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Regulatory Federalism and Broadband Divergence: Implications of Invoking Europe in the Making of Canadian Telecom Policy

In addition to its relevance for Europeans, the effectiveness of European telecommunications policy has become a contested area in debates influencing telecom policy design in other countries. Individual European countries, as well as Europe as an aggregated construct, are often used as examples in these debates. Invocations of Europe are increasingly evident in Canadian debates about wholesale broadband access, consumer protection, network neutrality and basic service policies. While some stakeholders in Canadian debates point to national and local approaches in Europe that appear to have been relatively successful in fostering broadband infrastructure development, others suggest that Europe is lagging behind and Canada should avoid Europe's purported policy errors:

> The mismanagement of broadband in Europe – where state-imposed mandates and top-down regulations have contributed to underinvestment and poor network quality – offers a cautionary tale for Canada as it seeks to develop its innovation agenda.[1]

Understanding the empirical underpinnings of competing characterisations of the European experience is relevant for policymakers in countries such as Canada that are searching for policies that are effective in promoting private sector incentives to improve broadband Internet connectivity. Previous research on the evolution of telecom investments and Internet connectivity indicates that there is no single "European experience", as public policy, firm-level strategies and broadband outcomes vary significantly in individual and different groups of countries.[2] European experiences offer an empirical puzzle, which can be challenging for foreign policymakers to appreciate.

Empirical research on regulation, investment and broadband development in Europe documents that investments by incumbents have tended to be lower in European countries with relatively more intensive national regulatory frameworks than in those with more streamlined rules and standards.[3] On the other hand, EU member states with regulatory frameworks that have been more successful in promoting service-based competition tend to have higher measured connectivity speeds and penetration of next generation fibre-to-the-premises (FTTP) broadband networks.[4] Access regulation and service-based competition may be associated with lower investment inputs, but they are positively associated with network infrastructure outcomes as measured by broadband speeds. In other words, higher capital expenditures do not always translate into the development of faster broadband connectivity.

The reasons for this puzzle from Europe are not yet very well understood, but potentially include: too little cooperation in fixed cost sharing, too much inefficient duplication of network infrastructure in the absence of credible wholesale access obligations, lack of competitive discipline needed to improve service quality, and stranded capital expenditures on legacy assets. While further research is required, existing evidence from Europe clearly illustrates the limitations of the traditional telecom policy framework that assumes the existence of a trade-off between investment and competition incentives, particularly when it comes to deploying advanced technologies requiring irreversible capital expenditures. As summarised in a review of the evidence by the European Parliament, "the relevant point here is whether or not operators are able to translate their capital expenditures into real improvements in the quality of the network".[5]

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1 Macdonald-Laurier Institute (MLI): Steering Canada clear of Europe's disastrous broadband strategy: MLI study by Andrea Renda, press release on report entitled "Winners and Losers in the Global Race for Ultra-Fast Broadband", Ottawa, 24 August 2016, available at http://www.macdonaldlaurier.ca/steering-canada-clear-of-europes-disastrous-broadband-strategy-mli-study-by-andrea-renda/.

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2 See W. Lemstra, W. Melody: The Dynamics of Broadband Markets in Europe – Realizing the 2020 Digital Agenda, Cambridge 2014, Cambridge University Press.

3 See M. Grajek, L. Röller: Regulation and investment in network industries: Evidence from European telecoms, in: Journal of Law and Economics, Vol. 55, No. 1, 2012, pp. 189-216.

4 See R. Rajabiun, C. Middleton: Regulation, investment and efficiency in the transition to next generation broadband networks: Evidence from the European Union, in: Telematics and Informatics, Vol. 32, No. 2, 2015, pp. 230-244.

5 See European Parliament: Reforming EU Telecoms Rules to create a Digital Union, Study for the ITRE Committee, 2016, p. 27, available at http://bookshop.europa.eu/en/reforming-eu-telecoms-rules-to-create-a-digital-union-pbQA0216237/.

Over the past two years, insights from Europe about the relevance of policies that promote cooperation and risk sharing in network development have played a part in convincing the Canadian telecommunications regulator – the Canadian Radio-television and Telecommunications Commission (CRTC) – to determine that fibre-to-the-premises (FTTP) networks of the future are non-duplicable[6] and should therefore be subject to third party wholesale access obligations.[7] At the same time, the CRTC has closed the door on mandating access to fibre transport facilities, as recommended by rural municipalities, and to Mobile Virtual Network Operators access regulations.[8] Perceptions of success and failure of public policy and industry practices in Europe continue to play a part in these and other aspects of telecom policymaking in Canada, including differential traffic pricing and prioritisation practices of fixed and mobile Internet access infrastructure providers.[9] It seems that they may also play such a part in policy formation processes in other advanced and developing countries.

This article examines evidence and arguments regarding European approaches to telecommunications policy that stakeholders have increasingly inserted into public consultation processes and policy debates in Canada. Using broadband speed measurements, we compare broadband Internet access quality in Canada with individual and clusters of European countries experiencing distinctive paths of broadband network development. In addition to the relevance of the analysis in the context of Canadian policy debates, differentiation in broadband Internet infrastructure quality within Europe is particularly important to consider, as EU member states and stakeholder groups contemplate reforms to EU telecom rules via the "connectivity package" proposed by the Commission.[10]

Context: Broadband network and policy development in Canada

In the early 1990s, Canadian policymakers were among the first in high-income countries to recognise that access to essential network infrastructure controlled by incumbent telecom network operators represented a barrier to the development of data services that were needed to meet the anticipated needs of businesses and residential consumers. Despite the relatively early adoption of wholesale and unbundling obligations on incumbents' copper networks in Canada, these early policies were not very effective in promoting service-based competition or incentivising incumbent operators to extend broadband connectivity. Nevertheless, initiatives by cable TV providers to invest in their networks to deliver higher speed access as infrastructure competitors, combined with strong demand by Canadian consumers for Internet connectivity, provided a basis for relatively rapid growth in broadband penetration rates. By the early 2000s, Canada had one of the highest broadband penetration rates of the advanced economies.[11]

Much like in the US, the past success of infrastructure competition back in the early stages of the development of Internet connectivity continues to cast a long shadow over the design of telecom policy in Canada. Unlike the US, which abandoned wholesale access obligations on legacy DSL operators in the aftermath of the 2002 financial crisis in order to promote infrastructure investment incentives, the CRTC retained and extended them to cable broadband providers. Importantly, however, in Telecom Decision CRTC 2008-17, the regulator chose to forbear from mandating wholesale access to fibre transport and next generation fibre access facilities in order to promote incentives for legacy DSL and cable network operators to invest in fibre.[12]

Formal regulatory mandates to provide third party access have not succeeded in promoting substantive service-based competition in Canada.[13] Two decades after the introduction of essential facilities obligations, service-based competitors

6 Canadian Radio-television and Telecommunications Commission (CRTC): Telecom Regulatory Policy CRTC 2015-326, Review of wholesale wireline services and associated policies, July 2015, available at http://www.crtc.gc.ca/eng/archive/2015/2015-326.htm.

7 See R. Rajabiun, C. Middleton: Public Interest in the Regulation of Competition: Evidence from Wholesale Internet Access Consultations in Canada, in: Journal of Information Policy, Vol. 5, 2015, pp. 32-66.

8 Canadian Radio-television and Telecommunications Commission: Telecom Regulatory Policy CRTC 2015-177, Regulatory framework for wholesale mobile wireless services, May 2015, available at http://www.crtc.gc.ca/eng/archive/2015/2015-177.htm.

9 This is particularly the case for policy debates over network neutrality or quality of service differentiation. At the time of writing, the CRTC was reviewing differential pricing practices; see Canadian Radio-television and Telecommunications Commission: Telecom Notice of Consultation CRTC 2016-192, Examination of differential pricing practices related to internet data plans, October 2016, available at http://www.crtc.gc.ca/eng/archive/2016/2016-192.htm.

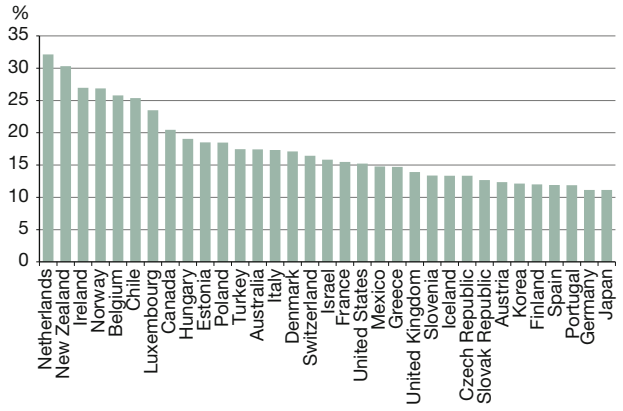
10 European Commission: Digital Single Market, Improving connectivity and access, September 2016; proposals are available at https://ec.europa.eu/digital-single-market/en/connectivity-european-gigabit-society.

11 See the OECD Broadband Portal for historical data, e.g. http://www.oecd.org/dataoecd/63/53/41551452.xls. See also R. Rajabiun, C. Middleton: Multilevel governance and broadband infrastructure development: Evidence from Canada, in: Telecommunications Policy, Vol. 37, No. 9, 2013, pp. 702-714.

12 As noted above, the regulator reversed course and mandated access to fibre networks in a 2015 decision. The description of Canadian broadband services offered in the following paragraphs reflects the market conditions that existed before access to fibre networks was mandated by the CRTC.

13 This is due in part to a relatively high regulated wholesale price intended to promote investment incentives of competing DSL and cable operators, as well as lack of reseller control over service quality (i.e. Layer 3 versus 2 control).

Figure 1
Investment in telecommunications as a per cent of revenue, 2013



Source: OECD Digital Economy Outlook, 2015, Fig. 2.33; spectrum fees excluded.

generate less than ten per cent of retail market revenues.[14] These regulatory obligations also do not appear to have had a negative impact on investment incentives of operators. As documented in Figure 1, network investments as a percentage of operator revenues in Canada are among the highest in OECD countries – notably, substantially higher than in the US, where the FCC has resisted calls to mandate third party access obligations in order to promote infrastructure competition and investment in next generation FTTP networks. Notably, Canadian operators tend to invest more of their revenues in telecom networks compared to countries such as Japan and Korea, where substantive investments in FTTP networks were made in the late 2000s. This highlights the importance of locally specific considerations in interpreting what investment levels mean for public policy and business strategy.

More disaggregated data on the capital intensity of operators in Canada indicates that cable operators have historically invested a larger proportion of their revenues on their networks relative to copper/DSL providers.[15] Despite some variation across firms and over time, the capital expenditure levels in Canada have remained substantially higher than in all but a few other high-income countries, even though the CRTC mandates third party wholesale access obligations on both copper/DSL and cable operators.

What has been particularly puzzling about the Canadian experience is that relatively high capital expenditure levels have not resulted in the delivery of relatively high network speeds or investments in next generation FTTP networks. As documented in Figure 2, average measured download speeds in Canada are on par with the average for many high-income countries, which is around two to three times lower than in leading countries in East Asia and Europe that are further along in the transition to such networks (see Figure 3).

The divergence of international outcomes in terms of average broadband network performance noted above highlights the importance of history and technology for explaining how capital inputs are translated into network outcomes. In leading countries in East Asia and Europe, legacy copper platforms were largely decommissioned as FTTP networks were rapidly deployed in the mid-to-late 2000s. Early investment in early adopter countries such as Japan and Korea has made it relatively less capital intensive for operators in these countries to scale their networks in response to subsequent growth in demand for higher speed connectivity associated with the adoption of advanced Internet content and application services. Essential facilities obligations that incentivise FTTP deployment and minimise the potential for inefficient duplication help explain why operators in these countries can deliver superior service levels, despite the relatively low capital intensity of their telecom operators in recent years. In Europe, some leading countries in terms of FTTP deployment (e.g. Sweden, Norway) have relied on municipal leadership to invest in next generation networks, reduce duplication and promote service-based competition. Others, such as the Netherlands, have instead relied on substantive infrastructure competition on legacy platforms to meet rapidly growing demand for connectivity, which causes the FTTP penetration rate to remain below average (12% for the Netherlands versus the OECD average of around 20%).

International comparisons suggest that forbearance from mandating access to next generation FTTP networks in Canada and the US has not been conducive to their development. This is particularly the case in Canada, where FTTP penetration remains about half of the US level and three to four times lower than the OECD average. This failure of the CRTC 2008-17 decision ultimately resulted in the CRTC reversing course in the CRTC 2015-326 decision. In the 2015 reform, the CRTC extended wholesale access obligations to next generation fibre access facilities and adopted a wholesale pricing framework designed to incentivise investments in them by allowing first movers in FTTP deployment to earn an attractive rate of return on their irreversible capital expenditures.[16] Following the decision, several of Canada's largest legacy network op-

14 Canadian Radio-television and Telecommunications Commission: Communications Monitoring Report, 2015. Note that mandated wholesale access to fibre networks is not yet commercially available.

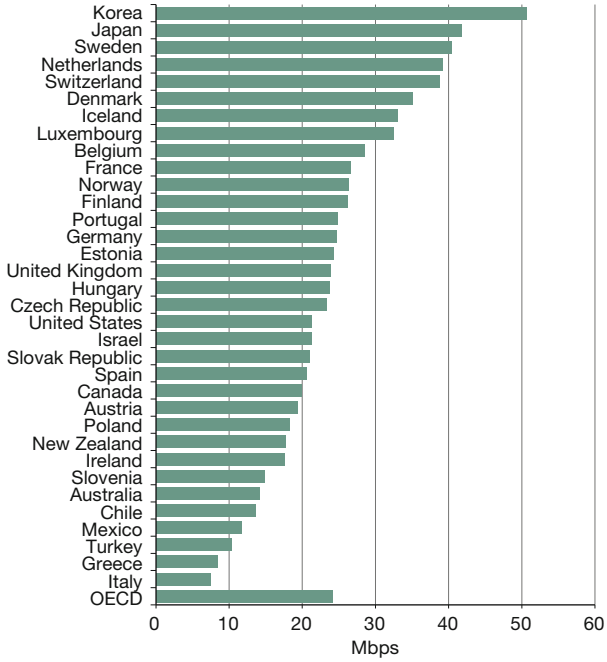
15 Cable operators have invested around 40% versus 25% for copper/DSL providers; see CRTC, 2015, Table 5.0.5 "Telecommunications capital expenditures as a percentage of revenues".

16 The authors of this article participated in the CRTC 2013-551 wholesale consultation process, presenting research on the Canadian and European experience, as well as offering an approach to pricing wholesale services that is intended to limit incentives to invest in legacy platforms and promote those in the long-term transition to FTTP.

Figure 2

Divergence of broadband speeds, 2014

Upper bound of measured average download speeds

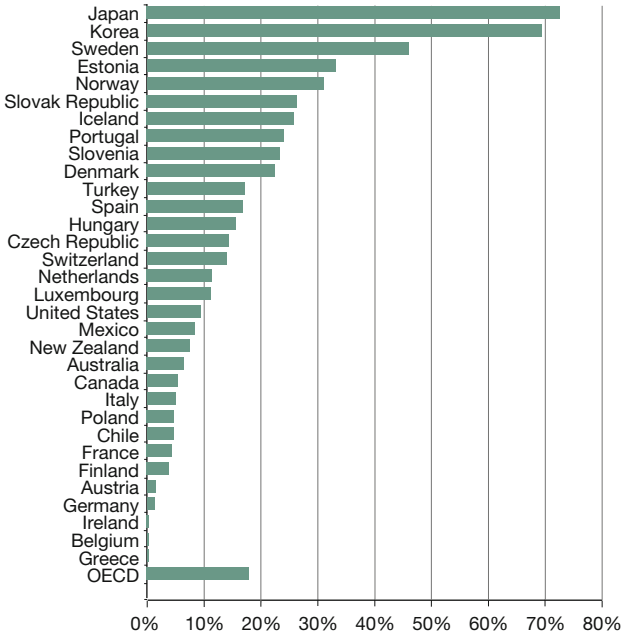


Source: OECD Broadband Statistics, Table 5.5. Ookla/Speedtest.

Figure 3

Diffusion of fibre access networks in selected countries, 2015

Percentage of fibre connections in total broadband subscriptions



Source: OECD Broadband Statistics, Table 1.10.

erators announced that they would start deploying next generation technologies in certain low-cost urban areas.[17] The extent to which the new framework will succeed in achieving its objectives in terms of FTTP deployment and service quality improvements will not be known for a number of years.

Private interests and perceptions of Europe in Canadian telecom policy formation

An examination of the policy development process leading to the adjustment to Canada's wholesale access regime highlights the evolving positions of interest groups trying to shape public policy. As expected, consumer advocacy groups and service-based competitors asked the CRTC to reduce wholesale access rates and extend regulatory obligations to FTTP networks, rural communities asked for wholesale access obligations to be extended to fibre transport facilities, and incumbent copper and cable network providers opposed these proposed reforms, with some of them asking for a phase-out of existing obligations on legacy platforms.[18] By the end of the proceeding, however, cable companies started to recognise that a shift to a technologically neutral wholesale access regime for next generation access technologies might actually be in their interests.

It is important to note that most of the submissions to the regulator in this matter only provided evidence regarding Canada and local challenges created by the existing wholesale regulatory framework for the affordability and quality of broadband in Canada. In the early stages of the process, only a small number of participants incorporated international evidence in their arguments. However, as the regulatory process involved a number of stages and provided for replies by the parties to each other's arguments, questions about the relevance of international experiences – particularly those relating to the US, Europe and Japan – became more pronounced in the latter stages of the proceeding. Examples of insertions of the European experience in the Canadian regulatory proceeding are discussed below.

17 See e.g. Bell Gigabit Fibe internet service launched in Ontario, Quebec, CBC News, 11 August 2015; Rogers announces Ignite Gigabit internet, 4K sports broadcasts, CBC News, 5 October 2015; Telus boosts Vancouver's internet network with $1B upgrade, CBC News, 2 October 2015. It is also relevant to note that one of the bigger service-based competitors declared bankruptcy subsequent to the decision. See Primus in court creditor protection as it seeks to revamp mission, The Globe and Mail, 21 January 2016.

18 The texts of all written and oral submissions to the proceeding are available in the Telecom Notice of Consultation CRTC 2013-551, available at http://crtc.gc.ca/eng/archive/2013/2013-551.htm. For a more detailed analysis of this CRTC process, see R. Rajabiun, C. Middleton: Public Interest..., op. cit.

Infrastructure providers

Cable operators: At the initial stages of the proceeding, Rogers, the largest cable network operator in Canada, commissioned an expert report on the international experience in order to capture "The Incentive Effects of Wholesale Unbundling Regulation on Investment".[19] Based on the assumption that the so-called "ladder of investment" theory represents the logical underpinning of wholesale access obligations and on selective international evidence, Rogers used this report to highlight that few European countries imposed wholesale access obligations on cable providers and went on to argue that the CRTC should "phase out" wholesale access obligations on cable providers in order to

> provide entrants with the opportunity and incentive to move up the ladder of investment and thereby promote the development of facilities-based entry. It would also send the correct investment signals to existing and potential suppliers of wholesale and retail services.[20]

Copper/DSL operators: Bell, the largest vertically integrated infrastructure operator in Canada, attached a set of expert reports to its CRTC submission that starkly contrasted the US and Japanese experience with the state of affairs in Europe:

> The elimination or reduction of mandated access obligations in the U.S. has supported extensive investment in facilities by U.S. carriers. …The opposite situation has prevailed in Europe, where mandated access has depressed investment and caused many European countries to fall behind in the race to deploy next generation networks. … [T]he economic literature "strongly supports the hypothesis that access regulation does not promote, and may hamper, telecommunications investment and broadband penetration" and specifically that "reliance on access regulation seems to have had a negative impact on investment in new broadband networks." As a result, Europe lags behind the US, Canada and Japan in terms of investment, speed, and penetration of fast and ultra-fast broadband.[21]

Beside the fact that Japan actually used wholesale access regulation very successfully to promote FTTP deployment in the mid-to-late 2000s,[22] the idea that Europe somehow lags behind according to certain indicators offers an excellent example of how a complex reality can be easily simplified by narrow interests trying to shape public policy. The fact that investment inputs are emphasised by the incumbent as a measure of outcomes also represents a key to the standard regulatory model operators tend to promote, which assumes the existence of a trade-off between competition and investment incentives in the development of network infrastructure. An expert for Bell summarises this perspective on the European experience:

> Overall, the situation is close to disastrous: countries that have relied extensively on access regulation, like the United Kingdom, today feature 1% coverage of FTTP...[23]

Telus, the dominant DSL/FTTN incumbent in Western Canada, similarly centralised failures in an aggregated construct of Europe to warn Canadian policymakers against extending essential facilities obligations to next generation FTTP networks in a submission in support of Bell's efforts to have the decision overturned:

> In the light of the CRTC decision 2015-326, ironically the policy trajectories in Canada and Europe are going in different directions; While Europe – recognizing its policy failures - is heading towards a more investment friendly environment, Canada has put in place a decision that would adopt failed European policies. This route would obviously be detrimental for the country.[24]

Further submissions by Bell in its petition to the Cabinet to overturn the CRTC decision add a legal opinion to the aggregated construction of Europe by arguing that "under EU regulation, ILECs in Canada would not be subject to mandatory network sharing".[25] Although this characterisation of high-level EU directives is factually correct, it hides the substantial regulatory autonomy EU members retain in the implementation of telecom policy in general, and essential facilities access regulations in particular.[26] This autonomy allows individual member states to adopt implementation strategies that meet their local needs and conditions, an option that is not available to lower levels of government in Canada or the US.

19 S. Wallsten: The Incentive Effects of Wholesale Unbundling Regulation on Investment, 2014, available at https://services.crtc.gc.ca/pub/DocWebBroker/OpenDocument.aspx?DMID=2068486.

20 Rogers Communications first intervention in CRTC 2013-551, page iii, paragraph ES14.

21 First intervention by Bell to CRTC 2013-551, pp. 32-34.

22 N. Minamihashi: Natural Monopoly and Distorted Competition: Evidence from Unbundling Fiber-Optic Networks, Bank of Canada Working Paper No. 2012-26, 2012.

23 Ibid., p. 3.

24 G. Serentschy: Mandated Access to Fibre: Lessons for Canada from Europe, Appendix B of submission by Telus in support of Bell petition to Governor in Council, 2015, p. 6, available at https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/DGTP-002-2015-TELUS-AppendixB.pdf/$FILE/DGTP-002-2015-TELUS-AppendixB.pdf.

25 A. Renda: Regulating Broadband: Lessons from the European Union, and Implications for Canada, Attachment 5 of petition by Bell to Governor in Council, 2015, p. 2, available at https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/TRP-CRTC-2015-326-Bell-Canada-Attachment5.pdf/$file/TRP-CRTC-2015-326-Bell-Canada-Attachment5.pdf.

26 For a detailed characterisation, see European Commission: Regulatory, in particular access, regimes for network investment models in Europe, 2016, available at https://publications.europa.eu/en/publication-detail/-/publication/c0da75d9-9a8c-11e6-9bca-01aa75ed71a1.

Access seekers

Wholesale access obligations in Canada have not been conducive to the development of service-based competition, and the market share of non-incumbents is below ten per cent in terms of retail market revenues. A number of this class of firms participated in the proceeding and documented challenges for their business models caused by relatively high wholesale prices mandated by the CRTC, which are designed to provide infrastructure operators with an attractive rate of return to promote investment in essential facilities. Representing a number of service-based competitors, the Canadian Network Operators Consortium (CNOC) pointed to Europe as an empirical model to convince the CRTC to adopt an Equivalence of Inputs (EOI)[27] approach to wholesale pricing:

> Indeed, The European Commission ("EC") has identified EOI as the "surest way to achieve effective non-discrimination." A robust EOI regime, therefore, should represent the next stage in Canada's telecom regulatory framework.[28]

The CRTC ultimately did not adopt this recommendation and retained its so-called Phase II costing methodology. In addition, CNOC used the international experience as a basis for arguing why the CRTC should provide its members with access to next generation FTTP networks:

> Canada has been a laggard in the deployment of FTTP networks compared to Europe, Asia, and Australia...[29]

Having failed to convince the CRTC to adopt an EOI-based wholesale pricing model, CNOC took serious issue with the manner in which the European experience was characterised by Bell in the subsequent appeal to the Cabinet. In addition to detailing various factual errors in submissions by incumbents, it urged the Canadian policymakers to be

> especially cautious of international comparative evidence with the EU given that the EU consist of 28 different member states each with distinct economic, social, cultural, political, legal and regulatory environments.[30]

27 EOI represents a wholesale regime in which services offered by an infrastructure provider to third party entities are provided at an equivalent price, quality, terms and timescale, using the same systems and processes that incumbent carriers use to supply their own retail operations.

28 Canadian Network Operators Consortium (CNOC): First submission to CRTC 2013-551, p. 77.

29 Ibid., p. 112.

30 Ibid., p. 9.

Diversity of outcomes: From investment inputs to network outcomes

The idea of Europe as a homogeneous place where bad public policies cause developmental failures in broadband markets is a hyperbole invoked to achieve a specific purpose by particular groups of private interests trying to shape public policy. Nevertheless, use of such semantic strategies to reduce a complex reality for a political purpose is common in various areas of policymaking and can have real consequences on policy outcomes. Even if it is strategic for particular interest groups to utilise selective evidence to create a perceived reality that helps achieve their objectives, the "noise" from contradictory comparative assessments can create substantive uncertainty about what policies and strategies are relevant given local conditions, needs and capacities.

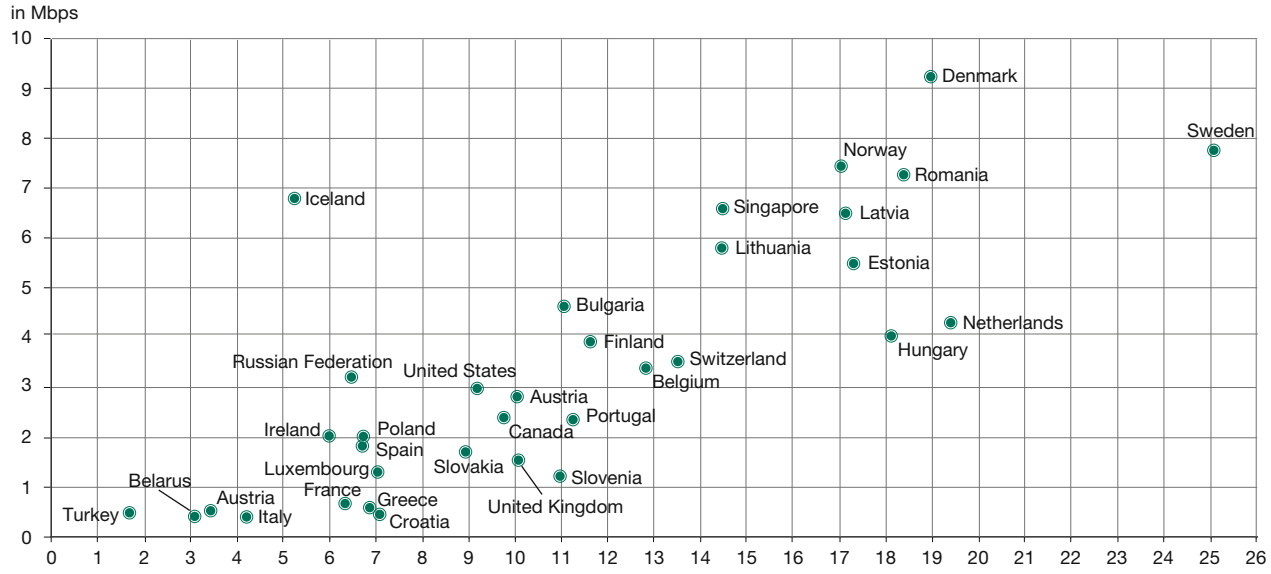
To illustrate the diversity of broadband outcomes, we analyse data from the M-Lab Network Diagnostic Test (NDT) distributed network measurement platform to provide a relatively comparable and detailed look at the reality of Internet connectivity.[31] While informative as comparative indicators of the development of broadband infrastructure quality, speed measurements do not explicitly take account of structural differences across countries, including potentially relevant supply and demand side factors such as broadband technologies in use, population density and users' willingness to pay for high-speed connectivity. Speed measurements nevertheless represent a realistic proxy for the incentives and ability of infrastructure providers to invest in additional network capacity in response to growing demand by consumers for more network-intensive Internet applications and cloud-based services.

Figure 4 documents measured median download and upload speeds as of the beginning of 2016 for a selected group of relatively high-income countries.[32] Operators in countries on the top right tend to deliver higher speed and more symmetric connections, which partly reflects the relatively higher rate of transition from legacy copper and cable to next generation

31 The M-Lab platform enables users to test their connections and collect a large set of metrics regarding their connection quality and potential variables that might explain it (Web 100 statistics). M-Lab NDT results are generated via a standard-based methodology using "off net" measurements between the test device and a server outside the ISP of user conducting the test. Partly because of this, in absolute terms M-Lab speed measurements tend to be lower than most other broadband speed tests promoted by operators such as Ookla/Speedtest and Samknows. M-Lab speed tests tend to be consistent with those from Akamai State of the Internet Report, which evaluates connection quality while delivering internet content and applications. We use Google Public Data Explorer for median measured speeds and the RIPEstat Observed Network Capacity Widget to characterise sample distributions of the results. See https://www.measurementlab.net/.

32 Please note that some relevant European and East Asian countries are not included due to data limitations.

Figure 4
Broadband network speeds in selected countries, 2016



Note: Median measured speeds; x-axis: download speed; y-axis: upload speed.

Sources: M-Lab; Google Public Data Explorer.

FTTP in these countries. The leading European countries are mostly in northern and eastern Europe, where obligations to interconnect with third parties have fostered a faster rate of technological change relative to larger western and southern European countries. Although the Scandinavian experience is somewhat unique, as it required significant municipal leadership, the contrast between "old" and "new" Europe is particularly important for capturing the interplay between the EU's regulatory framework and national policy regimes. As part of the accession process in the 2000s, eastern European countries implemented relatively clear and effective essential facilities obligations on infrastructure operators. Policies intended to promote entry into these markets have had a positive long-term impact in terms of both connection speeds and FTTP deployment rates.[33]

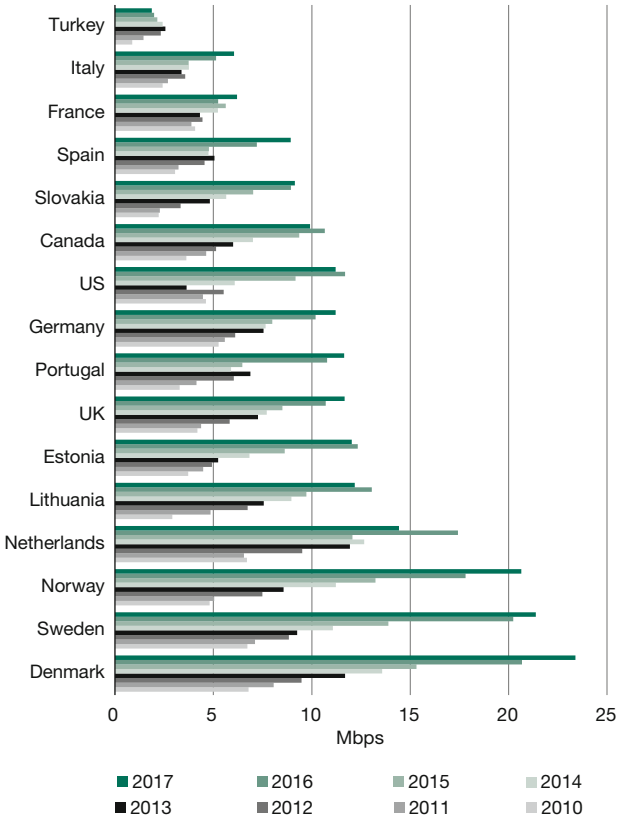
These speed measurements suggest a high degree of clustering within Europe. The leading cluster of countries are relatively smaller in terms of geography and population and tend to have highly educated populations. To the extent that education, demand and willingness to pay for Internet access might be correlated, this might be a factor in creating an institutional environment that is relatively successful in promoting broadband infrastructure development. The smaller size of these jurisdictions might further have a role to play by making central government regulators more accountable for the quality of infrastructure that is available to residents and businesses. Operators in larger, lower-income countries such as Italy, Poland, France and Turkey deliver some of the lowest broadband speeds to their customers. Although this requires further research, this "size effect" suggests improving broadband infrastructure in larger countries that are lagging behind can require some degree of regional and municipal leadership.

In terms of the broader international comparisons, median download and upload speeds delivered by operators in North America are somewhere in the middle of the diverse experiences in Europe. There is little evidence to suggest that Internet connectivity is superior in North America relative to Europe, or vice versa. Countries with institutional arrangements that have enabled the incumbents to "sweat the copper" as a business strategy tend to have developed subpar broadband networks (e.g. France, Italy), but this is not the case everywhere. A notable exception to this appears to be the Netherlands, where relatively high investments in legacy networks are associated with relatively high measured speeds.

Figure 5 provides a historical perspective on the evolution of measured download speeds since 2010 that captures the growing unevenness of broadband infrastructure quality within Europe and compared to North America. Most advanced economies ended the first stages in the development of broadband networks in the 2000s with median speeds of around 5 Mbps. In the more recent stages of the development

33 See R. Rajabiun, C. Middleton: Regulation, investment and efficiency ..., op. cit.; and G. Serdarević, M. Hunt, T. Ovington, C. Kenny: Evidence for a ladder of investment in Central and Eastern European countries, in: Telecommunications Policy, Vol. 40, No. 6, 2016, pp. 515-531.

Figure 5
Broadband network speeds in selected countries, 2010-2017



Note: Median download speed.

Source: M- Lab.

of connectivity, and in the face of rapidly growing demand by end users for network intensive content and application services, median broadband speeds in European countries have increasingly diverged. In countries with institutional arrangements that have encouraged the transition to scalable next generation FTTP networks, operators have been able to increase the amount of capacity they provide relatively faster as demand has grown (i.e. northern and eastern/central Europe). Where free cash flows (FCF) from legacy platforms have inhibited incentives of operators to decommission them and extend access to FTTP, increasing network speeds in response to growth in demand for network resources has proven to be more challenging (i.e. western and southern Europe, North America). Capacity gaps have increased between the lagging and the leading cluster of European countries, where a combination of policy and business innovation has fostered a higher rate of creative destruction from legacy to next generation broadband technologies. Overall, broadband infrastructure quality – as measured by speeds in Canada and the US – has remained somewhere in the middle of the lagging cluster of countries in Europe, substantially lower than median speeds in the leading European countries (two to three times lower).

The country-level broadband speed measurements discussed above hide significant complexity and differentiation in the delivery of Internet connectivity. For example, in theory, upgrading legacy copper and cable networks to advanced standards (VDSL, DOCSIS 3.0) should enable operators to deliver higher speed connectivity. In practice, actual connection speeds can vary significantly from the theoretical maximums of particular technologies for a number of reasons, including congestion due to operators' under-investment in upstream network assets, distance to the fibre node, user equipment limits, and price/service quality differentiation strategies of operators aimed at segmenting the market to maximise revenues. For example, in North America around half of users subscribe to cable broadband services, which theoretically should be able to deliver much faster speeds than last mile copper/DSL connections. Because of this structural difference, the fact that median speeds in Canada and the US are on par with European countries where legacy DSL-based operators face limited infrastructure competition from faster cable and FTTP providers is surprising.

More infrastructure competition among legacy platform operators necessitates higher aggregate investment into networks in North America, but these capital flows into networks are associated with mediocre network speeds and low FTTP deployment incentives. This stands in contrast to the experience in European countries with substantive infrastructure competition, for example the Netherlands and Denmark, where relatively high capital expenditures appear to translate to superior speeds. Competition from municipally and regionally led FTTP deployment initiatives in those two countries represents one plausible explanation for the substantially higher speeds infrastructure competitors are able to deliver there than in Canada or the US.

To better understand distinctive paths of network development, we explore distributions of tests underlying the high-level network speed indicators noted above for a sub-set of countries. Canada represents our baseline frame of reference. The Netherlands and Denmark are European countries with a relatively high degree of infrastructure competition, as well as higher FTTP penetration and measured speeds than Canada. The UK, Germany, France and Italy are countries where incentives to deploy next generation FTTP networks have been limited as operators have remained strongly committed to "sweating the copper". The US has a broadly similar degree of legacy DSL/cable infrastructure competition and comparable overall speeds as Canada, but double the FTTP penetration rate. Among European countries, Sweden is furthest along in the long-term transition from legacy to next generation broadband networks, an outcome driven primarily

Table 1
Observed network capacity distributions in selected countries
in % of connections

	Basic service (< 10 Mbps)	Next generation access (> 30 Mbps)
Canada	40	25
US	35	35
Netherlands	25	45
Denmark	25	40
Germany	40	25
UK	45	25
France	65	15
Italy	70	5
Sweden	30	40

Source: M-Lab/RIPEstat, July-August 2016.

by the adoption of a carrier-of-carriers strategy by municipal and regional governments that minimises the potential for inefficient duplication and promotes service-based over-the-top competition.[34]

Table 1 documents the proportion of tests of relatively high-speed next generation access connections (> 30 Mbps) and lower-speed, basic broadband connections (< 10 Mbps) within each country, using downstream capacity measurements over the 30-day period prior to 20 August 2016.[35]

Higher capacity connections are relatively more prevalent in Canada and the US than in the lower performing European countries like France and Italy, but they are substantially less prevalent than in smaller European countries with substantive legacy infrastructure competition, such as the Netherlands and Denmark. Higher speed connections are more prevalent in the US than in Canada, which is not surprising given that the US has double the FTTP penetration rate. More surprising are the UK and German cases, where access to faster cable and FTTP networks remains limited and most users rely on last mile copper/DSL connections. Despite this reliance on legacy copper networks, consumers in the UK and Germany are accessing a similar proportion of higher capacity connections as in Canada, where more than half of all broadband services are delivered via the relatively faster networks of cable operators. The proportion of connections below 10 Mbps is substantially lower in the Netherlands, Denmark and Sweden than in Canada. The majority of connections remain below 10 Mbps in France and Italy, but the prevalence of slower connections in Germany and the UK is about the same as in Canada.

Conclusion

Although EU member states have developed a unified regulatory framework and established common broadband infrastructure quality targets in their efforts to create a Digital Single Market, they retain significant national regulatory autonomy with respect to key policy instruments that impact broadband development. Internet speed measurements document growing disparities in connectivity levels within the EU, with some countries leveraging this regulatory federalism to promote private sector incentives to increase broadband network quality more effectively than others. The experiences with regulatory federalism and experimentation in Europe offer a unique body of knowledge for decision makers in other jurisdictions searching for policies that fit local needs and conditions.

Aggregated indicators of capital expenditures on telecom networks and low network quality in some large European countries can create the impression that Europe is lagging behind North America in broadband infrastructure development and "European" policies should therefore be avoided. However, there is little evidence to support this hypothesis, as there are a number of distinct European experiences. In certain European countries, past regulatory decisions have accentuated the incentives of incumbent operators to "sweat the copper" rather than invest in network capacity enhancements and next generation FTTP technologies. Nevertheless, there is little evidence to suggest the European experience as a whole is such a disaster relative to North America to offer a relevant "cautionary tale". In terms of lessons from infrastructure competition and regulatory forbearance from mandating wholesale access obligations to next generation FTTP networks in Canada and the US, they appear to be associated with relatively high aggregate capital expenditure levels on networks. However, forbearance from mandated wholesale access has not been effective in promoting FTTP deployment incentives, and network outcomes in terms of measured speeds in North America remain at about the EU average.[36] The apparent gap between investment inputs and network outcomes suggests infrastructure competition among legacy network operators may not be a very efficient arrangement for promoting innovation and creative destruction in the transition from sunset to sunrise technologies.

34 B.G. Mölleryd: Development of High-speed Networks and the Role of Municipal Networks, OECD Science, Technology and Industry Policy Papers, No. 26, 2015, available at http://dx.doi.org/10.1787/5jrqdl7rvns3-en.

35 The remaining proportion of tests is in the middle of this range, with speeds between 10 and 30 Mbps.

36 But they are notably around two to three times lower than leading countries in Europe and East Asia. See Figures 2, 4 and 5.