Determinants of health care expenditure in Sweden

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Abstract

Sweden faces increasing pressures on health funding. Total expenditure on health care currently accounts for about 10.92% of GDP, which suggests an increase of about twofold over the last five decades. This paper examines the short-run and long-run relationship between income and health care expenditure in Sweden during the period 1980–2017. The study focused on the differences between short- and long-term elasticities. Consistent with the conventional findings, the income elasticity for health care is found to be greater than one, suggesting that health care is a luxury good in Sweden. Additionally, the age structure variable is found to have a significant positive impact on health care expenditure. Finally, the importance of another non-income variable, relative price, is also confirmed, an increase in relative price is associated with lower quantity of health care expenditure.
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I Introduction

The objective of this article is to examine the short- and long-run effects of income and prices of health care expenditure in Sweden, using 1980-2017 annual time-series data.

A series of studies\(^1\) have focused on using cross-sectional data and panel data to investigate the relationship between the health care expenditure and the determinants across countries. These studies differ in terms of the time period covered, determinants selected, country chosen and econometric techniques employed in the estimation. Obviously, these studies provide meaningful and useful guide to understand the reason why health care expenditure varies significantly across countries, but on the other hand, they cannot be generalized to individual country since the aggregate level empirical analyses are less able to capture the complexity and peculiarity of the economic environments of each individual country. Hence, any inferences derived from these studies can only provide a general understanding of the broad relationship between these variables.

In this spirit, country-specific case studies may give more exact description on how income and prices affect health care expenditure in the studied countries. Gbesemete and Gerdtham (1992); Ang (2010); Seshamani and Gray (2004); Murthy and Okunade (2016) and Morgan, Gmeinder and Wilkens (2017) examine the evolution and determinants of health care expenditure in specific country by using systematic time-series data. To some extent, the main finding of these studies offers guidance and constructive suggestions for policy formulation in the country-specific studied.

The literature about the relationship between health spending and GDP have been popularized by the early work of professor Joseph Newhouse (1997). He inferred that over 90 percent of the sample variation between countries in HE could be explained by variations in per capita GDP, with an income elasticity in the range 1.15 to 1.31. Subsequently, other economists have been attracted to the study of international comparisons of health expenditure and empirical studies\(^2\) have supported the hypothesis that there is strong positive relationship between per capita health spending and per capita GDP.

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Other than the GDP per capita, economists are also interested in the non-income determinants of health care expenditure. A group of studies have found that the age structure of the population (usually measured by the percentage of population over age 65) are significantly associated with health care expenditure.

In addition to GDP and the age structure of the population, the relative price of health care can also be viewed as a determinant that affect the demand of health care. In the literature, Lorenzoni and Koechlin (2017) argued that “health-specific price levels play an important role in explaining differences in per capita health care volumes across countries. Hospital price levels for 2014 are for the first time available for all OECD countries (http://stats.oecd.org/Index.aspx?DataSetCode=PPP2014).” Considering relative price of health care is related to the quantity of health care funding, such non-income variable may also be treated indirectly as determinants of health care.

As mentioned above the aim of this article is to examine the short- and long-run relationship between the health care expenditure and its determinants in Sweden by using 1980-2017 annual time-series data. In studying the relationship between the quantity of health care expenditure ($q_t$), the real income(GDP per capita/consumer price index) ($y_t$), the relative price ($p_t$) of health care and demographics (OLDt), defined as the percentage of the population 65 years old and older, this study applied unit root test and co-integration theory to analyze the econometric relationship between time series and then adopt the error correction model to unravel the short and long-run relationship among the variables.

The study’s objective was achieved in three steps. Firstly, non-stationarity of each observed time-series was tested by using the standard approaches which are to estimate augmented Dickey–Fuller ADF regression (ADF test) and Phillips–Perron test(PP), and then ascertain the order of integration of the data series. Secondly, by applying Engle-Granger two-step method, results were obtained regarding the existence of long-run cointegration relationships between the variables in the data. Thirdly, the short and long-run elasticities of real income ($y_t$) and relative price ($p_t$) were estimated by adopting an Error Correction Model (ECM).

Briefly foreshadowing the main conclusions, the present study finds that the quantity of health care expenditure($q_t$), the real income ($y_t$), the relative price ($p_t$) of health care and demographics (OLDt) are integrated of order one and are cointegrated in the Engle-Granger cointegration test. The long-run results reveal that while real income ($y_t$) and demographics (OLDt) have a positive and statistically significant effect on the quantity of health care ($q_t$), relative price ($p_t$) is also statistically significant but with a negative effect as expected. More specifically, the current study finds that the short-run elasticity of quantity of health care with respect to real income is below one, around 0.81-0.88, while the long-run elasticity is above one, in the range of 1.42-1.64, which suggest that health care in long-run is a luxury good in Sweden.

3see e.g. Hitiris and Posnett (1992), Lago-Peñas, Cantarero-Prieto, and Blázquez-Fernández(2013), Ang (2010), Braendle and Colombier (2016).
This paper is most closely related to Ang (2010) who studied the determinants of health care expenditure using Australian data from 1960 to 2003 and found that the determinants, including real income, demographic structure (both percentage of population above 65 years old and below 15 years old), density of health care services and public finance on health care expenditure, impose a significant positive influence on health care expenditure. Specifically, pointing out the long-run elasticities of health care expenditure with respect to real income are found to be in the range of 1.207–1.252 implying that health care is a luxury good in Australia. The present paper contributes by introducing in the relative price which is assumed to have an impact on the quantity of health care, and using relatively new Swedish data.

The rest of this article is organized as follows: Section II analyses the theories on which this paper is based. In section III, the data and analytical framework for modelling was described. In section IV the econometric techniques employed in this study are described, and also the results are presented and analyzed. The last section summarizes and concludes.

II Theoretical bases

The paper is based on a few fundamental economic theories.

The theory of consumer demand is applicable for explaining the relationship between the health care expenditure and real income, also the relative price of health care. The income effect is a phenomenon observed through changes in purchasing power, revealing the change in quantity demanded brought by a change in real income. In general, the relationship between income and quantity demanded is positive, while classic economics predicts that quantity demanded decreases with increasing price.

As we know, normal goods are those goods for which the demand rises as income rises, while inferior goods are goods whose demand decreases as consumer income rises (or demand increases when consumer income decreases). (Jurion, B.J. 1978) Obviously, health care appears to be a normal good. On the other hand, a luxury good is a good for which demand increases by a greater proportion than income. (Varian, Hal 1992) In contrast, a necessary good is a good for which demand increases by a smaller proportion than income. For the long-run elasticity is found to be above one, in the range of 1.41-1.64, which suggests that health care in long-run is a luxury good in Sweden.

For most goods, elasticities are often lower in the short run than in the long run. Changes that just are not possible to make in a short amount of time are realistic over a longer time. In the short-run, the health care expenditure is lagging behind GDP growth. Adjustments for demanding and supplying need a certain period of time to be realistic. For instance, the increase in health care centers, medical personnel and hospital beds etc. takes time to adjust after observing the increasing in the economic growth.
III Data and analytical framework

In the previous health economics studies, per capita GDP, the proportion of population under 15 and/or over 65 have been identified as the key determinants of health care expenditure. Other than these two determinants, this study introduces the relative price of health care into the analytical framework, since economic theory predict that the relative price of a good should affect the quantity for a normal good.

The formulation of the empirical specification of the health care demand equation was given in Equation 1.

\[
\ln q_t = f(\ln y_t, \ln p_t, OLD_t) \tag{1}
\]

where \( q_t \) is the ratio of total health care expenditure per capital to the producer price index PPI(2015=100) of medical and dental instruments and supplies; \( y_t \) is the ratio of per capital GDP to the consumer price index CPI (1980=100); \( p_t \) is the producer price index (2015=100) of medical and dental instruments and supplies divided by the consumer price index CPI; and \( OLD_t \) is the percentage of population aged over 65.

All variables (other than \( OLD_t \)) are expressed in natural logarithms for the usual statistical reasons. The reason for using producer price index (2015=100) of medical and dental instruments and supplies instead of the consumer price index of medical care to derive the relative price is that the household out-of-pocket payment of the total health care expenditure account for a small proportion, around 15%. However, up to 56% of the total health care expenditure in Sweden is funded by the county councils and enterprises owned by the county councils and about 25% is funded by municipalities. In such particular circumstance, the consumer price index does not fully reveal the relative price trend of the health care, but the producer price index is an appropriate alternative choice. Annual data covering the period 1980–2017 in Sweden were used in the estimation. All data were gathered from OECD Health Data (2018) and SCB, (except that the PPI during the period 1980-1990 is estimated on CPI 1980-1990 through OLS regression, because of the lack of data resource for it, as explained in the appendix.)

A graph of the changing trend of quantity of the total health care expenditure (\( \ln q_t \)), per capital GDP (\( \ln y_t \)), the relative price (\( \ln p_t \)) and the percentage of population above 65 years old (\( OLD_t \)) is presented as follow. In general, the growth rate of quantity of the total health care expenditure (\( \ln q_t \)) and per capital GDP (\( \ln y_t \)) is similar as predicted, while the relative price (\( \ln p_t \)) and the percentage of population above 65 years old (\( OLD_t \)) appears comparatively constant.
Before adopting any time series model, stationary tests for all variables are necessary in order to detect and avoid spurious regressions. A unit root test is used to study if a time series variable is non-stationary and possesses a unit root. In general, there are several tests for it, including augmented Dickey–Fuller test (ADF), Phillips–Perron test, KPSS test, ADF-GLS test. In this article, augmented Dickey–Fuller test (ADF) and Phillips–Perron test (PP), which are the most common unit root test, were used to test the stationarity of the time series. With this aim, ADF test and PP test for \(lnq_t\), \(lny_t\), \(lnp_t\) and \(OLD_t\) have been carried out. A summary of results is reported in Table 1. The null hypothesis \((H_0)\) that the tested series has a unit root is accepted in the level of all series which indicates that \(lnq_t\), \(lny_t\), \(lnp_t\) and \(OLD_t\) are all non-stationary. This results are the same as Gerdtham and Löthgren (2000) reported for health expenditure and GDP. However according to both of ADF test and PP test, all series of \(lnq_t\), \(lny_t\), \(lnp_t\) and \(OLD_t\) are stationary process after first order difference. Hence all series may be treated as \(I(1)\).
Table 1  unit root test

<table>
<thead>
<tr>
<th>test types(c t m)</th>
<th>lnq_t</th>
<th>lny_t</th>
<th>lnpt</th>
<th>OLD_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0,0,0)</td>
<td>1.33</td>
<td>1.32</td>
<td>-1.39</td>
<td>0.72</td>
</tr>
<tr>
<td>(c,0,0)</td>
<td>0.483</td>
<td>0.39</td>
<td>-2.23</td>
<td>-2.03</td>
</tr>
<tr>
<td>(c,t,0)</td>
<td>-1.99</td>
<td>-1.69</td>
<td>-2.88</td>
<td>-3.68**</td>
</tr>
<tr>
<td>(0,0,1)</td>
<td>-4.7***</td>
<td>-3.33***</td>
<td>-6.42***</td>
<td>-3.14***</td>
</tr>
<tr>
<td>(c,0,1)</td>
<td>-4.84***</td>
<td>-3.59***</td>
<td>-6.65***</td>
<td>-3.23***</td>
</tr>
<tr>
<td>(c,t,1)</td>
<td>-5.41***</td>
<td>-4.19***</td>
<td>-6.58***</td>
<td>-4.24***</td>
</tr>
<tr>
<td>(0,0,0)</td>
<td>1.09</td>
<td>1.30</td>
<td>-1.23</td>
<td>1.89</td>
</tr>
<tr>
<td>(c,0,0)</td>
<td>0.19</td>
<td>0.51</td>
<td>-2.05</td>
<td>-0.21</td>
</tr>
<tr>
<td>(c,t,0)</td>
<td>-1.99</td>
<td>-1.63</td>
<td>-2.80</td>
<td>-0.99</td>
</tr>
<tr>
<td>(0,0,1)</td>
<td>-4.74***</td>
<td>-3.24***</td>
<td>-6.69***</td>
<td>-4.20***</td>
</tr>
<tr>
<td>(c,0,1)</td>
<td>-4.82***</td>
<td>-3.59***</td>
<td>-7.09***</td>
<td>-5.69***</td>
</tr>
<tr>
<td>(c,t,1)</td>
<td>-5.41***</td>
<td>-4.22***</td>
<td>-6.98***</td>
<td>-8.67***</td>
</tr>
</tbody>
</table>

Notes: For ADF, AIC was used to select the lag length and the maximum number of lags was set to be nine. For PP, AR spectral-GLS detrend was used as the spectral estimation method. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. For the test type (c,t,m), c denotes with intercept, t with intercept and trend, and m indicates lagged differences.

IV. Co-integration test

Since all series are stationary process after first order difference, there might exist cointegration relationships between the variables. By applying the Engle-Granger two-step method, results can be obtained regarding the existence of long-run cointegration relationships between the variables in the data.

In the first step, OLS regression was conducted with lnq_t as the explained variable and lny_t, lnpt and OLD_t as the explanatory variables. The regression result is presented as follow (Table 2):

Table 2  OLS regression on lnq_t

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-6.14</td>
<td>0.65</td>
<td>-9.396</td>
<td>0.0000</td>
</tr>
<tr>
<td>lnyt</td>
<td>1.42</td>
<td>0.082</td>
<td>17.22</td>
<td>0.0000</td>
</tr>
<tr>
<td>lnpt</td>
<td>-1.23</td>
<td>0.36</td>
<td>-3.41</td>
<td>0.0017</td>
</tr>
<tr>
<td>OLDt</td>
<td>7.72</td>
<td>2.18</td>
<td>3.55</td>
<td>0.0012</td>
</tr>
</tbody>
</table>

R-squared 0.958  Mean dependent var 3.468
Adjusted R-squared 0.955  S.D. dependent var 0.304
S.E. of regression 0.064  Akaike info criterion -2.54
Sum squared resid 0.142  Schwarz criterion -2.367
Log likelihood 52.25  Hannan-Quinn criter. -2.478
F-statistic 261.64  Durbin-Watson stat 0.73
Prob(F-statistic) 0.000000
In the second step, the residual series is made out from the OLS regression above and then conducted the ADF test for the residual series generated. The t-statistic value of the residual series in the ADF test is -2.86, less than the critical value of the 1% significance level, -2.63. Therefore, it can be considered that the residual error series is stationary, indicating the existence of long-run cointegration relationships between the variables in the data.

IV. III Error Correction Model

Since the residual of the OLS regression is considered to be stationary in the cointegration analysis, which indicates the existence of long-run cointegration relationships between the variables. The error correction model (ECM) can be adopted to estimate the long-run equilibrium relationship between quantity of health care expenditure and its determinants. By applying the ECM, the short-run dynamic adjustment has also been revealed, which are critical in any time-series investigation. The effects of the determinants of health care expenditure are often different in the short and long run.

Below the error correction model (ECM) was set out, by just formulating one equation \( \Delta lnq = a_0 + a_1 \Delta ln y + a_2 \Delta ln p + a_3 \Delta OLD + \lambda_1 \Delta ln e_{t-1} + \beta_1 ln y_{t-1} + \beta_2 ln p_{t-1} + \beta_3 OLD_{t-1} + e_t \) (referred as model A) and by using Engle-Granger two-step approach (referred as model B), respectively.

In model A, the short-run elasticities of all the determinants can be obtained directly from the estimated result, including the real income elasticity, the price elasticity and demographic semi-elasticity. The corresponding long-run elasticities can be derived indirectly by adopting \( \beta_k / \lambda \) for \( k=1,2,3 \). When applying this model, the error correction term is not necessary to be generated during the regression process.

On the other hand, while adopting model B, it is necessary to obtain the error correction term first, by regressing the long-run steady-state model in the first step and making residuals out of it. The long-run elasticities are obtained directly during first step. While in the second step, by bringing in the error correction term, error correction model (ECM) is set out and short-run elasticities can be obtained.

Firstly, the following long-run steady-state solution is obtained in the cointegration test. \( \Delta lnq = -6.14+1.42 \Delta ln y+1.23 \Delta ln p+7.72 \Delta OLD \) (refer to Table 2).

Next, the Error-Correction Term (ECT) can be obtained by taking \( lnq_{t-1} - a_0 - b_1 ln y_{t-1} - b_2 ln p_{t-1} + b_3 \Delta OLD_{t-1} \) to formulate the error correction model (ECM) as shown in Equation \( \Delta lnq = \delta_1 \Delta ln y_t + \delta_2 \Delta ln p_t + \delta_3 \Delta OLD_t - \mu (ecm_{t-1}) + e_t \). Where \( ecm_{t-1} = lnq_{t-1} - a_0 - b_1 \Delta ln y_{t-1} - b_2 \Delta ln p_{t-1} + b_3 \Delta OLD_{t-1} \). The ECT captures the health care expenditure evolution process by which agents adjust for prediction errors made in the last period. The stationarity of the ECT provides evidence that the long-run relationship exists.

Slightly different results are acquired from the two models. The results are presented in Table 3. But in general, all long-run effects are significant at the conventional levels and have the expected signs and reasonable magnitudes.
(1) The regression results for model A, reported in panel 2 of Table 3, provide the short-run dynamic changes pattern. Other than the demographic variable (OLDt) which indicates no short-run inference can be made about this variable, all other coefficients are statistically significant at the 5% level. In the first differenced form, real income (Inyt) and relative price (Inpt) appear to be statistically significant at the 1% level, and therefore short-run inference can be made. The short-run income elasticity is 0.81, indicating when per capital GDP grows 1%, the quantity of health care will increase by 0.81% in the current year. The short-run price elasticity has the expected negative sign and implies that an increase in relative price of health care by 1% will decrease the quantity consumed by 1.34%.

The coefficient on Inyt-1 is about 0.45, indicating the quantity of health care in the previous year increasing by 1% will lead to the quantity in current year rising by 0.45% .The possible explanation is that the fixed assets and personnel investment proposed in the previous year in health care have a stimulating effect on the health care expenditure in the following period of time.

The long-run elasticity of quantity of health care with respect to per capita GDP is around 1.64 with standard error 0.31, suggesting that the real income long-run elasticity is above 1. The result implies that health care in long-run is a luxury good in Sweden.
Such a finding is consistent with a number of previous studies, including Newhouse (1977), Leu (1986), Gerdtham and Jönsson (1991), Milne and Molana (1991), Hitiris (1997) and Ang (2010). The long-run price elasticity is around -3.07 with standard error 1.68. This point estimated is below that reported by Gerdtham and Jönsson (1991), Marc Pomp and Sunčica Vujić (2008), in which the relative price elasticities are between minus one and zero. However due to the large standard error, the 95% confidence interval range from -6.43 to -0.29, and therefore do not contradict that the true effect is between minus one and zero. The possible explanation is that the use of predicted prices for some years resulting in the large standard error. And the use of different approaches to derive the relative price of the health care could be another reason.

(2) Engle-Granger two-step approach (model B)

The regression results for model B are presented in table 3.

The coefficients on ecm_{t-1} is -0.303, which measure the speed at which adjustment returns to the long-run equilibrium value, is statistically significant at the 1% level with the expected negative sign. This indicates that the quantity of health care adjusts at the speed of 30.3% every year to restore equilibrium when there is a shock to the steady-state relationship.

While the estimated short-run income elasticity δ₁ is around 0.88, the long-run elasticity is 1.42 with standard error 0.08. This result also suggests that health care in long-run is a luxury good in Sweden. And while the estimated short-run price elasticity δ₂ is around -1.01, the long-run elasticity is -1.23 with standard error 0.36. The magnitudes of the coefficients for relative price are slightly different from that obtained in model A, and closer to that found in previous studies.

The coefficient on OLD₁ is found to be around 7.58 with the expected (positive) sign and statistically significant at the 1% level. The result suggests that the quantity of health care expenditure rises significantly with the increase in elderly population (over 65) relative to total population, which is expected. To this extent, the results support the view that demographic factors are crucial in explaining the variations in health care expenditure, as reported by the previous studies of Gerdtham and Jönsson (1991a), Hitiris (1997), Gerdtham et al. (1992) and Murthy and Ukpolo (1994)

V Summary and conclusions

Sweden faces increasing pressures on health funding. Total expenditure on health care currently accounts for about 10.92% of GDP in Sweden, suggesting an increase of about twofold over the last five decades. It is crucial to examine the underlying causes of this increase and provide some fundamental guidelines for health policy designing.

This paper investigated the short and long-run economic relationship between quantity of health care and its determinants, including per capital GDP, relative price and age structure (the percentage of population above 65 years old). Using a time-series data of Sweden followed about 39 years, this paper has studied the non-stationarity and cointegration properties of all the series. The analysis indicates that health care expenditure and the three determinants studied are non-stationary, but there exists long-
run cointegration between the variables. Our results show that there exists strong positive relationship between quantity of health care and per capita GDP as reported in previous studies, and also indicate that health care in long-run is a luxury good in Sweden, with a long-run income elasticity greater than one, consistent with the previous studies Newhouse(1977). As for non-income determinants, our analysis indicates the percentage of population above 65 yeas old plays a quite important role in explaining health expenditure variations as previous studies implied. And finally, from the results obtained, relative price is also an important determinant of the demand for health care since its coefficient is significant at 1% level in both models.

Several limitations of this study need to be acknowledged. One limitation concerns the fact that there may be some omitted variables which affect the demand for health. This could lead to omitted variables bias. Another limitation concerns issues of data. Because of lacking for relative price from 1980 to 1990, it had to be imputed. On the other hand, future studies on health care expenditure growth may further expand the study by empirically test different variables and related health indexes with GDP. And it may be worthwhile to try using longer time series to study if the elasticities have changed over time.

Acknowledgement

In the acknowledgement of this thesis, I would like to thank different people who directly or indirectly contributed to my thesis via their time, efforts, knowledge, expertise. Particularly I would like to thank my supervisor, David Granlund, for his efforts, support and guidance. David has provided his feedback and supervision throughout the research work in a professional manner. His criticism and suggestions were always constructive as far as the improvements in the thesis were concerned. I also would like to thank those who supported me throughout the process.
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Appendix

Data of the consumer price index and producer price index was collected from SCB. While the CPI is presented from 1980 to 2017, the PPI only presented from 1990 to 2017. Considering that the PPI generally appears to have similar trend as CPI, PPI in the period of 1980-1990 is predicted by using data of CPI. Firstly, set out regression equation \( \ln\text{PPI}=\alpha+\beta \ln\text{CPI} \), following results were obtained.

<table>
<thead>
<tr>
<th>( \ln\text{PPI} )</th>
<th>Coef.</th>
<th>St.Err.</th>
<th>t-value</th>
<th>p-value</th>
<th>[95% Conf Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln\text{CPI} )</td>
<td>1.054</td>
<td>0.065</td>
<td>16.23</td>
<td>0.000</td>
<td>0.921-1.188</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.520</td>
<td>0.365</td>
<td>-4.17</td>
<td>0.000</td>
<td>-2.270-0.770</td>
</tr>
</tbody>
</table>

| Mean dependent var | 4.403  | SD dependent var | 0.126 |
| R-squared         | 0.910  | Number of obs    | 28,000 |
| F-test            | 263.561| Prob > F          | 0.000 |
| Akaike crit. (AIC)| -100.859| Bayesian crit. (BIC) | -98.194 |

*** \( p<0.01 \), ** \( p<0.05 \), * \( p<0.1 \)

Next, PPI was predicted by using the reported regression model. PPI during the period of 1980-1990 is obtained. The data of total health care expenditure and GPD is collected from OECD health care database.