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Every Standard Counts – How Standardization Boosts the Canadian Economy

Standards Council of Canada

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Authorship and acknowledgements

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Executive Summary

Standards touch all facets of our lives. They are embedded in the products, processes and services we rely on in both work and personal lives, from the food sold in grocery stores to the skyscrapers that enable the expansion of a city. The purpose of this research was to quantify the benefits of the standardization system to the Canadian economy.

Over the last two decades, an increasing number of studies have demonstrated the economic benefits of standardization for various economies. This study is the third of its type released by the Standards Council of Canada (SCC) to evaluate standards' contribution to the Canadian economy.

In combination with other facts, standardization generates economic benefits by allowing economies to expedite and capitalize on technical knowledge (Ward and Antunes, 2015). Standards can drive innovation, help organizations streamline the internal process and facilitate access to new markets (ISO, 2013). These gains can spread beyond the companies themselves and collectively contribute to the wider economy through improved interoperability, reduced intermediate goods and services, quality assurance of products and distribution of technical know-how (Grimsby, 2018).

This report gives an overview of the standardization system in Canada, highlights the benefits that organizations receive from standardization and quantifies the benefits for the economy as a whole. Similar to studies by other national economies and the previous Canadian research, this study finds that standards play a vital role in boosting the economy in Canada:

- Standardization activity is significantly and positively associated with the growth of labour productivity. A 1% growth in the annual stock of standards is associated with a 0.056% increase in labour productivity.
- Over the time frame of the study (1981 to 2019), standardization is associated with 38.4% of the growth of labour productivity and 17.4% of the growth of GDP in Canada.
- In 2019 alone, growth in standardization contributed up to CAN$5.86 billion of Canada's total increase in GDP, which was CAN$33.7 billion. Assuming that the impact of standardization remains constant over the whole study time frame, by the end of 2019, real GDP could have been roughly $293 billion lower had there been no growth of standards over the past four decades.

It is worth noting that, in this study, standardization serves as a proxy for the broader infrastructure that supports the sustainable growth of productivity in Canada. Thus these estimations should be treated as the upper bound of the economic benefits that standardization brings to the Canadian economy.

Introduction

Economy of scale is a key driver behind the transition of human society from the agrarian age to the industrial age. Standardization plays a critical role in this process. It not only ensures quality and safety but helps improve compatibility and interoperability of products and systems, thus enabling repeatability and commoditization of formerly custom processes (Blind, 2004).

The housing industry illustrates this transition. Until the early 1900s in Canada, the construction of single-family homes varied from one to another. Each home, regardless of size and type, was to some extent custom made. It was not until the development of "ready-to-assemble" houses that the housing "industry" was really born (Canadian Heritage Information Network, 2012). Standardization of construction allowed builders to improve efficiency and accelerate the process from designing site plans to assembling new houses. This drove housing prices down, which led to the increased demand for single-family homes and the blossoming of the housing industry. In 2019, investment in residential construction reached CAN$123.9 billion in Canada, more than twice the investment in non-residential construction (CAN$57.9 billion). Hundreds of standards are referenced in Canada's national model codes[1], not only enabling a high degree of uniformity in construction across the country, but also ensuring quality and safety of the building even under extreme weather conditions (National Research Council Canada, 2020).

The International Organization for Standardization (ISO) describes standards as "a formula that describes the best way of doing something" and "the distilled wisdom of people with expertise in their subject matter."[2] The SCC is the national standardization body in Canada that oversees the standardization system across the country and ensures that the benefits of voluntary standards are maximized to advance the national economy and improve the health, safety and well-being of Canadians (see text box: Standardization System in Canada).

1 The Canadian National Model Codes are developed to ensure high degree of uniformity in building construction and fire safety across the country. It consists of five codes: the National Building Code of Canada (NBC), the National Fire Code of Canada (NFC), the National Plumbing Code of Canada (NPC), The National Energy Code of Canada for Buildings (NECB), and the National Farm Building Code of Canada (NFBC). They must be adopted by a regulatory authority to come into effect. In some cases, the Codes are amended and/or supplemented to suit regional needs, and then published as provincial codes. For more details, please visit: https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-development-process/canadas-national-model-codes-development-system

2 Quote obtained from the International Organization for Standardization (ISO). Standards. Accessed August 31, 2020. Available from: https://www.iso.org/standards.html

Standardization System in Canada

Mandated to promote efficient and effective standardization in Canada, SCC was created by the Government of Canada as a Crown corporation in 1970. SCC carries out a variety of functions to facilitate and coordinate standardization activities across the country aimed at strengthening Canada's competitiveness and well-being. Specifically:

- **SCC oversees the national standards development system.** SCC does not develop standards; rather, it prescribes the rules and requirements for the accreditation of Standards Development Organizations (SDOs) to develop National Standards of Canada (NSCs). NSCs developed under SCC's oversight are required to adhere to the principles of consensus, openness, transparency, equal access and effective participation by interested parties. SCC also manages the potential of duplication of standards.[3] SCC also works with various stakeholders to facilitate the use of standards in Canada. It delivers national standardization strategies that support innovation in Canada and break down barriers to trade in both the domestic and the international market.
- **SCC represents Canada's interests in regional and international standardization networks.** SCC is Canada's member body to the ISO and the International Electrotechnical Commission (IEC), representing Canadian interests in international standardization activities. This is done through mirror committees (MCs) established by SCC, where subject experts from different areas, including governments, academia, private sectors and the broader civil society may participate in the development of international standards.
- **SCC is the national accreditation body in Canada.** SCC accredits conformity assessment bodies,[4] such as testing laboratories and product certification bodies, to ensure that accredited organizations are competent to perform specific tasks and meet the internationally or nationally prescribed standards. As a part of the collective effort to build a global accreditation system, SCC has been promoting the international acceptance of conformity assessment results with the goal of "one standard, one test — accepted everywhere."[5]

Standards can help organizations optimize internal processes, improve operational efficiency and reduce transaction costs, thus becoming more competitive and profitable (Gerundino, Weissinger, Grosfort and Damond, 2014). They also provide an effective means of spreading and applying technical knowledge to a broad group of institutions, which in turn create benefits for the wider economy and ensure sustainable economic growth in the long run (Grimsby, 2018).

Standardization does not act independently to generate economic benefits; instead, it acts in combination with several factors such as research and development, assurance programs, market forces and regulations to expedite and capitalize on technical knowledge (Ward and Antunes, 2015). Over the last two decades, a rising number of studies have been conducted on the economic benefits of standardization. This study is the third of its type released by the SCC.[6] It updates the previous macroeconomic analyses using data from 1981 to 2019.

3 Standards Council of Canada. Requirements & Guidance – Accreditation of Standards Development Organizations (2019).
4 Conformity assessment is the practice of determining whether a product, service or system meets the requirements of a particular standard.
5 Standards Council of Canada.
6 The previous two reports were published in 2007 and 2015 (see Haimowitz and Warren, 2007; Ward and Antunes, 2015).

How Standards Help

Research has demonstrated the contributions of standards to individual businesses and specific sectors (see, for example, Haimowitz and Warren, 2007; Miotti, 2009; Standards Australia, 2006; Stokes, Dixon, Generosa and Nana, 2011; Verlag, 2000). To support research on standardization, ISO developed a methodology (called "ISO Methodology") to provide a systematic approach for the assessment and evaluation of standards' impact in the organizational or sectoral level (Gerundino and Weissinger, 2011; ISO, 2013). Since then, ISO has worked with its member bodies from more than 20 countries that have conducted case studies using the ISO Methodology (Gerundino and Weissinger, 2012).[7] Results of these studies consistently demonstrate the tangible benefits that companies can achieve from using standards (Gerundino et al., 2014).[8]

How organizations benefit from standardization

Standards can help organizations streamline internal processes. They enable companies to reduce internal costs in various business functions and increase efficiency. They enable an organization to reach a desired level of service quality helping to ensure its long-term viability. For example, by introducing the ISO 9001 quality management system standard, Chococam, a chocolate producer based in Cameroon, was able to streamline the production process and provide more clarity on staff functions and responsibilities. These improvements led to substantial saving in the cost of stock-keeping and maintenance, higher customer satisfaction and an increase in sales revenue. Gains from standards were estimated to reach US$1.96 million per year, or 5.2% of the company's annual sales.

Standards can be a driver of innovation by capturing new ideas and enabling their repeated use. Participation in standardization activities offers participants not only the exposure to "insider" knowledge of cutting-edge technologies, but also the ability to influence standards development, which in turn benefits the company they represent (Wakke, Blind and Ramel, 2016). Mapei, a world-leading manufacturer of construction materials is famous for its high-quality innovative products. Its ability to innovate is closely related to its active participation in the standard development process, which gives it access to first-hand information on new trends in the industry and the opportunity to influence content in the standard. This allows it to take advantage of the latest knowledge and lead innovation in the industry.

Standards can also help businesses facilitate access to new markets. Compliance with standards sends a positive signal on the quality of products, thus helping establish consumers' confidence in a new product or a company entering new markets. Take the case study of Danper (one of the largest food exporters in Peru) as an example. Demonstrating compliance with standards plays a critical role in establishing Danper's credibility and reputation on the international market. By meeting the requirements in standards, Danper can prove its ability to produce and deliver high-quality products to overseas customers and penetrate new markets.

Although standards are typically created to ensure quality and safety of products, processes and services, rather than for specific economic outcomes, they have an economic impact in the long run *because of their ability to improve quality and safety* (Stokes et al., 2011). For example, health and safety standards can help control risks and prevent accidents in the workplace. This can lead to long-term economic benefits to organizations through reduced workplace injuries and increased labour productivity. The gains that organizations obtain from the use of standards can spread beyond the companies themselves and collectively contribute to the wider economy and societal environment in which they exist (ISO, 2013).

7 The majority of these case studies are businesses located in the manufacturing sector, which is not surprising given the historical relevance of technical standards in this sector.

8 Summaries of benefits and examples provided here draw on the ISO report published in 2014 (Gerundino at al., 2014).

How the economy benefits from standardization

Grimsby (2018) summarized five aspects of how standardization can impact the economy, based on the analytical model proposed by Swann (2000). **Standards can improve interoperability**. A major function of standards is to enhance the compatibility between systems and products, which is particularly important in the information and communications technology (ICT) sectors (Stokes et al., 2011). Take the cellphone charger as an example. Today, almost all Android smart phones use the same type of charger. You can borrow the charger of a Google phone from your friend if the battery runs low in your Samsung phone, thanks to the harmonization of standards on chargers for data-enabled mobile phones (initiated by the European Commission in 2009).[9] Increased interoperability in the supply chain can lead to reduced transaction costs and product prices, and thus intensify competition in the market and bring a positive impact on the overall productivity for the whole industry (Grimsby, 2018). Developments in the ICT sectors have demonstrated how standards can improve interoperability and compatibility and bring economic benefits (Stokes et al., 2011).

Standards can reduce market inefficiency and lead to economies of scale by decreasing variability in intermediate goods and services (Grimsby, 2018). Ten years ago, laptops were a lot thicker, with a variety of ports designed for different types of connectors. Today, almost any electronic device, including keyboard, mouse, headphone, hard disk, cellphone, etc., can be connected to the laptop easily with a Universal Serial Bus (USB), a widely used standard for connection, communication and power supply between devices (Johnson, 2019). In 2020, the global market for USB 3.0 alone (the most popular USB used today) is estimated to reach US$2.1 billion and is expected to triple by 2027, not to mention the benefits it brings to the whole industry as millions, if not billions, of devices have adopted it.[10]

Standards provide a means to verify the quality of products or services. Quality and price are two most important dimensions that consumers evaluate when they make a purchase. While prices are easy to obtain, quality is difficult to verify, as a result of information asymmetry between buyers and sellers (Grimsby, 2018). When uncertainty of quality is high, consumers may go for the cheaper product (which is usually the one with lower quality, or the "lemon"), leading to price competition and the creation of the "Lemon Market" (Akerlof, 1978; Philips, 1983). In other words, consumers are unwilling to pay for higher priced items when they cannot evaluate the quality of products. This eventually squeezes high-quality products out of the market. Standards can resolve this problem by providing quality assurance on products or services, thus reducing information asymmetries between producers and consumers and creating a more efficient market (Grimsby, 2018). Today, there are more than 6,000 references to standards in Canadian federal, provincial and territorial regulations, which not only serve as a safeguard for the health and safety of Canadians but create a more efficient market that provides quality products.

In addition to the direct impacts on the economy, **standards can also increase productivity by distributing technical know-how**. Through the distribution of standards, technological progress can be diffused to a wider group of institutions. This is an efficient way to reduce information asymmetries between competitors, which ultimately creates a more efficient market (Grimsby, 2018). Diffusion of technical knowledge can also occur in formal or informal standardization networking such as seminars, conferences, industry publications, social media and events where technical know-how can be distributed to a wide range of stakeholders (Stokes

9 Following the requirement of the European Commission, 14 world-leading cellphone producers signed an agreement to harmonize chargers for data-enabled mobile phones sold in Europe. To respond, European standardization bodies CEN (European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization) and ETSI (European Telecommunications Standards Institute) harmonized standards needed to manufacture mobile phones compatible with common chargers. Source: European Commissions. (2010). Shaping Europe's digital future. Commission welcomes new EU standards for common mobile phone charger. Press Release. December 29, 2010.

10 ReportLinker. (2020). Global USB 3.0 Industry. Accessed September, 2020. Available from: reportlinker.com/p01171467/Global-USB-3-0-Industry.html

et al., 2011). For example, in 2019, the SCC launched a Canadian Data Governance Standardization Collaborative, where more than 200 experts and stakeholders from across government, industry, academia and broader civil society have participated. The purpose of the collaborative is to articulate the need and accelerate the development of industry-wide data governance standardization strategies. Participants can also benefit from the knowledge and information shared in the networks to make better informed and quality decisions.[11]

While standardization can confer numerous benefits on the economy, it may also have adverse impacts on the economy, particularly in the short term. There is a time lag between a standard being developed or adopted and the economic impact it brings. For instance, adopting an indoor air quality standard may raise an organization's expense on overhead in the short term and cause interruption in regular work schedule if any construction work is needed. However, it is estimated to save Canadian businesses between CAN$1.4 billion and $2.8 billion from the cost of sick leave attributed to poor indoor air quality and increase labour productivity by CAN$7.5 billion in the long run (Parkouda and Marcovitch, 2017B). There is also a non-linear relationship between the number of standards and market efficiency (Stokes et al., 2011). While standards can reduce information asymmetries and pave the way for an efficient market, they can also become "technical barriers to trade" if unnecessary duplication in standards requirements exists. Therefore, the SCC has been working with its standardization bodies to promote the harmonization of standards that allows "one standard, one test — accepted everywhere."[12]

Understanding the unique cumulative effect of standardization on the economy is challenging. The first macroeconomic analysis on the value of standardization can be traced back to 2000, when DIN (German Institute for Standardization) first published a report on the economic benefits of standardization (Verlag, 2000). Since then, similar studies have been conducted on different economies to evaluate the contribution of standardization to national productivity as a whole. Most of these studies were published by the countries' national standardization bodies (NSBs). All these studies have demonstrated a positive impact of standardization on national productivity. In Canada, several studies were conducted to evaluate standards' contribution to international trade and the overall economy (see Haimowitz and Warren, 2007; Parkouda and Marcovitch, 2017A; Ward and Antunes, 2015). These studies make a substantial contribution to the literature on the economic impact of standards (ISO, 2013).

11 Standards Council of Canada. (2020). Canadian Data Governance Standardization Collaborative. Available from: https://www.scc.ca/en/flagships/data-governance

12 Standards Council of Canada.

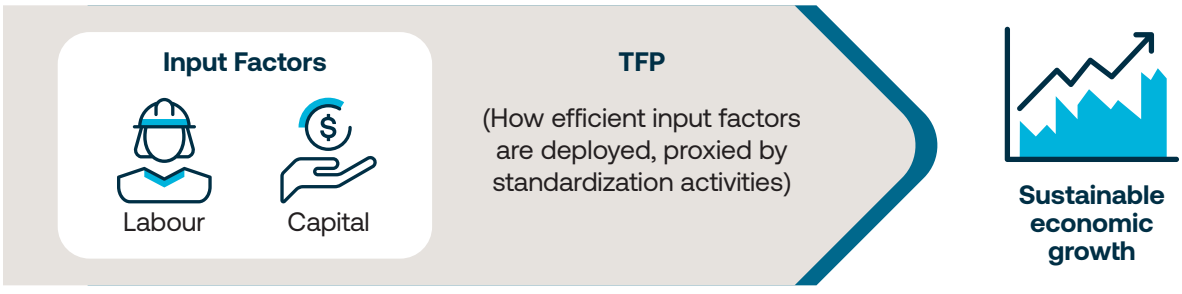
Research Methodology and Data

Similar to previous studies, this research to quantify the impact of standardization on the Canadian economy is based on the Cobb–Douglas production function, an economic model that has been widely used to evaluate standards' contribution to the broader economy (Cobb and Douglas, 1928). Economic growth is driven by the quantity of labour and capital employed, and how efficiently they are used (Ward and Antunes, 2015). As an economy matures, the amount of additional output produced by additional units of input factors diminishes. By improving the efficiency with which these input factors are deployed, which is also known as the total factor productivity (TFP), economic growth over the long run can be sustained (Hogan, Sheehy and Joyasuriya, 2015).

TFP is a combination of technological knowledge and efficiency, a measure of how effectively capital and labour can be combined to produce sustained economic growth (Stokes et al., 2011). Increases in TFP are driven by a number of factors, including advances in technical knowledge, which can be influenced by standards, patents, research and development and other forms of technological progress that enhances the efficiency of processes and techniques (Hogan et al., 2015; Stokes et al., 2011). A key assumption in this study is that standardization activities, as a specific form of technology transfer, play a critical role in promoting technological advancement and the dissemination of technical knowledge, and thus can be used as a proxy of TFP (Miotti, 2009). The stock of standards is typically used to measure standardization activity as it provides a consistent, quantifiable way to capture nationwide standardization activities across all industry. A visualization of the economic model adopted in this study is presented in Figure 1.

It is important to note that the stock of standards acts as a proxy for standardization activity. In other words, it is not the stock of standards per se that is important, but what it represents (i.e., activities and trends in Canada's standardization system). Examining SCC's full stock of standards from 1981 to 2019, we see a downward trend over the last two decades.[13] Because the stock of standards is a proxy for standardization activity, using the full stock would indicate that standardization activity is declining in Canada. However, that is not the case (see text box: A Snapshot of Standardization Activities in Recent Years), and as a result the full stock of standards, which was used in previous studies (Haimowitz and Warren, 2007; Ward and Antunes, 2015), is no longer a suitable proxy.

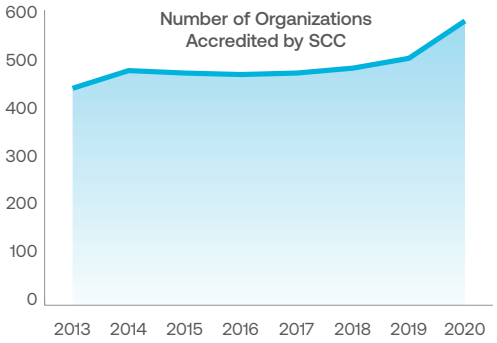
Figure 1: Economic Model of This Study Based on the Cobb–Douglas Production Function

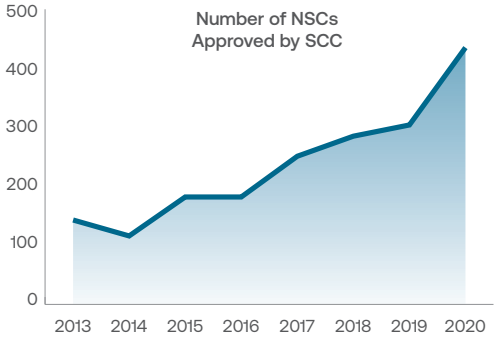


13 It is important to note that a decrease in the stock of standards can happen for a number of reasons. For example, there may be a reduction in standardization activities, which results in fewer standards published; there could be greater efforts to harmonize standards, which results in fewer potentially more impactful standards; or there could be changes to accreditation. In the case of SCC, one SDO did remove a number of its standards from SCC accreditation; however, these standards are still available from other sources. Consequently, when using the stock of standards as a proxy for standardization activity, changes to the stock need to be understood in the larger context.

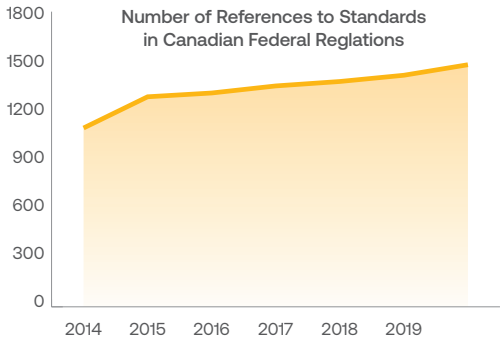
A Snapshot of Standardization Activities in Recent Years[14]

In 2020, SCC celebrated its 50th anniversary. The organization's longevity is a testament to its continued relevance. Additionally, examining SCC activities in key areas over the last couple of years, the growth of SCC's influence is readily apparent.





Organizations are seeing value in SCC accreditation; the number of accredited organizations has increased by 31% in the last seven years. Annually, more National Standards of Canada (NSCs) being approved, a strong indication of standardization activity.



Source: SCC internal data

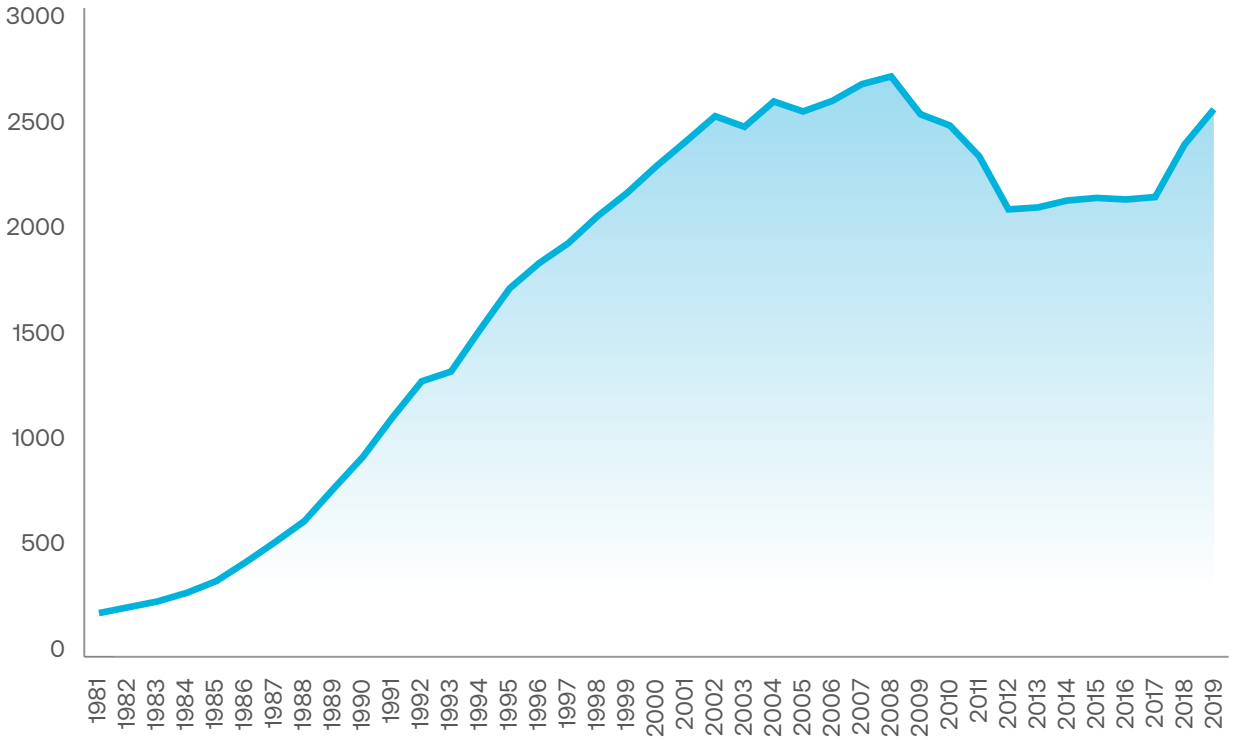
Federal regulators are increasingly using standards in their regulations. And internationally, Canada is assuming a greater leadership role in technical committees at ISO and IEC.

14 Numbers are collected based on March 31 of each year (fiscal end). Number of organizations accredited by SCC includes all the accreditation programs under SCC, indicating both the development (i.e. standards development organizations) and use (i.e. conformity assessment organizations) of standards in Canada, Number of Canadian leadership roles participating with ISO and IEC includes international chair, secretary and convenor but excludes project leaders.

In place of the full stock of standards, we have opted to use the stock of National Standards of Canada (NSCs). NSCs are the most common standard deliverable recognized by SCC. They must be developed by consensus of a balanced committee of stakeholders, undergo public scrutiny and be consistent with or incorporate existing international and pertinent foreign standards. NSCs are usually available in both official languages to ensure accessibility and suitability of use across Canada. All NSCs fall under SCC's accreditation and are required to meet the prescribed rules for standards development.

Importantly, the active number of NSCs does better reflect the trend of increased standardization activities in Canada in the long run. It can be traced back to 1981 and provides a consistent and quantifiable way to measure activities and trends in Canada's standardization system (see Figure 2: Annual Stock of NSCs). Thus, NSCs are considered a more appropriate proxy for standardization activities and are used in this study.[15,16]

Figure 2: Annual Stock of NSCs



Source: SCC internal data

15 Changing the methodology for calculating the stock of standards is not unprecedented. For example, the national study from New Zealand proposed an age-adjusted measure to improve the measure of standards as a legitimate proxy for the quality of standards being produced (Stokes, et al., 2011).

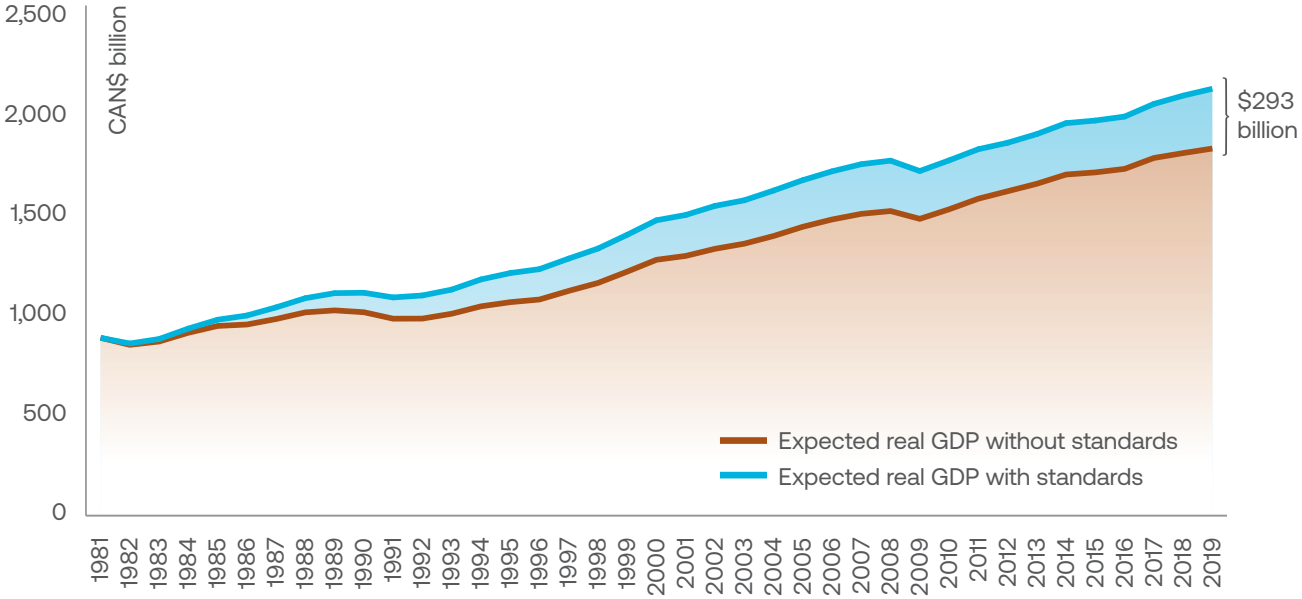
16 When we replicate the previous Canadian economic study (2015) with NSCs, the results are consistent and positive. This further enhances the reliability and validity of using NSCs as an indicator of standardization activities in Canada.

Standards' Contribution to the Canadian Economy

Consistent with previous studies, we found that standardization activity is significantly and positively related to labour productivity and gross domestic product (GDP) growth. Specifically, a 1% growth of the stock of national standards is associated with a 0.056% increase in labour productivity or GDP (see Appendix A for detail methodology of the economic model). Assuming that the impact of standardization remains constant over the whole study time frame, the growth in national standards is associated with 38.4% of the growth of labour productivity and 17.4% of the growth of GDP in Canada from 1981 to 2019. These findings are consistent with the findings of similar studies conducted in other developed countries (see text box: Key Results from Comparable National Studies on the Economic Impact of Standardization).

Translating into a dollar value, by the end of 2019, real GDP could have been roughly $293 billion lower had there been no growth in National Standards of Canada over the past four decades (see Figure 3: Comparison of GDP Growth With and Without the Impact of Standards in Canada). That's about the GDP of British Columbia in 2019, the fourth largest province in terms of economic size in Canada. In 2019 alone, growth in standardization contributed CAN$5.86 billion out of a total CAN$33.7 billion growth of GDP.

Figure 3: Comparison of GDP Growth With and Without the Impact of Standards in Canada



Key Results from Comparable National Studies on the Economic Impact of Standardization

Canada is not alone in conducting research to quantify the contributions of standardization to the economy. Macroeconomic analyses were conducted in the UK, Germany, France, Australia and other countries to evaluate the economic impact of standardization. These studies have consistently shown that standards contribute between 19% and 28% of the growth in GDP. Like Canada, these countries report that standardization is contributing to economic growth.

Country	Published year	Study period	Standards' share in the growth of GDP
Germany[17]	2000	1960–1996	27%
Australia[18]	2006	1962–2003	22%
France[19]	2008	1950–2007	24%
UK[20]	2015	1921–2013	28%
Nordic[21]	2018	1976–2014	28%
Belgium[22]	2020	1994–2018	19%

17 See Blind, Jungmittag and Mangelsdorf (2011).
18 See Standards Australia (2006).
19 See Miotti (2009).
20 See Hogan et al. (2015).
21 See Grimsby (2018).
22 See Buts, Dooms, Soyeur, Droogenbroeck and Willems (2020).

Research Considerations

By supporting the broader infrastructure that enhances the efficiency of the economy, standardization is associated with increased labour productivity and GDP growth. While exact dollar values vary, research quantifying the economic impact of standardization has shown that standardization has a consistently positive and significant impact on the Canadian economy. Moreover, as previously noted, the results are in line with research by other comparable national economies. Standards add value. At the same time, it is important to note that this study, like all research, has limitations. An understanding of those limitations is essential to the interpretation of the results.

In particular, there are three assumptions that underlie the model used in this analysis. **The first assumption is that standardization activity can capture the technological advancement and dissemination of technical knowledge within the economy (Standards Australia, 2013)**. Standards are often referenced as the "invisible infrastructure" that enhances interoperability of products, enables economies of scale, reduces transaction costs and mitigates risks. These collectively contribute to the improved efficiency of the economy (or TFP). Thus, standardization activity is treated as a proxy of TFP. In reality, it is impossible to isolate standards from other components of the economy and measure their unique impact (Grimsby, 2018). Standardization does not act alone. Instead, it plays a symbiotic and complementary role with other factors such as research and development, levels of education and rules and regulations to catalyze innovation and generate economic growth (Grimsby, 2018; Ward and Antunes, 2015). To the extent that the interdependent relationship between standardization and these other factors explains the TFP estimated in the production model, standards' contribution to the economy is considered overestimated (Hogan et al., 2015). Some have referred to the overestimation as the upper bound of standards' economic benefit (Temple, Witt, Spencer, Knut, Jungmittag, and Swann, 2005).

Secondly, the model assumes that the stock of standards is an accurate reflection of standardization activity. To the extent that increases in the number of standards are associated with increased activity, and declining stocks are associated with declining activity, this assumption holds. However, if the stock of standards is independent from standardization activity, if for example a national standards body made a concerted effort toward harmonization, the stock would no longer be appropriate. In Canada, a decrease in the stock of standards was not considered indicative of a similar decrease in standardization activity. As a result, the stock of national standards was used as that was considered more indicative of the growth in standardization activity in Canada. As SCC endeavours to ensure the responsiveness of the standardization system, it has introduced new deliverables (see text box: New Standards Deliverables Developed by SCC to Respond to the Speed of Innovation). An understanding of this assumption is vital to selecting the proxy and determining whether this model is appropriate.

New Standards Deliverables Developed by SCC to Respond to the Speed of Innovation

To support cutting-edge innovators, SCC released the guideline for Technical Specifications (TS), Workshop Agreements (WA) and Community Sourced standards deliverables. These three additional standards products can be developed much faster than an NSC. Development of these deliverables requires a sound project approval process to ensure quality and is subject to limited peer review with the option of going to full public comment if it is deemed to be warranted. These documents offer access to initial best practices and information such as common languages for new concepts and technologies, and can therefore help Canadian businesses establish credibility, attract investments and access new markets via licensing opportunities.

Finally, it is worth noting that in this model it is assumed that each standard contributes an equivalent benefit to the economy, which is unlikely to hold (Hogan et al., 2015). Standards in manufacturing and technical industries may generate more economic benefits than standards in the health sector. Standards that are an international adoption from ISO and IEC might play a bigger role in facilitating trade and increasing exports. Some standards are more widely used than others as they are referenced in regulations and become mandatory for businesses operating in those sectors. More sector-specific research may help to disentangle these differential impacts.

Accordingly, interpretation of the research results should be treated with caution and with these key assumptions in mind. Going forward, the appropriateness of this methodology will continue to depend on the reasonableness of these assumptions in the given context.

Conclusion

Quantifying the economic benefits of standards is critical for improving awareness and support for standards development, as well as for promoting the use of standards (Gerundino and Weissinger, 2012). Research has demonstrated the economic benefits of standardization in terms of both the micro business level and the macroeconomic performance. This study is the third of its type released by the SCC to demonstrate the value of standardization in Canada.

Results of the analysis indicate that standardization is associated with 38.4% of the growth in labour productivity and 17.4% of the growth in GDP. This translates into a maximum of CAN$5.86 billion in 2019 alone or up to $293 billion for the whole study period from 1981 to 2019. While a change to the proxy for standardization activity makes a comparison between the current results and the previous studies impractical (Haimowitz and Warren, 2007; Ward and Antunes, 2015), it is noteworthy that SCC has seen a consistent positive effect. Standardization is making an important contribution to the Canadian economy as a whole.

While this research gives a broad overview of the benefit of standardization to the Canadian economy, additional research is still needed to understand the specific mechanisms through which standardization contributes to economic growth and sector-specific effects. Further research is needed to understand how standards can benefit Canadians in terms of improved safety and social well-being. Micro-level studies derived from surveys or case studies can also serve to quantify the benefits of specific standards or the impact of standards on specific areas or sectors. To fill this gap, future study can consider adopting the ISO Methodology to research the above topics. This will allow easy comparison with other studies that use a similar research approach.

Canada has a robust standardization system that is responsive to the needs of Canadian regulators, industry and consumers. Importantly, this research shows that standards are also playing a vital role in boosting the economy in Canada.

Appendix A: Technical Analysis and Empirical Results

Similar to the previous study and other national economic research on standardization (see Hogan et al., 2015; Miotti, 2009; Stokes, et al., 2011; Verlag, 2000; Ward and Antunes, 2015), this study is based on the Cobb–Douglas production function, an economic model that has been widely used in macroeconomics to estimate the relationship between the input factors and the overall economic outputs (Cobb and Douglas, 1928).

The production function can be specified as:

$$Y_t = A_t K_t^{\alpha} L_t^{(1-\alpha)} \quad (0 < \alpha < 1) \quad \text{..... (1)}$$

where the economy-wide output (Y_t) over the time period (t) is assumed to be a non-linear function of TFP (A_t), capital input (K_t) and labour input (L_t) at the time (t).

The Cobb–Douglas production function can be transformed into a linear relationship by taking the logarithm of both sides.

$$\ln(Y_t) = \ln(A_t) + \alpha \ln(K_t) + (1-\alpha)\ln(L_t)$$

$$\ln(Y_t) - \ln(L_t) = \ln(A_t) + \alpha(\ln(K_t) - \ln(L_t))$$

$$\ln\left(\frac{Y_t}{L_t}\right) = \ln(A_t) + \alpha \ln\left(\frac{K_t}{L_t}\right) \quad \text{..... (2)}$$

The left-hand side of equation (2) is the labour productivity measured by GDP per hour worked (Y_t / L_t), and the right-hand side consists of TFP (A_t) and the capital-labour ratio (the value of investment per hour worked). Here, TFP (A_t) is modelled as a function of the collection of national standards in a time trend.

$$A_t = \exp(\lambda T_t) \times NSC_t^{\varepsilon} \quad \text{..... (3)}$$

Combining equation (2) and (3), the production function can be finalized as:

$$\ln\left(\frac{Y_t}{L_t}\right) = \beta + \varepsilon \ln(NSC_t) + \alpha \ln\left(\frac{K_t}{L_t}\right) + \lambda T_t + u_t \quad \text{..... (4)}$$

where

Y_t = GDP in Canada[23]

L_t = Total hours worked in the labour market in Canada (including both full- and part-time employment)[24]

Y_t / L_t = Labour productivity at time

NSC_t = Annual stock of National Standards of Canada

K_t = Stock of fixed non-residential capital from all industries at each year end[25]

T_t = Exogenous time trend

u_t = Unexplained variation (residual) in productivity

We calculate the annual stock of NSCs based on the following method:

Number of active NSCs in year t = Number of active NSCs in year t - 1 + Number of NSCs published in year t - Number of NSCs withdrawn in year t

For the historical data, there were some standards that were missing withdrawn dates. To obtain these missing values, we used the following calculation.

Withdrawn year of a withdrawn standard from SDO(A) = Published year of this withdrawn standard + Median age of standards from SDO(A) - 1

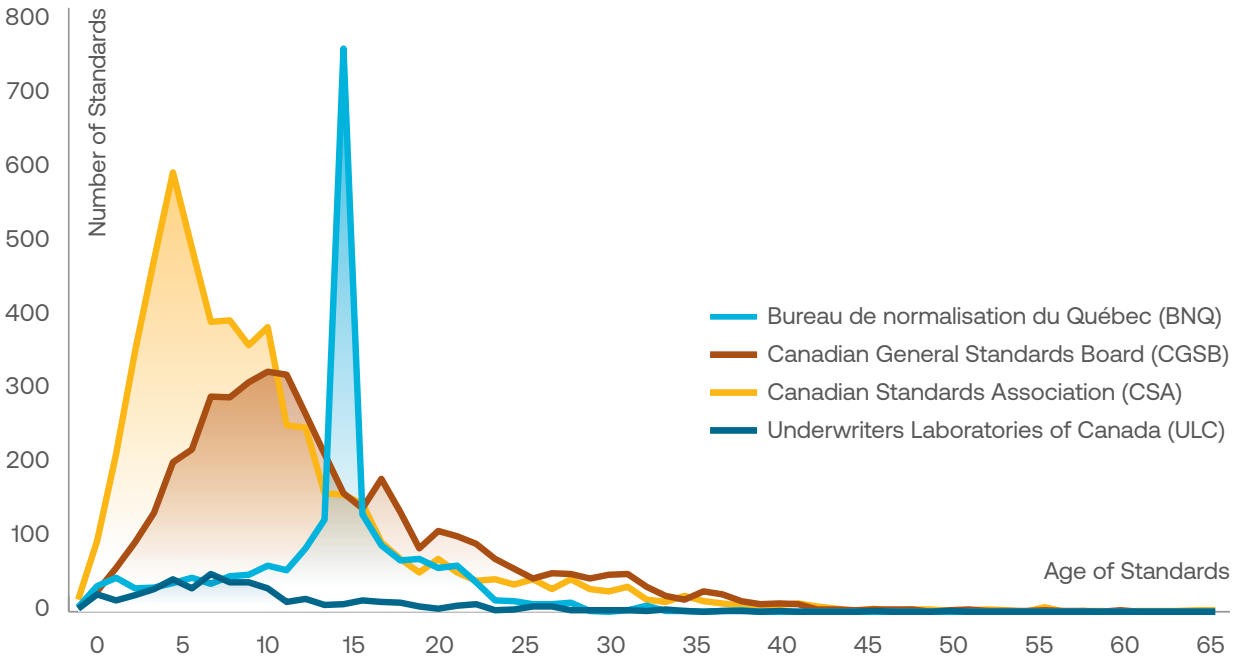
We use the median age of standards rather than the average age as the age distribution of standards was positively skewed (see Figure A-1: Age Distribution of Standards). In addition, since median ages of standards vary by SDOs, the calculation for missing withdrawn years is specific to each SDO.

23 Statistics Canada. Table 36-10-0104-01 Gross domestic product, expenditure-based, Canada, quarterly (x 1,000,000). Accessed March 31, 2020. DOI: https://doi.org/10.25318/3610010401-eng

24 Statistics Canada. Table 14-10-0043-01 Average usual and actual hours worked in a reference week by type of work (full- and part-time), annual (x 1,000). Accessed March 31, 2020. DOI: https://doi.org/10.25318/1410004301-eng

25 Statistics Canada. Table 36-10-0096-01 Flows and stocks of fixed non-residential capital, by industry and type of asset, Canada, provinces and territories (x 1,000,000). Accessed March 31, 2020. DOI: https://doi.org/10.25318/3610009601-eng

Figure A-1: Age Distribution of Standards to Calculate Missing Withdrawn Dates (Top 4 SDOs under SCC's Accreditation)



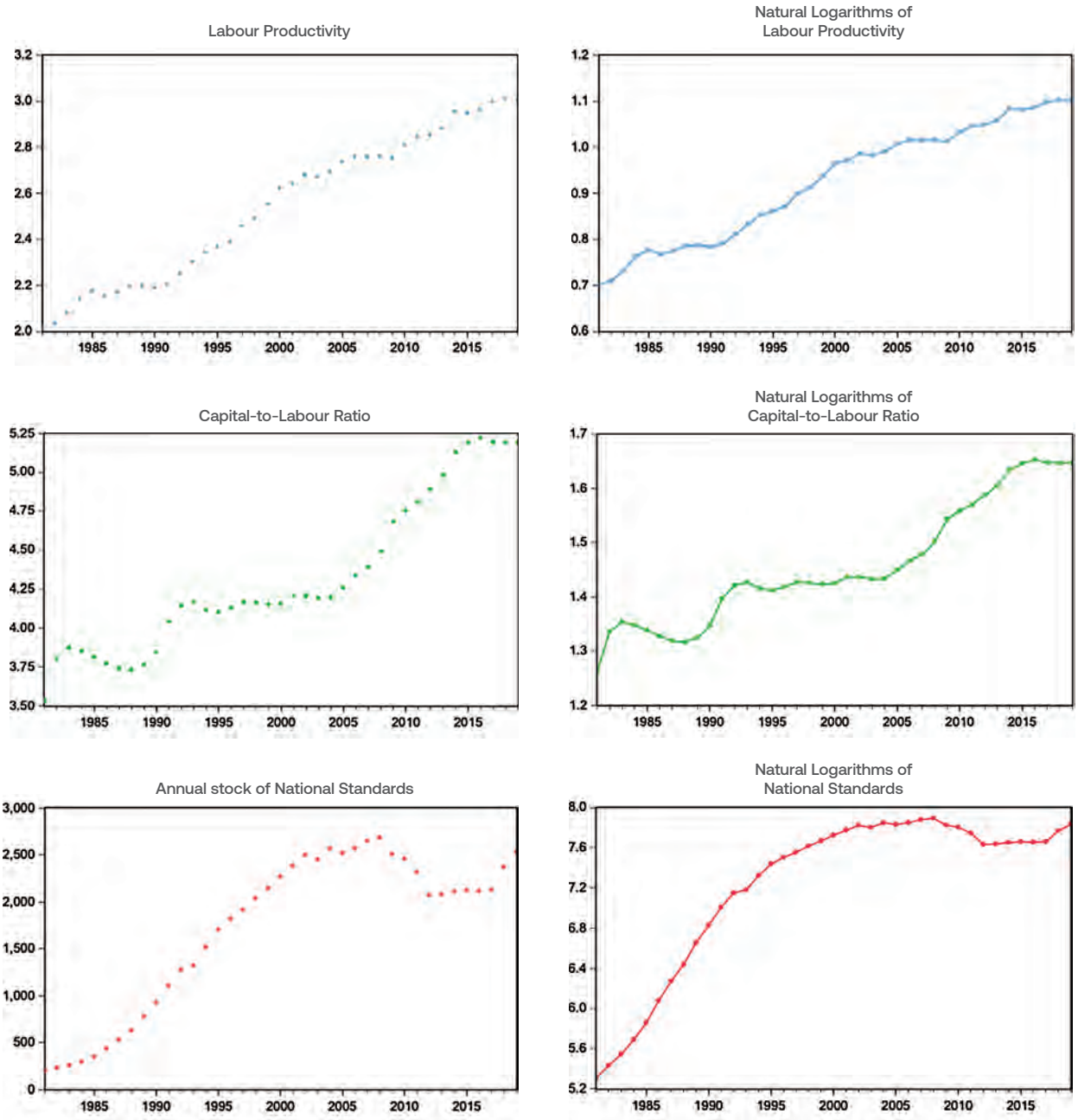
Source: Canadian Standards Database

The annual stock of National Standards of Canada is used as a proxy of the technical knowledge at time. It should be kept in mind that this is only a proxy and might not fully capture the complexity of TFP. The unexplained variation is captured in the residual (u_t). ε is the coefficient, or elasticity of standards, indicating that 1% increase of the stock of national standards is associated with ε% increase of the growth of labour productivity. Due to the limited data availability on the annual stock of national standards, the period covered for analysis in this study is from 1981 to 2019.

To determine the best approach to model the production function, the first step is to test whether each variable exhibits non-stationary time trend. Figure A-2 indicates that stochastic trends are presented in labour productivity, capital-to-labour ratio and the stock of national standards, even after taking the natural logarithms of all three variables. To confirm, we perform Augmented Dickey–Fuller (ADF) tests on the natural logarithms of these three variables. Results from these tests show that all these variables present stochastic trends.[26] Therefore, a framework of co-integration analysis, proposed by Engle and Granger (1987) for estimation when variables are not covariance stationary, is selected for modelling of the production function in this study.

26 A trend and intercept were included in these ADF tests. In all cases the tests were unable to reject the null hypothesis of a unit root at the 10% level, indicating the presence of stochastic trends.

Figure A-2: Trends of Labour Productivity, Capital-to-Labour Ratio and Stock of National Standards



The results from statistical modelling are shown in the table below.

Dependent Variable: LOG(Labour Productivity)				
Method: ARMA Maximum Likelihood (BFGS)				
Sample: 1981 2019				
Included observations: 39				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LOG(Stock of National Standards)	0.055983	0.013466	4.157301	0.000200
LOG(Capital/Labour)	0.297322	0.060577	4.908163	0.000000
@TREND	0.004558	0.001204	3.787178	0.000600
AR(1)	0.876157	0.084358	10.386130	0.000000
SIGMASQ	0.000141	0.000039	3.656612	0.000900
R-squared	0.991167			
Adjusted R-squared	0.990127			
S.E. of regression	0.012713			
Durbin–Watson stat	1.369517			
ADF test of the residual (P-value)[27]	-4.518	(0.0047)		

As is shown in the result table, all coefficients in the regression are positive and statistically significant. The ADF test of the residual is significant, indicating that residuals from the production model do not contain stochastic trends. This suggests that results obtained from this production model are not spurious and conclusions based upon the estimation can be considered meaningful. Both national standards and capital-to-labour ratio (i.e., capital investment per hour worked) have a significantly positive impact on labour productivity. Specifically, the coefficient or elasticity of the stock of national standards is estimated to be 0.056 ($p<0.01$). This means that a 1% growth of standard stock is associated with a 0.056% increase in labour productivity (GDP per hour worked).

It should be kept in mind that due to the small size of sample (39 observations), results of this production model are vulnerable to variations in estimation specification. Thus, we replicate the production model using alternative specifications of labour (using employment instead of total hours worked for all industries) and the association between standards and labour productivity remain significantly positive. This complements the relatively short sample period for the time series and further enhances the validity of our production model.

To further investigate the value of standardization to the Canadian economy, we estimate standards' contribution to labour productivity and real GDP using the following calculation. Please note that we present the calculation based on GDP. Standards' contribution to labour productivity can use the same process by simply replacing GDP with labour productivity.

27 The non-hypothesis of the ADF test here is that there is a unit root in the residual. The result is significant in all 1%, 5% and 10% levels ($p<0.01$), indicating that the non-hypothesis is rejected and there is no unit root in the residual — i.e., the residual does not contain stochastic trend.

Standards' expected impact on the growth rate of GDP in a given year can be obtained through multiplying standards' growth rate with the elasticity of standards.[28]

$$\left(\begin{array}{c}\text{Standards' expected impact}\\ \text{on the growth rate of GDP}\end{array}\right)_t = \left(\begin{array}{c}\text{Standards'}\\ \text{growth rate}\end{array}\right)_t \times \left(\begin{array}{c}\text{Estimated elasticity}\\ \text{of standards}\end{array}\right)$$

This allows us to calculate the expected GDP growth rate, thus expected GDP without the impact of standards in a given year.

$$\left(\begin{array}{c}\text{Expected growth rate of GDP}\\ \text{without standards}\end{array}\right)_t = \left(\begin{array}{c}\text{Actual growth rate of}\\ \text{GDP with standards}\end{array}\right)_t - \left(\begin{array}{c}\text{Standards' expected impact}\\ \text{on the growth rate of GDP}\end{array}\right)_t$$

$$\left(\begin{array}{c}\text{Expected GDP}\\ \text{without standards}\end{array}\right)_t = \left(\begin{array}{c}\text{Expected GDP}\\ \text{without standards}\end{array}\right)_{t-1} \times \left(\begin{array}{c}\text{Expected growth rate}\\ \text{of GDP without standards}\end{array}\right)_t$$

Through the calculation of compound annual growth rate (over the study time frame from 1981 to 2019), we can obtain the average GDP growth rate with and without the impact of standards.

$$\left(\begin{array}{c}\text{Average GDP growth}\\ \text{rate with standards}\end{array}\right) = \sqrt[\frac{1}{n-1}]{\frac{\left(\begin{array}{c}\text{Actual GDP}\\ \text{with standards}\end{array}\right)_n}{GDP_1}} - 1$$

$$\left(\begin{array}{c}\text{Average GDP growth}\\ \text{rate without standards}\end{array}\right) = \sqrt[\frac{1}{n-1}]{\frac{\left(\begin{array}{c}\text{Expected GDP}\\ \text{without standards}\end{array}\right)_n}{GDP_1}} - 1$$

The differences between GDP's average growth rate with and without the impact of standards is standards' contribution on the growth of GDP — i.e., the proportion of GDP growth rate that can be attributed to standards.

$$\begin{array}{c}\text{Standards' contribution to}\\ \text{the growth rate of GDP}\end{array} = \frac{\begin{array}{c}\text{Average GDP growth}\\ \text{rate with standards}\end{array} - \begin{array}{c}\text{Average GDP growth}\\ \text{rate without standards}\end{array}}{\begin{array}{c}\text{Average GDP growth}\\ \text{rate with standards}\end{array}}$$

Assuming that standards' estimated impact on GDP is constant over time, we can calculate the dollar value of standards' contribution to GDP in a given year.

$$\left(\begin{array}{c}\text{Standards' contribution}\\ \text{to GDP}\end{array}\right)_t = \begin{array}{c}\text{Standards' contribution to}\\ \text{the growth rate of GDP}\end{array} \times \left(\begin{array}{c}\text{Actual GDP}\\ \text{growth}\end{array}\right)_t$$

Using the above calculation, our estimates suggest that technological progress proxied by the growth of standardization activities is associated with 38.4% of the growth of labour productivity and 17.4% of the growth of GDP in Canada over the study time frame from 1981 to 2019. It also suggests that 61.6% of the growth in productivity and 82.6% of the growth of GDP can be attributed to other factors such as growth in investment, research and developments, and improved levels of education that are captured by the capital-labour ratio and the residual of the econometric model.

Translating into dollar value, by the end of 2019, GDP in Canada could have been $293 billion lower had there been no technological advancement associated with the growth of national standards over the past four decades. In 2019 alone, standards contribute to CAN$5.86 billion out of a total CAN$33.7 billion growth of GDP.

28 In the following calculation, t indicates a given year over the study time frame from 1981 to 2019; n indicates the total number of sample (or year), which equals 39 in this study.

Appendix B:
Terms and Glossary

GDP (Gross Domestic Product): An indicator that measures the total market value of all final goods and services produced over a specific time period.

IEC (International Electrotechnical Commission): The International Electrotechnical Commission prepares and publishes international standards for electrical, electronic and related technologies.

ISO (International Organization for Standardization): The International Organization for Standardization is the largest standards development organization in the world.

MCs (Mirror Committees): Also known as Canadian sub-committees (CSCs), where Canadian stakeholders provide input into the development of international standards that are produced by ISO and IEC technical committees or sub-committees.

NSBs (National Standardization Bodies): In general, each country or economy has a single recognized national standardization body, which is also likely the sole member from that economy participating in ISO and IEC.

NSCs (National Standards of Canada): A standard developed by an SDO compliant to SCC's Requirements & Guidance for a) accreditation of SDOs and for b) adoptions.

SCC (Standards Council of Canada): The national accreditation body for Canada with a mandate to promote efficient and effective standardization in Canada.

SDO (Standards Development Organization): Bodies that specialize in the development of standards through the process of consensus and participate in the regional and international standardization process.

TFP (total factor productivity): Also known as multi-factor productivity, a measure of economic efficiency to explain growth in output that is not explained by growth in inputs traditionally measured by labour and capita.[29]

TS (Technical Specifications): A tool developed by SCC as a faster and cost-competitive path to standardization that helps support cutting-edge innovators.

WA (Workshop Agreement): A document that is developed to begin the consensus process normally associated with an NSC. It can be developed in any field where there are many unknowns and where speed of delivery rather than full consensus is of paramount importance.

29 Sickles, R., & Zelenyuk, V. (2019). Measurement of Productivity and Efficiency: Theory and Practice. Cambridge: Cambridge University Press. doi:10.1017/9781139565981

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