Catalogue no. 11-626-X — 2019008 - No. 094
ISSN 1927-503X
ISBN 978-0-660-30695-7

Economic Insights

Environmentally Adjusted Productivity Growth and the Market Price of Greenhouse Gas Emissions for the Canadian Manufacturing Sector

by Michael Willox

Release date: May 8, 2019

Statistics Canada Statistique Canada

Canada

How to obtain more information

For information about this product or the wide range of services and data available from Statistics Canada, visit our website, www.statcan.gc.ca.

You can also contact us by

Email at STATCAN.infostats-infostats.STATCAN@canada.ca

Telephone, from Monday to Friday, 8:30 a.m. to 4:30 p.m., at the following numbers:

- Statistical Information Service 1-800-263-1136
- National telecommunications device for the hearing impaired 1-800-363-7629
- Fax line 1-514-283-9350

Depository Services Program

- Inquiries line 1-800-635-7943
- Fax line 1-800-565-7757

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, Statistics Canada has developed standards of service that its employees observe. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published on www.statcan.gc.ca under "Contact us" > "Standards of service to the public."

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Published by authority of the Minister responsible for Statistics Canada

An HTML version is also available.

Cette publication est aussi disponible en français.

Environmentally Adjusted Productivity Growth and the Market Price of Greenhouse Gas Emissions for the Canadian Manufacturing Sector

by Michael Willox
Economic Analysis Division, Analytical Studies Branch, Statistics Canada

This article in the *Economic Insights* series examines how accounting for greenhouse gas emissions as part of economic activity changes the measurement of productivity growth. Productivity growth is a commonly used measure of economic performance; it is defined as the amount of output produced relative to inputs used in production. Results indicate that, in the Canadian manufacturing sector, productivity growth that includes greenhouse gas emissions as an undesirable output of production was higher than standard measures of productivity growth, which include only desirable outputs. Higher environmentally adjusted productivity growth reflects the decline in greenhouse gas intensity (the amount of undesirable output, such as greenhouse gas emissions, relative to the amount of desirable output) of manufacturers. This article also provides estimates of the market price of greenhouse gas emissions, which are required to estimate environmentally adjusted productivity growth.

Introduction

Historically, statistical agencies such as Statistics Canada have measured economic activity with more focus on how much desirable output is produced (goods and services) and less focus on how much undesirable output (pollution) is produced as a by-product.

To determine the degree to which economic performance and environmental performance are tied, economic activity must be measured as a process that creates both desirable and undesirable outputs. Moreover, standard measures of economic activity that measure only desirable output are incomplete. One of those standard measures is productivity, which can be defined most simply as efficiency in production (Baldwin et al. 2014 and OECD, 2001). Productivity growth matters because it is one of the most important contributors to economic growth and prosperity, especially over long periods of time.

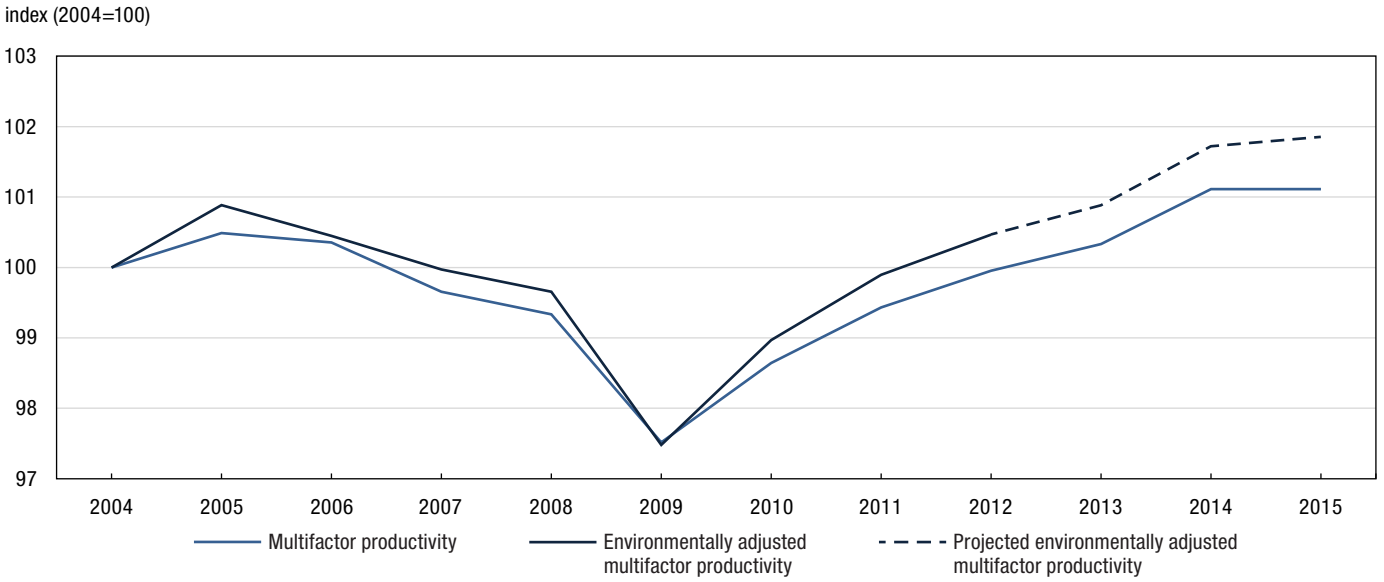
A standard productivity measure called multifactor productivity (MFP) growth compares how much desirable output is produced relative to the amount of factor inputs (labour, capital and intermediate inputs) that are used in production. A more inclusive productivity measure is environmentally adjusted multifactor productivity (EAMFP), which compares how much total output (desirable and undesirable) is produced with the same factor inputs. EAMFP was developed in a recent Statistics Canada study, *Environmentally Adjusted Multifactor Productivity Growth for the Canadian Manufacturing Sector* (Gu, Hussain and Willox 2019). This article summarizes the main findings of that study.

Productivity growth in Canada's manufacturing sector from 2004 to 2015 was somewhat faster when businesses' greenhouse gas[1] (GHG) emissions were included in the measurement of productivity growth (Chart 1). Faster productivity growth was largely caused by a decline in the intensity of GHG emissions (defined as tonnes of GHG emissions per dollar of desirable output, adjusted for inflation) among the largest GHG emitters in the manufacturing sector.[2]

Although the data used in this study end in 2012, information from Statistics Canada's annual MFP accounts can be used to project EAMFP growth for 2013 to 2015, as represented by the dashed line in Chart 1.[3] On average, EAMFP grew 0.17% per year, compared with 0.10% for MFP over the extended 2004-to-2015 period.

1. GHGs include several gases that contribute to global warming. Each type of GHG has a different capacity or potential to raise global temperatures. The most common GHG is carbon dioxide, so the differences in GHG potential among the gases were weighted to make them measurable in terms of carbon-dioxide-equivalent units.
2. The study by Gu, Hussain and Willox (2019) also examined how productivity is affected by three specific types of GHG and by eight criteria air contaminants that are associated with respiratory illness and commonly observed as smog. This article focuses on total GHG emissions, which contribute to climate change—one of the most pressing current issues debated among Canadians.
3. The projections for Chart 1 are based on Equation 14 from Gu, Hussain and Willox (2019) and information from Statistics Canada's annual MFP accounts (also known as the KLEMS database, Table 36-10-0217 [Statistics Canada n.d.a], formerly CANSIM Table 383-0032) and the physical flow account for GHG emissions (Table 38-10-0097 [Statistics Canada n.d.b], formerly CANSIM Table 153-0114). Research is being undertaken to extend this analysis beyond 2012, using the revised Annual Survey of Manufacturing and Logging Industries (ASML) and other databases. The methodology for the ASML was revised to be consistent with Statistics Canada's Integrated Business Statistics Program, starting in 2013.

Chart 1
Index of multifactor productivity and environmentally adjusted multifactor productivity growth



Note: Projections are based on Equation 14 from W. Gu, J. Hussain and M. Willox, 2019, Environmentally Adjusted Multifactor Productivity Growth for the Canadian Manufacturing Sector.
Source: Statistics Canada, authors' calculations. See Footnote 3 for details.

Calculating environmentally adjusted multifactor productivity

The difference between EAMFP and MFP reflects the fact that total output is calculated differently for the two productivity measures. In the case of MFP, total output includes only desirable output. For EAMFP, total output also includes the undesirable output that is jointly produced with desirable output. Because it is unwanted, undesirable output is subtracted from desirable output, making the total output for EAMFP lower than that of MFP. Since both productivity measures are calculated as their respective total output relative to the same inputs, the **level** of EAMFP is lower than that of MFP, except when no undesirable output is produced.

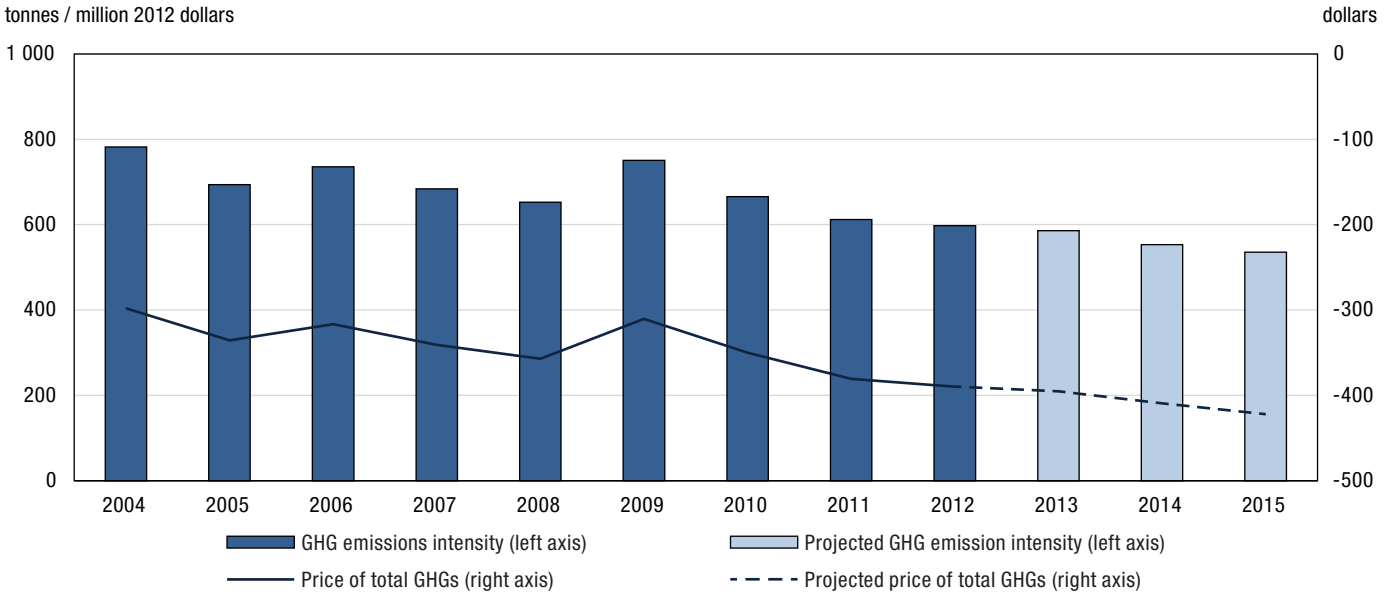
However, the **growth** of MFP and EAMFP is a different story. When the quantity of inputs does not change over time but desirable output increases, MFP grows. If GHG emissions also decline, EAMFP growth will be higher than MFP growth. Put another way, if the quantity of GHG emissions relative to the quantity of desirable output produced (i.e., GHG emission intensity) declines, EAMFP will grow faster than MFP. The general decline in GHG emission intensity among Canadian manufacturers was the primary source of stronger EAMFP growth.

Measuring the quantity of pollution

Information on GHG emission quantities from Environment and Climate Change Canada was combined with information from Statistics Canada's Annual Survey of Manufacturing) to calculate the GHG emission intensity of large emitting manufacturers (manufacturers that emitted 100,000 tonnes of GHGs or more annually). The intensity of these businesses' GHG emissions, shown in Chart 2 (the bars for 2013 to 2015 are projected values), generally declined with some volatility over the period examined in the study.[4]

4. The projections for Chart 2 are based on Equation 5 from Gu, Hussain and Willox (2019) and data from Statistics Canada Tables 36-10-0217 and 38-10-0097, as in Chart 1.

Chart 2
Greenhouse gas emissions intensity and market price for large emitters in the manufacturing sector



Note: Greenhouse gas (GHG) emissions intensity is measured as tonnes of GHG emissions per million 2012 dollars of real gross output for businesses that emit 100,000 tonnes of GHG or more between 2004 and 2012. Projections are based on Equation 5 from W. Gu, J. Hussain and M. Willox, 2019, *Environmentally Adjusted Multifactor Productivity Growth for the Canadian Manufacturing Sector*.
Source: Statistics Canada, authors' calculations. See Footnote 4 for details.

Measuring the cost of pollution

With information on quantities of undesirable outputs, price information for undesirable outputs—which is needed to calculate EAMFP—was estimated using an economic model similar to those used in two studies from the Organisation for Economic Co-operation and Development by Brandt, Schreyer and Zipperer (2014), and Dang and Mourougane (2014). Over the 2004-to-2012 period examined, the market price of GHGs, indicated by the solid line (right axis) in Chart 2, fell from a high of -$298 per tonne for large emitting manufacturers in 2004 to about -$422 per tonne in 2015.[5] This negative price indicates that, in 2015, the cost of reducing GHG emissions by one tonne would be equal to reducing production by $422 worth of desirable output. In other words, the negative price of GHGs reflects a trade-off in which reducing undesirable output means that desirable output must also be reduced proportionately.[6]

While the modelling of an estimated market price of GHGs is helpful, there are three reasons to interpret these findings with some caution. First, the price of GHGs for the manufacturing sector does not apply to the whole economy. The manufacturing sector is generally more pollution-intensive than other sectors, especially the services sector. Second, the data used to create price estimates included only businesses that emitted 100,000 tonnes of GHGs or more annually. This means that the businesses that are included in the dataset are typically larger than the average manufacturer, and likely more emissions-intensive.[7] Therefore, the price estimates in the study may not reflect the price of GHGs for all other manufacturers. Third, the prices for undesirable outputs derived in the study reflect the cost of reducing emissions for producers. They are not the social prices or costs of undesirable outputs, which would also account for the impact of undesirable outputs on public institutions and infrastructure, social justice, and the health and income of individuals.

5. The price estimate for GHGs from 2004 to 2012 is statistically significant for a 99% confidence interval.
6. The cost of GHG emissions on a per-tonne basis is often referred to in the media as the price of carbon. However, this study makes an important distinction between the price and the cost of an undesirable output. For desirable outputs, like the goods and services that consumer's purchase, the price of purchasing the output can be thought of as the cost of acquiring it. In this case, the price and the cost are the same. In contrast, prices of undesirable outputs, like pollution, are generally negative because the owners of undesirable outputs want to get rid of them. The cost they pay to have them removed (more technically called an abatement cost) is the price of the undesirable output once the minus sign is dropped.
7. This is consistent with findings of Baldwin, Leung and Rispoli (2014): large firms were more capital-intensive than small firms.

Conclusion

From 2004 to 2012, the decline in the intensity of GHG emissions among the largest emitters in the manufacturing sector was the main reason that EAMFP growth outpaced MFP growth. A decline in GHG emission intensity was also the primary driver behind the falling price of GHGs. From a business perspective, the market price of GHGs represents the cost of reducing emissions, which increased from $298 per tonne of GHG emissions in 2004 to $390 per tonne in 2012.

References

Baldwin, J.R., W. Gu, R. Macdonald, and B. Yan. 2014. *What Is Productivity? How Is It Measured? What Has Canada's Performance Been over the Period 1961 to 2012?* The Canadian Productivity Review, no. 38. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, J.R., D. Leung, and L. Rispoli. 2014. *Canada-United States Labour Productivity Gap Across Firm Size Classes*. The Canadian Productivity Review, no. 33. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Brandt, N., P. Schreyer, and V. Zipperer. 2014. *Productivity Measurement with Natural Capital and Bad Outputs*. OECD Economics Department Working Papers, no. 1154. Paris: OECD Publishing.

Dang, T., and A. Mourougane. 2014. *Estimating Shadow Prices of Pollution in OECD Economies*. OECD Green Growth Papers, no. 2014-02. Paris: OECD Publishing.

Gu, W., J. Hussain, and M. Willox. 2019. *Environmentally Adjusted Multifactor Productivity Growth for the Canadian Manufacturing Sector*. Analytical Studies Branch Research Paper Series, no. 425. Statistics Canada Catalogue no. 11F0019M. Ottawa: Statistics Canada.

OECD (Organisation for Economic Co-operation and Development). 2001. *Measuring Productivity—OECD Manual: Measurement of Aggregate and Industry-Level Productivity Growth*. Paris: OECD Publishing.

Statistics Canada, n.d.a. *Table 36-10-0217 Multifactor productivity, gross output, value-added, capital, labour and intermediate inputs at a detailed industry level*. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv-action?pid=3610021701 (accessed January 29, 2019).

Statistics Canada, n.d.b. *Table 38-10-0097 Physical flow account for greenhouse gas emissions*. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv-action?pid=3810009701 (accessed January 29, 2019).