Experimental Measures of Output and Productivity in the Canadian Hospital Sector

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1. Introduction

The issue of how efficiently resources are used in the hospital sector and other health care sectors has been a major concern in Canada and other OECD countries. While various measures of efficiency for the business sector are available from the Canadian System of National Accounts, such measure of efficiency for the hospital sector is not available from the National Accounts in Canada and other countries. The volume of output of the hospital sector in the existing Canadian System of National Accounts is measured by the volume of the inputs and it is estimated by deflating the nominal value of the hospital sector output by the price of the inputs (Statistics Canada, 2001). This input-based approach to measuring the output essentially assumes that there is no productivity growth in the hospital sector.

The weakness of the existing approach to the measurement of the output of the hospital sector and other healthcare service sector has been recognized in Canada and many other countries (Statistics Canada 2001, Schreyer 2010). Attempts have been made to develop direct quantity measures of the output of the hospital sector and other health care service sectors in a number of countries. Dawson et al. (2005) present various approaches for measuring the output of the healthcare sector and develop experimental measures of the healthcare sector output. Aizcorbe and Nestoriak (2010) develop a price index of medical care services that can be potentially used to construct a real output and productivity measure of medical services. A quantity measure of healthcare has been also developed in other countries--including Australia, Germany, and Netherlands (see Schreyer, 2010 for a review of ongoing work in the OECD countries).

The objective of this paper is to develop an experimental index of output for the Canadian hospital sector which can be compared with inputs to measure the productivity

performance of the hospital sector. It uses the approach as outlined in the OECD Handbook on the measurement of the volume output of education and health services (Schreyer, 2010) and collects data to implement it for Canada. It is but a first step in asking whether data can be developed to improve our measurement system.

The output index used here is based on the number of treatments and procedures that the hospital sector provides for inpatients and outpatients. More specifically, the output index of the hospital sector is derived by aggregating the number of treatments and procedures across different categories using their unit costs as weights.

The rest of the paper is organized as follows. Section 2 outlines the methodology used for constructing the output index of the hospital sector. Section 3 presents the data sources that were brought together for this exercise. Section 4 presents our estimate of the output of the hospital sector and compares it with the estimate in the Canadian National Accounts. Section 5 concludes the paper.

2. Methodology

The paper adopts the approach for measuring the output of the hospital sector as outlined in Schreyer (2010). The approach is also proposed by the U.S. National Research Council (2010) and Eurostat (2001).

These studies make a distinction between activities, outputs, and outcomes. Activities refer to the number of interventions or the number of patients treated. Outputs refer to the complete course of treatment of a disease or a condition which may require a bundle of activities. The outcomes refer to the characteristics of output that affect health. Schreyer (2010) argues that ideally, one would like to be able to identify all activities received by a patient as they undergo a course of treatment, and measure output in terms of the number of complete treatments of a disease (Eurostat, 2001). This is not

possible with the data systems currently available in Canada; therefore, our estimate of output indices will be based on activities.

In this paper, the unit of output for measuring the hospital service is the number of treatments that patients received. The volume index of the hospital sector output is constructed using data on unit costs to aggregate the number of treatments by different categories. Tornqvist aggregation is used.[1]

The volume index of the hospital sector output Q can be expressed as follows,

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

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

where q_i is the number of treatments for category i, c_i is the unit cost per treatment for category i, and s_i is the share of treatment in a category in total costs.

The changes in outcomes of treatment over time can be used to make quality adjustment for constructing the price and quantity index of the hospital care output. If the increases in the costs of treatment of a disease can be partly attributed to improvement in the outcomes of treatment (such as survival, quality of life, longevity), some of the increase in costs should be counted as an increase in the volume of the hospital sector output rather than increases in the price of the hospital sector output. However, for this paper, we will not make a quality adjustment in constructing a quantity index of the hospital care.

3. Data

The volume index of the hospital care in this paper covers two main activities of hospitals: inpatient hospitalizations and day procedures. Inpatient treatment statistics are

[1] Alternatively, Fisher aggregation can be adopted to construct the volume index. The results are similar.

obtained from the Discharge Abstract Database (DAD) from the Canadian Institute for Health Information (CIHI). Day procedure statistics are obtained from the DAD and the National Ambulatory Care Reporting System (NACRS).[2]

The Discharge Abstract Database (DAD) captures administrative, clinical and demographic information on hospital discharges (including deaths, sign-outs and transfers) for all provinces except Quebec. Data from Quebec is submitted to CIHI and is included in the Hospital Morbidity Database (HMDB). A number of provinces also use the DAD to capture day procedures. Day procedure statistics for Ontario are obtained from NACRS. Currently day procedure statistics are not available for two provinces (Quebec and Alberta).

The inpatient cases in the DAD are assigned to Case Mix Groups or CMG with a complexity/ comorbidity level and age adjustment. The CMG is a classification methodology for grouping acute care inpatient cases with similar clinical and resource utilization characteristics.[3] The assignment is based on the most responsible diagnosis according to the International Classification of Diseases (ICD). The CMG methodologies have changed over time. The most recent change was introduced in 2005 to take advantage of increased clinical specificity of ICD-10 and CCI. A change to the CMG methodology was also made in 1997 to introduce complexity overlay. There are 560 CMG categories for the period 2005 to 2010 and 478 categories for the period 1997 to 2004.

As the resource utilization differs with the severity of disease and the age of the patients, the CIHI calculates Resource Intensity Weights or RIW which measure the relative resource utilization of patients for each CMG, complexity/comorbidity and age

[2] Those databases have been used by Yu and Ariste (2009) to construct the volume index of the hospital sector output for the periods 1996 to 2000 and 2003 to 2005.

[3] A similar classification methodology is adopted in other countries and is called diagnosis related groups (DRGs) (OECD, 2010).

category. For the 1997 to 2004 period, four complexity levels (no complexity, chronic condition, serious/important conditions, and potentially life threatening conditions) and three age categories (0-17, 18-69 and 70+) are used (CIHI, 2002). After 2005, more detailed age categories and six comorbidity levels are used to capture the differences in resource utilization between cases (CIHI, 2009). The resources required for older patients and patients with higher complexity/comorbidity level are higher.

A key feature of the RIW methodology is that the RIW for all typical inpatient cases is averaged to a value of one each year. Atypical cases (e.g. deaths, transfers and long stay cases) are assigned an RIW based on the typical RIW for that case adjusted for length of stay and cost curves defined through statistical techniques (CIHI, 2002. 2009). The RIW is used by CIHI to calculate the Average Cost per Weighted Case (CPWC) or average cost of an inpatient case weighted by its RIW in order to provide a cross-sectional comparison of institutional workloads and costs.

For the purpose of this paper, the resource intensity weights provide relative costs for specific CMG, complexity/comorbidity levels, and age categories. The RIW can be used to calculate the share of each category of treatments in the total costs for aggregating the number of treatments across different categories to derive the volume index of hospital sector (equation 1).

Day procedure statistics are obtained from the DAD for all provinces except Quebec, Ontario and Alberta. Day procedure statistics for Ontario are obtained from the National Ambulatory Care Reporting System (NACRS). Day procedures in the DAD are assigned to Day Procedure Groups (DPGs) and those in the NACRS are assigned to Comprehensive Ambulatory Classification System (CACS). Day Procedure Groups (DPG) and Comprehensive Ambulatory Classification System (CACS) are a national classification system for ambulatory hospital care patients that focus on the area of day procedures. Patients assigned to the same DPG or CACS groups represent a

homogeneous cluster with similar clinical episodes and requiring similar resources. The DPG grouping methodology is based on the CCI (the Canadian Classification of Health Interventions (CCI)[4].

Each DPG and CACS group is assigned a resource-intensity weight (RIW). The RIW for DPG and CACS are comparable to the inpatient RIW for CMG. The comparability of RIW for DPG, CACS and CMG means that the volume index of inpatient treatments and day procedures can be combined to derive the volume index of the hospital sector output.

4. The Volume Index of Output of the Hospital Sector

This section presents our estimate of the volume index of the output of the hospital sector for the period 2002 to 2010. The choice of the period for this study is determined by data availability. The CMG grouping methodology with complexity overlay was introduced in 1997. One of the main databases used for his paper -- the Discharge Abstract Database (DAD) -- was not available to us for the fiscal years 1999/2000 and 2000/2001. The data in the health databases (DAD and NACRS) are all based on fiscal years, and they have been converted to calendar years based on the months during which treatments are provided. For those various reasons, we will focus on the period 2002 to 2010.

Inpatient care statistics for Quebec are not included in the DAD databases that are used to calculate the number of inpatient treatments. Instead, inpatient care statistics for Quebec are available from the HMDB database, but only for the period up to fiscal year 2005.[5] Day procedure statistics for Quebec, Ontario, and Alberta are not included in the DAD. Day procedure statistics for Ontario are obtained from NACRS. Our estimate of

[4] The CCI was developed to accompany the Canadian version of the International Classification of Disease (ICD).

[5] The data for Quebec from the HMDB after 2005 are available at the Canadian Institute for Health Information, but not available for use at Statistics Canada.

the quantity index of hospital care will exclude Quebec for inpatient care, and exclude Quebec and Alberta for day procedures.[6]

Table 1 presents the structure of total costs for the hospital sector in year 2007. The inputs used in the hospital sector include capital (medical equipment and buildings), labour (doctors, nurses, janitors, etc.), intermediate inputs (energy, purchased materials such as drugs and purchased services). The largest component of total hospital expenditure is the wages and salaries of doctors and nurses, which accounted for 61% of total expenditures in 2007. Intermediate inputs accounted for 32%. The consumption of capital was the smallest component, accounting for 5% of total expenditures in 2007.

Figure 1 presents the number of inpatient treatments and the number of day procedure cases over the period 2002 to 2010. There was little change in the number of inpatient treatments while the number of day procedures increased. The number of inpatient cases increased from 2.36 million in 2002 to 2.41 million in 2010. The number of day procedure cases increased from 1.18 million in 2002 to 2.02 million in 2010. The relative growth of day procedures compared with inpatient treatments has been reported previously (CIHI 2007). This has been attributed largely to a shift in elective surgeries from an inpatient to a day-surgery setting (CIHI 2007).

Table 2 presents the volume index of hospital care over the period 2002 to 2010. The volume index is constructed from a Tornqvist-aggregation of the number of cases, cross-classified by CMG, complexity/co-morbidity, and age groups using their cost shares as weights. The volume index of inpatient care increased at 0.6% per year over the period 2002 to 2010. The growth of the volume index of inpatient care was higher than the growth in the number of unweighted inpatient care cases. This difference was due to the increasing share of cases accounted for by the elderly, which are more

[6] Quebec accounted for 21% of the total hospital expenditures in Canada in 2008, Alberta accounted for 12%.

resource-intensive. CIHI (2007) found that the share of total cases accounted for by persons over 70 rose from 23.7% in 1996-1997 to 25.5% in 1999- 2000. This trend continued after 2000 as a result of the aging population. Other factors contributing to that difference include the increase in the number of cases that involved new resource intensive technologies, and the transfer of cases from inpatient to outpatient care.

The volume index of day procedures increased at 8.0% per year over the period 2002 to 2010. The increase was faster than the growth in the unweighted number of day procedure cases, which reflects the shift in the day procedures towards those that use more resource-intensive technologies.

The last column of table 2 presents the volume index of the hospital care by aggregating inpatient care and day procedures using their relative cost share as weights.[7] The volume index of hospital care increased at 1.7% per year. The growth in the volume index of hospital care was less than the growth in the total number of the inpatient and day procedure cases. The difference reflects the compositional shifts in hospital care towards day procedures, which are less resource intensive.

The increase in the number of day procedures largely reflects the shifts in elective surgeries from an inpatient to a day-procedure setting. As the day procedures are less costly than inpatient care, this shift reduced the overall growth of the volume index of the hospital care. But to the extent that the patient values day procedures and inpatient care equally, the cost-weighted index constructed using unit costs as weights will under-estimate the growth in the volume index of the hospital sector. This possible bias in the cost-weighted output index has been noted previously (Schreyer 2008).

Table 3 compares the growth rate of our estimate of the volume index of hospital care with that from the National Accounts. The two estimates are also plotted in Figure

[7] The share of day procedure in total costs is calculated from RIW in the DAD. It was 11.7% in 2002 for the eight provinces whose statistics on both inpatient case and day procedures are included in the DAD (Quebec and Alberta are not included in the DAD).

2. The estimate of the gross output of the hospital sector is obtained from the annual input/output accounts of Statistics Canada which are available up to year 2008. As the hospital sector in this paper excludes Quebec, we also excluded Quebec in the National Accounts estimate. The table also compares the growth in the price index of the hospital care from National Accounts with our estimate. Our estimate of the price index of the hospital care is constructed by dividing the nominal value of gross output by our estimate of the volume index of the hospital care.

The volume index of the hospital sector output increased at 1.3% per year over the period 2002 to 2008, while the volume index of the hospital sector from the National Accounts increased at 4.0% per year over the same period. Our price index of the hospital care increased at 5.3% per year over the period 2002 to 2008, which was faster than the rate of growth in the price of output of the hospital sector derived from the National Accounts.[8] Our estimate of the price of the hospital sector output also increased at a faster rate than that of gross domestic product in the Canadian economy. The price of real gross domestic product in the Canadian economy increased at 3.2% per year over that period.

The last row of Table 3 and Figure 3 presents the annual growth of labour productivity in the hospital sector. The present estimate of labour productivity in the hospital sector derived from National Accounts shows an increase of 1.9% per year over the period 2002 to 2008.[9] The estimate shows that labour productivity declined at 0.8% per year over the period 2002 to 2008.

[8] Our estimate of the rate of increase in the price of hospital care for Canada is similar to the estimate of the price of the medical care for the U.S. in Aizcorbe and Nestoriak (2010). They estimated that the price of medical care for the U.S. increased at 11% from 2003:1 to 2005:4.

[9] The volume of the output in the hospital sector is measured by the volume of the inputs in the Canadian System of National Accounts. The growth rate of the output should be similar to the growth rate of the combined inputs in the hospital sector which includes capital, intermediate, and labour inputs. The fact that the output increased faster than total hours worked suggests that the total costs of drugs and investment in medical equipments and building increased faster than the number of doctors and nurses in the hospital

After 2008, labour productivity increased in the hospital sector (as shown in Figure 3). Over the period 2002 to 2010, labour productivity in the hospital sector was virtually unchanged. The decline in labour productivity in the hospital sector between 2005 and 2008 was a result of a large increase in the number of doctors and nurses in the hospital sector over that period (shown in Figure 4) that was not accompanied by a similar increase in the number of inpatient and day procedure cases. The increases in the doctors and nurses in that period coincided with the large increases in health expenditures following the 2004 health accord between the federal government and provinces.

5. Conclusion

This paper has constructed an experimental volume index of the output of the hospital sector following recent suggestions for measurement of output in this area. The volume index is estimated from aggregating the number of treatments and procedures for inpatient care and day procedures of different categories using their cost share as weights. This resulting volume index of the hospital care increased at 1.7% per year over the period 2002 to 2010. The price index of the hospital sector output increased at 5.3% per year over the period 2002 to 2008. The price of the hospital sector output increased at a faster rate than that of gross domestic product in the Canadian economy. The price of real gross domestic product in the Canadian economy increased at 3.2% per year over that period.

Labour productivity in the hospital sector calculated using this volume index was virtually unchanged over the period 2002-2010, as the growth rate of hours worked was similar to the growth rate of the volume index of output in the hospital sector.

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sector. For the period 2002 to 2008, the data from the Annual input/output tables shows that the intermediate input in constant dollars increased at 7.1% per year in the hospital sector which is faster than the annual growth of 2.1% in hours worked for that period.

It is important to note that the experimental measure of the hospital sector output provided by this study does not take into account possible improvements in the quality of hospital care that took place over this time period. To the extent the quality in hospital care increased, labour productivity based on a quality-adjusted volume index of hospital care would be higher. Furthermore, our measure of the hospital sector output is based on unit costs as weights. A measure that is based on the price that the patients are willing to pay for hospital care (or shadow price) could show a faster increase in the volume index of hospital sector output than the one based on unit costs as weights. A volume index of hospital sector output based on shadow prices as weights might show a higher rate of growth in labour productivity in the hospital sector over the period 2002 to 2010 than that presented here.

Future work could integrate our measure of output for the hospital sector in a growth accounting framework that provides a more comprehensive multifactor productivity growth measure for the hospital sector (Jorgenson et al., 2005). Future work might also focus on the development of a quality-adjusted measure of the hospital output to provide a more accurate measure of productivity of the hospital sector.

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Table 1
The cost structure of the Canadian hospital sector, 2007

	Million dollars
Intermediate inputs	16,811
Net taxes	833
Labour income	31,908
Other operating surplus	2,728
Total costs	52,281
	Percent of total costs
Intermediate inputs	32.2
Net taxes	1.6
Labour income	61.0
Other operating surplus	5.2
Total costs	100.0

Sources: Tabulations from input/output tables of Statistics Canada.

Table 2
The volume index of output of the hospital sector

	Inpatient treatments		Day procedures		All	
	No of treatments	Volume index	No of procedures	Volume index	No of procedures	Volume index
2002	2,356,831	100.0	1,184,308	100.0	3,541,139	100.0
2003	2,348,664	99.5	1,214,654	103.9	3,563,318	100.0
2004	2,415,560	100.8	1,344,605	119.6	3,760,165	103.0
2005	2,442,606	101.3	1,474,170	134.3	3,916,776	105.0
2006	2,398,748	98.3	1,581,470	145.3	3,980,218	103.5
2007	2,402,617	99.6	1,673,311	155.0	4,075,928	105.7
2008	2,388,758	100.7	1,779,115	167.4	4,167,873	108.0
2009	2,400,698	103.2	1,975,697	184.9	4,376,395	112.1
2010	2,405,770	105.2	2,018,235	190.0	4,424,005	114.5
Average % growth over 2002-2010						
	0.3	0.6	6.7	8.0	2.8	1.7

Note. Inpatient treatments exclude Quebec. Day procedures exclude Quebec and Alberta.

Table 3
The annual growth rates of the output and labour productivity in the hospital sector, 2002-2008

	National accounts	Experimental measure
Volume index of output	4.0	1.3
Price index of output	2.6	5.3
Hours worked	2.1	
Labour productivity	1.9	-0.8

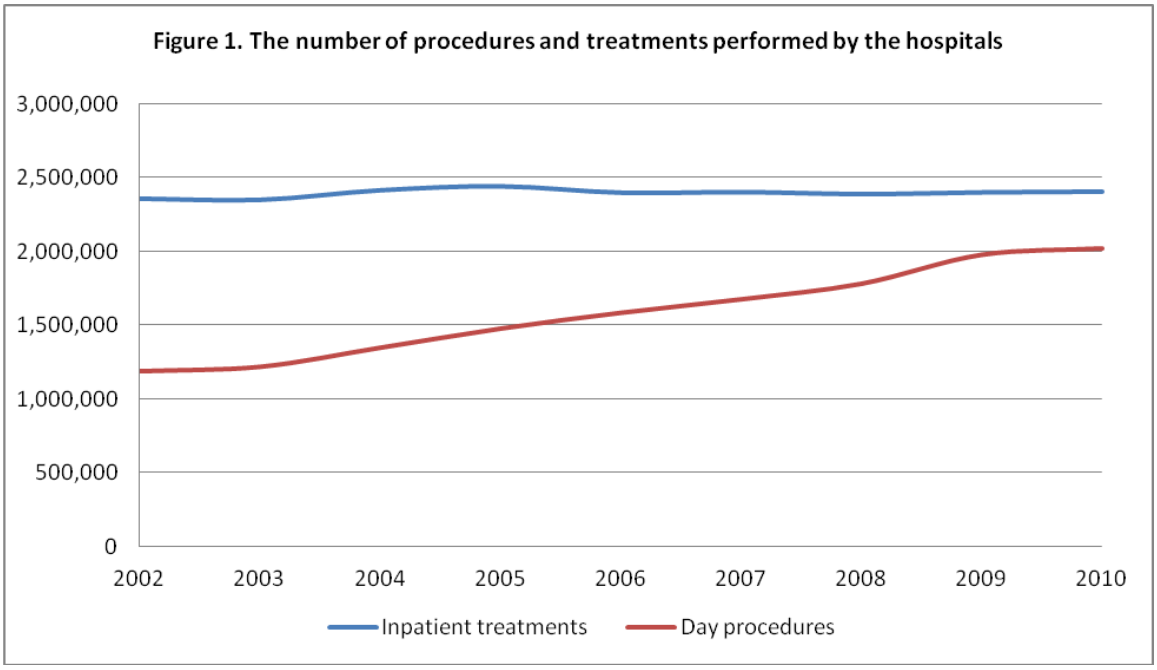
Figure 1. The number of procedures and treatments performed by the hospitals
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
Inpatient treatments
Day procedures

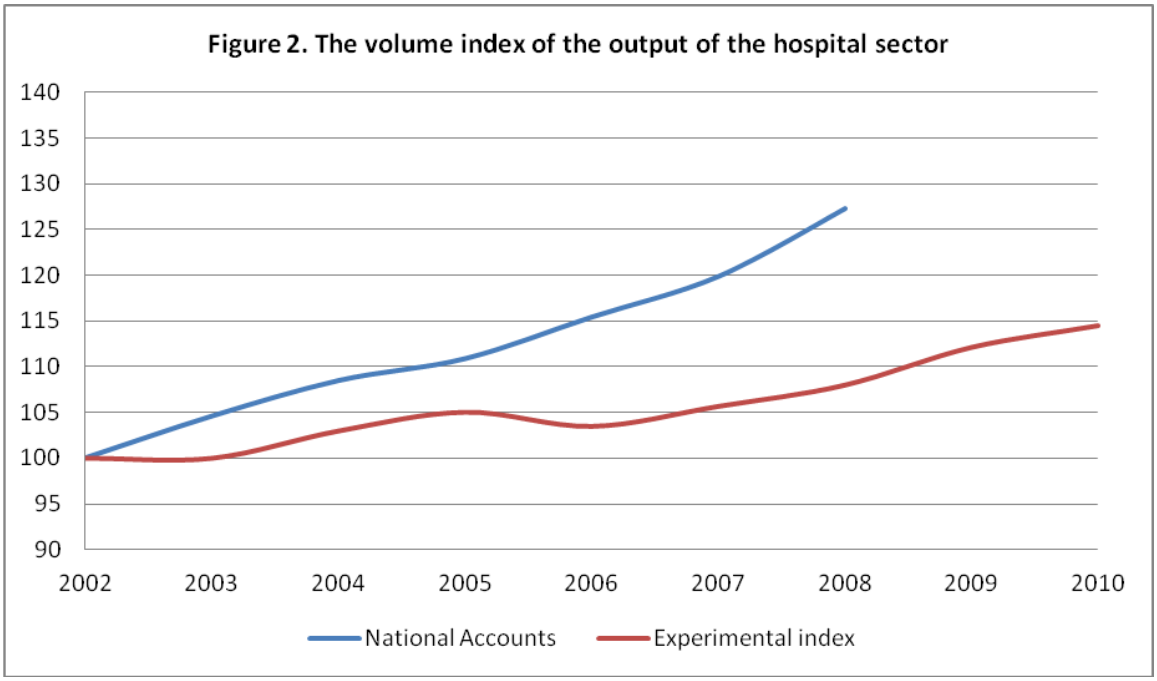
Figure 2. The volume index of the output of the hospital sector
140
135
130
125
120
115
110
105
100
95
90
2002
2003
2004
2005
2006
2007
2008
2009
2010
National Accounts
Experimental index

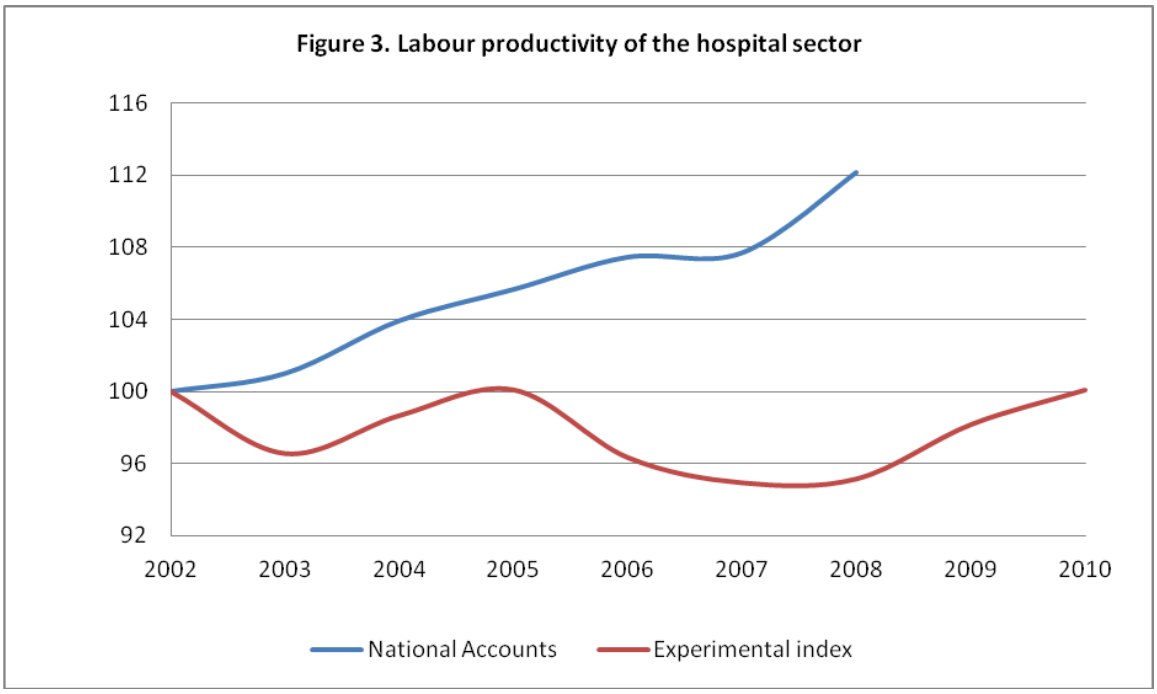
Figure 3. Labour productivity of the hospital sector
116
112
108
104
100
96
92
2002
2003
2004
2005
2006
2007
2008
2009
2010
National Accounts
Experimental index

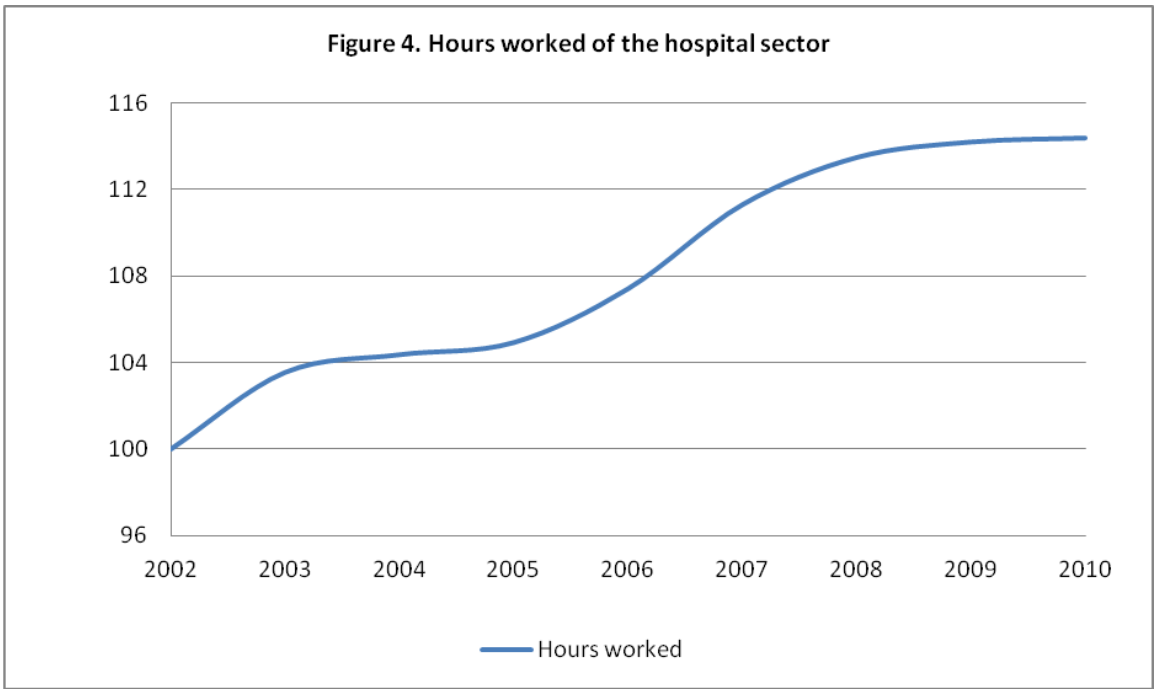
Figure 4. Hours worked of the hospital sector
116
112
108
104
100
96
2002
2003
2004
2005
2006
2007
2008
2009
2010
Hours worked