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The Determinants of Canadian Provincial Health Expenditures: Evidence from a Dynamic Panel

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Abstract

This article seeks to reveal the magnitude of the income elasticity of health expenditure and the impact of non-income determinants of health expenditure across Canada. For this purpose, panel data on GDP, the relative price of health care, the share of publicly funded health expenditure, the share of senior population and the life expectancy at birth have been used to investigate the determinants of Canadian provincial health expenditures over a 28-year period. Dynamic models of health expenditure are analyzed via Generalized Instrumental Variables and Generalized Method of Moments. Results indicate that the long-run income elasticity of health expenditure is substantially lower than one. Thus health care is far from being a luxury in Canada.

Keywords: Health expenditure, Income elasticity, Dynamic panel, GIV, GMM

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Determinants of Canadian Provincial Health Expenditures

1 Introduction

In Canada, rising public expenditure on health care has become a major policy concern and public sector fiscal problems have placed an additional burden on public funding for health care. In this light, an important question for policy analysis is to determine the causes of growth in provincial government health care spending. There is a considerable literature on the determinants of health expenditure in Canada, but to date, there is still no consensus on the statistical methods or the type of data to be used. We argue that this is due to weak theoretical guidance.

The pioneering studies emphasize the importance of national income in explaining the variation in health care expenditure (henceforth HE) along with a selection of non-income variables. Some of these variables are the relative price of health care (i.e. ratio of medical CPI to GDP price index), the proportion of the population over the age of 65, urbanization rate and the publicly funded proportion of HE among others. While the significance of non-income variables depends on the structure of health sector and population, GDP accounts for most of the variation in aggregate health care expenditure (Parkin et al., 1987).

Di Matteo and Di Matteo (1998) focuses on the determinants of Canadian provincial government health expenditures by employing a pooled time-series cross-section framework for the period 1965-1991. The determinants of provincial government health expenditures are the real per capita provincial income, the share of senior population and real provincial per capita federal transfers.

Determinants of Canadian Provincial Health Expenditures

Di Matteo (2000) examines public and private Canadian health expenditures over the period 1975-1996. The major determinants of public-private mix are per capita income, the share of individual income held by the top quintile of the income distribution and the federal health transfers. Health expenditures are examined as total and sub-expenditure categories such as hospital, physician and drug spending. The empirical evidence suggests that increases in per capita income are associated with more private health care spending relative to public spending.

Ariste and Carr (2003) uses provincial data on real per capita income, the proportion of the population over the age of 65 and the ratio of the deficit/surplus to GDP to explain the variation in real per capita government health expenditures. The determinants of government health expenditures are income, the ratio of the deficit/surplus to GDP, the share of senior population and a time trend capturing technological progress.

Di Matteo (2005) assesses the impact of income, age distribution and time on health expenditures in the US and Canada. The results suggest that when time or the technological change is captured by a (possibly non-linear) time trend, only 8.8 percent of the increase in real per capita health expenditure in Canada is attributable to rising income, 10.3 percent is attributable to an increasing ageing population and 64.2 percent is attributable to technological innovation or time. A similar finding by Cantarero (2005) in the Spanish case shows that absent time trends, the most important determinant of regional health expenditure is the ageing population while income has less importance in explaning the variation in regional health spending[1].

Few points that are not considered by Di Matteo and Di Matteo (1998) and Ariste and Carr (2003) are worthy of discussion. First, if the relative price of health care is known to have an influence on HE, the failure to incorporate this variable in the analysis will lead to specification error and biased and inconsistent estimates due to combined income and price effects[2]. Second, studies on the determinants of Canadian provincial health expenditures can be characterized by a lack of dynamics. Income may have permanent and transitory components and increments on income may not be fully spent in the same period, but rather spending may be allocated through time. Further, current period health spending may also depend on its past values, known as expenditure inertia[3]. While Roberts (1999) argues that the structure of the adjustment process of health spending is not currently well known, Getzen (2000) contends that one should expect lags on the right-hand side as the budget is prepared at least a year in advance. These shortcomings indicate that the early estimates of the determinants of Canadian health expenditures may have been biased and the conclusions drawn could have been misleading.

The aim of this article is to re-examine the impact of income and non-income determinants (i.e. the relative price of health care, the share of publicly funded health care, the share of senior population and the life expectacy at birth) of real per capita provicial government expenditures on health care using a dynamic panel data model that allows expenditure inertia. The motivation behind

[1] See also Cantarero and Lago- Peñas (2010).
[2] The income coefficient due to the exclusion of the health price variable may be biased in either direction. See Bac and Le Pen (2002) and Okunade and Karakus (2001) for example.
[3] See Okunade and Suraratdecha (2000).

the analysis of the determinants of health spending is to identify the forces that drive the persistent increase in health care expenditures in Canada and to explain the disparities in provincial health expenditures. For this purpose, income elasticity and other non-income elasticites are estimated via Generalized Instrumental Variables (GIV) and Generalized Method of Moments (GMM) estimations. The determinants of provincial health expenditures are examined for total health expenditures, government health expenditures and private health expenditures. Disaggregation allows for the examination of the differing responsiveness againts the income and price changes for the government and the private sector as well as total health spending. Further, identifying the effects of income and institutional factors on public and private health expenditures allow inference about the trends in the public-private mix in Canadian health sector. The structure of this mix has been the center of the debate of whether increasing centralization or privatization would yield more efficient outcomes[4].

2 Factors affecting health expenditure

The early studies on the determinants of health expenditures contend that income is the major explanatory factor of HE. The economic theory argues that other things being equal, the amount of health expenditure should depend on what an individual is capable of spending. Therefore it is expected that provinces with higher income should spend more on health taking other factors as given[5].

[4] Di Matteo (2000) provides an excellent discussion on the public-private mix of Canadian health expenditures.
[5] Macro and micro outcomes may differ due to insurance or pooling of resources in which case micro constraints may exist but macro constraints may not. These micro and macro disparities may render different or inconsistent outcomes.

However, since health care is heavily subsidized in Canada, the ability to pay should be a less important determinant of health expenditures (Di Matteo, 2005). The role of income in explaining the variation in health care expenditures translates into estimating the magnitude of the income elasticity of health expenditure which has several implications for policy. Health care can be seen as a luxury good if the responsiveness is sensitive to income changes (i.e. the income elasticity exceeds unity) and as a necessity good if the responsiveness is insensitive to income changes (i.e. the income elasticity is below unity)[6]. Those who argue that health care is a necessity good support greater public involvement in health care and that the delivery of health is determined according to needs[7]. On the other hand, if health care is a luxury good, this indicates that it should be left to market forces just like any other commodity. (Di Matteo, 2003, 2005). Getzen (2000) argues that health care is neither a necessity nor a luxury because income elasticity of health expenditure varies with the level of analysis. Further, the income elasticity not only depends on the level of analysis but also the range of income and economic development. Using nonparametric techniques, Di Matteo (2003) confirms that the income elasticity of health expenditure in Canada is higher at low income levels and lower at high income levels as opposed to simple parametric approaches arguing for either an income elastic or income inelastic health spending.

Spending decisions concerning health are not solely affected by the income level but also by the price of health care. Especially in case of higher out-

[6] See Newhouse (1977).

[7] According to Kyriopoulos and Souliotis (2002), if the income elasticity of health expenditure is less than one, then the public health sector does not have a high priority among the goals for social and economic development.

of-pocket payments, decisions rely on the price level. On one hand, the government is heavily involved in the delivery and supervision of health care. On the other hand, health care has special characteristics that are different than those of other services. Such features pose problems about our expectations of the magnitude of the price effect and its sign[8]. This variable is included principally to separate income and price effects. From an econometric point of view, the failure to include the price variable, if effective, results in misleading inference.

With the exception of few countries, health care decisions and a considerable volume of health spending is driven by governments and public institutions. Therefore, it is expected that the share of publicly funded health expenditures affect health spending. If this share is effective in explaining private heath spending, then inferences can be made regarding the interaction between public and private spending. However, as Roberts (1999) points out both theory and empirical evidence are contradictory regarding the magnitude and the sign of this effect[9].

The share of senior population is considered to be another explanatory factor of HE. The elderly population consumes health care at a higher rate than others and the depreciation rate of health is an increasing function of age

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[8] Consumers never face prices for the health services and therefore this variable may be completely irrelevant for the analysis. Secondly, price of health is heavily subsidized in Canada so that even its effect is not zero, it should be almost zero or negligible.

[9] If T, G and P denote the real total, public and private health expenditures respectively and since $T = G + P$, the share of publicly funded health expenditures is $\psi = G/(G+P)$. Then, $G = \psi T$, $P = (1-\psi)T$. Thus, $\partial P / \partial \psi = ((1-\psi)\partial T / \partial \psi) + (T \partial (1-\psi)/ \partial \psi)$ where $\partial T / \partial \psi = -G / \psi^2$ and $\partial (1-\psi)/ \partial \psi = -1$. The effect of a marginal increase in ψ on private health expenditures is $\partial P / \partial \psi = -((1-\psi)G / \psi^2) - T = -((PG/T)(T/G)^2) - T$ $= -(PT/G) - T = -T^2 / G = \partial T / \partial \psi < 0$. The sign of this effect is negative as long as G is positive. See López-Casasnovas and Sáez (2007), Hitiris (1999) and Roberts (1999) for empirical evidence on the magnitude of this effect.

(Grossman, 1972). Especially for those over the age of 65, higher and prolonged periods of cost are involved. The treatment of senior's population is complex and the elderly patients are not completely cured in most of the cases. Diabetes, cardiovascular diseases are few examples that require relatively more technical knowledge and equipment for treatment and diagnosis. The delivery of health services to elderly population is therefore associated with higher spending on health.

The relationship between HE and health status indicators is controversial[10]. The reason to include life expectancy at birth variable is to identify any potential correlation between expenditure and health level. The shortcoming of this variable is that it measures quantity rather than the quality of life[11]. An increasing share of senior population implies increasing health expenditures due to higher costs of treatment of the elderly. However, increasing life expectancy or health status is associated with long-term care. Theoretically, the sign of this effect is ambiguous. If marginal increases in health status increase health expenditures, this would imply that more expenditure on health care is needed to make people live longer. However, if marginal increases in health status decrease health expenditures, the cost of maintaining previous levels of health decreases as the health condition improves. This situation leads to less need for and thus less expenditure on health care.

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[10] Kyriopoulos and Souliotis (2002) states that there is no correlation between HE and health status in the OECD countries. On the other hand, Maxwell (1981) shows evidence of correlation between the total health spending as a percentage of GDP and infant mortality rate.
[11] At the data collection level, Disability Adjusted Life Expectancy as a closer proxy for health status than life expectancy at birth is considered. However, it is excluded due to its short time span.

3 Econometric Methodology

One-way fixed effect error component models are considered due to our focus on the provincial differences in health expenditures rather than differences across time. It is first assumed that these differences can be captured by the differences in the endowments of HE. We start off to show the preliminaries of the first model in which the dependent variable is total per capita health spending. The following dynamic model is considered:

$$h_{it} = \alpha + \rho h_{i,t-1} + X'_{it}\beta + \varepsilon_{it} \qquad (1)$$

$$\varepsilon_{it} = \mu_i + \upsilon_{it} \qquad (2)$$

where h denotes total per capita health expenditure, i denotes the provinces and t denotes time, β. is a $K \times 1$ vector where K is the number of explanatory variables, X_{it} is the it^{th} observation on K regressors, X_{it} includes per capita GDP, the relative price of health care, the share of publicly funded health expenditure, the share of senior population and life expectancy at birth, μ_i is the homoscedastic province specific effect and υ_{it} is the stochastic disturbance term. The following assumptions have been made:

i. h_{i0} is fixed.

ii. $\upsilon_{it} \sim (0,\ \sigma_i^2)$

iii. $E\left(X'_{it}\upsilon_{it}\right) \neq 0$

iv. $\upsilon_{it} = \varphi\upsilon_{i,t-1} + u_{it}$, $|\varphi| < 1$ and $u_{it} \sim$ IID $(0,\ \sigma_u^2)$

Assumption *i* is the initial condition that starts up the process in (1) which is standard in dynamic panel literature. Assumptions *ii* and *iii* assume cross-section heteroscedastic errors and failure of orthogonality or strict exogeneity for a subgroup of regressors respectively and *iv* allows errors to follow an AR(1) process due to possible through-time-allocated effects of shocks to the error term. The unit root results are detailed in the appendix.

The absence of strict exogeneity for a subgroup of regressors results in failure to satisfy the orthogonality condition which renders biased and inconsistent estimates. Two variables in the dataset are expected to be endogenous in relation to health spending. First, the relative price of health care may be predetermined rather than strictly exogenous. Second, life expectancy at birth as a proxy for health status may be endogenous because changing health status may occur as a result of spending more on health care and vice-versa, suggesting a two-way causality that may run from health spending to health status as well[12].

In vector form (1) and (2) can be written as:

$$h = \alpha\iota_{NT} + h_{-1}\rho + X\beta + \varepsilon \tag{3}$$

$$\varepsilon = Z_{\mu}\mu + \upsilon \tag{4}$$

Substituting (4) into (3):

$$h = \alpha\iota_{NT} + h_{-1}\rho + X\beta + Z_{\mu}\mu + \upsilon = Z\delta + Z_{\mu}\mu + \upsilon \tag{5}$$

where $Z = \left[\iota_{NT}, X, h_{-1}\right]$ and $\delta' = \left[\alpha', \rho', \beta'\right]$

Arellano (2003) demonstrates that since h_{it} is correlated with the disturbance, it follows that $h_{i,t-1}$ will also be correlated with the disturbances through the error component even if the disturbances are not serially correlated.

[12] The endogeneity of income is not considered here and it is argued that causality runs from income to health spending and not the other way. See Ariste and Carr (2003).

Therefore the lagged dependent variable is an endogenous variable. This will render the OLS estimator to be biased and inconsistent. To overcome this problem, the estimation is performed via Instrumental Variables (IV) where $h_{i,t-2}$ is uncorrelated with the error term and appropriate as an instrument for $h_{i,t-1}$. From (5), one obtains the generalized instrumental variable (GIV) estimator of δ as:

$$\hat{\delta}_{GIV} = \left(Z'QP_{\tilde{W}}QZ\right)^{-1}\left(Z'QP_{\tilde{W}}Qh\right) \qquad (6)$$

Q is the fixed effects transformation operator, $\tilde{W} = QW$, $P_{\tilde{W}} = (\tilde{W}(\tilde{W}'\tilde{W})^{-1}\tilde{W}')$ is the projection matrix. $\tilde{W}$ is a matrix of instruments satisfying $E(\tilde{W}'Z) \neq 0$, $E(\tilde{W}'\upsilon) = 0$.

Anderson and Hsiao (1981) suggests that (5) can also be written in difference form to wipe out the individual effects. This method is further considered as a remedy against the above-mentioned drawback of OLS.

$$\Delta h = \Delta h_{-1}\rho + \Delta X\beta + \Delta\upsilon \qquad (7)$$

The first differenced form introduces bias and serial correlation in OLS because the lagged dependent variable is correlated with the first order moving average error term. Therefore, IV estimation is required to consistently estimate the parameters in (7), if not efficiently, where the appropriate instrument for $\Delta h_{i,t-1}$ is simply $h_{i,t-2}$. However, (5) can be estimated efficiently via Generalized Method of Moments (GMM) using the orthogonal deviations transformation which wipes out the individual effects as in (7) but does not introduce serial correlation in the transformed residuals[13]. Arellano and Bond (1991) N-step GMM is employed for the estimation which continuously updates the weight matrix.

Consider the following dynamic model for the government:

$$\ln g_{it} = (\alpha + \mu_i) + \beta_1 \ln y_{it} + \rho \ln g_{i,t-1} + \beta_2 \ln r_{it} + \beta_3 p65_{it} + \beta_4 x_{it} + \lambda t + \upsilon_{it} \quad (8)$$

where g is real per capita government HE, y is real per capita GDP, r is the relative price of health care, $p65$ is the proportion of the population over the age of 65, x is life expectancy at birth, *ln* denotes the natural logarithm and the variable t denotes the linear time trend. The inclusion of time trend has serious implications. First, health expenditures in Canada tend to increase over time therefore it may be appropriate to include a linear trend to separate its effect on the estimated long-run coefficients. Second, without a trend variable in (8), the t-statistics can be misleading due to the common trends. The linear trend can also be seen as a measure that captures the technological progress which has an important role in the rising cost of health care (Blomqvist and Carter, 1997). From (8), the respective long-run income and price elasticity of government health expenditures are $E_{g,y} = \beta_1 / (1-\rho)$; $E_{g,r} = \beta_2 / (1-\rho)$.

Equation (8) can be written such that the estimated parameters are direct long-run elasticities. This transformation is due to Bewley (1979). Subtracting $\rho \ln g_{i.t}$ on both sides and dividing by $(1-\rho)$, (8) becomes:

$$\ln g_{it} = \Gamma_i + \Phi_1 \ln y_{it} - \Psi \Delta \ln g_{it} + \Phi_2 \ln r_{it} + \Phi_3 p65_{it} + \Phi_4 x_{it} + \Pi t + \nu_{it} \quad (9)$$

[13] See Arellano (2003) and Arellano and Bover (1995) for a technical discussion on this transformation.

This transformation also requires IV estimation due to the correlation between the transformed lagged dependent variable and the error term where $\ln g_{i,t-2}$ is the appropriate instrument for $\Delta \ln g_{it}$. The remaining regressors in (8) can serve as their own instruments as long as they are strictly exogenous. Either lags of endogenous variables or external measures, given they satisfy the orthogonality condition, can be used as instruments.

4 Results and policy implications

The assumption made about the differences in the intercepts has been incorporated via fixed effects[14]. The results show that the dynamics of HE exhibit a significant role in the adjustment process of explanatory variables. Before analyzing the precise effects of those variables, we should confine ourselves to the reparameterized models we made use of, based on Bewley (1979), to directly estimate the average long-run effects of the explanatory variables. This reparameterization helps to assess the significance of the long-run effects and their standard errors. Table 1 reports the results. All factors have statistically significant long-run effects on total HE with the exception of the share of senior population. The long-run effect of the relative price of health care is statistically significant at conventional levels and carried a negative sign suggesting that marginal increases in relative prices decrease total health spending by 0.13

[14] The F-test has been performed to test the joint significance of the individual fixed effects under the null hypothesis, , H$_o$: $\mu_1 = \mu_2 = ... = \mu_{10} = 0$. The F-test results are 41.81, 22.85 and 131.70 for total, government and privat HE respectively, resulting in favor of rejecting the null hypothesis.

percent on average. Once other potential factors have been controlled for, the long-run income elasticity of total health expenditure is 0.36 on average, suggesting that a 1 percent increase in per capita GDP is associated with a slower increase of total health expenditure around 0.36 percent. In contradiction with the theory, the effect of the share of publicly funded health expenditure on total health expenditures carried a positive sign. But the magnitude of this effect is very small.

Concerning the government HE model, all long-run effects are statistically significant. The evidence suggests that the effect of the share of senior population is neither high as it is previously found by Di Matteo and Di Matteo (1998), nor insignificant as argued by Ariste and Carr (2003)[15]. The long-run income elasticity of government health expenditure is 0.44 after controlling for other determinants of government HE. The evidence also indicates that the long-run effect of relative price of health care is more pronounced for the government with a price elasticity of -0.74. A possible explanation of the significance of price effect is that provincial governments face the full price of health services even though the cost is not projected on patients through billings. Regardless of this fact, the provision of public health care is not free and there are national constraints and long-term issues in financing of public health spending (Brown, 1991).

The effect of life expectancy at birth on government health spending is considerably large. For the sample period, the government health expenditures

[15] According to Di Matteo and Di Matteo (1998), the impact of the log of the share of the population over the age of 65 on log of government health expenditures is 0.81 whereas Ariste and Carr (2003) found no evidence on its statistical significance.

decrease by 19 percent as result of a one-year increase in life expectancy[16]. If it can be postulated that the life expectancy at birth increases roughly by one year on average in every 7 years in Canada, this result indicates a considerable shrinkage in government health expenditures and that improvement in health status leads to less need and thus less use of health care, ceteris paribus.

The long-run income elasticity of private health expenditures is 0.26 on average, lower than that of government HE. This indicates that government health expenditures increase faster than the private health expenditures and thus a 1 percent increase in per capita GDP is associated with increasing centralization, ceteris paribus. This result contradicts the findings of Di Matteo (2000). For the relative prices, the long-run price elasticity is statistically significantly not different from zero at conventional levels. A possible reason for the insignificance of the price effect is that many consumers of private health care do not directly face full prices because of private insurance. Also in face of high private insurance coverage, price elasticities are zero or close to zero (Getzen, 2000).

The share of publicly funded HE is included in the analysis of private sector to evaluate a potential trade-off between private and public health expenditures and its size. The empirical evidence supports the a priori expectation. Our findings indicate a statistically significant negative trade-off between the share of public HE and private HE.

The coefficient of trend is significant at conventional levels for all three models. This suggests that total, government and private health expenditures

[16] It proved impossible to properly instrument the life expectancy at birth by its lags in the Total HE model.

grow at an average rate of 2.0, 3.5 and 1.6 percent respectively after the remaining factors are accounted for. This result is a consequence of the fast-growing cost of medical technology.

The models are further estimated via GMM with Bewley transformation. It should be noted that the GMM is designed and expected to perform well under large *N* and small *T* which is not our case. The long-run income elasticity of total health spending is around 0.34 on average, very close to the GIV estimate of 0.36. The effect of relative price of health care on total health spending in the GMM estimation is not statistically significantly different from zero at conventional levels compared to a statistically significant price elasticity of -0.13 obtained via GIV.

For the government, the GMM estimates a slightly higher income elasticity of 0.45 and in absolute value a lower price elasticity of -0.46 compared to their respective GIV counterparts which are 0.44 and -0.74. The GMM estimation shows that life expectancy at birth has a statistically significant and negative effect on government health expenditures. However, the effect of the share of the senior population is not statistically significantly different from zero at conventional levels.

For the private sector, the GMM long-run effects of income and public provision are very close to their GIV counterparts. The GMM long-run income elasticity with respect to private health spending is 0.27 and the effect of the share of publicly funded health expenditure is -0.037. Autonomous growth in health spending is in general lower in GMM compared to GIV estimates with 2.1, 1.8

and 1.0 percent for total, government and private health expenditures respectively.

5 Conclusion

This article employed a one-way fixed effect dynamic panel model to examine the income elasticity and the impact of non-income determinants of health care expenditures in the Canadian provinces using panel data on per capita GDP, relative price of health care, the share of publicly funded health expenditures, share of senior population and the life expectancy at birth over the period of 1975-2002. The estimation results show that on average, the long-run income elasticity of health expenditures is around 0.34-0.36 indicating that health care is a necessity good in Canada and that the delivery of health care is dominated by the needs rather than the ability to pay. The evidence is in line with some previous regional as well as some international research (Di Matteo and Di Matteo, 1998; Gerdtham and Jönsson, 2000; Ariste and Carr, 2003; López-Casasnovas and Sáez, 2007; Costa-Font and Pons-Novell, 2007). However, our estimates are smaller than those of the previous Canadian studies and it is due to the inclusion of a dynamic adjustment of health expenditures and other factors which have not been previously considered. In order to understand our results concerning income elasticity, one must take into account that choices on health care are strongly affected by the emphasis placed on the equality of citizens' access and by the control of revenues devoted to provincial public health care. Our results also indicate that the relationship between health expenditures and its determinants is of autoregressive structure; government health expenditures are constrained by the relative price of health care; statistically significant effects of the share of senior population and the share of publicly funded health expenditures are small; and there is correlation between health spending and health status.

The inclusion of time trend for statistical reasons and to capture possible changes in medical technology is of importance since the results provide evidence of considerable autonomous growth of health care spending, ceteris paribus. This result is consistent with the findings of Blomqvist and Carter (1997) that when the time trend is excluded from the regression models, the long-run income elasticity of health expenditures is higher.

One of the difficulties encountered in this study was whether the panel can be described as group stationary whose results are relegated to appendix B. The IPS and Hadri's panel unit root tests gave contradictory result regarding the unit root problem. Most of the panel unit root tests are based on and therefore valid only under joint or sequential limit and evidence presented confirms that these tests are known to render conflicting results. Based on this problem, it is argued that the effects of shocks to Canadian public sector can be best characterized as temporary rather than permanent and a traditional analysis has been followed.

Some of the studies of health care expenditure based on the OECD health data argued that there are substantial differences in the structure of health sectors and demographics in the OECD countries. It is also argued that imposing slope homogeneity is unrealistic and may lead to misleading coefficients (Roberts, 1999). Slope heterogeneity is not considered here due to the relatively homogeneous nature of our data compared to the data used for cross-country analysis and due to misleading and biased estimates under dynamic estimation with heterogeneous parameters (Pesaran and Smith, 1995). Also the preliminary estimation under heterogeneity gave conflicting results. It is worth noting that provincial GDP growth would be translated into more health care spending in provinces enjoying higher tax autonomy but not in the rest. Therefore slope heterogeneity may render higher income elasticities for some provinces and lower income elasticities for others.

Extreme caution should be exercised when interpreting the results. The small sample behavior of GMM and the validity of the instruments are questionable matters and they indicate that some bias may not have been removed. The limitation of this paper is that we have not considered the effect of measures that are indicators of the quality of life and health. Proxy measures for the effectiveness of the health system, the quality of health services and health status can serve for such purposes, thereby allowing one to examine the consequences of an increase in the quality of health care on health expenditures.

Appendix A: Data Source

The data covers 10 provinces (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Québec, Saskatchewan) in Canada for the period 1975-2002. The provincial total, private and government health expenditures are taken from the Canadian Institute for Health Information[17]. These variables are deflated by the provincial CPI (1992=100) and divided by the provincial population to obtain real per capita

[17] http://www.cihi.ca

provincial total, real per capita provincial private and real per capita provincial government health expenditures. The share of publicly funded health expenditure is obtained by dividing public health expenditures by total health expenditures. The provincial medical CPI (1992=100), provincial proportion of the population over the age of 65, life expectancy at birth and the provincial GDP are collected from CANSIM[18]. The provincial GDP is deflated by the provincial CPI (1992=100) and divided by the provincial population to obtain the real provincial per capita GDP. The provincial medical CPI is divided by the provincial GDP price index (1992=100) to obtain the relative price of health care for each province.

Appendix B: Unit Root test results

Unit root is a severe problem in the sense that if the appropriate tests are not employed, the inferences drawn might be misleading and seemingly good results may occur because of a common trend rather than a true economic relationship (Granger and Newbold, 1974). We considered Augmented Dickey-Fuller (ADF) unit root test proposed by Dickey and Fuller (1979) under the null of unit root with its extension to panel by Im et al. (2003, henceforth IPS) and KPSS test proposed by Kwiatkowski et al. (1992) under the null of stationarity with its extension to panel data by Hadri (2000). The ADF results in Table 2 show that for most of the series of health expenditures, GDP and the share of publicly funded health expenditures, the null hypothesis of unit root cannot be rejected. Concerning total health expenditures, the null can only be rejected for New Brunswick, Prince Edward and British Columbia. In the case of GDP, this null can only be rejected

[18] CANSIM table numbers are 384-0003, 102-0025, 326-0002, 051-0001, 384-0001. http://www.cansim.ca

for Prince Edward and British Columbia. The IPS panel tbar-statistics show that all of the variables can be described as group stationary. The KPSS individual unit root tests in Table 3 show that for most of the series except the share of senior population, the null of trend stationarity cannot be rejected. However, Hadri's panel unit root tests show that the null hypothesis of either level or trend stationary can be rejected for all the series at the 5 percent significance level. This result might be induced from the fact that the test proposed by Hadri is valid under sequential limit in which $T \rightarrow \infty$ followed by $N \rightarrow \infty$.

The first issue in unit root testing is whether to include a time trend. While Hansen and King (1998) claimed that ADF regression should include a linear trend, McCoskey and Selden (1998) argued that it should not. We argue that most macroeconomic variables have tendency to increase over time, therefore it is appropriate to include a deterministic component into unit root testing. Karlsson and Löthgren (2000) warn that unit root test such as IPS has high power in panels with large T and researchers might mistakenly conclude that the whole panel is stationary even though most of individual series are nonstationary. The converse is true if T is small. This argument is reconciled for both unit root tests that are undertaken. The decision concerning unit roots is inconclusive. For the IPS test, a significant fraction of the series is individually nonstationary but they appear to be stationary as panel. However, for Hadri's test a significant fraction of the series is individually stationary but they appear to be nonstationary as panel.

There is a growing literature on panel unit root testing that allows for structural breaks[19]. Omitting the presence of structural breaks in unit root testing, particularly in international comparisons, has resulted in misspecification that leads to spurious non-stationarity. In this paper, we did not address the presence of structural breaks. Our primary concern is whether the relationship between the Canadian HE and its determinants would be spurious if one analyzes this relationship in levels of the variables. From an economic point of view, shocks to the Canadian health sector have temporary effects rather than effects that alter the level of expenditure permanently. Thus, the analysis proceeded by assuming that the panel is weakly stationary.

[19] See Kurozumi (2002), Jewell et al. (2003), Carrion-i Silvestre et al. (2005), Carrion-i Silvestre (2005) and recently Chan and Pauwels (2010).

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Table 1: The determinants of health care expenditures in the Canadian provinces, 1975-2002

	Total Health Expenditure		Government Health Expenditure		Private Health Expenditure	
	GIV	GMM	GIV	GMM	GIV	GMM
Income						
Log of per capita GDP	0.364**(0.061)	0.338**(0.148)	0.439**(0.153)	0.450**(0.186)	0.261**(0.059)	0.275**(0.108)
Price						
Log of relative price of HE	-0.127**(0.056)	-0.224 (0.156)	-0.740**(0.195)	-0.467**(0.181)	0.008 (0.091)	0.087 (0.093)
Centralization						
Share of publiclly funded HE	0.003**(0.001)	0.003 (0.003)	-	-	-0.034**(0.001)	-0.037**(0.003)
Ageing						
Share of senior population	-0.004 (0.008)	-0.0007 (0.024)	0.080** (0.016)	0.048 (0.057)	0.027**(0.008)	0.013 (0.012)
Health Status						
Life expectancy at birth	-	-	-0.191**(0.068)	-0.068**(0.034)	-0.015 (0.030)	0.025*(0.014)
Time Trend	0.020**(0.001)	0.021**(0.004)	0.035**(0.012)	0.018**(0.006)	0.016**(0.004)	0.010**(0.003)
Change in dependent variable	-1.879**(0.312)	-2.589**(0.544)	-1.746**(0.431)	-3.169**(0.691)	-0.354**(0.076)	-0.383*(0.213)
R-squared	0.70	0.85	0.34	0.77	0.98	0.91
Sample size	230	220	160	190	180	190

Notes: All dependent variables are expressed in natural logarithm and per capita. The lagged dependent variable and the relative price of health care are instrumented by two-period lags. Exogenous explanatory variables served as their own instruments. Up to five-period lagged value is used as instrument for the life expectancy at birth. All GIV specifications include province fixed effects (not shown). GIV standard errors in parentheses are robust to heteroscedasticity of any form. The GMM transformation is via orthogonal deviations, the GMM weights are Arellano & Bond (1991) n-step period weights and the GMM standard errors in parentheses are robust to period heteroscedasticity and serial correlation. The parameters give the long-run effects. ** and * denote statistical significance at 5% and 10% levels respectively.

Table 2: Province by Province ADF τ-statistics and IPS Panel t-bar statistic

Province	Total HE		Government HE		Private HE		Share of publicly funded HE	
	Lag order	τ-statistic	Lag order	τ-statistic	Lag order	τ-statistic	Lag order	τ-statistic
Newfoundland	2	-1.841	3	-1.859	4	-1.939	3	-2.828
Prince Edward Island	2	-3.410*	4	-1.740	2	-3.586*	2	-3.395*
Nova Scotia	2	-2.012	3	-2.126	3	-2.176	3	-1.974
New Brunswick	3	-3.419*	3	-2.821	2	-4.062**	3	-3.739**
Québec	4	-2.551	1	-2.547	2	-2.207	2	-2.647
Ontario	2	-2.391	3	-2.361	3	-2.553	2	-1.538
Manitoba	3	-2.870	3	-2.947	3	-2.467	2	-2.255
Saskatchewan	2	-1.774	3	-2.882	2	-3.726**	3	-2.851
Alberta	2	-2.442	2	-2.417	3	-2.778	2	-2.178
British Columbia	4	-3.832**	3	-3.201	2	-2.067	2	-3.632**
Panel t-bar statistic		-2.654**		-2.539*		-2.756**		-2.713**

Note: ADF regressions include linear trend. ***, ** and * represent 1%, 5% and 10% significance levels respectively. The 1%, 5% and 10% critical values of the IPS t-bar test statistic are -2.79, -2.60 and -2.51 respectively.

Province	GDP		Relative price of health care ☆		Life expectancy at birth		Share of senior population ☆	
	Lag order	τ-statistic	Lag order	τ-statistic	Lag order	τ-statistic	Lag order	τ-statistic
Newfoundland	3	-2.364	3	-3.956***	2	-4.031**	1	-0.052
Prince Edward Island	0	-3.516*	3	-4.402***	1	-3.486*	2	-1.711
Nova Scotia	3	-1.723	1	-4.767***	1	-3.041	2	-3.904***
New Brunswick	0	-3.071	1	-2.101	1	-2.380	2	-2.921
Québec	2	-2.547	1	-1.264	1	-2.864	2	-1.667
Ontario	2	-2.900	2	-1.796	1	-2.776	3	-2.749
Manitoba	3	-2.347	1	-1.522	2	-1.805	3	-2.904
Saskatchewan	2	-1.186	4	-1.852	1	-1.572	3	-1.521
Alberta	1	-2.078	2	-2.242	3	-3.220	2	-0.857
British Columbia	3	-4.082**	2	-1.892	3	-3.480*	3	-1.619
Panel t-bar statistic		-2.583*		-2.579***		-2.865***		-1.990**

Note: ☆ represents that the ADF regressions do not include linear trend. ***, ** and * represent 1%, 5% and 10% significance levels respectively. The 1%, 5% and 10% critical values of the IPS t-bar test statistic are -2.21, -1.99 and -1.89 respectively.

Table 3: Province by Province KPSS η-statistics and Hadri's Panel Test statistic

Province	Total HE $l_4 = 3$		Government HE $l_4 = 3$		Private HE $l_4 = 3$		Share of publicly funded HE $l_4 = 3$	
	η_τ	η_μ	η_τ	η_μ	η_τ	η_μ	η_τ	η_μ
Newfoundland	0.112	0.780**	0.089	0.779**	0.112	0.219	0.087	0.527**
Prince Edward Island	0.066	0.790**	0.074	0.771**	0.066	0.675**	0.067	0.078
Nova Scotia	0.140	0.767**	0.125	0.741**	0.131	0.786**	0.094	0.740**
New Brunswick	0.173**	0.771**	0.161**	0.765**	0.158**	0.760**	0.100	0.648**
Québec	0.098	0.791**	0.113	0.745**	0.095	0.776**	0.098	0.746**
Ontario	0.155**	0.774**	0.151**	0.697**	0.126	0.806**	0.143	0.690**
Manitoba	0.115	0.776**	0.108	0.734**	0.091	0.771**	0.097	0.465**
Saskatchewan	0.132	0.762**	0.133	0.686**	0.091	0.747**	0.124	0.215
Alberta	0.128	0.672**	0.130	0.463	0.057	0.794**	0.143	0.624**
British Columbia	0.100	0.795**	0.091	0.778**	0.054	0.794**	0.085	0.364
Hadri Panel Statistic	4.973**	12.78**	4.516**	11.88**	2.973**	12.40**	2.297**	8.406**

Province	GDP $l_4 = 3$		Relative price of health care $l_4 = 3$		Life expectancy at birth $l_4 = 3$		Share of senior population $l_4 = 3$	
	η_τ	η_μ	η_τ	η_μ	η_τ	η_μ	η_τ	η_μ
Newfoundland	0.089	0.677**	0.181**	0.534**	0.088	0.624**	0.098	0.805**
Prince Edward Island	0.110	0.660**	0.171**	0.615**	0.101	0.604**	0.185**	0.737**
Nova Scotia	0.167**	0.625**	0.182**	0.576**	0.133	0.643**	0.207**	0.791**
New Brunswick	0.113	0.652**	0.123	0.633**	0.166**	0.626**	0.202**	0.796**
Québec	0.076	0.628**	0.101	0.717**	0.127	0.643**	0.153**	0.807**
Ontario	0.066	0.588**	0.139	0.709**	0.117	0.644**	0.193**	0.798**
Manitoba	0.106	0.597**	0.126	0.597**	0.153**	0.605**	0.205**	0.751**
Saskatchewan	0.158**	0.450	0.170**	0.585**	0.140	0.585**	0.147**	0.773**
Alberta	0.122	0.223	0.177**	0.566**	0.145	0.632**	0.122	0.763**
British Columbia	0.046	0.637**	0.145	0.459	0.110	0.643**	0.185**	0.749**
Hadri Panel Statistic	4.051**	11.87**	7.932**	9.01**	4.68**	9.72**	8.43**	13.14**

Note: η_τ and η_μ are the trend and the level stationarity cases respectively. The 5% critical value of the Hadri Panel statistic is 1.645. ** denotes 5% significance level.