: there is evidence that data-localisation requirements have caused many types of firms to cease operations in foreign jurisdictions, perhaps because they make data-use decisions less efficient.[95] Facebook has stated that it will not build data storage centres in countries it regards as restricting freedom of expression.[96]

Requirements to account for the security and privacy of some data underpin many data-localisation requirements.[97] According to the OECD, concerns around privacy, regulation, security, and industrial policy may inform policymakers' decisions to alter international data exchange policy.[98] Around a third of the stipulations force companies to locally store data and ban them from transferring it abroad, while approximately a quarter require companies to hold a copy locally but allow them to process it elsewhere.[99]

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[92] Lexology (2019) 'The CPTPP Enters into Force: What Does it Mean for Global Trade?', https://www.lexology.com/library/detail.aspx?g=9941ebd7-a3f8-4630-bc65-c483931f81ba

[93] Organisation for Economic Co-operation and Development (2019) 'Trade and Cross-Border Data Flows', https://www.oecd-ilibrary.org/trade/trade-and-cross-border-data-flows_b2023a47-en, p32

[94] Information and Technology Foundation (2015) 'Cross-Border Data Flows Enable Growth in All Industries' http://www2.itif.org/2015-cross-border-data-flows.pdf; Organisation for Economic Co-operation and Development (2019) 'Trade and Cross-Border Data Flows', https://www.oecd-ilibrary.org/trade/trade-and-cross-border-data-flows_b2023a47-en, p33

[95] United States International Trade Commission (2017) 'Global digital trade 1: market opportunities and key foreign trade restrictions' https://www.usitc.gov/publications/332/pub4716.pdf, p278

[96] 'There's an important difference between providing a service in a country and storing people's data there. As we build our infrastructure around the world, we've chosen not to build data centers in countries that have a track record of violating human rights like privacy or freedom of expression. If we build data centers and store sensitive data in these countries, rather than just caching non-sensitive data, it could make it easier for those governments to take people's information'. Facebook (2019) 'A Privacy-Focused Vision for Social Networking' https://www.facebook.com/notes/mark-zuckerberg/a-privacy-focused-vision-for-social-networking/10156700570096634/

[97] The E15 Initiative (2015) 'Information Goes Global: Protecting Privacy, Security and the New Economy in a World of Cross-border Data Flows', http://e15initiative.org/publications/information-goes-global-protecting-privacy-security-and-the-new-economy-in-a-world-of-cross-border-data-flows/, p1

[98] Organisation for Economic Co-operation and Development (2019) 'Trade and Cross-Border Data Flows', https://www.oecd-ilibrary.org/trade/trade-and-cross-border-data-flows_b2023a47-en, p13. Cultural values have also been cited for restricting data flows. Countries such as China, Lebanon, Singapore, Turkey, Germany, Iran, and Vietnam ban information exchange on the internet that they deem prejudicial to cultural values and public order. See Mitchell D and Hepburn J (2017) 'Don't Fence Me In: Reforming Trade and Investment Law to Better Facilitate Cross-Border Data Transfer', https://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1128&context=yjolt, p191

[99] As countries navigate the data protection approaches they might adopt, there are a number of mechanisms available that make data exchange contracts more complete. These include business contracts with accepted privacy standards, corporate rules for internal transfers, enforceable corporate codes of conduct re transfers, consent given by data sources, and other methods. See Centre for Information Policy Leadership (2017) 'Essential Legislative Approaches for Enabling Cross-Border Data Transfers in a Global Economy',

Restrictions on the commercial use of data have been found to restrict services trade.[100] The European Centre for International Political Economy has found that countries which are more restrictive towards data use and exchange – including across borders – see their imports of services become less data-intense; and that countries with strong digital networks suffer from bigger effects on their services imports. Both effects suggest that stringent data restrictions distance the imposing country from international data-exchange networks.

Trust could be as important as any other factor when examining how a country's data infrastructure affects its trade competitiveness. Data subjects' trust in the organisations that use data affects data sharing; and it seems reasonable to believe that if coordination around data ethics and rules is hard at the national level it will be even harder at the international one. There is a large body of support in many countries for the domestic storage of personal data – more than 75% of surveyed internet users in Indonesia, China, India, Poland and Mexico – suggesting that there is a long way to go before the general public are willing to engage in cross-border data sharing in a way that would maximise the gains from trade.[101] This might be unsurprising, given that the web has connected people around the world in ways that they never have been before, and there may need to be a period of 'cultural learning' before such a difficult trade issue can be addressed.[102]

Digital Planet 2017, a report on digital competitiveness, argued that some countries have established more internal trust in their digital ecosystems than others.[103] It divided countries by whether users of digital services had trust and patience with their digital ecosystem, and found that consumers in countries such as China, Ireland, and Malaysia were more likely to balance their appreciation of digital services with their concerns about data; while those places like Estonia, France, and South Korea were less likely to and had less trust in the digital economy as a result. The report argued that consumers in the former were more likely to appreciate the use of such services and were willing to use them despite having less trust in the use of their data and suchlike.

China's mix of market size and weak institutions challenges the argument that trust and standards are a competitive advantage for all countries. The Global Competitiveness Index ranks China's the 27th most competitive economy in the world, but mostly due to its domestic market, primary public services, and macroeconomic stability.[104] In 2015, information and communications technology services produced 2.6% of value-added in the Chinese economy, but in the same year only Hong Kong's exports of telecommunications services registered among the

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https://www.informationpolicycentre.com/uploads/5/7/1/0/57104281/cipl_white_paper__final__-_essential_legislative_approaches_for_enabling_cross-border_data_transfers.pdf

[100] European Centre for International Political Economy (2018) 'Do Data Policy Restrictions Inhibit Trade in Services?', https://ecipe.org/wp-content/uploads/2018/10/Do-Data-Policy-Restrictions-Inhibit-Trade-in-Services-final.pdf

[101] CIGI and Ipsos (2014) '83% of Global Internet Users Believe Affordable Access to the Internet Should be a Basic Human Right', https://www.cigionline.org/sites/default/files/documents/internet-survey-2014-factum.pdf, p15

[102] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit', https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y, p66

[103] Charavorti B and Chaturvedi RS (2017) 'Digital Planet 2017: How Competitiveness and Trust in Digital Economies Vary Across the World', https://sites.tufts.edu/digitalplanet/files/2017/05/Digital_Planet_2017_FINAL.pdf

[104] World Economic Forum, 'China' http://reports.weforum.org/global-competitiveness-index-2017-2018/countryeconomy-profiles/#economy=CHN

world's most competitive.[105] Despite the growth of Chinese firms such as Huawei and Lenovo, the European Centre for International Political Economy has argued that China is underperforming in the internet economy.[106]

Involving social groups, public representatives, and others in the construction of data infrastructure can help to reduce cultural, ethical and other indirect barriers to trade.[107] There are many other actors who can be included in data infrastructure questions, including data intermediaries who might coordinate data exchange between parties and have a role in maintaining legal and technical standards; reusers of data, who might be several steps along a data-use chain and can affect trust in the use of data all along it; and academic researchers, who might be working with the most sensitive types of data, such as health data.[108]

Coordination over data standards somewhat mimics international discussion of internet governance. States, businesses, civil society, intergovernmental organisations, technical communities, and academics are involved in determining how the internet operates.[109] The World Wide Web Consortium, for example, develops standards for the web, while the Internet Corporation for Assigned Names and Numbers works on identifiers and coordinates naming on the internet.[110]

Achieving stable and internationally attractive domestic coordination around data ethics could lead to greater trade competitiveness. The United Nations Conference on Trade and Development has noted the high levels of data protection coordination in international agreements, but also the divergent implementation. It has recommended that countries adopt principles such as organisations being open about their data collection; specifying the purpose of data collection; and allowing data subjects to access and correct data about themselves.[111] The Global Competitiveness Index lists intellectual property protection; corporate ethics; and legal system efficiency as some of the leading measures of assessing a country's competitiveness. Perhaps data ethics and associated behaviour could be a future addition if measuring it becomes feasible.[112]

Several approaches to balancing the security, efficiency, and productivity of cross-border data transfers in international agreements have emerged in recent years. The US International Trade Commission believes that they broadly divide into the Asia-Pacific Economic Cooperation (APEC) model, the EU's GDPR, and some hybrid or sector-driven approaches.[113] The EU's approach has been described as one which uses adequacy requirements for data exchange between jurisdictions, with exceptions applied, and has extended the EU's reach to countries storing data

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[105] UNCTAD (2017) 'Information Economy Report 2017: Digitalization, Trade and Development' https://unctad.org/en/PublicationsLibrary/ier2017_en.pdf, p23, p29
[106] European Centre for International Political Economy (2017) 'China's technology protectionism and its non-negotiable rationales', https://ecipe.org/wp-content/uploads/2017/06/DTE_China_TWP_REVIEWED.pdf
[107] World Bank (2012) 'Trade Competitiveness Diagnostic Toolkit', https://openknowledge.worldbank.org/bitstream/handle/10986/2248/673620PUB0EPI007869B009780821389379.pdf?sequence=1&isAllowed=y
[108] Open Data Institute (2018) 'Mapping data ecosystems', https://docs.google.com/document/d/1vSqoHOYT5u6vrCHlebCS0rze0gWwXOspeEowWzwake8/edit#heading=h.gqlbnitjgdiq, p10
[109] World Bank (2016) 'World Development Report 2016: Digital Dividends', http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf, p294
[110] W3C, 'About W3C', https://www.w3.org/Consortium/; ICANN, 'Welcome to the Global Community!', https://www.icann.org/get-started
[111] UNCTAD (2016) 'Data Protection Regulations and International Data Flows: Implications for Trade and Development', https://unctad.org/en/PublicationsLibrary/dtlstict2016d1_en.pdf, p56
[112] World Economic Forum (2018) 'The Global Competitiveness Report 2018', http://reports.weforum.org/global-competitiveness-report-2018/
[113] United States International Trade Commission (2017) 'Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions', https://www.usitc.gov/publications/332/pub4716.pdf, p274

outside the union. The APEC approach seeks to harmonise members' data protection laws while facilitating cross-border data transfers.[114] The commission considers countries such as Indonesia and Russia to have taken the EU's approach; while China, India, and the US – which is one of several common-law countries that might be thought of as taking an approach that tends towards accountability, due diligence, and appropriate protection – address the question by sector rather than comprehensively.[115]

As suggested by the US International Trade Commission, GDPR has affected the sale of data-driven services by foreign producers into EU markets. Professional services companies in Canada, for example, offer GDPR-readiness assessments and implementation roadmaps. Fines violating GDPR rules can be up to €20 million or up to 4% of the annual worldwide turnover of the preceding financial year in case of an enterprise, whichever is greater.[116]

There are ongoing developments in the data-exchange relationship between the EU and the US. Model contracts and the EU-US Privacy Shield have been developed to facilitate data-enabled trade between the US and the EU, but these may have been insufficient to prevent US companies from needing to build cloud storage centres in the EU.[117] Safe Harbour was developed because the EU thought the US privacy regime inadequate.[118]

As data regulation regimes develop, improving their interoperability may be more efficient than global coordination.[119] This would mean that countries would adopt codes of conduct, mutual recognition of standards, or other agreements that clarify issues between countries rather than requiring lots of them to accede to one agreement at once. Such an approach would also align with interoperability approaches in software development, where developers often aim to make systems interoperable rather than create one system for all uses.

Incentives for trade and investment

Incentives for data-enabled trade and investment are about how easy it is to create value from data, attract capital, and export. In recent years it has become clear that companies with an entrepreneurial approach to data-enabled goods and services have a competitive advantage. A country's business environment can affect the dynamism of firms being established, operated, and closed down as they pursue growth at home and abroad. The ease of doing that affects how attractive a country's business climate is to foreign companies who may want to operate a data-enabled business in the country.

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[114] United States International Trade Commission (2017) 'Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions', https://www.usitc.gov/publications/332/pub4716.pdf, p274; Centre for Information Policy Leadership (2017) 'Essential Legislative Approaches for Enabling Cross-Border Data Transfers in a Global Economy', https://www.informationpolicycentre.com/uploads/5/7/1/0/57104281/cipl_white_paper__final__-_essential_legislative_approaches_for_enabling_cross-border_data_transfers.pdf, p1

[115] United States International Trade Commission (2017) 'Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions', https://www.usitc.gov/publications/332/pub4716.pdf, p274

[116] Christen L etal (2013) 'The Impact of the Data Protection Regulation in the E.U.', http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.657.138&rep=rep1&type=pdf

[117] United States International Trade Commission (2017) 'Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions', https://www.usitc.gov/publications/332/pub4716.pdf, p282

[118] US Chamber of Commerce (2014) 'Business Without Borders: The Importance of Cross-Border Data Transfers to Global Prosperity', https://www.huntonprivacyblog.com/wp-content/uploads/sites/28/2014/05/021384_BusinessWOBorders_final.pdf, p21

[119] Heyder M (2014) 'Getting Practical and Thinking Ahead: "Interoperability" Is Gaining Momentum', https://iapp.org/news/a/getting-practical-and-thinking-ahead-interoperability-is-gaining-momentum/

Public institutions inform the incentives for data-enabled trade, and regulatory sandboxes can be a way for them to test ways in which to do so. Britain's Financial Conduct Authority created sandboxes for new fintech services in 2016, giving companies the chance to sell new products to consumers under six months' close interaction with the financial regulator to gauge and adjust the performance of the product within guidelines.[120] Such an approach gives companies an opportunity to understand how to use and share users' data, and the UK's Financial Conduct Authority believes that it allows companies to test new market offerings early while also facilitating investment.[121] The Hong Kong Monetary Authority established its Fintech Supervisory Sandbox in 2016.[122]

Britain's Information Commissioner's Office is extending regulatory sandboxes into more data-enabled sectors.[123] The commissioner has been keen to find ways to allow data-enabled innovation that respects regulation while allowing regulators to respond to technology developments that it would have been difficult to foresee. These include developments in biometrics, the Internet of Things, and wearable technology. These may need a mix of regulator advice on rules and standards; the regulator adopting frameworks rather than rules, and being ready to remove innovation-stifling stipulations; or becoming better at anticipating change.

Assessing the quality of a data ecosystem has been a strong point of data infrastructure analysis for a few years. The World Bank has sought to understand and encourage private sector demand for government data around the world through its Open Data for Business Tool. The Govlab has tried to identify organisations that might use data to solve problems – after recognising that the public release of data in many countries was falling into a habit of creating data portals with little appreciation of how the data might be used. There are also applications in the financial sector through the Open Banking Index, and for assessing national geospatial capabilities with the Geospatial Readiness Index.[124]

Many governments have recently made governance a point of institutional competitiveness in artificial intelligence.[125] Several countries have artificial intelligence strategies which cover developing the skills for data manipulation; setting technical standards; and coordinating between public research organisations and private companies. For example, Japan has developed artificial intelligence utilisation principles; Kenya has a task force on distributed ledgers and artificial intelligence; and South Korea has published a 'Master plan for the intelligent information society'.[126]

Australia has put data exploitation at the centre of its Australia 2030 economic strategy.[127] It advocates making access to public data more useful for entrepreneurs,

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[120] Financial Conduct Authority (2017) 'Regulatory sandbox lessons learned report', https://www.fca.org.uk/publication/research-and-data/regulatory-sandbox-lessons-learned-report.pdf, p4
[121] Ibid, p5
[122] Hong Kong Monetary Authority (2019) 'Fintech Supervisory Sandbox (FSS)', https://www.hkma.gov.hk/eng/key-functions/international-financial-centre/fintech-supervisory-sandbox.shtml
[123] Information Commissioner's Office (2019) 'Sandbox beta phase discussion paper', https://ico.org.uk/media/about-the-ico/documents/2614219/sandbox-discussion-paper-20190130.pdf
[124] IDC (2018) 'Ready for Open Banking?' https://www.finastra.com/sites/default/files/2018-11/Open%20Banking%20Readiness%20Index.pdf; Gebuiz (2018) 'Countries Geospatial Readiness Index 2018 (CGRI-2018)' https://geobuiz.com/Countries-Geospatial-Readiness-Index-2018.html
[125] Nesta (n.d.) 'Mapping AI governance' https://www.nesta.org.uk/data-visualisation-and-interactive/mapping-ai-governance/
[126] Ibid
[127] Australian Government, Department of Industry, Innovation and Science (2017) 'Australia 2030: Prosperity Through Innovation', https://www.industry.gov.au/data-and-publications/australia-2030-prosperity-through-innovation

and developing more high-performance computing to allow more research in data-heavy activities. In the strategy, Australia has recognised that firms become more competitive abroad if they are subject to the pressure of competition at home. It reports that domestic competition filters weak market offerings, redistributing financial and human capital to firms that are best able to innovate and efficiently meet demand. The strategy notes that it is more likely that these firms will have sophisticated business models that can survive foreign competition.[128]

Australia is using its Consumer Data Right to drive domestic competition in data-heavy sectors.[129] The right gives consumers access to data about them in machine-readable form, allowing them to extract it from one service and give it to another. This ease of data portability incentivises data holders to improve digital services, as customers can easily move to competitor services with better offers. Australia has approached the question of data access and competition by giving regulatory leadership to the Australian Competition and Consumer Commission, supported by the Office of the Australian Information Commissioner. The right will start in highly regulated sectors such as banking, energy, and telecommunications.

Encouraging data portability may improve entry into digital markets and improve competition. Data portability allows consumers to extract data from one holder and give it to another so that they can better direct how data is used. This is likely to improve the goods and services provided to them by the selected company.[130] GDPR provides a right to data portability that is stronger than the previous right to data access.[131] Through the Smart Data Review the UK government is exploring strengthening data portability in multiple sectors.[132]

Regulatory sophistication towards data-enabled digital sectors has recently become more of a competitive advantage.[133] A recent report on digital competition for the British government recommended that data openness and common standards would allow more competition in data-heavy industries, some of which were liable to quickly 'tipping' and making one company dominant in the market. But such interventions are new and untested beyond a few cases, and the report mentioned the difficulty of defining a digital market in which a firm might be dominating. Competition in digital markets will drive innovation and productivity growth. But developing countries face the problem of growing local companies in the face of international firms that have established strong market positions – and the ability of regulators to develop sophisticated interventions may affect the competitiveness of their jurisdictions for years to come.[134]

Australia's Consumer Data Right is starting in the financial sector because open banking has become a leading example of the benefits of a good data ecosystem. The Open Data Institute was part of establishing the UK's Open Banking Working Group in 2015, showing how open application programming interfaces between the UK's banks could ease the transfer of data between them, encouraging

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[128] Ibid, p4
[129] Treasury.gov.au, 'Consumer Data Right - Fact Sheet', https://static.treasury.gov.au/uploads/sites/1/2018/02/180208-CDR-Fact-Sheet-1.pdf
[130] Information Commissioner's Office (2018) 'Right to data portability', https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/individual-rights/right-to-data-portability/
[131] Open Data Institute (2018) 'Will GDPR and data portability support innovation?', https://theodi.org/article/will-gdpr-and-data-portability-support-innovation/
[132] HM Government (2018) 'Smart Data Review', https://www.gov.uk/government/publications/smart-data-review
[133] Kay L (2019) 'How to pit a small regulator against big tech?', https://medium.com/@lawrencebernardkay/how-to-pit-a-small-regulator-against-big-tech-3f1b000f99be
[134] World Bank (2018) 'Data-Driven Development', https://openknowledge.worldbank.org/handle/10986/30437, p29

the development of new services.[135] The open banking reforms built on the UK's financial sector strengths to attract around $5.6bn of investment in 2018.[136] Versions of the initiative have spread to Canada, Japan, Mexico, and other countries.

Factor conditions

Factor inputs are the resources that firms use to create products and services, and the conditions in which they access them affect the costs of production. Factor inputs include capital and labour, and in data infrastructure terms means the access that firms have to data in given sectors, and its quality. Labour force skills drive the extraction of value from the data.[137]

Data release by public organisations has long been a way to stimulate data flows. For example, Australia's 2015 Public Data Policy Statement provided a mandate for Australian Government entities to optimise the use and reuse of public data to drive innovation across the economy.[138] The statement included mandating the release of data as 'open by default' when it is safe to do so and since then there has been a dramatic increase in the number of datasets publicly available: data.gov.au now hosts over 29,900 data records.

Recent figures suggest that there is a surge of finance available for data applications that use artificial intelligence. The OECD has estimated that there was nearly $17bn of equity investment into artificial intelligence across China, the EU, Israel, the US, and some other places in 2017.[139] It found that in the same year around 12% of worldwide private equity investment had gone to artificial intelligence startups, up from 3% in 2011.[140]

Investment into artificial intelligence startups is a bet on a firm having access to data, and having the technical efficiency to exploit it. The returns to scale – the quantitative change in output resulting from a proportionate increase in inputs – of data manipulation allow firms to improve their existing products, such as internet search, while also learning about how they might produce new ones and expand into further markets.[141] But there is evidence to suggest that some of the world's largest firms have been unable to develop useful data exploitation and artificial intelligence skills: more than half of the large US firms responding to a recent survey said that they were not treating data as an asset, nor using it to compete.[142] This is despite the fact that 'data-driven decision making' has been found to raise firms' productivity by as much as 6%.[143]

There is a data feedback loop in artificial intelligence applications, which has already had effects on international trade. Artificial intelligence improves by using

[135] Open Data Institute (2016) 'Introducing the Open Banking Standard', https://www.scribd.com/doc/298568600/Introducing-the-Open-Banking-Standard
[136] KPMG (2018) 'UK remains leader in fintech investment but loses global crown', https://home.kpmg/uk/en/home/media/press-releases/2019/02/uk-remain-leader-in-fintech-investment-but-loses-global-crown.html
[137] Romer P (1989) 'Endogenous Technological Change', http://www.nber.org/papers/w3210.pdf
[138] Australian Government (2015) 'Australian Government Public Data Policy Statement', https://www.pmc.gov.au/sites/default/files/publications/aust_govt_public_data_policy_statement_1.pdf
[139] OECD (2018) 'Private Equity Investment in Artificial Intelligence', https://www.oecd.org/sti/ieconomy/private-equity-investment-in-artificial-intelligence.pdf
[140] Ibid
[141] Goldfarb A and Trefler D (2017) 'AI and International Trade', https://www.nber.org/chapters/c14012.pdf, p21
[142] Bean R and Davenport TH (2019) 'Companies Are Failing in Their Efforts to Become Data-Driven', https://hbr.org/2019/02/companies-are-failing-in-their-efforts-to-become-data-driven
[143] Brynjolfsson E etal (2011) 'Strength in Numbers: How Does Data-Driven Decisionmaking Affect Firm Performance?', http://www.socialserviceworkforce.org/system/files/resource/files/Data%20Driven%20Decisions.pdf

an initial dataset, using it to carry out a task, and then getting better through learning from the results and receiving more data.[144] When consumers have so many products and services to choose from, using artificial intelligence to more efficiently link them with sellers could raise consumer welfare, and some studies have shown that artificial intelligence has raised international trade possibilities by as much as 20%.[145]

A range of business models for extracting value from data are being tested in sectors all over the world.[146] There are internal, supply-chain, and industry platforms that determine many business models in sectors using large amounts of data. But these may be only frontier examples, with the skills and management systems available to undertake extensive data manipulation in low supply and firms around the world not operating with modern information technology.[147]

Allocating data science skills through an efficient labour market could have significant effects on how well a country can maximise its data infrastructure competitiveness. Skills for data manipulation have become some of the most remunerative in the modern labour market. In the US job market, they are thought to enjoy base salaries that are as much as 36% higher on average than people with statistics skills but no coding ability.[148]

Despite the emergence of online freelance platforms, geographic concentrations of data skills are becoming common. It is possible that one of the least mobile inputs into the development of data-enabled digital services – labour – is concentrated in only a few areas of the world – such as Berlin, Shanghai, and Toronto. And this concentration of expert labour could be behind some of the biggest advances in sectors such as artificial intelligence.[149] This is perhaps driven by firms with valuable data being unwilling to share it with more than a few organisations around the world; or by the advantages – management efficiency and control of a complicated process – gained by having a small number of highly educated people in one place.

Several countries have noticed the geographic concentration of data skills and are investing heavily in education and the supply of skills for technology careers. For example, Canada's Ontario province is spending C$3bn through its Innovation Agenda to improve its business climate, labour skills, and ability to compete in developing internationally competitive digital services.[150] This is in addition to its Advanced Manufacturing Supercluster strategy, for which public authorities are coordinating skills training and technology adoption to boost capabilities in machine learning and associated activities.[151]

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[144] Brynjolfsson B, Hui X, and Liu M (2018) 'Does Machine Translation Affect International Trade: Evidence from a Large Digital Platform', http://ide.mit.edu/sites/default/files/publications/Machine_Translation_NBER.pdf, p1
[145] Ibid, p1
[146] Open Data Institute (2018) 'The role of data in AI business models', https://theodi.org/article/the-role-of-data-in-ai-business-models/; (2016) 'Open Enterprise: How Three Big Businesses Create Value with Open Innovation', https://theodi.org/article/open-enterprise-how-three-big-businesses-create-value-with-open-innovation/
[147] OECD (2004) 'CT, E-Business and Small and Medium Enterprises', https://www.oecd-ilibrary.org/science-and-technology/ict-e-business-and-small-and-medium-enterprises_232556551425;jsessionid=4wjQLkUDoKvvMJkAERRYfn6t.ip-10-240-5-34
[148] Press G (2018) 'The Salaries Of Data Scientists Remain Steady But Still Sexy With AI On The Horizon', https://www.forbes.com/sites/gilpress/2018/05/04/the-salaries-of-data-scientists-remain-steady-but-still-sexy-with-ai-on-the-horizon/#1fbf993b733d
[149] Goldfarb A and Trefler D (2017) 'AI and International Trade', https://www.nber.org/chapters/c14012.pdf, p9
[150] Ontario (n.d.) 'Seizing Global Opportunities: Ontario's Innovation Agenda', https://www.ontario.ca/page/seizing-global-opportunities-ontarios-innovation-agenda
[151] Government of Canada (n.d.) 'Advanced Manufacturing Supercluster', https://www.ic.gc.ca/eic/site/093.nsf/eng/00010.html

There are many schemes around the world for increasing worker skills in a way that increase the ability to extract skills from data. MexicoFIRST has raised the quality of information and communications technology (ICT) skills and increased job opportunities. Surveys show that MexicoFIRST trainees credit the training programme certification and skills with finding work or for gaining better salaries and promotions. Over 100,000 trainees have received international standard certifications; over 80,000 university students have attended MexicoFIRST courses; and 40,000 have found a new job in the IT industry. Digiboost Finland was launched in 2015 and aims to increase the use of ICT in small and medium-sized enterprises by employing ICT specialists. The programme funds the hiring of one or more digital experts for a year who then help firms to use ICT. Since 2015, 220 firms have employed over 250 digital experts.

Intermediate inputs and backbone services

A data-enabled firm's access to resources and services that it does not have in-house affects how easily it can create value from data. This tends to mean access to information and communications technology and associated infrastructure, data science consultancy, and its connections in a vibrant data ecosystem. For example, the ICT Development Index looks at factors such as mean years of schooling in a population, the number of households with a computer, and the number of fixed-broadband subscriptions. Hong Kong was ranked sixth in the world in 2017, and its information and communications technology services sector employs approximately 108,000 people and contributes 6.6% to its annual GDP.[152]

Including more people and organisations in creating data infrastructure can help with the supply of digital skills and services. They can be:

- public servants that want to know how to better share data for the improvement of public services
- developers that want to establish standards that make it easier to work with their peers across the world
- entrepreneurs that need policymakers to understand that they need access to more workers with digital skills
- firms with promising business models that cannot enter a market because of unfair practices from incumbents
- international freelancers that want to work in a place for a short time before moving on.[153]

Allowing more of these voices to be heard during the development of data infrastructure - especially by policy-makers - can contribute to diversity in the supply of services.

Building data infrastructure with many users in mind invites open innovation and increases dynamism in the creation of data-enabled goods and services. Large firms that want to be more innovative can benefit from allowing small firms with specialist skills into their research and development processes, and it is easier to do

[152] ICT Development Index 2017 (2017) 'ICT Development Index 2017', http://www.itu.int/net4/itu-d/idi/2017/index.html; Census and Statistics Department, HKSAR (2018), Table 017: Number of Establishments, Persons Engaged and Vacancies (other than those in the civil service) Analysed by Industry Section, https://www.censtatd.gov.hk/hkstat/sub/sp452.jsp?tableID=017&ID=0&productType=8

[153] Dodds L and Wells P (2019) 'Open Data and Data Infrastructure' https://docs.google.com/document/d/1tAeidONKZEkpCf9Jkwe4amWZKbQHTMiHJb8rW7PV7Fs/

that if there are more organisations that they can collaborate with.[154] Firms can foster this openness to innovation by setting up challenge prizes and development networks, with corporations building digital tools to bring new ideas in more quickly.

There are ever more examples of how innovation by data management services could feed more future innovation. There are a range of approaches to increasing access to data.[155] Newer approaches being explored include personal data stores. Mydex, for example, helps digital service users to monitor and control personal data about them, while at the same time assisting companies improve their data security credentials with their customers. Digi.me operates in a similar way, and is seeking to help consumers, companies engage in private data sharing. It is also aiming to spread such services to medical records in the UK's healthcare system.[156] Other approaches involve new institutions such as data trusts, data clubs and data cooperatives.[157]

Public–private partnerships for data exchange and use have emerged, such as Data 61 is Australia.[158] It is seeking to work across the public sector, academia, and enterprise, to create a data innovation ecosystem. Data 61 offers consultancy and connections on the use of data, research, testing new market offerings, particularly in sectors such as smart cities, health and wellness, and machine learning.

Public exchanges and platforms for data use have found a role. The Amsterdam Data Exchange, for example, is seeking to establish a system of data exchange between researchers, businesses, citizens, and government organisations for a variety of purposes.[159] DECODE, a project by Nesta, is establishing decentralised and open-source technical standards for sharing data that could allow them to more easily engage with projects that would value data.[160]

International development agencies have fostered data institutions, such as the Africa Regional Data Cube, to boost data use for anti-poverty aims.[161] The project is using satellites to help Kenya, Senegal, Sierra Leone, Ghana, and Tanzania with agriculture, deforestation, and water supply. As it does so, partner governments and organisations are being assisted to develop their capacity for collecting, analysing, and using data for policy ends, thereby developing their data ecosystems.[162]

Public sector adoption of artificial intelligence may be a part of encouraging wider adoption. Hong Kong's Innovation and Technology Fund has supported 57 artificial and robotics-related projects with over HK$200 million in the past three years.[163] The Hong Kong government is also looking to use more artificial intelligence

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[154] Febvre J and Bone F (2018) 'Five open innovation mechanisms for successful startup-corporate collaborations', https://www.nesta.org.uk/blog/five-open-innovation-mechanisms-successful-startup-corporate-collaborations/

[155] Open Data Institute (2018) 'Data access archipelago: mapping the myriad ways we share data', https://theodi.org/article/data-access-archipelago-mapping-the-myriad-ways-we-share-data/

[156] Mydex (n.d.) 'Trust, identity & data management — solved', https://mydex.org/; digi.me (n.d.) 'See what your data can do for you with digi.me', https://digi.me/

[157] Jeni Tennison (2019) 'New institutions are needed for the digital age', https://www.ft.com/content/5f46f102-6741-11e9-b809-6f0d2f5705f6

[158] Data 61 (n.d.) https://www.data61.csiro.au/

[159] Amsterdam Data Science (2018) 'Launch of the Amsterdam Data Exchange (Amdex)', https://amsterdamdatascience.nl/news/launch-of-the-amsterdam-data-exchange-amdex/

[160] Bass T and Meesen P (2018) 'DECODE: A technical explainer', https://www.nesta.org.uk/blog/decode-technical-explainer/

[161] Global Partnership for Sustainable Development Data (2018) 'Africa Regional Data Cube', http://www.data4sdgs.org/initiatives/africa-regional-data-cube

[162] Global Partnership for Sustainable Development Data (2018) 'Resources', http://www.data4sdgs.org/index.php/resource-listing

[163] Computerworld HK (2018) 'HK Budget 2018: Innovation gets a big boost with $50bn of Investment', https://www.cw.com.hk/it-hk/hk-budget-2018-innovation-gets-a-big-boost-50b-investment

in public administration, such as city management, transport, and customs inspection.

Cities around the world are centres of data innovation, and this size and level of innovation is ideal to analyse and identify the services that support data exploitation. Connected Places Catapult, a British research institute, found that the following roles and organisations had helped to foster data innovation in cities in the UK:

- City data platforms for sharing data between organisations, such as CityVerve Manchester which runs demonstration projects on how the Internet of Things can improve the use of data to address urban issues.[164]
- Data catalogues for access to open data such as the Comprehensive Knowledge Archive Network, which creates tools for openly publishing and analysing datasets.[165]
- Suppliers in the Internet of Things, who in addition to collecting data, offer analysis and visualisation services. Examples include Cleanspace, which helps urban residents to track pollution in their area.[166]
- Cloud service providers that often host large datasets and can provide data analysis and visualisation services, such as Amazon Web Services and Microsoft Azure.
- Data producers who earn revenue through selling access to data, such as that for maps. Examples in the include Ordnance Survey, Britain's national mapping service.[167]
- Large technology providers for database services and suchlike. Examples include IBM and Cisco.
- Support organisations who are often doing research while providing consultancy, such as universities.
- Data science providers.[168]

Artificial intelligence firms are an example of how business models for data exploitation can be affected by the services and data ecosystem available.[169] Because open or easily accessible data attracts people and organisations to work with it, firms can pitch an approach on a spectrum that invites more or less collaboration with others working on similar problems. There could be five stock business models that mix judgements about how much a firm should use external collaboration opportunities or internal and procured skills in the development of artificial intelligence products:

1. Open algorithm and closed data model: with this approach firms restrict access to data but give access to their algorithms, using open source toolkits to work with interested specialists and allowing others to develop complementary services.
2. Closed algorithm and closed data model: this approach treats data and a company's algorithms as intellectual property, relying on internal resources and available services for exploitation.

[164] Cityverve (n.d.) 'What is Cityverve?', https://cityverve.org.uk/what-is-cityverve/
[165] CKAN (n.d.) 'CKAN, the world's leading Open Source data portal platform', https://ckan.org/
[166] Cleanspace (n.d.) 'The world's first personal air pollution smart sensor', https://our.clean.space/
[167] Ordnance Survey (n.d.) https://www.ordnancesurvey.co.uk/
[168] Future Cities Catapult (2017) 'City Data Sharing Toolkit', https://futurecities.catapult.org.uk/wp-content/uploads/2018/10/City-Data-Sharing-Toolkit_V1.1_FCC_Oct2018.pdf
[169] Open Data Institute (2018) 'The role of data in AI business models', https://docs.google.com/document/d/14g0p6KSyH1r1J_PrykJIXUX-rdeP1B4CLIffAyFPOnk/edit#heading=h.rcydy9gttjg4

3. Closed algorithm and open data model: this is also known as the 'proprietary algorithm model' with which firms give access to data and low access to algorithms. This approach tends to be favoured by firms that want to create competitive algorithms without having to control a large dataset, as a startup might want to.
4. Open algorithm and open data model: an approach that perhaps allows innovation to occur more quickly, but requires a firm to restrict access to its skills, hardware, or other assets, if it is to be commercially viable.
5. Shared algorithm and shared data model: an approach that is favoured by consultancies that license access to their artificial intelligence systems.

Physical infrastructure for data-enabled trade affects how well firms can share data and reach consumers. Data centres play a leading role in international finance Data is collected, stored securely and analysed in data centres. Canada's Digital Economy Action Plan is spending over C$100m on digital infrastructure in Quebec, but the costs of building data centres across the world can differ substantially and affect competitiveness – perhaps varying by as much as $60.9m in Brazil, $51.2m in Chile, and $43m in the US.[170]

Access to cloud computing is one of the most analysed aspects of data-enabled competitiveness.[171] Estimates of annual global spending on cloud computing services run from around $70bn to up to $90bn, with the US accounting for more than double the spending in the EU and the rest of the world combined, although spending has risen considerably in recent years in countries such as Brazil.[172] There are essentially two types of product on offer: physical infrastructure for cloud computing, and services for access to the infrastructure. Developing countries spend more on the former than the latter, and developed countries the reverse.[173]

Cloud computing as a service can improve business processes and reduce barriers to entry, especially for firms in developing countries.[174] Cloud computing services reduce the information and communications technology costs that firms have to bare. They remove the need for company servers and allow entrepreneurs to store and manipulate data without having to invest in their own hardware before they have proven their business model.[175] Infrastructure service providers benefit from economies of scale, gaining market share and reducing costs for their customers; and in mature markets, companies have been able to use multiple suppliers to build bespoke services while reducing the risks from being dependent on one.[176] Large US cloud computing suppliers have entered large developing country markets, but have been challenged in recent years by local competitors.[177]

Geography appears to matter more in the provision of cloud computing than might be expected. The latency in access to software as a service for data-heavy activities introduces extra geographic aspects into data-enabled trade competitiveness, meaning that some services might be better provided if they are

[170] US Chamber of Commerce (2014) 'Business Without Borders: The Importance of Cross-border Data Transfers to Global Prosperity', https://www.huntonprivacyblog.com/wp-content/uploads/sites/28/2014/05/021384_BusinessWOBorders_final.pdf, p13
[171] United States International Trade Commission (2017) 'Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions', https://www.usitc.gov/publications/332/pub4716.pdf, p58
[172] Ibid, p71, p73
[173] Ibid, p74
[174] Ibid, p189
[175] Ibid, p67
[176] Ibid, p63
[177] United States International Trade Commission (2017) Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions, p76

close to servers.[178] With the introduction of online-only digital services such as gaming, speed and geography questions may become more pertinent, while connectivity demands could mean that servers are best placed in climates in which they can be kept cool without high energy costs.[179] There is also some evidence that cultural and legal familiarity has motivated European companies to choose local cloud services suppliers.[180]

Cutting the cost of internet and data access and making them available to more people domestically, is a competitiveness question.[181] A country's digital skills base is boosted through more people using the internet from an early age and being more prepared for internet-driven processes in the workplace, while the price per month for a gigabyte of data to download can vary from around 1% of GDP per capita in Mauritius to 45% in Zimbabwe.[182] The Global Competitiveness Index regards internet access in schools – and by extension access to data – to be an 'efficiency enhancer', meaning that more familiarity with the internet during education helps employees to be better managers in the workforce.[183]

The nature of data exploitation, and availability of services, skills, and data infrastructure could help explain geographic clusters of data competitiveness. The agglomeration of skills and other resources for data-enabled sectors in a region may have several causes, including the economies of scope that become possible once a firm has set up the ability to manipulate and manage data; the difficulty of moving data across jurisdictions, as mentioned above; and the benefits of firms locating in their largest market.[184] But it is difficult to extrapolate effective industrial policies from these observations.

China's Greater Bay Area is an example of a data and technology cluster.[185] The area includes Hong Kong, Macau and nine other cities in China's Guangdong province, has 67 million people, and creates 12% of China's GDP. The Chinese government has a vision for the region to rival Silicon Valley in the US and Tokyo Bay in Japan, and to help achieve it, respective public authorities have made interventions such as establishing research centres – specialising in healthcare technologies, artificial intelligence and robotics technologies – at the Hong Kong Science Park.[186]

Trade promotion

Export promotion is about attracting foreign consumers, and investment promotion is about attracting foreign investors. There are few examples of countries using their data infrastructure credentials to promote themselves, but many

[178] Ibid, p59
[179] Onezero (2019) 'Google Just Showed Us the Future of Gaming', https://onezero.medium.com/google-just-showed-us-the-future-of-gaming-37ccec59e2dd; World Bank (2018) 'Data-Driven Development', https://openknowledge.worldbank.org/handle/10986/30437, p13
[180] United States International Trade Commission (2017) 'Global Digital Trade 1: Market Opportunities and Key Foreign Trade Restrictions', https://www.usitc.gov/publications/332/pub4716.pdf, p76
[181] Economist Intelligence Unit (2019) 'The Inclusive Internet Index 2019', https://theinclusiveinternet.eiu.com/
[182] World Bank (2018) 'Data-Driven Development', https://openknowledge.worldbank.org/handle/10986/30437, p26
[183] World Economic Forum (2017) 'The Global Competitiveness Report 2017-2018', http://reports.weforum.org/global-competitiveness-index-2017-2018/#topic=methodology
[184] Goldfarb A and Trefler D (2017) 'AI and International Trade', https://www.nber.org/chapters/c14012.pdf
[185] German Industry and Commerce HK (2018) 'What is the Guangdong-Hong Kong-Macau Bay Area Development All About?', https://hongkong.ahk.de/news/news-details/?tx_news_pi1%5Bnews%5D=14032&cHash=465e53bafa36416edb3eaa4a46f22d8a
[186] World Economic Forum (2019) 'This is China's plan to eclipse Silicon Valley', https://www.weforum.org/agenda/2019/02/this-is-china-s-plan-to-eclipse-silicon-valley/

of the elements that go with it – such as digital skills – are at the centre of strategies for attracting investors to dynamic, digital sectors. Export promotion for data-enabled goods and services tends to focus on digital services.

The EU made a move for data-enabled trade competitiveness in 1996 with its Database Directive.[187] The directive was partly about creating data rights for data collectors, in an attempt to incentivise European firms to create valuable databases that would make them more internationally competitive.

Access to data is being used by some countries as an incentive for foreign investment. For example, Singapore has increased access to government datasets for location and transportation; while Hong Kong's data portal has become a forerunner to the Hong Kong Hospital Authority establishing a data analytics platform for biotechnological research.[188] Canada's open government drive is identifying high-value datasets, and spreading adoption of the Open Data Charter, while the country's Open Data 150 – a project that maps Canadian companies that use open data – allows potential open data users to see what applications are possible.[189]

Objectives for digitisation and more data use are some of the highest economic priorities for OECD countries.[190] In 2017 the OECD found that within the digital strategies of its member countries: 22 had objectives for developing their telecommunications infrastructure; 16 had objectives for promoting information technology skills; and 16 had objectives to generate more science and innovation.[191] Countries such as Australia, Brazil, and Germany have been racing in recent years to write artificial intelligence strategies and data protection frameworks that they hope will push them ahead in developing and selling advanced technology abroad in sectors such as automobiles, finance, and satellites.

If data standards become an aspect of trade competitiveness, subsidies for certification could be an export support policy. Helping producers in one country achieve the quality standards of another has long been an intervention favoured by policymakers – particularly in developing countries – for raising the amount of value that firms can gain from their exports.[192] Guidance on data standards set by the International Organization for Standardization include ISO 8000 on data quality.[193] Traditional interventions for helping firms to achieve such standards in the production of goods, have included establishing national quality certification centres, facilitating integration with international systems, and increasing demand for certification.[194]

'Fintech bridges' between the UK and several countries have been some of the most prominent examples of promoting exports and investment in a data-enabled sector. The UK–Australia FinTech Bridge is the most prominent

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[187] European Commission (2017) 'The economics of ownership, access and trade in digital data', https://ec.europa.eu/jrc/sites/jrcsh/files/jrc104756.pdf p4
[188] Computerworld HK (2018) 2018 Policy Address: Local R&D gets a boost for tech sector growth', https://www.cw.com.hk/it-hk/2018-policy-address-local-r-d-gets-a-boost-for-tech-sector-growth
[189] Govlab (n.d.) 'Open Data 500', http://canada.opendata500.com/; Canada Open Government Working Group (2017) 'Draft Work Plan 2017-2018', https://open.canada.ca/ckan/en/dataset/5cc8b7ea-1fb2-527c-a73f-824da6ef69a6
[190] OECD (2017) 'OECD Digital Economy Outlook 2017', https://read.oecd-ilibrary.org/science-and-technology/oecd-digital-economy-outlook-2017_9789264276284-en#page38, p36
[191] Ibid, p36
[192] Guasch JL etal (2007) 'Quality Systems and Standards for a Competitive Edge', https://openknowledge.worldbank.org/bitstream/handle/10986/6768/405160Quality0101OFFICIAL0USE0ONLY1.pdf?sequence=1&isAllowed=y
[193] International Organization for Standardization (n.d.) 'ISO/TS 8000-1:2011', https://www.iso.org/standard/50798.html
[194] Guasch JL etal (2007) 'Quality Systems and Standards for a Competitive Edge', https://openknowledge.worldbank.org/bitstream/handle/10986/6768/405160Quality0101OFFICIAL0USE0ONLY1.pdf?sequence=1&isAllowed=y

example, and was established partly as a market access and coordination mechanism. It directs collaboration between the respective governments, financial regulators and industry; and encourages fintech firms to use the facilities and assistance available in the other jurisdictions to explore new business opportunities and reduce barriers to entry.[195] The bridge also serves as an intervention by the respective governments for focusing financial services on either country, and firms with export potential have access to one-stop shops giving for legal, regulatory and practical advice.

Associations for sector coordination have become some of the most common examples of data-driven industries, and affect export competitiveness. Several countries have installed organisations for the development and coordination of artificial intelligence research and commercialisation. For example, Canada has Canada.ai for celebrating Canadian advances in artificial and machine learning.[196]

[195] Australian Government, The Treasury (2018) 'UK-Australia FinTech Bridge', https://treasury.gov.au/fintech/uk-australia-fintech-bridge/
[196] Canada AI (n.d.) http://canada.ai

Conclusion

Data offers considerable innovation possibilities, but analysis of what determines a country's data-enabled trade competitiveness has only just begun. Data is unlike other resources and can be reused without depletion while often holding delicate information about people – driving the development of new technology such as artificial intelligence. But data as a resource also poses novel policymaking questions about the rules, institutions, and understanding necessary for its full economic exploitation. How countries answer those questions could affect their ability to create valuable goods and services, sell them abroad, and grow, for decades to come.

Blending classic trade competitiveness analysis with the concept of data infrastructure offers guidance to policymakers on the choices they face. The discussion here has suggested that delineating issues of data infrastructure – using the World Bank's Trade Competitiveness Toolkit framework – outlines the policy choices that affect the ability of firms to create new and better digital services with data and sell them to consumers in foreign markets. Years of research on digital competitiveness offers a foundation for how to consider such questions, but data infrastructure raises new issues with regard to data ethics, security of contract, and technological standards for data exchange.

Becoming competitive in data-enabled trade may be a question of how to develop openness and data sharing in a cautious manner. Surveys from countries around the world suggest public hesitation towards cross-border data exchange. And the nature of collection of – often personal – data through mobile technology brings ever more people and organisations into the discussion of which datasets should be shared and with whom. Some countries are approaching questions of data innovation by using regulatory sandboxes and reconsidering their competition frameworks.

International coordination of data exchange is nascent, and many countries are faced with some strategic choices over which framework they adopt. GDPR has become the most prominent example of international data collection and use regulations, and its approach has naturally been adopted by EU countries while spreading to others in the union's neighbourhood. But GDPR strikes a balance between policymakers' competing objectives of efficient cross-border data exchange and protection of personal data, that the US and jurisdictions within APEC are approaching differently. Dealing with the classic international trade problem of incomplete contracts in a world of enormous quantities of data is a relatively young topic.

Mistrust and the attraction of defending domestic firms from international competition may be driving data use from openness and towards protectionism. The discussion here has relayed research on the rising number of countries that are requiring firms to store or use the data they collect in the country in which it was collected. This may be due to contracts for international data exchange being inadequate for the nature of data and its mix of personal and non-personal information.ut the consequence is that it limits the range of information that countries can exchange – and may limit the ability of firms in restrictive countries to extract value from the data they have access to.

Geography matters in the trade of data-enabled goods and services. The further a cloud storage server is away from using the data in it, the slower the speed with which it can be accessed, giving a competitive advantage to countries that host servers with large amounts of data.

Not being like China may be a long-run advantage for many countries. China has generated large amounts of data on its citizens, allowing its firms to create digital services that have made them some of the most valuable companies in the world. But that is without China having developed the means for its companies to sell large amounts of digital services abroad. It would be understandable for policymakers to want to emulate China's success, but that may be difficult without China's domestic market size. Establishing an international reputation for high data standards may be a more competitive approach for many countries.

The field of data-enabled trade competitiveness study will grow in the coming years to answer some of the questions that this report has raised. A research agenda could answer pressing questions such as: whether data flows between countries show anything about their export performance; how data exchange options between countries might be formalised in trade agreements and how these might affect their ability to export data-enabled products; how competition policy towards digital firms might affect a country's ability to produce competitive firms in markets dominated by existing ones; and whether trade promotion activities could help some places to attract investment because of their data ethics standards. The Open Data Institute will be analysing some of these issues in future work.