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**Economics MA Paper**

**The determinants of drug expenditure in Canada**

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**Abstract**

Drug spending is one of the most fast-growing components in Canadian health care spending due to its financial and clinical importance. This paper uses data from Statistics Canada and the Canadian Institute for Health Information (CIHI) to find out the determinants of provincial drug expenditure from 1981 till 2014. During this period, provincial government spending on drugs was changing rapidly and was coupled with policy changes. This paper includes a variety of socioeconomic, demographic variables, and provincial dummies. Real per capita provincial government drug spending and real provincial government drug spending are dependent variables in two regression equations. Ordinary Least Squares (OLS) technique is used in the statistical analysis and then is followed by Generalized Least Squares (GLS) estimates. Log-linear and log-log forms are estimated. The statistically significant variables in the results are real per capita GDP, proportion of population aged 45-64, 65-74, 75-84, family physicians per 1000 population, provincial government hospital expenditure as a share of provincial government health expenditure, private sector health expenditure as a share of total health expenditure, and some provincial dummies. In general, Ontario and Quebec have the largest provincial spending among 10 provinces. The results from this paper are consistent with previous studies in related fields.

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**Table of contents**

Abstract………………………..………………………………………………….….…………....1

Acknowledgement………………...…..…………………………………………………...…..….2

1. Chapter 1: Introduction……………………………….……………………………….………..4

2. Chapter 2: Literature Review………………………….…………………….………………….7

* 1. Pharmaceutical evolution……………….…….…………………………..….….….…7
  2. Policy change………………………….….………………………………….….....….8

2.3 Provincial coverage……………………………………...………………….…….....11

2.4Market failure…………………………………….………………………….…..…...12

2.5 Determinants of drug expenditures……………..….……………………….….....….13

3. Chapter 3: Data description…………………………………………………………………...17

3. 1Overall Trends in Provincial Government HealthExpenditure …….……….….......17

3.2 Province Specific Trends in Provincial Government Health Expenditure ...……......18

4. Chapter 4: Empirical Model & OLS Estimates...………………………………………..........25

5. Chapter 5: Results for GLS Estimates..…………………………………………….….….......35

6. Chapter 6: Discussion..…………………………………………………………….….…........35

7. Chapter 7: Conclusions…………………………………………………………………….….42

References……………………………………………………………………………….…….…44

Appendix…………...……………………………………………………………….…..……......47

**1. Introduction**

Drugs are one of many critical components in the Canadian health care system due to their clinical and financial importance. Drug spending has grown faster than other health care components such as physician spending. Thus, drug spending became the second-largest category in Canadian health care spending over the past twenty years (CIHI, 2014). As identified in the Canadian Institute for Health Information (CIHI) report, expenditure on prescription drugs outside of hospitals grew at an average rate of 10.6 percent annually between 1985 and 2005, and with a growth rate of 7.6 percent between 2005 and 2010. During the period 1997-2007, Canadian per capita drug expenditure grew at an annual rate of 5.2 percent compared to 6.1 percent in U.S., making Canada the second largest country worldwide in terms of average annual growth rate (CIHI, 2014).

There are several sources of financing for the Canadian health care system. They consist of provincial governments, federal transfers, and social security funds, which are included in public expenditure. Private insurers and individuals paying for their own health care are important private sources of expenditure. According to CIHI report (2016), the public sector financed 42.6 percent of the drug expenditure in 2014 whereas private insurers and individuals’ out-of-pocket financed 35.2 percent and 22.2 percent respectively. Accordingly, the provincial government has significant effect on the health care market although the share of drug expenditure in total health care spending varies from one province to another. As shown in Figure 1 and Figure 2, total provincial government health and drug expenditures can be broken into three periods: the slow growth rate before 1997, the rapid growth from 1997 to 2010, and the slower growth after 2010.

The aim of this study is to examine the determinants of real per capita provincial government drug expenditure and real provincial government drug expenditure in Canada by using province-level data between 1981 and 2014. Regression analysis relates a variety of socioeconomic, demographic variables, and provincial dummies to real per capita provincial government drug expenditure and real provincial government drug expenditure. The study focuses on provincial drug expenditure since provincial spending accounts for large portion of total health care expenditure.

Additionally, the change in provincial government spending – namely the extension of provincial government drug plans had a profound effect on the pharmaceutical market. There has been a positive relationship between drug spending and economic growth in Canada since the 1970s (CIHI, 2016). In this paper, drug spending is shown to have a positive relationship with real per capita GDP growth. In other words, the demand for drugs is likely to increase with the increase in per capita income as shown in Figure 3. Population aging is a highly significant factor in this study since drug demand is also likely to increase with aging. Seniors are more likely to develop chronic disease that cost even more. This study also included province-specific constant terms to allow comparisons among provinces. In general, Ontario and Quebec spend more compared to other provinces in all models. Furthermore, family physicians per 1000 population, provincial hospital spending as a share of provincial government health spending, and the private sector health spending as a share of total health spending are significant contributors to drug expenditure in all models. These factors are significant since they are highly related to drug prescriptions. The increasing number of physicians is especially important since more prescriptions will lead to a rise in provincial drug expenditure.

The next section presents a literature review of the health care system in Canada. The third section provides an overview of the data. The fourth section presents the specifications of the regression models in this study. The fifth section presents empirical results and discusses the implications. The last section provides a conclusion to this paper.

**2. Literature review**

**2.1 Pharmaceutical evolution**

Historically, there have been three waves of innovation associated with the rising significance of pharmaceuticals (Morgan, 2008). The first wave began with the discovery with anti-infective medications around World War II period (1939-1945). The growth in anti-infective medicines was life-saving, especially for war veterans, and was associated with the development of therapeutic technologies. It is the innovation of medications and technologies during and prior to war that changed the way many health conditions were treated. The revolutionary change also contributed to the huge increase in drug spending after the war. In 1969, the Canadian government fortified compulsory licensing. This granted generic products market power to compete against patent-holders and therefore reduced the drug prices. At that time, government assistance program was intended to help those who lacked access to drugs since most of people could not afford them. Because of the compulsory licensing, drug innovations came at a much slower growth rate in 1970s.

In between the 1970s and 1980s, there was the second wave of drug innovation – the so called ‘rational drug design’ era. In this period, technology growth and drug development improved the efficiency of drug use and raised the costs associated with it dramatically (Mowery, 2004; Temin, 1980). As a result, the financial cost rose with improved quality of treatment. It is important to note that many of the drugs developed in that period have the same importance today. Pharmaceuticals therefore became the second-largest element in healthcare spending in Canada (CIHI, 2012).

The third wave occurred since 1997 when the pharmaceutical industry promoted ‘disease management’ healthcare with rising marketing activities. In this period, firms were spending lots of money on R&D but yielding little in the way of innovations. These chronic disease management drugs are typically brand-name and patented drugs for a long period of time at a rising cost. Therefore, the third wave was identified as change in marketing strategies as well as the upward trend of shifting drug treatment target to manage chronic diseases.

**2.2 Policy change**

While it has been a long time since universal Medicare was established, universal pharmacare has never been available to Canadians due to various reasons including the consideration of the financial burden on public health spending (Morgan, 2012; Di Matteo, 2010, 2013). As a result of the Hospital Insurance and Diagnostic Services Act of 1957, Canadian standards for hospital insurance were created. Then, medical insurance for physician services followed with the Medical Care Act of 1966. But since then, no more federal legislation on universal coverage has followed. Since no national level drug insurance program existed, the ten provinces and three territories established their own health care insurance over the period 1970 to 1980. Staring from late 1970s, the pharmaceutical industry has experienced nearly exponential growth in new drug introduction. This market expansion is also associated with significant price increases in that period (Mowery, 2004; Temin, 1980; Morgan and Daw, 2012).

Di Matteo and Grootendorst (2007) illustrated the timeline for drug patent policy. In 1969, Canadian government modified the ‘compulsory licensing’ rules by allowing generic drug producers to produce and sell patented products. This modification is due to the concern over high drug prices and low R&D levels prior to late 1980s. In 1987, the government weakened ‘compulsory licensing’ as part of US-Canada Free Trade Agreement.

Further international negotiations and promises by pharmaceutical industry to increase R&D levels led to the elimination of compulsory licensing under Bill C-91. As a result, Bill C-91 in 1993 eliminated compulsory licensing and it granted firms 20-year patent terms. Bill C-22 gave the power of market exclusivity of seven years to patentee firms.

The introduction of a series of government policies in this period also reduced the patentees’ profit (Vandergrift and Kanavos, 1997; Anis, 2000). First, in 1987, Canadian government established the Patented Medicine Prices Review Board (PMPRB) as provided for in Bill C-22 (Di Matteo and Grootendorst, 2007; Lexchin, 1997). The PMPRB is responsible to make sure the increase in patented drug price is below those of the CPI for a period of time. Second, provincial governments have reduced their subsidies to subsidy recipients through beneficiary co-payments, prescribing restrictions and other cost control methods. These methods were expected to reduce public spending if consumers were sensitive to price changes and therefore reduce industry profit. Since the 1990s, the co-payment and co-insurance were prevalent in Canada since it could rationalize patients’ consumption behavior. Both of them can reduce financial burden on health care insurers by having payments from consumers. The co-payment means pay certain amount for the health service while the co-insurance means pay a percentage of the health service after meeting any deductible (Di Matteo and Marchildon, 2014).

In the 1990s, British Columbia tried to bring drug expenditures under control by introducing a series of evidence-based drug coverage policies, including ‘reference based pricing’. The reference-based pricing policy as defined by BC Pharmacare would only give subsidies according to the lowest drug price within a class. Morgan and Cunningham (2008) tried to find the effects on pharmaceutical R&D spending in BC after the implementation of such policies. They first looked for changes in inflation-adjusted R&D spending per capita in BC. Then, they compared the trend in BC to other provinces looking for factors that may affect R&D spending other than the Pharmacare policies. Also, they apply ordinary least squares (OLS) regression to a set of data between 1988 and 2006. Morgan and Cunningham (2008) claimed that there were no significant changes in R&D spending in real terms in BC compared to rest of Canada. The pharmaceutical spending in BC has consistently been at low level. Furthermore, they pointed out that the technical infrastructure and scientific capacity may play key roles in local R&D level.

Di Matteo and Grootendorst (2002) examined a collection of social, demographic, economic, and policy variables that may have an impact on real per capita provincial drug spending. They use provincial data from 1975-2000 to compare the trend of public drug spending in each province. Due to nationwide budget control strategies and the change in Bill C-22 and Bill C-91, policy was expected to change the pattern of drug spending. The year variable captures the changes following patent extension in 1987 and the elimination in 1993. Their results indicated that although there were some variations in each province, the relationship between income and public drug spending was not significant for most of the provinces. They also demonstrated that provincial government receiving federal transfers may not increase drug spending. Population aging was a key determinant since spending rose dramatically after age 65. Seniors were the main target of public coverage but interestingly spending growth moderates after age 75. Furthermore, the change of insurance policy reduced public drug spending since the introduction of co-payment plan.

**2.3 Provincial coverage**

Starting from the 1970s, many provinces started to generate savings by permitting generic substitution when prescribed brand name drug (Di Matteo and Marchildon, 2014). Provincial governments have financed nearly 40 percent of total spending on prescription drugs since 1990 via provincial government drug plans (CIHI, 2012). Initially, provincial medical coverage was designed to assist those who lacked access to health services, such as those in low-income group and seniors. Before 1990, BC Pharmacare pay mostly all drugs in the Canadian market for low-income people and seniors (Morgan et al., 2004). The result of this policy was a large increase in drug spending. Governments responded to this situation by enacting cost control policies.

In 1994, BC Pharmacare only covered the drug price equal to the price of its generic version. This change of the insurance policy shifted the financial burden to consumers. Additionally, BC has been included in the group of lowest-spending provinces compared to higher drug spending provinces such as Quebec, Nova Scotia, New Brunswick, and Newfoundland and Labrador.

Devlin and Wang (2016) listed six provincial subsidy programs introduced in Ontario, Manitoba, Quebec, British Columbia, Newfoundland and Labrador, and Nova Scotia. All of these programs, excluding Quebec, match drug coverage with household income. They take a closer look at Quebec since the policy in Quebec requires all residents to be covered by either public or private insurance. This means the new policy now covers those who were not covered by private insurance. The additional coverage of 22 percent of the population was expected to largely increase public drug spending. Devlin and Wang further assessed the impact of the policy in Quebec between 1985 and 2012 by using Ordinary Lease Squares (OLS) regression technique.

They use three major socioeconomic and demographic variables: real provincial GDP, the local employment rate, and senior age groups as proportions of provincial population. They find a significant increase in public drug spending after the implementation of the policy in 1997. Additionally, they find a significant decrease in per capita spending on over-the-counter (OTC) drugs after the policy change. This suggests that OTC drugs may be a substitution for prescription drugs.

**2.4 Market failure**

In Canada, it is difficult to have the market to decide the drug price by matching consumer demand and industrial supply (Morgan, 2008). This is due to the many layers of regulation, patent protection, market distortion, and price-insensitive consumers. The relationship between physicians and patients can be termed as a principal-agent problem. Physicians (the principal) act on behalf of their patients (the agents). There exists information asymmetry between physicians and patients, health care funders and patients. For example, patients generally do not have the professional knowledge to decide which drug is the best for their treatment. Therefore, it is up to physicians to decide for their patients. In addition, physicians typically have the information of how much benefit they can extract from a health service. Due to information asymmetry and moral hazard, physicians may not prescribe the cheapest generic drug available to patients but rather give them more expensive patented drugs when patients become insured (Di Matteo and Grootendorst, 2002). Patients are likely to make sub-optimal decisions due to information asymmetry and moral hazard problem. Furthermore, adverse selection occurs when information is asymmetric between health care funder and patients. For example, healthy people might choose an insurance plan that covers less whereas less healthy people might choose a more generous plan. Insurance companies will increase the premium for all people since insurers cannot sustain the excessive amount of payment for less healthy people. The healthier people will exit due to the high premium and as a result, the market will be left with less healthy people. In this situation, nobody has the power to monitor and regulate the whole system while bearing the monitoring costs except the government. The government not only pays for health services but also has large collective power to negotiate agreements for patients.

**2.5 Determinants of Drug Expenditures**

Morgan (2008) and CIHI (2012) identified several factors that have an impact on drug spending. A report conducted by Canadian Institute for Health Information (2012) uses data from 1998-2007 to show the determinants of drug costs. During the 10-year period, the average annual growth of prescription drug spending outside of hospitals was estimated to be 10.1 percent. Furthermore, CIHI report (2012) identified six major contributors to drug spending in Canada. Increased number of prescriptions as volume effect and changes in treatment mix effect were two important reasons that significantly increased drug expenditures. The increased prescriptions accounted for an average annual growth rate of drug spending of 6.2 percent whereas the change in treatment accounted for a 2 percent growth rate. The volume effect captures the changes in disease prevalence, treatment and changes in treatment guidelines. That is to say, increased disease prevalence and diagnosis play a significant role in rising per capita drug expenditure.

According to the CIHI report (2014), population growth and aging exhibited modest effects on drug spending with 1 percent annual growth rates each. However, Di Matteo and Grootendorst (2002) and Brogan Inc. (2002) reported population aging could be a significant contributor to drug spending growth. Older people (65+) are more likely to develop chronic disease than other younger age group. As a result, it is reasonable to presume that aging increases drug spending. General inflation accounted for 2.6 percent of average annual drug spending growth rate while price effects accounted for a negative 2.7 percent, suggesting that price growth was at a rate much lower than inflation.

Morgan (2008) suggested that a large proportion of the increase in drug spending in recent years was mainly due to two reasons: increased drug use to treat common conditions and the tendency to select new and expensive drugs. One patient taking more drugs rather than many patients taking one drug is defined as poly-therapy and this accounted for nearly half of drug spending trends.

In a research conducted by Di Matteo and Grootendorst (2007), they tried to find the effects on drug spending, prices and R&D due to patent policy change. They included the R&D spending in the motor vehicle sector as a control group for R&D tax credits and other factors that might increase R&D spending in pharmaceuticals. The research indicated that the policy change in 1987 was associated with a significant growth in R&D spending of 4 billion (1997 dollars). They further estimated the effects of changes in the Patent Act and the decrease in public subsidies by running an OLS regression on data from 1988 till 2002.

The dependent variable is provincial total retail prescription drug spending. The independent variables are year, region dummies, lagged real public drug spending, and other variables that include: real per capita GDP, different age groups as proportions of population (18-44, 45-64, 65-74, 75+), and per capita number of physicians. Their results suggested that there were no remarkable changes following the patent term extension in 1987. They identified a dramatic increase in total expenditure in 1996. The patent term extension and drug price control might have caused the delayed growth in drug costs. They pointed out that there was huge variation in drug spending among provinces. Drug spending increases with older age groups. They also found a U-shaped relationship between physician numbers and drug spending. The result suggested that drug use increases when people have access to more physicians but eventually decreases as more physicians are available.

Another paper by Di Matteo (2005) used US and Canadian data to assess the effect of income, age and time on health expenditures. The finding pointed out that these three factors are positively associated with per capita health spending. In the paper, age is an important factor in both simple and complex estimated models. The more complex model suggested that time is more important since it captures the technological changes and explains two-thirds of the growth in real per capita health spending. Some of the technological changes include the innovation of new drugs. However, the drugs on the market today are mostly still the replicates of those blockbuster drugs since the 1980s. New drugs are competing for the market share with old drugs and while they are not necessarily better, they are definitely more expensive than their generic versions. These new ‘me-too’ drugs are four times more expensive than old drugs in the same class (Morgan, 2008). While those old drugs are considered‘tried and true’, the safety and efficacy of new drugs still remain questionable due to limited data.

There is also concern over the sustainability of Canadian public health spending. Di Matteo (2010) defined health expenditure sustainability as the growth in government health spending not exceeding the growth in resource base as measured by variables, such as per capita GDP, per capita federal transfers, and per capita provincial government revenues. The finding suggested that the growth rate of provincial government health spending was at a rate higher than the rate of resource base. The economy cannot sustain the higher rate of public health spending relative to the resource base consistently. It is therefore important to find out what the major determinants of provincial drug spending are so that future cost control policies can find clearer targets.

This paper is a follow-up to work by Di Matteo and Grootendorst (2002) using data from period 1981 to 2014. This paper differs from earlier work by also using real provincial government drug expenditure as a dependent variable. Furthermore, this paper includes three expenditure share ratios to capture their effect on provincial drug spending: provincial government health expenditure as a proportion of total provincial government expenditure, provincial government hospital expenditure as a proportion of provincial government health expenditure, and private sector health expenditure as a proportion of total health expenditure.

**3. Data Description**

The data in this study are for the period of 1981 to 2014. They were collected from the CIHI and Statistics Canada. Province-specific health data on provincial government health expenditure for the period 1981-2014 were obtained in National Health Expenditure Trends data tables from Canadian Institute for Health Information (CIHI). The CIHI drug spending data underestimates provincial government drug expenditures since it excludes drug dispensed in hospitals, municipal government drug spending, and ‘social security funds’ (Di Matteo, 2002). The Canadian Socio-economic Information Management System (CANSIM) from Statistics’ Canada provided information to construct socioeconomic and demographic variables. Physician numbers in each category were obtained in Supply, Distribution and Migration of Physicians in Canada data tables from Scott’s Medical Database (SMDB) Metadata. Real Per Capita data were calculated by dividing provincial health expenditure by total population and using the Government Current Expenditure Implicit Price Index (1997 dollars) from the CIHI to convert the data into real terms. There are some data overviews and health expenditure analysis for the period 1981 to 2014 provided in this section.

**3.1 Overall Trends in Provincial Government Health Expenditure**

Figure 4 plots the per capita provincial government health expenditure in nominal and real terms (1997 dollars). In 1981, the real per capita provincial government health spending was around $1400. It rose gradually until 1992, and reached $1800 – a 30 percent increase in real per capita spending. It then declined due to the fiscal restraint in early 1990s – reached $1650 in 1996 and then started to soar again and rose to $2600 in 2010. There has been a slight decrease since 2010 and over the period 1996-2010 spending increased 60 percent. It then hit $2500 in 2014. The graph indicates a much faster growth rate from 1997 to 2010.

Figure 5 presents the per capita provincial government drug expenditure in nominal and real terms (1997 dollars). In 1981, the real per capita provincial government drug expenditure was around $40. It rose to $110 until 1992 – a 175 percent increase in real per capita spending. It then experienced fluctuations with up and down around $100 from 1992 to 1997. There has been a drastic increase since 1997 and reached $200 in 2010 and then declined gradually to $190 by 2014. The provincial government drug spending doubled over the period 1997 to 2010.

Figure 4 and figure 5 present a smooth growth at a similar growth rate from 1981 to 1996. However, while both graphs present a rapid growth rate in real dollars since 1997, the nominal growth rate is even higher.

**3.2 Province Specific Trends in Provincial Government Health Expenditure**

Figure 6 plots real per capita (1997 dollars) provincial government health expenditure. In 1981, average real per capita provincial government health expenditure was around $1450. It gradually increased to $1750 until 1992– an increase of 20 percent. It then declined – reached $1700 in 1996 and then began to shoot up again and hit $2800 in 2010. There has been a 65 percent increase in real per capita spending from 1996 to 2010. Figure 7 presents real per capita public sector health expenditure in 1997 dollars. Both of these graphs present the same trend in real per capita spending. In addition, Newfoundland and Labrador has grown from lowest spending province in 1981 to highest spending province in 2014.

Figure 8 plots real per capita provincial government drug expenditure in 1997 dollars. In 1981, average real per capita provincial government drug expenditure was $50 dollars. It inclined to $90 until 1992 – an increase of 80 percent in real per capita spending. It then slightly decreased to $80 in 1996 and then started to climb up again until reached $200 in 2010. The growth rate was much faster from 1992 to 2010. After 2010, the average spending stared to decline until reached $170 in 2014.

Figure 9 presents real per capita total health expenditure in 1997 dollars. In 1981, average real per capita total health expenditure was $2400. The growth rate has not change much over the period 1981-1996. It then started to shoot up again since 1997 and reached $5000 in 2014 with a doubling in real per capita spending. The growth rate over the period 1997-2014 is much higher than 1981-1996.

Figure 10 plots real per capita private sector health expenditure in 1997 dollars. In 1981, average real per capita private sector health expenditure was $600. It then gradually rose to $700 in 1996, which was a 15 percent increase in real per capita spending. The average health expenditure started to incline again at a much faster pace since 1997 and reached $1400 by 2014. Based on the graph, the health spending in private sector has kept increasing over time with no significant decline. In addition, New Brunswick has the highest private sector spending in 2014.

Finally, figure 11 presents the relationship between real per capita (1997 dollars) provincial government drug expenditure and physicians per 1000 people. The scatter plot indicates the number of physicians has a positive relationship with drug expenditure. Over the period 1981-2014, number of physicians per 1000 people were between 1 and 2.5 across all provinces . Most provinces have 1.5 to 2 physicians with real government drug spending of $50 to $180 dollars per person. There are no extreme outliers outside of 1-2.7 physicians’ region based on the graph.

All graphs indicated that the growth rate was much higher over the period 1997-2010. According to CIHI (2016), the slowdown in total health spending before 1997 was due to the reason that governments tightened their financial budgets in the wake of the 1991 recession and the federal transfer reduction. As for drug spending, the Patented Medicine Prices Review Board (PMPRB) in 1987 and drug-coverage policy changes in 1990s both reduced the profits and eventually slowed the spending growth of the pharmaceutical industry before 1997.

As identified in previous studies, the industry did not carry out their promise immediately to increase their R&D spending as exchange for the elimination of compulsory licensing in 1993. Di Matteo and Grootendorst (2007) identified a rapid increase in total expenditure in 1996. They explained the delayed increase in drug spending was due to the patent term extension and drug price controls. The trend of drug spending in this paper is consistent with previous studies (Di Matteo, 2010; Wang, 2015, 2016) as there was no immediate expenditure change until 1997.

Many investments on health care industry stimulated health expenditure, made it grow closer to or faster than GDP since 1998 to 2010. This is consistent with the third wave of spending since 1997 as identified in the literature review. The growth since 1997 was due to change in marketing strategies and rise in drug treatment. In addition, massive investments into R&D by pharmaceutical industry also stimulated the expenditure. After that, government tired to control budget deficits due to the recession in 2009. As a result, the budgetary controls slowed the growth rate of health spending after 2010.

**4. Empirical Model & OLS Estimates**

A pooled time-series cross-sectional econometric model is specified and estimated for the regression equations in this section. The statistical software used is Stata 14 and testing was conducted based on data collected from CANSIM and CIHI as mentioned in data description.

There are two econometric models in this paper to examine the effect on provincial government drug expenditure by employing a series of socioeconomic, demographic, and provincial variables. The two models are in the form:

i = 1,…, 10; t= 1,…,34

where i represents ten provinces and t indicates the annual time period from 1981 to 2014.

There are four equations with the models in log-linear and log-log form as shown below. Logarithm transformation is able to help in stabilizing the variance of a time series. It also allows for interpreting the coefficients as either percentages (log-linear) or elasticities (log-log). One of the dependent variables is the natural log of real per capita provincial government drug expenditure (L\_RPCPGDE). This variable is able to quantify the effects on provincial government drug expenditure per person. The second dependent variable is the natural log of real provincial government drug expenditure (L\_RPGDRUGE). This variable is able to capture the effect on provincial drug expenditure in total.

The independent variables include a vector of socioeconomic, demographic variables and provincial dummies as shown in table 1. Socioeconomic variables include real per capita GDP, and real per capita federal transfers. They were included as a measure of income (Di Matteo, 2002, 2005, 2010, 2013, 2014; Day and Tousignant,2005; Dreger and Reimers, 2005). Demographic variables are the proportion of population aged 45-64, 65-74, 75-84, and 85 and over. Seniors were expected to spend more on drugs relative to young people, ceteris paribus, especially given that all the provinces have provincial government drug plans that begin at age 65. Ten provincial dummies were also included to capture time-invariant regional fixed effects with Alberta as the benchmark.

Furthermore, specialist physicians per 1000 population and family physicians per 1000 population were included to get a better understanding of their effect on provincial drug spending. More drugs being prescribed by the increasing number of physicians were expected to increase provincial drug spending. Physicians are gatekeepers to the health care spending system, they approve prescriptions, and therefore they have an important role as a health and drug expenditure driver. Therefore, these two variables were included to capture their impact on provincial government drug expenditure as number of physicians per 1000 population changes.

Provincial government hospital expenditure as a proportion of provincial government health expenditure was included to capture the impact on provincial government drug expenditure by institutional spending given hospital spending is the largest component of health spending. There might be some substitution between hospital based care and care outside of hospitals that relies more on medications.

It is reasonable to expect that drug expenditure rises as physician number increases. However, the amount of change will vary from province to province due to different market structures and fee schedules. Physicians can be complements to provincial government drug spending. That is, the drug demand will increase when there are more physicians prescribing drugs.

In addition, variables were included to examine how drug spending changes as a result of the importance of health spending in provincial budgets and the importance of private sector health spending. Provincial government health expenditure as a share of total provincial government expenditure was included to capture the impact of changing provincial government health spending. In other words, does drug expenditure rise when the budgetary proportion of provincial government health expenditure increase? Similarly, private sector health expenditure as a proportion of total health expenditure was included to see if increased privatization of health spending had an effect on provincial government health spending.

Inflation was adjusted for by using the province-specific price indexes (1997 dollars) in each year: GDP deflator-implicit price index (IPI), consumer price index–health care component (HCPI) and the government current expenditure implicit price index (GCEIPI). Real GDP per capita was deflated using the GDP deflator. Real per capita private sector health expenditure and real per capita total health expenditure were deflated using HCPI. Real per capita provincial government health expenditure, real per capita provincial government drug expenditure, real per capita public sector health expenditure, real per capita provincial government physician expenditure, and real per capita federal transfers were deflated using GCEIPI.

Ordinary Least Squares (OLS) was applied in estimating the models. Table 2 (log-linear) and table 3 (log-log) provide the results for LN\_ Real per capita provincial government drug expenditure in seven specifications progressing from the most restricted to the least restricted. Table 4 (log-linear) and table 5 (log-log) present results for LN\_ Real provincial government total drug expenditures. The log transformation is appropriate when dealing with more than two categorical variables. Box- Cox testing results as shown in appendix indicated the log-linear and log-log transformation fit the data better than linear form in this study. The seven specifications rank from most restricted to least restricted. The most restricted model includes only real per capita GDP, real per capita federal cash transfers, and a constant. The least restricted model includes a variety of factors that potentially have impact on drug spending.

The adjusted R-squares for the least restricted model as shown in appendix is 0.87 in table 2 and table 3, 0.98 in table 4 and table 5. The high adjusted R-squares indicated that the model may have a spurious problem. A spurious problem means two or more variables are not related to each other despite the high r-squared. However, it may be incorrectly inferred that they are related due to the upward trend of provincial drug spending. Therefore, year was included in the specification VII as an indicator variable to absorb some of the ascending trend.

F statistics as shown in appendix were computed for the four functional forms by using the residual sum of squares between the least restricted model and the most restricted specification. It is to see if the independent variables included in the model were significantly related to the dependent variable. The results show they are statistically significant indicating that they are factors that affect provincial drug spending.

Specification VII includes all potential contributors to provincial drug spending. Many of the variables in specification VII are significant as shown from the results in table 2 to table 5. Real per capita GDP is significant in all models. The proportion of population aged 85 and over is significant in all models while proportion of population aged 75-84 is significant in two of the log-log formats. Provincial government health expenditure as a proportion of total provincial government expenditure is insignificant in three models except in table 5.

Provincial dummies show most of them are significant compared to Alberta as the benchmark. Quebec and Ontario have significantly more provincial government drug spending than Alberta in all models. In these regressions, some provinces are slightly less important. In general, provincial dummies matter a lot even if some of the provincial dummies are not significant in one or two regression.

Provincial government hospital expenditure as a proportion of provincial government health expenditure is a significant contributor in three models except in table 5. Specialist physicians per 1000 population is negative and significant while family physicians per 1000 population is positive and significant in all models.

Lastly, private sector health expenditure as a proportion of total health expenditure is significant and negatively related to provincial government drug expenditure in all models.

**Table 1**

Regression variables

**Dependent variables**

LN\_Real per capita provincial government drug expenditure in 1997 dollars deflated using the Government current expenditure implicit price index.

LN\_Real provincial government drug expenditure in 1997 dollars deflated using the Government current expenditure implicit price index.

**Independent variables**

Real per capita gross domestic product in 2007 dollars. Deflated using the Government Current Expenditure Implicit Price Index.

Real per capita federal transfers. Deflated using the Government Current Expenditure Implicit Price Index.

Proportion of population aged 45-64

Proportion of population aged 65-74

Proportion of population aged 75-84

Proportion of population aged 85 or greater

Provincial government health expenditure/ Total provincial government expenditure

1 if Newfoundland and Labrador, 0 otherwise.

1 if Prince Edward Island, 0 otherwise.

1 if Nova Scotia, 0 otherwise.

1 if New Brunswick, 0 otherwise.

1 if Quebec, 0 otherwise.

1 if Ontario, 0 otherwise.

1 if Manitoba, 0 otherwise.

1 if Saskatchewan, 0 otherwise.

1 if British Columbia, 0 otherwise.

Number of specialist physicians per 1000 population

Number of family physicians per 1000 population

Provincial government hospital expenditure/ Provincial government health expenditure

Private sector health expenditure/ Total health expenditure

Year (defined as a time indicator variable running from 1 to 34)

**Table 2 (OLS results in log-linear)**

Regression estimates for determinants of LN\_ Real per capita provincial government drug expenditure in specification I to VII

I II III IV V VI VII\_\_\_\_\_

Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t

Real per capita GDP ***2.89e-05 11.93 9.30e-06 4.35 8.93e-06 4.21 2.2e-05 4.07 3.05e-05 5.54 3.24e-05 6.05 1.97e-05 4.12***

Real per capita federal ***1.34e-04 3.5 -9.19e-05 -3.39 -6.35e-05 -2.21 1.38e-04 2.53*** 9.98e-05 1.9 ***1.11e-04 2.17*** 5.71e-05 1.24

transfer

Proportion of population ***8.99******12.33 8.37 11.07 3.97 3.28 5.14 4.31 4.56 3.9 3.02 2.93***

aged 45-64

Proportion of population ***-7.38 -2.88 -6.47 -2.53 -4.76 -2.02*** -3.2 -1.00 -2.63 -0.84 -1.25 -0.46

aged 65-74

Proportion of population ***23.05 5.88 24.24 6.20 28.2 6.29 21.34 4.8 12.39 2.58*** -3.46 -0.7

aged 75-84

Proportion of population ***-16.83 -2.53 -24.45 -3.42*** -10.94 -1.36 ***-15.65 -2.01 -17.30 -2.29* *-42.86 -5.88***

aged 85 and over

Provincial government health ***1.43 2.75*** 1.24 1.74 0.77 1.10 0.42 0.61 -0.39 -0.65

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador 0.16 0.92 0.20 1.22 ***0.38 2.3*** 0.24 1.69

Prince Edward Island -0.13 -0.56 0.15 0.66 0.41 1.77 ***0.41 2.04***

Nova Scotia 0.35 1.66 ***0.73 3.39 1.04 4.72 1.17 6.12***

New Brunswick 0.22 1.06 ***0.48 2.30 0.74 3.51 0.72 3.95***

Quebec ***0.51 2.76 0.92 4.69 1.03 5.32 0.94 5.66***

Ontario ***0.50 2.97 0.89 5.09 0.99 5.77 1.07 7.26***

Manitoba -0.003 -0.02 ***0.42 2.16 0.62 3.18 0.65 3.83***

Saskatchewan 0.16 1.01 0.26 1.61 ***0.36 2.23*** ***0.47 3.15***

British Columbia 0.24 1.37 ***0.43 2.49******0.50 2.97 0.70 4.70***

Specialist physicians per 1000 population ***-1.07 -3.83 -1.07 -3.94 -1.13 -4.81***

Family physicians per 1000 population ***1.05 4.94 1.13 5.43 0.47 2.48***

Provincial government hospital ***-2.00 -4.36 -1.52 -3.79***

expenditure proportion of

provincial government health

expenditure

Private sector health expenditure  ***-2.59 -4.66***

proportion of total health

expenditure

Year  ***0.05 10.13***

Constant ***3.28 23.99 2.12 10.93 1.78 7.74 1.36 5.06 0.80 2.92 1.99 5.21 4.21 10.27***

Bold italics indicate significant at the 5% level (n=340)

**Table 3 (OLS results in log-log)**

Regression estimates for determinants of LN\_ Real per capita provincial government drug expenditure in specification I to VII

I II III IV V VI VII\_\_\_\_\_

Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t

LN\_Real per capita GDP ***1.42 15.27 0.59 6.21 0.60 6.33 0.98 4.08 1.44 5.9 1.41 5.85 1.05 4.70***

LN\_Real per capita ***0.29 5.49*** -0.04 -0.95 0.01 0.26 0.12 1.73 0.1 1.4 0.13 1.91 0.03 0.51

federal transfer

LN\_Proportion of population ***1.94 11.93******1.81 10.85*** 0.54 1.83 ***0.88 3.02 0.87 3.04*** 0.46 1.73

aged 45-64

LN\_Proportion of population  -0.30 -1.61 -0.26 -1.42 ***-0.36 -2.12*** -0.14 -0.64 -0.11 -0.52 -0.08 -0.39

aged 65-74

LN\_Proportion of population  ***0.99 5.6******1.1 6.16 1.18 6.38 0.94 5.15 0.76 4.08 0.62 3.45***

aged 75-84

LN\_Proportion of population  ***-0.32 -3.32 -0.44 -4.26*** -0.09 -0.78 ***-0.24 -2.07 -0.32 -2.72* *-0.53 -4.43***

aged 85 and over

LN\_Provincial government health    ***0.46 2.87 0.53 2.55 0.51 2.48 0.46 2.30*** 0.26 1.44

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador 0.29 1.6 0.32 1.83 ***0.37 2.11*** 0.27 1.69

Prince Edward Island 0.01 0.04 0.30 1.15 0.41 1.58 0.39 1.67

Nova Scotia 0.39 1.72 ***0.81 3.54 0.93 4.06******1.04 5.01***

New Brunswick 0.30 1.33 ***0.56 2.48******0.67 2.96******0.66 3.23***

Quebec ***0.52 2.62 0.95 4.69 0.92 4.59 0.90 4.99***

Ontario ***0.4 2.53 0.77 4.67 0.77 4.76 0.88 6.00***

Manitoba -0.06 -0.31 0.39 1.95 ***0.45 2.28* *0.47 2.61***

Saskatchewan 0.07 0.45 0.15 0.92 0.17 1.07 0.17 1.11

British Columbia 0.16 0.92 ***0.38 2.22******0.34 2.06* *0.51 3.29***

LN\_Specialist physicians per 1000 population ***-0.9 -4.57******-0.84 -4.32 -0.93 -5.27***

LN\_Family physicians per 1000 population ***0.83 4.56******0.89 4.93 0.47 2.73***

LN\_Provincial government hospital ***-0.72 -3.37 -0.49 -2.48***

expenditure proportion of

provincial government health

expenditure

LN\_Private sector health expenditure  ***-0.63 -4.21***

proportion of total health

expenditure

Year  ***0.04 8.17***

Constant ***-12.39 -10.14 2.53 2.07*** 2.35 1.95 -2.90 -0.89 ***-8.46 -2.60 -9.84 -3.05 -8.94 -3.03***

Bold italics indicate significant at the 5% level (n=340)

**Table 4 (OLS results in log-linear)**

Regression estimates for determinants of LN\_ Real provincial government drug expenditure in specification I to VII

I II III IV V VI VII\_\_\_\_\_

Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t

Real per capita GDP ***2.59e-05 4.69 -2.3e-05 -3.8 -2.44e-05 -4.10 2.21e-05 3.63 3.35e-05 5.47 3.51e-05 5.79 1.75e-05 3.55***

Real per capita federal *-****1.24e-03 -14.21 -1.67e-03 -21.74 -1.56e-03 -19.34 1.38e-04 2.25*** 9.15e-05 1.56 1.01e-04 1.745.93e-05 1.25

transfer

Proportion of population ***27.94******13.55 25.58 12.07*** 2.73 1.99 ***4.31 3.24 3.83 2.9 2.20 2.06***

aged 45-64

Proportion of population ***-30.51 -4.21 -27.05 -3.77 -5.51 -2.07***  -2.51 -0.7 -2.04 -0.58 0.98 0.35

aged 65-74

Proportion of population -6.19 -0.56 -1.67 -0.15 ***35.4 6.99 26.63 5.37 19.38 3.58*** -8.24 -1.61

aged 75-84

Proportion of population ***-53.05 -2.82 -82.01 -4.10*** -7.17 -0.79 -13.48 -1.56 -14.81 -1.73 ***-55.17 -7.32***

aged 85 and over

Provincial government health ***5.45 3.73 2.49 3.10******1.96 2.52******1.68 2.17*** 0.49 0.80

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador ***-1.49 -7.63******-1.43 -7.79******-1.29 -6.88 -1.5 -10.07***

Prince Edward Island ***-3.25 -12.71 -2.93 -11.39******-2.72 -10.36******-2.75 -13.29***

Nova Scotia ***-0.87 -3.64*** -0.39 -1.62-0.13 -0.52 0.02 0.11

New Brunswick ***-1.19 -5.08 -0.88 -3.81******-0.67 -2.81 -0.73 -3.87***

Quebec  *1.46* ***7.01 2.01 9.14 2.09 9.59 1.99 11.53***

Ontario ***1.76 9.26 2.25 11.59 2.33 12.07 2.43 15.89***

Manitoba ***-1.06 -5.00******-0.52 -2.42*** -0.36 -1.65 -0.24 -1.38

Saskatchewan ***-1.01 -5.55******-0.90 -4.94******-0.83 -4.53******-0.52 -3.32***

British Columbia 0.40 1.98 ***0.64 3.32******0.70 3.65 1.01 6.57***

Specialist physicians per 1000 population ***-1.45 -4.67 -1.45 -4.73 -1.54 -6.36***

Family physicians per 1000 population ***1.29 5.42 1.35 5.74 0.45 2.31***

Provincial government hospital ***-1.62 -3.13 -0.84 -2.03***

expenditure proportion of

provincial government health

expenditure

Private sector health expenditure  ***-2.06 -3.59***

proportion of total health

expenditure

Year  ***0.08 13.93***

Constant ***15.24 48.92 14.51 26.45 13.20 20.53 11.30 37.21 10.59 34.58 11.56 26.74 14.17 33.46***

Bold italics indicate significant at the 5% level (n=340)

**Table 5 (OLS results in log-log)**

Regression estimates for determinants of LN\_ Real provincial government drug expenditure in specification I to VII

I II III IV V VI VII\_\_\_\_\_

Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t Coeff t

LN\_Real per capita GDP ***1.51 6.56*** -0.04 -0.13 -0.02 -0.070.51 1.87 ***1.09 3.89 1.06 3.82 0.58 2.42***

LN\_Real per capita ***-1.61 -12.33 -2.08 -15.43******-1.87 -12.97*** 0.09 1.12 0.06 0.79 0.09 1.10 -0.02 -0.22

federal transfer

LN\_Proportion of population ***5.69 11.00******5.20 9.83*** 0.41 1.22 ***0.83 2.51 0.83 2.50*** 0.30 1.07

aged 45-64

LN\_Proportion of population  -0.80 -1.34 -0.65 -1.11 ***-0.45 -2.26*** -0.14 -0.55 -0.12 -0.47 -0.001 -0.00

aged 65-74

LN\_Proportion of population  0.52 0.92 0.96 1.70 ***1.47 6.88 1.17 5.64 1.05 4.85 0.72 3.79***

aged 75-84

LN\_Proportion of population  ***-1.12 -3.71 -1.61 -4.91*** 0.09 0.70 -0.09 -0.70 -0.15 -1.10 ***-0.55 -4.28***

aged 85 and over

LN\_Provincial government health   ***1.78 3.51 0.83 3.49 0.82 3.51 0.79 3.39 0.50 2.54***

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador  ***-1.62 -7.66 -1.59 -7.88******-1.56 -7.75 -1.69 -10.04***

Prince Edward Island    ***-3.57 -12.1 -3.25 -10.98 -3.17 -10.69 -3.18 -12.79***

Nova Scotia    ***-1.21 -4.58******-0.70 -2.67 -0.62 -2.34 -0.45 -2.01***

New Brunswick   ***-1.49 -5.7*** ***-1.19 -4.58 -1.11 -4.27 -1.12 -5.13***

Quebec    ***1.13 5.00 1.67 7.16 1.64 7.08 1.65 8.46***

Ontario    ***1.41 7.66 1.85 9.79 1.85 9.85 2.02 12.78***

Manitoba   ***-1.43 -6.49 -0.90 -3.97 -0.85 -3.78 -0.74 -3.83***

Saskatchewan    ***-1.36 -7.54*** ***-1.28 -6.98 -1.26 -6..92 -1.14 -6.82***

British Columbia   0.04 0.20 0.30 1.54 0.28 1.42 ***0.56 3.38***

LN\_Specialist physicians per 1000 population  ***-1.12 -4.95******-1.08 -4.77 -1.21 -6.38***

LN\_Family physicians per 1000 population   ***0.97 4.64******1.01 4.84 0.39 2.11***

LN\_Provincial government hospital   ***-0.53 -2.11*** -0.14 -0.68

expenditure proportion of

provincial government health

expenditure

LN\_Private sector health expenditure    ***-0.65 -4.04***

proportion of total health

expenditure

Year  ***0.06 11.58***

Constant ***10.14 3.36 32.73 8.44 32.05 8.40 14.51 3.86 7.81 2.1*** *6.81 1.83* ***7.22 2.29***

Bold italics indicate significant at the 5% level (n=340)

**5. Results for GLS Estimates**

It is highly likely that heteroscedasticity and cross-sectional correlation are issues in this panel data. The Breusch-Pagan / Cook-Weisberg test shows that there exists heteroscedasticity in the data.[[1]](#footnote-1) Heteroscedasticity means the error terms have different variances (Greene 2012 p.257). To correct for heteroscedasticity and autocorrelation, General Least Squares (GLS) technique was used under the assumption that the data were heteroscedastic with cross-sectional correlation, and a common AR (1) coefficient for all panels. Table 6 and 7 present the results by applying the GLS estimator.

In the GLS estimates, the main positive and significant variables (at the 5% level of significance) are real per capita GDP, proportion of population aged 45-64, 75-84, family physicians per 1000 population, and some provincial dummies. The main negative and significant variables include proportion of population aged 65-74, provincial government hospital expenditure as a proportion of provincial government health expenditure, and private sector health expenditure as a proportion of total health expenditure. These variables are significant in all four of the regression equations and consistent with existing studies (Di Matteo, 2002, 2014; Wang, 2015) of drug expenditure.

**6. Discussion**

Given that provincial drug plans are for individuals on social assistance and the elderly over age 65, the age variables are especially interesting. The results suggest the big age driver is not necessarily the 65-74 demographic but the 45-64 and the 75-84 age groups. This suggests that social assistance may be a bigger driver of provincial government drug spending below age 65, while when it comes to the elderly, it is the population of ‘very old’ as opposed to ‘young old’ that is the more important driver. However, most of that effect is for the 75-84 age category and a healthy survivor effect seems to take effect after age 84 (Di Matteo, 2010). The effect on drug spending of the proportion of population aged 75-84 is elastic with elasticity value of 1.15 and 1.43 respectively. It means this age group is more responsive to real per capita provincial government drug expenditure and real provincial government drug expenditure than other age groups.

However, the results show that the proportion of population aged 65-74 is negative and significant for drug spending. A previous study identified the same result when studying the determinants of provincial government health spending (Di Matteo, 2010). Di Matteo suggested that there may exist potential economies of scale for large populations when it comes to health care costs. Overall, the aging effect on per capita provincial drug spending can be complicated.

As for provincial fixed effects, Ontario and Quebec are positive and significant whereas Prince Edward Island, Manitoba and Saskatchewan are negative and significant. Alberta is the benchmark in all the regression models. It means the coefficients of the provincial dummies need to be compared with Alberta when interpreting the results. For example, Ontario real per capita government drug spending is 37 percent more than Alberta and real government drug spending is 167 percent more for Ontario, ceteris paribus.

Researchers typically include real per capita GDP in the regression as a measure of real per capita income. In all models, it is positive and significant. A one-dollar increase in real per capita GDP will cause real per capita provincial government drug expenditure to rise by 0.00129 percent, and real provincial government drug expenditure to rise by 0.00126 percent, ceteris paribus. It means per capita provincial drug spending increase as per capita income increases. This is consistent with the existing studies presenting real per capita GDP having a significant impact on health care expenditures (Di Matteo, 2002, 2014).

The income elasticity of real per capita provincial government drug expenditure is 0.47. The income elasticity of real provincial government drug expenditure is 0.3. They measure the responsiveness of provincial government drug spending to change in income. In other words, how much will it affect the provincial government drug spending if income rises? In this case, provincial government drug expenditure is inelastic since both are less than one, which means provincial government drug spending is not that sensitive to income.

In general, provincial dummies indicate that Ontario and Quebec have more provincial drug expenditure compared to Alberta. Prince Edward Island, Manitoba, and Saskatchewan have significantly less drug spending than Alberta. Every province have more or less provincial drug spending than the benchmark except B.C. is not significant in all models.

The large provincial drug spending in Ontario and Quebec are likely due to policy changes. Ontario introduced the Trillium Drug Program in 1995 whereas Quebec introduced the Public Prescription Drug Insurance in 1997. Both catastrophic drug plans significantly increased public drug spending in Ontario and Quebec. The policy change is consistent with the data description in this study as many provinces show rapid growth in provincial health spending after 1997. Wang (2015) also identified the same increase in provincial government spending.

The results suggest family physician per 1000 population is significant and positively related to drug spending in all models. One more family physician per 1000 population will cause real per capita provincial government drug expenditure to increase by 44 percent, and real provincial government drug expenditure to increase by 59 percent, ceteris paribus. This is a large effect since one more physician per 1000 population is close to a doubling of the physician workforce. Therefore, this means the increase in physician number will cause more provincial government drug expenditure. Based on the results, the number of family physicians is a complement to provincial government drug spending. This is consistent with previous studies in related field. For example, Di Matteo (2007, 2010) suggested this relationship is in line with the conventional wisdom that the increase in physician numbers can be a contributor to the growth in health care spending.

Provincial government hospital expenditure as a share of provincial government health expenditure is statistically significant and negatively associated with provincial government drug spending in all models. A one percent increase in provincial government hospital expenditure as a proportion of provincial government health expenditure will cause real per capita provincial government drug expenditure to decrease by 88 percent, and real provincial government drug expenditure to decrease by 73 percent, ceteris paribus. This is probably due to the reason that provincial spending on hospital and drugs are substitutes. With a fixed budget, the provincial government decreases the hospital spending as the spending for drug increases.

Private sector health expenditure as a share of total health expenditure is statistically significant and negatively associated with provincial government drug expenditure. A one percent increase in private sector health expenditure share of total health expenditure will cause real per capita provincial government drug expenditure to decrease by 135 percent, and real provincial government drug expenditure to decrease by 87 percent, ceteris paribus. It is reasonable since provincial government health spending and private health spending are substitutes. In other word, the larger provincial share of drug spending is associated with smaller share of private sector share of total health spending.

In all models, real per capita federal transfers, specialist physicians per 1000 population, proportion of population 85 and over, and provincial government health expenditure as a proportion of total provincial government expenditure are not significant.

In addition to the model above, the first difference (FD) form of these GLS models were estimated as shown in appendix. The first difference technique is able to help stabilize the mean of a time series. It removes fluctuations in the level of a time series in statistical analysis with panel data. It therefore eliminates trend and seasonality by doing this. The paper applies AR(1) instead of AR(2) since AR(1) is able to capture most of the error correlations. There are three variables significant in all four models. Two variables are positive and significant: the proportion of population aged 75-84, and that aged 85 and over. In addition, provincial government hospital expenditure as a proportion of provincial government health expenditure is negative and significant.

**Table 6 (GLS results with least restricted model; log-linear)**

Regression estimates for determinants

VII LN\_ Real per capita provincial VII LN\_ Real provincial government

government drug expenditure drug expenditure

Coeff z Coeff z

Real per capita GDP ***1.29e-05 5.29******1.26e-05 4.59***

Real per capita federal -7.37e-06 -0.41 -8.45e-06 -0.42

transfer

Proportion of population ***3.06 3.70 2.83 3.15***

aged 45-64

Proportion of population ***-5.82 -2.95 -8.14 -3.72***

aged 65-74

Proportion of population ***30.57 11.10 35.72 12.22***

aged 75-84

Proportion of population 5.36 1.04 7.97 0.13

aged 85 and over

Provincial government health 0.10 0.42 0.38 1.52

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador 0.16 1.57  ***-1.50 -12.27***

Prince Edward Island -0.19 -1.56  ***-3.30 -24.52***

Nova Scotia ***0.26 2.13 -0.95 -6.59***

New Brunswick 0.23 1.83 ***-1.15 -7.77***

Quebec  ***0.22 2.19 1.13 9.83***

Ontario  ***0.37 4.20*   *1.67 17.28***

Manitoba  -0.19 -1.80 ***-1.17 -10.04***

Saskatchewan -0.13 -1.09 ***-1.21 -8.78***

British Columbia -0.02 -0.25 0.16 1.53

Specialist physicians per 1000 population 0.07 0.61 0.08 0.67

Family physicians per 1000 population ***0.44 4.79 0.59 6.23***

Provincial government hospital ***-0.88 -4.98 -0.73 -4.02***

expenditure proportion of

provincial government health

expenditure

Private sector health expenditure ***-1.35 -5.72 -0.87 -3.52***

proportion of total health

expenditure

Constant  ***2.70 13.50 12.54 61.6***

Bold italics indicate significant at the 5% level (n=340)

**Table 7 (GLS results with least restricted model; log-log)**

Regression estimates for determinants

VII LN\_ Real per capita provincial VII LN\_ Real provincial government

government drug expenditure drug expenditure

Coeff z Coeff z

LN\_Real per capita GDP ***0.47 4.28*** ***0.30 2.57***

LN\_Real per capita federal -0.01 -0.24 -0.02 -0.53

transfer

LN\_Proportion of population ***0.67 3.40 0.62 2.94***

aged 45-64

LN\_Proportion of population  ***-0.33 -2.4 -0.51 -3.51***

aged 65-74

LN\_Proportion of population  ***1.15 9.71 1.43 11.1***

aged 75-84

LN\_Proportion of population 0.09 1.20  ***0.19 2.38***

aged 85 and over

LN\_Provincial government health 0.05 0.71 0.14 1.98

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador 0.11 1.03  ***-1.65 -13.72***

Prince Edward Island ***-0.32 -2.36 -3.63 -25.70***

Nova Scotia 0.14 1.14  ***-1.22 -9.14***

New Brunswick 0.12 0.86  ***-1.43 -9.73***

Quebec 0.12 1.16  ***0.93 8.43***

Ontario  ***0.22 2.53 1.42 16.34***

Manitoba  ***-0.33 -3.14 -1.45 -13.69***

Saskatchewan  ***-0.23 -2.00 -1.44 -11.49***

British Columbia -0.14 -1.55 -0.06 -0.65

LN\_Specialist physicians per 1000 population 0.05 0.60 0.03 0.35

LN\_Family physicians per 1000 population ***0.34 4.23 0.46 5.35***

LN\_Provincial government hospital  ***-0.38 -4.65 -0.30 -3.55***

expenditure proportion of

provincial government health

expenditure

LN\_Private sector health expenditure ***-0.28 -4.52 -0.18 -2.70***

proportion of total health

expenditure

Constant  ***3.39 2.19 16.73 10.50***

Bold italics indicate significant at the 5% level (n=340)

**7. Conclusion**

This paper employs a variety of socioeconomic, demographic, and provincial variables to try to capture the statistically significant contributors to provincial government drug spending. The dependent variables are real per capita provincial government drug expenditure and real provincial government total drug expenditure. Ordinary Least Squares (OLS) was used to examine the relationship in all models. Then a series of tests were conducted with the Box-Cox test showing that log-linear and log-log models were better than linear models. Then, both models were estimated in log-linear and log-log format and F tests were conducted to test if the coefficients were significant between the most restricted and the least restricted models. Heteroscedasticity and cross-sectional correlation are possible issues with time-series cross-sectional data and a Breusch-Pagan / Cook-Weisberg test confirmed heteroscedasticity existed in the data. The General Least Squares (GLS) technique was then used to estimate the regressions under the assumptions of heteroskedasticity with cross-sectional correlation, and common AR (1) coefficient for all panels. Finally, the appendix shows the results for a first difference specification for both models.

From the results of the GLS models, the key determinants of provincial government drug expenditures include real per capita GDP, the proportion of population aged 45-64, 65-74, 75-84, family physicians per 1000 population, provincial government hospital expenditures as a proportion of provincial government health expenditure, private sector health expenditure as a proportion of total health expenditure along with many provincial dummies. Ontario and Quebec appear to be the largest spenders among the ten provinces in this study, ceteris paribus.

Real per capita federal transfers, the proportion of population aged 85 and older, provincial government health expenditure as a proportion of total provincial government expenditure, and specialist physicians per 1000 population are not significant in the results.

According to Graham and Tabler (2005), increased federal transfers did not find the way into health care budget even as federal transfers were included in the Canada Health and Social Transfer for some period. It disguised explicit health transfers while muddying the impact of the transfers. As well, Canada is increasing in its physician numbers due to higher medical school graduations and immigration of international medical graduates (Di Matteo, 2014). This will increase provincial government drug spending since there will be more physicians prescribing drugs.

Meanwhile, the baby boom in Canada from 1947 to 1966 is likely to affect the provincial government drug spending since more people are entering the age range of 51-70. Furthermore, population has increased for many years and will continue this pace in the following years. Provincial government drug spending will keep rising since more people need medicine. Further public policy that try to balance government budgets by controlling provincial government expenditures on health care may have to focus more on drug spending.

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**Appendix**

**Table A1 (Box Cox tests for specification VII in OLS regressions)**

**Box Cox test for table 2**

|  |  |  |  |
| --- | --- | --- | --- |
| Test | Restricted | LR statistic | P-value |
| Ho: | Log likelihood | Chi2 | Prob > chi2 |
| Theta = -1 | -38.293603 | 358.20 | 0.000 |
| Theta = 0 | 31.931247 | 217.75 | 0.000 |
| Theta = 1 | 85.050447 | 111.52 | 0.000 |

**Box Cox test for table 3**

|  |  |  |  |
| --- | --- | --- | --- |
| Test | Restricted | LR statistic | P-value |
| Ho: | Log likelihood | Chi2 | Prob > chi2 |
| Theta = -1 | -32.378744 | 338.06 | 0.000 |
| Theta = 0 | 33.186116 | 206.93 | 0.000 |
| Theta = 1 | 82.059906 | 109.19 | 0.000 |

**Box Cox test for table 4**

|  |  |  |  |
| --- | --- | --- | --- |
| Test | Restricted | LR statistic | P-value |
| Ho: | Log likelihood | Chi2 | Prob > chi2 |
| Theta = -1 | -38.424046 | 232.08 | 0.000 |
| Theta = 0 | 34.853086 | 85.53 | 0.000 |
| Theta = 1 | 73.967644 | 7.30 | 0.007 |

**Box Cox test for table 5**

|  |  |  |  |
| --- | --- | --- | --- |
| Test | Restricted | LR statistic | P-value |
| Ho: | Log likelihood | Chi2 | Prob > chi2 |
| Theta = -1 | -30.59578 | 185.87 | 0.000 |
| Theta = 0 | 27.90055 | 68.88 | 0.000 |
| Theta = 1 | 58.334289 | 8.01 | 0.005 |

**Table A2 (F tests for specification I and VII)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Statistics for table 2** | | | | | | |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 31.051769 | 2 | 15.5258845 | F(2, 337) | = | 74.77 |
| Residual | 69.9749704 | 337 | .207640862 | Prob > F | = | 0.0000 |
| Total | 101.026739 | 339 | .29801398 | R-squared | = | 0.3074 |
|  |  |  |  | Adj R-squared | = | 0.3033 |
|  |  |  |  | Root MSE | = | .45568 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 88.9561507 | 21 | 4.23600718 | F(2, 337) | = | 111.60 |
| Residual | 12.0705887 | 318 | .037957826 | Prob > F | = | 0.0000 |
| Total | 101.026739 | 339 | .29801398 | R-squared | = | 0.8805 |
|  |  |  |  | Adj R-squared | = | 0.8726 |
|  |  |  |  | Root MSE | = | .19483 |

At least one parameter does not equal to zero.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Statistics for table 3** | | | | | | |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 42.212949 | 2 | 21.1064745 | F(2, 337) | = | 120.94 |
| Residual | 58.8137904 | 337 | .174521633 | Prob > F | = | 0.0000 |
| Total | 101.026739 | 339 | .29801398 | R-squared | = | 0.4178 |
|  |  |  |  | Adj R-squared | = | 0.4144 |
|  |  |  |  | Root MSE | = | .41776 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 88.7419332 | 21 | 4.22580634 | F(2, 337) | = | 109.39 |
| Residual | 12.2848061 | 318 | .038631466 | Prob > F | = | 0.0000 |
| Total | 101.026739 | 339 | .29801398 | R-squared | = | 0.8784 |
|  |  |  |  | Adj R-squared | = | 0.8704 |
|  |  |  |  | Root MSE | = | .19655 |

At least one parameter does not equal to zero.

**Statistics for table 4**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 410.031989 | 2 | 205.015995 | F(2, 337) | = | 190.52 |
| Residual | 362.645102 | 337 | 1.07609823 | Prob > F | = | 0.0000 |
| Total | 772.677092 | 339 | 2.27928346 | R-squared | = | 0.5307 |
|  |  |  |  | Adj R-squared | = | 0.5279 |
|  |  |  |  | Root MSE | = | 1.0374 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 759.793368 | 21 | 36.1806366 | F(2, 337) | = | 893.02 |
| Residual | 12.8837234 | 318 | .040514853 | Prob > F | = | 0.0000 |
| Total | 772.677092 | 339 | 2.27928346 | R-squared | = | 0.9833 |
|  |  |  |  | Adj R-squared | = | 0.9822 |
|  |  |  |  | Root MSE | = | .20128 |

At least one parameter does not equal to zero.

**Statistics for table 5**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 412.799987 | 2 | 206.399993 | F(2, 337) | = | 193.28 |
| Residual | 359.877105 | 337 | 1.06788458 | Prob > F | = | 0.0000 |
| Total | 772.677092 | 339 | 2.27928346 | R-squared | = | 0.5342 |
|  |  |  |  | Adj R-squared | = | 0.5315 |
|  |  |  |  | Root MSE | = | 1.0334 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SS | df | MS | Number of obs | = | 340 |
| Model | 758.552382 | 21 | 36.121542 | F(2, 337) | = | 813.23 |
| Residual | 14.124709 | 318 | .044417324 | Prob > F | = | 0.0000 |
| Total | 772.677092 | 339 | 2.27928346 | R-squared | = | 0.9813 |
|  |  |  |  | Adj R-squared | = | 0.9805 |
|  |  |  |  | Root MSE | = | .21075 |

At least one parameter does not equal to zero.

**Table A3 (GLS results with first differencing least restricted model; log-linear)**

First difference estimates for determinants

D\_LN\_ Real per capita provincial D\_LN\_ Real provincial government drug expenditure government drug expenditure

Coeff z Coeff z

D\_Real per capita GDP -1.30e-06 -0.77 -1.57e-06 -0.91

D\_Real per capita federal -6.15e-06 -0.82 -8.88e-06 -1.15

transfer

D\_Proportion of population -0.06 -0.02 1.91 0.78

aged 45-64

D\_Proportion of population 7.70 1.62 2.71 0.60

aged 65-74

D\_Proportion of population ***22.33 2.64 28.46 3.42***

aged 75-84

D\_Proportion of population ***7.53 2.21 7.93 2.36***

aged 85 and over

D\_Provincial government health 0.05 0.34 0.01 0.05

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador -0.01 -0.05 -0.08 -0.55

Prince Edward Island 0.03 0.28 -0.03 -0.20

Nova Scotia -0.03 -0.32 -0.10 -0.89

New Brunswick -0.03 -0.33 -0.10 -0.88

Quebec -0.06 -0.59 -0.12 -1.13

Ontario -0.02 -0.21 -0.08 -0.64

Manitoba  -0.01 -0.06 -0.06 -0.58

Saskatchewan -0.04 -0.33 -0.09 -0.76

British Columbia -0.03 -0.25 -0.08 -0.74

D\_Specialist physicians per 1000 population 0.03 0.48 0.07 1.10

D\_Family physicians per 1000 population 0.05 0.80 0.05 0.97

D\_Provincial government hospital  ***-0.43 -3.07 -0.47 -3.22***

expenditure proportion of

provincial government health

expenditure

D\_Private sector health expenditure -0.08 -0.48 -0.03 -0.19

proportion of total health

expenditure

Constant 0.07 0.79 0.11 0.95

Bold italics indicate significant at the 5% level (n=340)

**Table A4 (GLS results with first differencing least restricted model; log-log)**

First difference estimates for determinants

D\_LN\_ Real per capita provincial D\_LN\_ Real provincial government drug expenditure government drug expenditure

Coeff z Coeff z

D\_LN\_Real per capita GDP -0.03 -0.43 -0.04 -0.58

D\_LN\_Real per capita federal -0.02 -1.15 -0.01 -1.09

Transfer

D\_LN\_Proportion of population -0.05 -0.07 -0.49 -0.79

aged 45-64

D\_LN\_Proportion of population 0.62 1.84 0.35 1.06

aged 65-74

D\_LN\_Proportion of population ***0.95 2.82 0.71 2.14***

aged 75-84

D\_LN\_Proportion of population ***0.08 2.01 0.08 2.10***

aged 85 and over

D\_LN\_Provincial government health 0.02 0.440.02 0.51

expenditure proportion of

total provincial government

expenditure

Newfoundland and Labrador -0.01 -0.10 -0.02 -0.20

Prince Edward Island 0.04 0.33 0.03 0.21

Nova Scotia -0.02 -0.27 -0.04 -0.42

New Brunswick -0.03 -0.31 -0.05 -0.42

Quebec  -0.06 -0.60 -0.07 -0.66

Ontario -0.02 -0.18 -0.02 -0.24

Manitoba  -0.002 -0.02 -0.02 -0.12

Saskatchewan -0.04 -0.28 -0.06 -0.42

British Columbia -0.02 -0.21 -0.02 -0.23

D\_LN\_Specialist physicians per 1000 population 0.03 0.58 0.03 0.56

D\_LN\_Family physicians per 1000 population 0.05 0.94 0.05 0.82

D\_LN\_Provincial government hospital  ***-0.21 -3.04***  ***-0.21 -3.16***

expenditure proportion of

provincial government health

expenditure

D\_LN\_Private sector health expenditure -0.01 -0.29 -0.01 -0.25

proportion of total health

expenditure

Constant  0.06 0.68 0.09 1.02

Bold italics indicate significant at the 5% level (n=340)

1. The test shows Prob > chi2 = 0.0000 confirm the presence of heteroskedasticity [↑](#footnote-ref-1)