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Experimental Measures of Output and Productivity in the Canadian Hospital Sector, 2002 to 2010

Wulong Gu and Stéphane Morin

17.1 Introduction

Health care is an important economic activity in Canada (CIHI, 2011b). As a share of gross domestic product (GDP), health-care expenditures rose from 7.0 percent in 1975 to 11.7 percent in 2011.

Recent discussions about health-care spending have focused on two issues: (1) the extent to which the increase is due to an increase in the *quantity* as opposed to the *price* of health-care services, and (2) the efficiency and productivity of health-care providers.

For example, the Canadian Institute for Health Information (CIHI) examined sources of the increase in hospital expenditures between 1998 and 2008. Using the GDP price index as a proxy for the price index of hospital expenditures, CIHI (2012b) reported that total hospital expenditures rose 6.7 percent annually over the period, 2.8 percent of which was due to price changes. The remaining 3.9 percent was due to an increase in the quantity of hospital services as a result of factors such as population growth, population aging, and technical progress and innovation. In a related study, CIHI (2011a) examined factors behind the increase in total health-care expenditures.

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With regard to the efficiency and productivity of health-care providers, Sharpe, Bradley, and Messinger (2007) noted that accurate measures of health-care output and productivity are essential and recommended that more resources be allocated to develop better measures for Canada's health-care sector.

The key to addressing both issues is a direct output measure of health-care services—a measure that does not currently exist. In the national accounts, output of the health-care sector is measured by the volume of inputs, which includes labor costs for physicians, nurses, and administrative staff, consumption of capital, and intermediate inputs (Statistics Canada 2001). An input-based output measure assumes that there are no productivity gains in the health-care sector.[1] As a result, it does not provide a measure of productivity performance, nor does it allow a decomposition of total health-care expenditures into price and output quantity components.

The main objective of this chapter is to develop an experimental direct output measure for the Canadian hospital sector. The focus is on the hospital sector because hospitals make up the largest component of health-care spending, and the data are readily available. Hospital expenditures totaled $60.5 billion in 2011 and accounted for 29.2 percent of total health spending that year (CIHI 2011c).[2]

The direct output measure developed here is based on the number of "activities" in hospitals, with activities defined as episodes of treatment of diseases and conditions. Because the treatment of different diseases/conditions involves different types of service, weights must be applied to construct the direct output measure. Previous studies have proposed two alternative weights: one based on the unit costs of treatments, and the other based on the value of treatments to patients (the effect on the patient's health outcome) (Atkinson 2005; Dawson et al. 2005; Schreyer 2010). These studies acknowledge that the former is the most practical. Accordingly, this analysis constructs a direct output measure of the hospital sector using unit costs as weights—the cost-weighted activity index.

The cost-weighted activity index, when calculated inappropriately, introduces a bias in the estimate as a result of a shift from inpatient treatment toward cheaper outpatient treatment with improved or similar health outcomes (Schreyer 2010, 2012). The index will show a decline in the volume of hospital care, which is contrary to intuition that, because of the substitution of one mode of treatment for another, the volume of hospital care increased, or at least, did not change.

This chapter examines the substitution bias in the cost-weighted activity index as it is often calculated. It also examines aggregation bias or the effect

1. The input-based output measure implies that no multifactor productivity growth occurs in the health-care sector.

2. Other health-care expenditure categories include physicians, drugs, and other health institutions.

of using various levels of aggregation of case types to calculate the direct output measure. This is relevant because countries often classify case types at a high level of aggregation to overcome problems that are created by changes over time in classification at a detailed level.

Two previous Statistics Canada studies developed direct output measures for hospital care. Kitchen (1997) constructed a direct output measure for the hospital sector as the cost-weighted sum of the number of treatments for inpatients, outpatients, and chronic care during the 1986 to 1992 period. Statistics Canada (2001) extended the estimate for inpatient care to take into account differences in unit costs across 500 categories of inpatient treatments.

This study is related to Yu and Ariste (2009), who constructed a direct output measure for the hospital sector as a cost-weighted activity index for the periods 1996 to 2000 and 2003 to 2005. The present analysis differs in that it attempts to correct for substitution and aggregation biases.

The rest of the chapter is organized as follows. Section 17.2 outlines the methodology used to construct the direct output measure. Section 17.3 describes the data sources. Section 17.4 presents an estimate of hospital sector output and examines potential bias in the estimate. Section 17.5 concludes.

17.2 Methodology

This section summarizes the approaches used to measure the output of hospital sector and highlights challenges, issues, and data constraints that national statistical agencies encounter in implementing the various approaches.

This study employs the approach in the Organisation for Economic Co-operation and Development (OECD) handbook on measurement of the volume of output of education and health services (Schreyer 2010). That approach is similar to those proposed by the Atkinson review of the measurement of government output and productivity for the national accounts (Atkinson 2005), the US National Research Council (2010), and Eurostat (2001). It has been adopted by a number of countries to develop a direct output measure of the health-care sector (Schreyer 2010).

The Systems of National Accounts (SNA) 1993 (CEC et al. 1993) and SNA 2008 (EC et al. 2009) recommended an output-based approach for measuring the volume of health sector output.[3] Eurostat (2001) made similar recommendations and provided detailed guidance toward implementation in its *Handbook on Price and Volume Measures in National Accounts*. The

3. The principles for constructing the output-based measures of nonmarket services, including health care, go back to work by Hill (1975).

handbook became European law, obliging member states to implement the recommendations.

Measurement of direct output starts with a definition of the unit of output and weights used for aggregation. For the goods-producing business sector, the unit of output and the weights used for aggregation are straightforward. For example, to construct the direct output measure of the automobile manufacturing sector, the unit of output is defined as the number of cars manufactured, and market prices are used for aggregation. The hospital sector, however, is less straightforward.

Schreyer (2010) defines the unit of health services as the treatment of a disease or condition. Ideally, the unit of output should capture the complete treatment, encompassing the path a patient takes through heterogeneous health-care institutions to receive full and final treatment. This definition of the target measure, known as a disease-based estimate of health-care output, is similar to that used by the Eurostat handbook (2001), Berndt et al. (2001), Aizcorbe and Nestoriak (2011), and Triplett (2001).

Implementation of this ideal definition requires tracking individual patients across health-care institutions to measure complete treatment; existing data rarely allow such linkages. In addition, the concept of "complete treatment" is problematic if the objective is to construct a direct output measure for specific institutions such as hospitals. For practical reasons, Schreyer (2010) proposes a working definition of the unit of health-care services—activities relating to an episode of treatment of a disease/condition provided by specific institutions.

Because episodes of treatment of different diseases/conditions involve different types of service, weights must be applied to construct the direct output measure. Typically, market prices provide such weights, but because there are no market prices for most hospital services, Schreyer (2010) proposes that unit costs be used to obtain the cost-weighted activity index. The Atkinson report (Atkinson 2005) and Dawson et al. (2005) recommend that the marginal value of a treatment be used to derive a value-weighted activity index as the ideal output measure, where the marginal value is based on the effect of the treatment on the patient's health outcome. .

In Canada, the public sector (federal, provincial, and municipal governments) provides and finances 90 percent of hospital services. If well-functioning markets existed for hospital services, unit costs of treatments would tend to be the same as their value to patients, and market prices (which tend to be equal to unit costs and value to patients) should be used for aggregation. But because there are no markets for most publicly financed hospital services, unit costs of treatments may be different than values to patients, and consequently, the choice of weights matters for the direct output measure.

Because the effect of a treatment on health outcomes is often not available, the Atkinson report (Atkinson 2005) and Dawson et al. (2005) conclude that

the *cost-weighted activity index* is a practical approach for constructing the direct output measures for the hospital sector. However, a cost-weighted activity index might introduce a substitution bias (Schreyer 2010, 2012). Substitution bias arises when a shift from inpatient to outpatient treatment occurs, and inpatient treatment and outpatient treatment are assigned to different case types with different unit costs even though they both have the same effect on outcome. If outpatient treatment is less expensive, a cost-weighted activity index will indicate a decline in the hospital sector's volume of output. This is counterintuitive, since the volume of hospital service under the above assumption does not change when outpatient and inpatient treatments have same effect on health outcomes and are valued equally by patients.[4]

This counterintuitive result derives from an implicit assumption in the cost-weighted activity index: a treatment with lower unit costs has lower quality than a treatment with higher unit costs. But if treatments have a similar effect on health outcomes, they should have the same quality.[5] An appropriate measure for the example chosen would show no change in the volume of hospital output and a decline in the price of that output as a result of the shift toward cheaper outpatient treatment.

The bias can be removed by grouping treatments with similar health outcomes in the same case types (Schreyer 2010, 2012). This is not always feasible, as outpatient and inpatient cases are often assigned to different case types using different classification systems. And in some instances, there is no classification of case types for outpatient treatments.

Substitution bias arises from *quality* changes in hospital care that come from shifts between case types that the cost-weighted activity index does not capture. A *value-weighted activity index* captures such quality changes and does not suffer from substitution bias. For a value-weighted activity index, weights for aggregating treatments are based on the effect of treatments on health outcomes. To the extent that shifts from inpatient treatment to less expensive outpatient treatment have no effect on health outcomes, a value-weighted index will show a decline in the price of the hospital output but no change in the volume of hospital output.

To construct a cost-weighted activity index, treatments are assigned to various case types. The level of detail in the classification of treatments may introduce a bias when more aggregated levels of classification are used. This is referred to as aggregation bias in this chapter.

4. The substitution bias also exists in the relative price level of hospital services that the OECD constructed in its pilot study, because inpatient and outpatient treatments were assigned different case types and different unit costs were used as weights for the two types of service (Schreyer 2010; Koechlin, Lorenzoni, and Schreyer 2010).

5. Quality is defined as characteristics of a product that consumers value. For treatment of a disease, "quality" is the effect on health outcomes. Triplett (2006) provided an extensive discussion of quality adjustment.

The objective of this chapter is to construct a cost-weighted activity index for the hospital sector and examine the magnitude of substitution and aggregation bias. Hospital sector output includes both inpatient and outpatient care. The unit of output is defined as the number of episodes of treatment that patients received in hospitals—specifically, the number of discharges by case type (patient statistics are derived from hospital discharge registers). In this chapter, the terms "case," "treatment," and "discharge" are used interchangeably.

The cost-weighted activity index of the volume of hospital sector output Q is expressed as a Tornqvist aggregation of the number of patient cases, by case type, using unit costs as weights:

$$(1) \qquad (\ln Q_t - \ln Q_{t-1}) = \sum_i \overline{s}_i (\ln q_t - \ln q_{t-1})$$

$$s_i^t = \frac{c_i^t q_i^t}{\sum_i c_i^t q_i^t}, \quad \overline{s}_i = \frac{1}{2}(s_i^t + s_i^{t-1}),$$

where q_i is the number of cases for case type i, c_i is the unit cost per treatment for case type i, and s_i is the share of case type i in total costs.[6]

The volume index of the hospital sector output is then used to derive the price index of the hospital sector output.

An alternative approach is to construct the price index of hospital services and derive the volume index as deflated total expenditures of the hospital sector. The choice between the two methods is mainly driven by data availability. For example, Germany and Denmark use the deflation method and construct the price index of hospital services, while the Netherlands constructs the volume index of the output of hospital care (Schreyer 2010). The Bureau of Labor Statistics (BLS) uses the deflation method to construct the producer price index (PPI) of hospital expenditures for the United States (Carton and Murphy 1996). The BLS samples the costs of inpatient and outpatient treatments and derives the price index of hospital expenditures as the weighted sum of unit costs of inpatient and outpatient treatments, using their cost shares as weights.[7]

Unlike other countries, the unit cost for a case type in Canada is not a monetary value. Rather, the unit cost (resource intensity weight) represents the relative resource intensity of inpatient and outpatient cases compared with the average inpatient case, which has a value of 1.0. Therefore, the deflation method is not feasible using Canadian data.

To examine the substitution bias in the cost-weighted activity index, inpatients and outpatients in the same case types are combined, and the

6. In the estimation below, the case type for inpatients is further disaggregated based on the age of patients and the severity of the disease to obtain more homogeneous groups of patients with similar unit costs when that information is available.

7. Because the BLS also makes a distinction between inpatient and outpatient treatments, its hospital price index may introduce a substitution bias similar to that examined here.

same unit costs are used to weight inpatients and outpatients belonging to the same case types. The resulting estimate is compared with the estimate derived from classifying inpatient and outpatient cases as distinct activities, and then weighting them using different unit costs.

The approach adopted for the present study has been suggested by Schreyer (2010, 2012), but has not previously been implemented because classifications for outpatient treatments are often not the same as those for inpatient treatments, or are lacking altogether.

An alternative is to assume that, without the shift toward outpatient treatment, the growth of inpatient and outpatient care would be similar. Therefore, the relatively faster increase of outpatients would be entirely due to substitution. Growth of outpatient cases that exceeds the growth of inpatient cases is weighted using the unit costs for average inpatients to derive an alternative direct output measure. This assumes that outpatient treatment yields the same health-care services as inpatient treatment. The difference between the new and original estimates provides a measure of substitution bias.

17.3 Data

Hospitals are involved in inpatient care, outpatient care, and activities such as research, education, and social services. Inpatient and outpatient services accounted for 92.5 percent of total hospital expenditures in 2007, down slightly from 94.6 percent in 1999 (CIHI, 2012b).

The direct output measure of the hospital sector constructed in this chapter covers all provinces except Quebec, for which consistent time-series data are not available.[8] The nominal value of the hospital sector is estimated as total hospital expenditures, which are obtained from the income statements of all hospitals in the Canadian MIS Database (CMDB).

The data on inpatient and outpatient cases are from the hospital discharge register. The volume index constructed in this chapter covers inpatient and outpatient treatment, but not other hospital activities, which account for only about 5 percent of total hospital expenditures.

The databases used for estimating the nominal value and the volume index of the output of the hospital sector have the same coverage of hospitals (CIHI 2011a).[9] The volume index of the hospital sector output estimated from the hospital discharge register can be compared with total hospital expenditures from the CMDB to derive a price deflator for hospital sector output.

8. Outpatient data are not available for Alberta, and so are excluded from the estimates.

9. Hospitals in the DAD can be linked to the Canadian MIS Database, which contains hospital income statements and balance sheets.

17.3.1 Total Hospital Expenditures

Total expenditures for Canadian hospitals are from the CMDB, maintained by CIHI (CIHI 2011a). The CMDB includes financial information from hospital balance sheets and income statements.[10] Total hospital expenditures are published in *National Health Expenditure Trends* (CIHI, 2011b), and constitute the source data used to estimated the gross output of the hospital sector in the Canadian System of National Accounts.

17.3.2 Inpatients

Data on inpatient treatment are from the Discharge Abstract Database (DAD), maintained by CIHI (CIHI 2012a). The DAD contains administrative, clinical, and demographic information on hospital inpatients in all provinces except Quebec.

The DAD assigns inpatients to one of twenty-one Major Clinical Categories (MCCs) (table 17.1) based on their "most responsible" diagnosis. Inpatients in each MCC are further assigned to one of about 600 Case Mixed Groups (CMGs), which aggregate cases with similar clinical and resource utilization characteristics. These data may be further disaggregated by patient age or disease severity to obtain more homogeneous groups of patients with similar resource requirements. For 2009, there are twenty-one MCCs and 570 CMG categories. The number of age groups and complexity/comorbidity categories changed slightly over time: for the 2002 to 2004 period, four complexity levels and three age groups; after 2004, more detailed age groups and six comorbidity levels (CIHI 2007a).

Unit costs, or resource intensity weights (RIW), are calculated for inpatients in a specific CMG, age group, and complexity/comorbidity category.[11] All RIWs are relative to an average inpatient case, which is assigned an RIW of 1.0. For example, a patient with an RIW of 2.0 would require twice as many resources during the course of hospital treatment as the average inpatient.[12]

The RIW is used to estimate the cost per weighted case that measures the relative cost-efficiency of a hospital's inpatient care. This indicator compares a hospital's total inpatient care expenses to the weighted number of inpatient cases. The result is the hospital's average cost of treating average inpatients.

In this chapter, RIWs are used to aggregate inpatient cases across case types to derive the volume index of inpatient care in hospitals.

10. In provinces and territories where hospitals are part of a regional health authority, regional hospital data are submitted to the CMDB.

11. Resource intensity weights (RIW) is a measure of the relative amount of hospital resources used to treat an inpatient or outpatient. RIW are calibrated annually so that the average inpatient acute care case in Canada has a value of one (CIHI 2007a).

12. Unit costs for atypical cases (which include acute care transfers, sign out, and death) are calculated using a per diem-based approach. Unit costs for atypical cases are then expressed relative to that for an average case (CIHI 2007a).

Table 17.1 Major Clinical Category (MCC)

Number	Title
1	Diseases and Disorders of the Nervous System
2	Diseases and Disorders of the Eye
3	Diseases and Disorders of Ear, Nose, Mouth and Throat
4	Diseases and Disorders of the Respiratory System
5	Diseases and Disorders of the Circulatory System
6	Diseases and Disorders of the Digestive System
7	Diseases and Disorders of the Hepatobiliary System and Pancreas
8	Diseases and Disorders of the Musculoskeletal System and Connective Tissue
9	Diseases and Disorders of the Skin, Subcutaneous Tissue and Breast
10	Diseases and Disorders of the Endocrine System, Nutrition and Metabolism
11	Diseases and Disorders of the Kidney, Urinary Tract and Male Reproductive System
12	Diseases and Disorders of the Female Reproductive System
13	Pregnancy and Childbirth
14	Newborns and Neonates With Conditions Originating in the Perinatal Period
15	Diseases and Disorders of the Blood and Lymphatic System
16	Multisystemic or Unspecified Site Infections
17	Mental Diseases and Disorders
18	Burns
19	Significant Trauma, Injury, Poisoning and Toxic Effects of Drugs
20	Other Reasons for Hospitalization
99	Miscellaneous CMG and Ungroupable Data

Source: Canadian Institute for Health Information (2007a).

17.3.3 Outpatients

Data on outpatient services for all provinces except Ontario, Quebec, and Alberta are also from the DAD. Outpatient data for Ontario are from CIHI's National Ambulatory Care Reporting System (NACRS). Outpatient data for Alberta and Quebec are not available for the period covered in this chapter.

The DAD makes a distinction between inpatient and outpatient treatments. Inpatient and outpatient cases are assigned to the same case types at the aggregate level of classification, but to different case types at more detailed levels. Outpatient cases and day procedures are assigned to one of twenty-one MCCs at the aggregate level, and to one of around 100 Day Procedure Groups (DPGs) at the detailed level according to the principal procedure recorded. Those assigned to the same DPG constitute a homogeneous group with similar clinical episodes and requiring similar resources.

Outpatient cases and day procedures in the NACRS are assigned to one of about twenty Major Ambulatory Clusters (MACs) at the aggregate level, and to one of about 300 case types using the Comprehensive Ambulatory Classification System (CACS). The CACS provides a more detailed classification of outpatient cases than DPGs in the DAD, but the classifications are similar, and MACs can be mapped to MCCs.

Each outpatient case is assigned an RIW. Because the RIW for outpatient cases is comparable to the RIW for inpatient cases (Hicks and Zhang 2003), the volume index of inpatient and outpatient cases can be combined to derive the volume index of the output of the hospital sector.

This study focuses on 2002 to 2010, because the data are consistent and no major changes in the classification of inpatient and outpatient cases were made during the period.[13] The two hospital register databases used in this analysis pertain to the April–March fiscal year; the data were converted to calendar years based on the month of patient discharge.

17.4 Direct Output Measures

This section presents direct output measures of the hospital sector for 2002 to 2010 for all provinces except Quebec,[14] for which consistent data are not available. Because outpatient data are not available for Alberta,[15] it was assumed that growth in the volume index of outpatient care in Alberta is equal to the average growth of outpatient care in the other provinces.

From 2002 to 2010, the number of inpatient cases rose slightly from 2.36 million to 2.41 million (figure 17.1). However, the number of outpatient cases and day procedures nearly doubled from 1.18 million to 2.02 million, an increase that has been attributed to a shift in elective surgeries from an inpatient to a day-surgery setting (CIHI 2007b).

This analysis first presents the cost-weighted activity index of hospital sector output when inpatient and outpatient cases are assigned to different case types, and different unit costs are used to aggregate inpatient and outpatient cases. Specifically, the index is estimated by aggregating inpatient and outpatient cases at the most detailed classification level. Inpatient cases are further disaggregated by patient age group and by disease/condition severity. Substitution and aggregation biases are then examined. Finally, the estimate is compared with the estimate from the Canadian System of National Accounts.

17.4.1 Cost-Weighted Activity Index: Inpatient and Outpatient Cases Assigned to *Different* Case Types

Table 17.2 presents the volume index of hospital sector output for the 2002 to 2010 period that results when inpatient and outpatient cases are assigned to different case types and different unit costs are used to weight them.

The volume index of *inpatient* care increased 0.6 percent per year. This

13. The classification of case types at the detailed level changed for 2004/2005. The volume index for that year was estimated based on the higher level of aggregation.

14. Quebec accounted for about 20 percent of hospital expenditures over the 2002 to 2010 period.

15. Alberta accounted for about 12 percent of hospital expenditures over the 2002 to 2010 period.

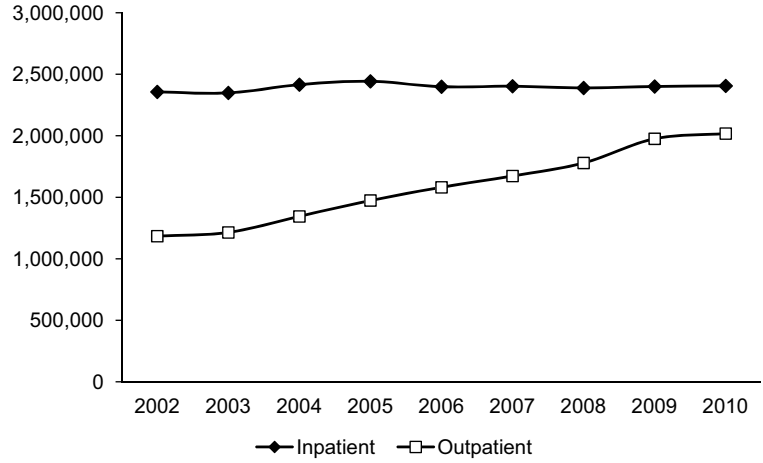

Fig. 17.1 Number of hospital inpatient and outpatient cases, Canada, 2002 to 2010
Source: Authors' estimate from the CIHI data.

Table 17.2 Direct output measure of hospital sector, Canada, 2002 to 2010

	All		Inpatient		Outpatient	
Year	Volume index of output	Number of cases (in thousands)	Volume index of output	Number of cases (in thousands)	Volume index of output	Number of cases (in thousands)
2002	100.0	3,541	100.0	2,357	100.0	1,184
2003	100.0	3,563	99.5	2,349	104.2	1,215
2004	103.2	3,760	100.8	2,416	122.2	1,345
2005	105.3	3,917	101.3	2,443	137.1	1,474
2006	103.7	3,980	98.3	2,399	148.4	1,581
2007	105.9	4,076	99.6	2,403	158.3	1,673
2008	108.3	4,168	100.7	2,389	170.9	1,779
2009	112.4	4,376	103.2	2,401	188.9	1,976
2010	114.8	4,424	105.2	2,406	194.1	2,018
			Average annual growth (%), 2002 to 2010			
	1.7	2.8	0.6	0.3	8.6	6.9

Source: Authors' estimates from the CIHI data.
Notes: Excludes Quebec. The volume index of output is set equal to 100 in 2002.

growth was faster than the increase in the unweighted number of inpatient cases (0.3 percent). The difference signals a change in the nature of inpatient cases toward those that are more resource intensive (e.g., elderly patients, CIHI 2007b), as a result of the aging of the population. Other factors contributing to the difference include an increase in cases that involve resource-intensive technologies and the general shift from inpatient to outpatient care.

The volume index of *outpatient* care rose 8.6 percent per year. This growth, too, was faster than the increase in the unweighted number of outpatient cases (6.9 percent), and reflects more use of resource-intensive technologies.

The volume index of the *hospital sector* overall is obtained by aggregating the volume indices of inpatient and outpatient care using their relative cost share as weights.[16] The volume index of the hospital sector increased 1.7 percent per year, which was slower than the increase in the total number of inpatient and outpatient cases (2.8 percent). The difference is mainly due to compositional shifts in hospital care toward outpatient treatment, which is less resource intensive, and therefore, less expensive than inpatient treatment. Thus, the shift, or "substitution," reduced the growth of the volume index of hospital care.

Using the same databases, Yu and Ariste (2009) constructed a cost-weighted activity index for the hospital sector (excluding Quebec) for 1996 to 2000 and for 2003 to 2005. The estimate for 2003 to 2005 in the present analysis is almost identical to theirs: both indicate growth of 2.6 percent per year in the volume index of the hospital sector output (data not shown).

For the table 17.2 estimates, inpatient and outpatient cases were assigned to detailed case types. To assess the effect of level of aggregation, an alternative estimate is derived by using a higher level of aggregation—the Major Clinical Category (MCC). The unit cost of an MCC is calculated as an average of unit costs among the detailed case types that comprise the MCC. Differences in unit costs between age groups and disease/condition severity are not taken into account.

Use of higher levels of aggregation reduced the growth in the volume index of the hospital sector by 0.6 percentage points per year (table 17.3). This aggregation bias appears in both inpatient and outpatient care, reducing annual growth in the volume index of inpatient care by 0.6 percentage points, and in the volume index of outpatient care by 0.4 percentage points.

17.4.2 Cost-Weighted Activity Index: Inpatient and Outpatient Cases Assigned to Same Case Types

To the extent that inpatient and outpatient treatments of the same disease/condition have a similar effect on health outcomes but there has been a shift towards less expensive outpatients, the cost-weighted index will underestimate growth.

To assess the substitution bias that occurs when inpatient and outpatient cases are assigned to *different* case types, they are grouped using the *same* classification and assigned to one of twenty-one MCCs. Relative unit costs for inpatient cases are used as weights to aggregate inpatient and outpatient

16. The share of total costs attributable to day procedures is calculated from RIW in the DAD. It was 11.7 percent in 2002 for the eight provinces whose statistics on both inpatient cases and day procedures are included in the DAD (Quebec and Alberta are excluded).

Table 17.3 **Effect of level of aggregation on direct output measure of hospital sector, Canada, 2002 to 2010**

	Annual average growth (%)		
	Detailed level	Broad level	Difference
All			
Volume index of output	1.7	1.2	–0.6
Number of cases	2.8	2.8	0.0
Composition	–1.1	–1.6	–0.6
Inpatient			
Volume index of output	0.6	0.0	–0.6
Number of cases	0.3	0.3	0.0
Composition	0.4	–0.2	–0.6
Outpatient			
Volume index of output	8.6	8.2	–0.4
Number of cases	6.9	6.9	0.0
Composition	1.6	1.2	–0.4

Source: Authors' estimates from the CIHI data.

Notes: The detailed level of aggregation consists of about 600 case types for inpatients, and 100 to 300 case types for outpatients. The broad level of aggregation consists of about twenty categories for both inpatients and outpatients.

treatments belonging to the same case type. This is compared with the cost-weighted activity index of the hospital sector when different unit costs for inpatient and outpatient cases belonging to the same MCCs are used for aggregation. The difference between the two estimates is a measure of the substitution bias in the cost-weighted activity index.

The substitution bias is considerable (see table 17.4). Removal of the bias increased the growth of the volume index of the hospital sector output during the 2002 to 2010 period by 2.6 percentage points.

The substitution bias can be regarded as resulting from quality changes in hospital service that the normal cost-weighted activity index fails to capture (Schreyer 2010, 2012), because it assumes that outpatient treatments with lower unit costs have lower quality than do inpatient treatments of the same disease/condition. Thus, the cost-weighted activity index will show a decline in volume of output when treatment shifts from inpatient to outpatient care. If inpatient and outpatient treatments have similar effects on health outcomes, a cost-weighted activity index that was adjusted for quality measure would show no decline in volume of output.

To remove substitution bias and capture quality changes from shifts in treatments between case types, Schreyer (2010, 2012) recommends that inpatient and outpatient cases be grouped together if they have a similar contribution to health outcomes. In practice, this is not always feasible, because inpatient and outpatient cases are often assigned to case types using different classification systems. And sometimes, outpatient cases are not classified at

Table 17.4 **Substitution bias in direct output measure of hospital sector, Canada, 2002 to 2010**

	Annual average growth (%)		
	Distinct grouping	Same grouping	Difference
All			
Volume index of output	1.2	3.7	2.6
Number of cases	2.8	2.8	0.0
Composition	–1.6	0.9	2.5
Inpatient			
Volume index of output	0.0	0.0	0.0
Number of cases	0.3	0.3	0.0
Composition	–0.2	–0.2	0.0
Outpatient			
Volume index of output	8.2	7.4	–0.8
Number of cases	6.9	6.9	0.0
Composition	1.2	0.5	–0.8

Source: Authors' estimates from the CIHI data.

Notes: "Distinct grouping" refers to assignment of inpatient and outpatient cases to distinct Major Clinical Categories (MCCs) with different unit costs. "Same grouping" refers to assignment of inpatient and outpatient cases to the same MCCs using the same unit costs.

all. In such instances, a cost-weighted activity index may seriously underestimate the volume index of the hospital sector when there is a large shift toward outpatient treatment, as has occurred in Canada.

17.4.3 Cost-Weighted Activity Index from a Counterfactual

The magnitude of substitution bias has been examined using a broad level of disaggregation of patient cases in section 17.4.2. Ideally, it should be examined using a more detailed level of disaggregation. To assess the robustness of the estimated substitution bias, this section provides an alternative estimate at a more detailed level using the assumption that the growth of inpatient cases and outpatient cases would be similar without the substitution. Therefore, the difference in the growth rates of outpatient and inpatient cases is entirely due to the substitution.[17] The growth of outpatient cases exceeding the growth of inpatient cases is weighted using the unit cost for average inpatient cases. The difference between the new estimate and the original estimate provides an assessment of the substitution bias in the cost-weighted activity index of the hospital sector.

The results of this counterfactual reveal a similarly large substitution bias in the cost-weighted activity index (table 17.5). The estimated volume index of the hospital sector from the counterfactual increased 4.0 percent per year

17. CIHI (2007a) attributes the relative growth difference between inpatient and outpatient cases mostly to a shift in elective surgeries from an inpatient to a day-surgery setting.

Table 17.5 Alternative estimates of direct output measure of hospital sector

	Average annual growth (%)		
	Volume index of output	Price index of output	Nominal expenditure
Detailed level of distinct case groups for inpatients and outpatients	1.7	5.2	7.0
Broad level of distinct case types for inpatients and outpatients	1.2	5.8	7.0
Broad level of same case types for inpatients and outpatients	3.7	3.3	7.0
Counterfactual estimate	4.0	3.0	7.0
Preferred estimate	4.3	2.7	7.0

Source: Authors' estimates from the CIHI data.

Note: Average annual growth in percent, 2002 to 2010, Canada.

during the 2002 to 2010 period, compared with 1.7 percent per year for the cost-weighted activity index.

17.4.4 Productivity Growth of Hospital Sector

Table 17.5 summarizes the alternative estimates of the direct output measure of the hospital sector and presents both volume and price indices. The price index is derived by dividing total hospital expenditures by the volume index of output.

The preferred estimate is the cost-weighted activity index based on the detailed case type aggregation and corrected for substitution bias. Growth in this quality-adjusted cost-weighted activity index of hospital sector output can be calculated as the growth in the volume index estimated from using different classifications for inpatient cases and outpatient cases at a detailed level (1.7 percent per year) plus the substitution bias in that estimate (2.6 percent). Alternatively, it can be calculated as the sum of the estimate from using the same classification for inpatient and outpatient cases at a broad level (3.7 percent) plus the aggregation bias in that estimate (0.6 percent).

The quality-adjusted estimate of hospital sector output over the 2002 to 2010 period rose 4.3 percent per year. The price index of hospital sector output derived from the quality-adjusted volume index measure increased 2.7 percent per year. Growth in the price of the hospital sector is slightly higher than growth in the price of gross domestic product over that period (2.5 percent per year).

Table 17.6 compares the quality-adjusted estimate of the direct output measure of the hospital sector with the output measure from the input-based approach in the Canadian System of National Accounts for the 2002 to 2008 period. Because the direct output measure of hospital sector examined in

Table 17.6 **Comparison of national accounts estimates of hospital sector output with direct output measure of hospital sector, Canada, 2002 to 2008**

	Average annual growth (%)	
	National Accounts	Experimental estimates
Volume index of output	4.1	4.2
Price index of output	2.7	2.8
Nominal hospital output	6.8	6.9

Source: Authors' estimates from the CIHI and Statistics Canada data.

this chapter does not include Quebec, Quebec is also not included in the estimate in the national accounts.

Nominal gross output of the hospital sector in the national accounts is estimated from total hospital expenditures in the Canadian MIS Database. Nominal gross output of the hospital sector is about 10 percent higher than total hospital expenditures, a difference that is quite stable over the period. The growth rate of nominal gross output in the hospital sector is similar to the growth rate in total hospital expenditures. The direct output measure of the hospital sector increased 4.2 percent per year, while the output measure of the hospital sector estimated as the volume index of inputs in the national accounts increased 4.1 percent per year.

Figure 17.2 displays an estimate of labor productivity (ratio of the volume index to hours worked) based on the quality-adjusted direct output measure constructed in this chapter. Hours worked for the hospital sector is obtained from Statistics Canada's Labour Productivity Program (Maynard 2005), estimated as total employment times average hours worked per worker. The employment data are from the Survey of Employment, Payrolls and Hours, which collects administrative information on employment for all establishments. The data on hours worked are from the Labour Force Survey, a monthly household survey that collects employment data for all workers.

Labor productivity in the Canadian hospital sector increased 2.6 percent per year over the 2002 to 2010 period. This represents annual growth of 4.3 percent for output and 1.7 percent for hours worked.

Based on the growth accounting framework of Solow (1957) and Jorgenson and Griliches (1967), table 17.7 decomposes growth in labor productivity from 2002 to 2008 into the contribution from investment (capital deepening), the contribution from intermediate input deepening, and multifactor productivity growth.[18] The contribution of capital deepening is estimated as the growth in capital per hours worked times the share of capital income in nominal gross output. The contribution of intermediate input deepening is estimated as the growth in intermediate input per hours worked times the

18. The data on gross output and intermediate input were available up to the year 2008.

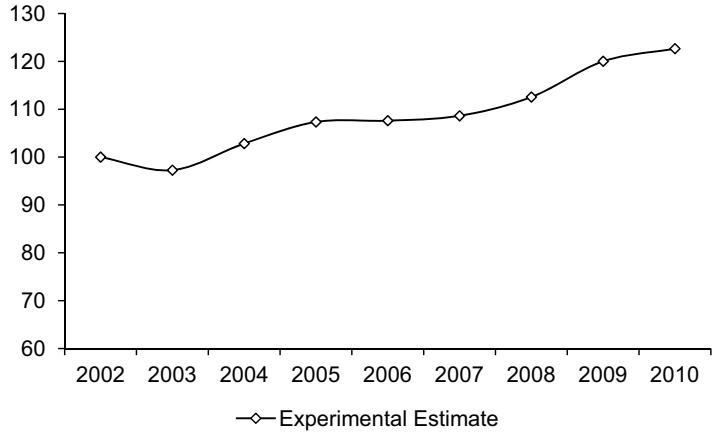

Fig. 17.2 Labor productivity in Canadian hospital sector, 2002 to 2010
Source: Authors' estimates from data from the CIHI and Statistics Canada.

Table 17.7 Sources of labor productivity growth in hospital sector, Canada, 2002 to 2008

	(%)
Labor productivity growth	2.0
Contribution of:	
Capital deepening	0.1
Intermediate input deepening	1.6
Multifactor productivity growth	0.3

Source: Authors' estimates from the CIHI and Statistics Canada data.

share of intermediate inputs. The residual component is multifactor productivity growth, which captures the effect of changes in technologies and organizations that are not embodied in investment in medical equipment.

Capital stock for the hospital sector is estimated from investment using the perpetual inventory method. The data on investment are from the annual Survey of Capital and Repair Expenditures, which collects data on capital expenditures for all business and government entities. The data on intermediate inputs are from the input/output accounts of Statistics Canada.

Labor productivity growth was largely due to intermediate input deepening, which includes expenditures on drugs. Multifactor productivity increased 0.3 percent per year over the 2002 to 2008 period.[19]

19. Because the capital income of the hospital sector in the national accounts includes only the consumption of capital, not the returns on capital, the share of capital income and the contribution of capital deepening are underestimated.

17.5 Conclusion

This chapter constructed an experimental volume index of hospital sector output by aggregating inpatient and outpatient cases using their cost share as weights. This cost-weighted activity index was corrected for substitution bias and aggregation bias. Substitution bias arises when a shift from inpatient to outpatient treatment occurs, and inpatient and outpatient cases are assigned to different case types and aggregated using their respective unit costs as weights. Aggregation bias arises when the index is constructed using a case-type classification at a high level of aggregation.

The analysis reveals a large substitution bias in the index when inpatient and outpatient cases are aggregated using their respective unit costs as weights. The substitution bias represents quality improvements stemming from shifts toward outpatient care that are not captured in the normal cost-weighted activity index.

The results of this study are consistent with the OECD recommendation that inpatient and outpatient cases not be separated for estimating the cost-weighted activity index (Schreyer 2010). Rather, they should be grouped together if they make a similar contribution to health outcomes. However, this is not always feasible, because they are frequently assigned to different case types using different classification systems. In such instances, the cost-weighted activity index may seriously underestimate the volume index of hospital services when there has been a shift toward cheaper outpatient treatment that yields similar or improved health outcomes.

The quality-adjusted estimate of the direct output measure of the hospital sector increased 4.3 percent per year over the 2002 to 2010 period. The price index of the output of the hospital sector increased 2.7 percent per year, slightly faster than the growth in the price index of gross domestic product. Labor productivity in the hospital sector based on the direct output measure increased 2.6 percent per year.

This chapter focuses on quality changes in the hospital sector as a result of the trend toward outpatient treatment of diseases/conditions that formerly had been handled on an inpatient basis. The study does not address the effect of quality improvements within the same types of treatments on the volume index. Dawson et al. (2005) found evidence of quality improvement within the same type of treatments, but the effect was not nearly as large as that arising from the substitution of outpatient for inpatient treatment described in this chapter.

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