Appendix: Canada's 2018 Innovation Policy Report Card

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Connecting Policy to Outcomes

In grading countries' innovation policies, choosing performance and activities indicators – that one would look at to determine whether innovation policy is successful or not – is the first major decision. As discussed in the paper, our report card focuses exclusively on policies or outcomes that are within the capacity of governments to directly influence. As a result, the report card doesn't include some conventional indicators of innovation performance or activities, such as business R&D expenditure or venture and growth capital raised, for example. In our model, these are outcomes or activities that result from optimal innovation policy, not indicators of the policy stance itself. Other innovation rankings often conflate innovation outcomes, activity and policy indicators.

There are two conventional methods for aggregating all the indicators of interest into one measure of innovation performance. The first is to equally weight them, which seems reasonable if there is no external evidence to inform the choice. Equal weights, however, have the disadvantage of not incorporating the existing evidence about the influence of each measure on innovation performance. The other conventional method of selecting weights uses existing research to inform a qualitative and subjective weighting, as we use in the paper.

To select weights to aggregate individual indicator scores into an overall measure of innovation policy, we first subjectively determine their importance to innovation, based on existing economic literature. We then adjust these subjective weights so that the resulting overall innovation policy ranking of countries approximates that based on our innovation performance and activity indicators.

To ensure that this selection is superior to alternatives, we further verify the subjective weighting against the equally weighted results and against other innovation index results (Table A-1).

As can be seen from the bottom line of Table A-1, the C.D. Howe Institute Innovation Policy Report Card correlates well with outcomes and activities that are the hallmark of successful innovation. This is even the case against indices such as the Bloomberg Innovation Index and the Conference Board of Canada Innovation report card, which directly contain R&D expenditures.

Table A-1: Correlation of Innovation Indices to Innovation Outcomes

	Labour Productivity	Actual Individual Consumption	Business Expenditures on Research & Development as % of GDP	Venture and Growth Capital Raised as % of GDP	Employer Enterprise Birth Rate	Overall
Global Innovation Index	0.34	0.21	-0.09	-0.45	0.12	**-0.01**
World Economic Forum Global Competitiveness Index	0.24	0.71	-0.09	-0.23	-0.22	**0.06**
Bloomberg Innovation Index	-0.31	-0.24	0.79	-0.08	-0.01	**0.48**
Contributors and Detractors: Ranking Countries' Impact on Global Innovation	0.45	0.23	-0.28	-0.53	0.18	**-0.14**
Tax Competitiveness Index	0.00	-0.18	-0.17	-0.15	0.00	**-0.28**
Conference Board	0.19	-0.38	-0.50	0.24	-0.09	**-0.52**
CD Howe Institute (Equally weighted)	0.25	0.27	-0.34	-0.59	0.19	**-0.27**
CD Howe Institute	0.02	0.17	0.22	0.12	0.57	**0.55**

Sources:

Dutta, Soumitra; Bruno Lanvin and Sacha Wunsch-Vincent. The Global Innovation Index 2017: Innovation Feeding the World. 10th ed. https://www.globalinnovationindex.org/gii-2017-report.

Schwab, Klaus. 2016. The Global Competitiveness Report 2016-17. World Economic Forum. http://www3.weforum.org/docs/GCR2016-2017/05FullReport/TheGlobalCompetitivenessReport2016-2017_FINAL.pdf.

Bloomberg Innovation Index. 2017. https://www.bloomberg.com/news/articles/2017-01-17/sweden-gains-south-korea-reigns-as-world-s-most-innovative-economies.

Ezell, Stephen. 2016. Contributors and Detractors: Ranking Countries' Impact on Global Innovation. Information Technology & Innovation Foundation. Tax Foundation: Washington. https://itif.org/publications/2016/01/20/contributors-and-detractors-ranking-countries-impact-global-innovation.

The Conference Board of Canada. 2013. Innovation: International Ranking: Canada benchmarked against 15 countries. http://www.conferenceboard.ca/hcp/Details/Innovation.aspx.

Pomerleau, Kyle. 2016. International Tax Competitiveness Index. https://files.taxfoundation.org/20170630141955/TF-ITCI-2016.pdf.

Technical Notes for Individual Indicators

Gender Balance in traditionally underrepresented occupations (STEM, skilled trades, management, political institutions)

Gender balance is evaluated along three domains: employment, education and representation. Each domain is the average (equally weighted) of the variables indicated in Table A-2. Gender balance is measured as the average across the three domains.

Table A-2: Component Variables in Gender Balance in Traditionally Underrepresented Occupations

Employment	
Female Entrepreneurship	Percent of female employment self-employed with employees relative to male employment in same category
Wage Gap	The gender wage gap is unadjusted and is defined as the difference between median earnings of men and women relative to median earnings of men. Data refer to full-time employees and to self-employed.
High Skill Employment	Ratio of female to male employment in occupations ISCO skill-level 3 and 4
Representation	
Corporate Boards	Gender composition of corporate boards, large publicly traded companies (Ratio of female to male)
Representation in Government	Gender composition of national parliaments (ratio female to male)
Education	
Parity of Tertiary Education (all fields)	Gender composition of tertiary education, by field of study (ratio, dominant gender in denominator)
Female Representation in STEM (masters and doctoral graduates)	Gender composition of advanced STEM degrees (ratio female to male graduates)

Sources:

OECD (2017), Self-employed with employees (indicator). doi: 10.1787/b7bf59b6-en (Accessed on 29 August 2017).

OECD (2017), Gender wage gap (indicator). doi: 10.1787/7cee77aa-en (Accessed on 29 August 2017).

International Labour Organization (2017). ILOSTAT: Employment by sex and occupation. (Accessed on August 29 2017).

OECD (2017). Social Protection and Well-being: Gender: Employment: Female share of seats on boards of the largest publicly listed companies. http://stats.oecd.org/index.aspx?queryid=54753.

Inter-Parliamentary Union (IPU) Women in National Parliaments database. PARLINE. http://archive.ipu.org/parline-e/parlinesearch.asp.

OECD (2017). Education at a Glance: Students: Graduates by Field.

Closeness to the Frontier of Efficiency in Core Government Services

Evaluating the efficiency of public expenditure is done using Data Envelopment Analysis (DEA). The idea is to evaluate the relative efficiency with which inputs are turned into output (i.e., 'production efficiency') by comparing a country's outcome in a particular area of public policy with that of the best performing countries. This measure of production efficiency determines to what extent output can be increased (compared to best-practice) while keeping inputs constant.

Data Envelopment Analysis (DEA) is a non-parametric statistical technique used to assess the relative efficiency of public spending. Using linear programming, a frontier of best-practice countries is constructed based on input-output data, which is then used as a benchmark against which the performance of less efficient units can be assessed. The estimated frontier thus "envelops" all available observations, and each deviation from that frontier is interpreted as an inefficient combination of inputs and/or outputs.

Farrell (1957) first suggested that such linear convex hull approach could be used for estimating the frontier of production possibilities and measuring efficiency. Charnes et al. (1978) then formalized the DEA methodology using linear programming to construct the frontier.

Efficiency is public spending is assessed across three core domains: health, education and public safety. The DEA model has a two input-one output structure, with at least one of the variables representing a composite indicator controlling for country-specific factors (socioeconomic environment and life-style factors, for example). The selection of inputs and outputs used to assess efficiency draw from Dutu and Sicari (2016) and are detailed in table A-3. Results are computed with R using the TFDEA package (Shott and Lim, 2015) and assume variable returns to scale.

A country's relative distance to the DEA-estimated frontier is interpreted as a measure of achievable efficiency gains and shows to what extent output could be expanded while keeping inputs constant. Table A-4 details the percentage increase in outputs that could be achieved if countries were as efficient as the frontier economies. Values of zero indicate that a country is on the efficiency frontier. While no country is efficient in all three core domains of government spending, Finland, Denmark, and Canada are the most efficient overall.

Table A-3: Factors of Production and Target Outputs of Core Government Services

	Inputs	Output	Sample Size
Safety	Police, judges and magistrates (per capita) GDP (per capita)	Population that feels safe walking alone at night (%)	33
Health	Health spending (per capita) Environmental control: • Population with tertiary education (%) • GDP (per capita) • Daily cigarette smokers (% of pop) • Air quality (PM2.5) • Alcohol consumption (Liters per capita) • Overweight or obese population (% of pop aged 15+)	Healthy life expectancy at birth (HALE) (WHO)	32
Education	Education spending (per student, primary and secondary) Socioeconomic Index (PISA)	Composite PISA scores (average of reading, math, and science scores, equally weighted)	34

Table A-4: Potential Output Efficiency Improvement by Country, percentage

	Overall	Education	Health	Safety
Australia	15.5	2.4	4.2	40.1
Canada	3.2	0.1	3.6	5.9
Germany	8.0	1.1	5.0	17.8
Denmark	2.9	0.8	5.2	2.7
Finland	1.9	0.6	5.1	0.0
France	9.2	1.1	3.2	23.3
United Kingdom	6.4	2.8	4.5	12.0
Ireland	7.0	0.0	4.8	16.4
Israel	10.1	0.0	0.0	30.4
Japan	7.5	0.0	0.0	22.4
South Korea	7.4	0.0	4.3	17.9
Netherlands	4.8	1.1	3.7	9.5
Sweden	4.9	0.9	0.0	13.9
United States	10.6	3.1	8.4	20.2

Sources:

Dutu, Richard, and Patrizio Sicari (2016). Public Spending Efficiency in the OECD, benchmarking Health Care, Education and General Administration. OECD Economics Department Working Papers No. 1278.

Shott, Tom, and Dong-Joon Lim (2015). TFDEA: Technology Forecasting using DEA (Data Envelopment Analysis). R package version 0.9.8.3. https://CRAN.R-project.org/package=TFDEA.

Data:

United Nations 2017. Statistics on Criminal Justice: System Resources United National Office on Drugs and Crime. Vienna: Austria. *uploaded on* 19 May 2017. https://www.unodc.org/unodc/en/data-and-analysis/crime-and-criminal-justice.html.

OECD 2016. Better Life Index – Edition 2016: Safety: Feeling Safe walking alone at night http://stats.oecd.org/Index.aspx?DataSetCode=BLI.

OECD (2017), Daily smokers (indicator). doi: 10.1787/1ff488c2-en.

OECD (2017), Alcohol consumption (indicator). doi: 10.1787/e6895909-en.

OECD (2017), Overweight or obese population (indicator). doi: 10.1787/86583552-.

OECD (2017), Health spending (indicator). doi: 10.1787/8643de7e-en.

OECD (2017), Education spending (indicator). doi: 10.1787/ca274bac-en.

OECD (2017), Population with tertiary education (indicator). doi: 10.1787/0b8f90e9-en.

OECD (2015) PISA – http://www.oecd.org/pisa/data/.

World Health Organization, Global Health Observatory data repository, Healthy life Expectancy (HALE) at Birth. http://www.who.int/gho/mortality_burden_disease/life_tables/hale_text/en/.

OECD (2017), Environment: Air Quality and Health: Exposure to PM2.5.