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The elasticity of demand for public health expenditure in South Africa: a cointegration approach

Elasticidade da demanda por despesas de saúde pública na África do Sul: uma abordagem de cointegração

Njabulo Innocent Mkhize*
University of South Africa, South Africa
mkhizni@unisa.ac.za

Abstract. To effectively evaluate the elasticity of demand for public health expenditure in South Africa, this study utilised a demand function approach to specify the functional relationship between public health expenditure, real GDP and other non-income explanatory variables. The study uses a double-log linear regression model to capture the elasticity of public health expenditure in respect of model explanatory variables. Empirical results suggest that public health expenditure, GDP, life expectancy and medical inflation were cointegrated over the period of the analysis. The findings also confirmed that the coefficients of these variables were statistically significant and of the expected signs. Specifically, the results reaffirm the importance of GDP and life expectancy as key determinants of health expenditure, both with an elasticity value above unity. The importance of medical inflation was also confirmed although its effect appears small.

Key words: elasticity of demand, public health, health expenditure.

Resumo. Para efetivamente avaliar a elasticidade da demanda por despesas de saúde pública na África do Sul, este estudo utilizou uma abordagem de função de demanda para especificar a relação funcional entre despesa de saúde pública, PIB real e outras variáveis não explicativas de renda. O estudo utiliza um modelo de regressão linear de duplo *log* para captar a elasticidade dos gastos de saúde pública em relação às variáveis explicativas do modelo. Resultados empíricos sugerem que as despesas de saúde pública, PIB, expectativa de vida e inflação médica foram co-integradas ao longo do período da análise. Os achados também confirmaram que os coeficientes dessas variáveis foram estatisticamente significativos e dos sinais esperados. Especificamente, os resultados reafirmam a importância do PIB e da expectativa de vida como principais determinantes das despesas de saúde, ambos com um valor de elasticidade acima da unidade. A importância da inflação médica também foi confirmada, embora seu efeito pareça pequeno.

Palavras-Chave: elasticidade da demanda, saúde pública, gasto em saúde.

* University of South Africa. P O Box 392, South Africa.

Introduction

There is a widespread belief that health care costs will increase significantly over the next decade as people live longer and are expecting to be given unconditional access public health care. This implies that, any formal structure or system for delivering health care will eventually be confronted with the inevitable situation of a limited amount of resources to serve a growing patient population (Zere *et al*., 2001). In South Africa, public health care expenditure accounts for approximately 4 per cent Gross Domestic Product (GDP) and supports a growing population of medically uninsured persons. South Africa suffers from a quadruple burden of disease where diseases of development such as communicable diseases co-exist with an expanding problem of chronic diseases and trauma (National Treasury, 2009). According to a report by the Financial and Fiscal Commission (2012), communicable and non-communicable diseases, injury and trauma continue to prevent faster development with HIV/AIDS, tuberculosis and malaria posing the greatest challenges.

Despite the rising allocations and progress made with the delivery of public health services, the health system continues to be challenged by the large burden of disease, not being adequately prevented (National Treasury, 2009). This has prompted policy makers and researchers in health care to mobilise for additional resources to address inequalities in access to health care.

Given the fact that a large proportion of public health spending is in district health and hospital services, it is important that a proper assessment of funding requirements of rendering these services is investigated and addressed. Failure to assess the full cost of providing these services will compromise the objectives of addressing inequality and access to health care.

Stuckler *et al*. (2011) used multivariate regression analysis to examine the determinants of health care funding allocations among the South African provinces between 1996 and 2007. Their study found that the burden of disease was increasingly negatively correlated to funding allocations and that it explained less than a quarter of the variation in allocations among provinces. Moreover, in the case of HIV the study found that since 2002 the scale of the inverse association increased substantially as HIV prevalence rose while allocations showed no response to the growing burden.

Econometric modelling of health expenditure has been among the most commonly used methods of regression based analysis in public health research. This approach has been used in studies by Hitiris and Posnett (1992), Hansen and King (1996), Milne and Molana (1991) and Newhouse (1977) to measure the response of health budgets to changes in non-income explanatory variables.

Since Newhouse (1977) drew attention to the correlation between per capita health care spending and per capita GDP, a number of economists have been attracted to study the relationship between public health expenditure and its effect on health care provisioning. A study by Hitiris and Posnett (1992) assessed the determinants and effects of health expenditure in developed countries between 1960 and 1987. The study found a negative correlation between expenditure on health care and burden of disease, as measured by crude mortality rates.

A study by Gerdtham *et al*. (1992) revealed that health care expenditure differ substantially across countries, regardless of how it is measured. The results of regression analyses used to explain the observed differences in health care expenditure across countries indicate that health care expenditure increases proportionally more than aggregate per capita income.

A study by Kleinman (1974) and Newhouse (1977) established a strong and positive correlation between national income and expenditure on health care. This is consistent with the findings of Milne and Molana (1991) and Hitiris and Posnett (1992), of a research examining the determinants of aggregate health care expenditure. These studies borrowed what is essentially a demand function approach in specifying their models. That is, per capita health care expenditure is hypothesised to

be a function of per capita income (GDP) and other non-income variables such as HIV prevalence.

The National Department of Health (NDOH) has driven a number of initiatives to develop and strengthen the health care system in South Africa. Some of these initiatives include, among others, the White paper for the transformation of the health system in South Africa (1997), the promulgation of the National Health Act (2003) which formalised the legal status of the District Health System (1994), the National Strategic and Ten Point plan (1999-2004), the Negotiated Service Delivery Agreement (2010-2014), the National Core Standards for Health Establishments in South Africa (2011), the re-engineering of primary health care (PHC) services and the clinic building programme (2011), and implementation of the National Health Insurance (NHI) (2012). These and many other initiatives have increased access and care for the majority of vulnerable South Africans.

However some of the primary gains have been compromised by a multiplicity of factors, including a quadruple burden of disease, low morale among health personnel, inadequate management systems and gaps between policy intentions and actual implementation (Schneider *et al*., 2007). As a result some of the health outcomes such as infant mortality, immunisation rates, early childhood malnutrition, maternal and crude mortality rates are poor and not proportional with the per capita rates of health expenditure. It is against this background that this study seeks to investigate the elasticity of public health expenditure in South Africa, with the view to identify the key determinants of public health expenditure that are intensive.

Through regression analysis the study seeks to measure and demonstrate the variation between public health expenditure and health outcomes as well as the continued investment on health in the country as its GDP grows. Ultimately, this will show whether or not public health expenditure is responsive to health outcomes, as well as the payoff from this investment in terms of increased longevity.

This paper is divided into four parts. Following this section is Section 2 which discusses the model, data sources and the variables used for this analysis. Section 3 presents and analyses the empirical results. Section 4 concludes the paper.

Model and data

Model specification

Following the demand function approach, as applied by Hansen and King (1996), Gerdtham *et al*. (1992), Stuckler *et al*. (2011) Mullahy (2009) and others, a hypothesised model of health expenditure will be estimated. Specifically, public health expenditure is hypothesised to be a function of real income and a selection of non-income variables, as follows:

$$PHE_t = f\,(\mathrm{GDP}_t, \mathrm{LeX}_t, \mathrm{Medic\_Infl}_t) \quad (1)$$
$$(+) \qquad (+) \qquad (+)$$
(expected sign of the parameters)

In order to capture the elasticity of public health expenditure with respect to the model explanatory variables, a double-log linear regression equation below will be estimated.

$$\ln PHE_t = \beta_0 + \beta_1 \ln \mathrm{GDP}_t + \beta_2 \ln \mathrm{LeX}_t + \beta_3 \ln \mathrm{Medic\_infl}_t + \varepsilon_t \quad (2)$$

where t = 1, …, 18 indicate years. Our dependent variable, PHE_t represents total public health expenditure, in thousands of rands in South Africa, in year t. The explanatory variables are:

GDP_t = GDP in constant 2005 prices. GDP was chosen following the findings of Gerdtham *et al*. (1992) and Hansen and King (1996). The main insight in this case is that an increase in economic output will generate an increase in public health expenditure.

LeX_t = a measure of average life expectancy at birth, calculated by the Medical Research Council (MRC). The choice of this variable is based on findings by Hitiris and Posnett (1992) and Stuckler *et al*. (2011). The variable

was chosen in order to identify whether there is a variation of the impact of average life expectancy on public health expenditure.

Medic_infl$_t$ = medical inflation, metropolitan and other urban areas (Index 2000 = 100). This variable was chosen as a control variable to identify whether uncertainty regarding prices has an impact on public health expenditure.

Interpretation of elasticities

The logarithmic specification of Equation 2 ensures that β_i can be interpreted as elasticities (Koop, 2005). The parameter of primary interest in this study will be β_2, the elasticity of public health expenditure in respect of average life expectancy, which provides a measure of the responsiveness of public health funding due to changes in average life expectancy. Hence, the elasticity coefficient will show how public health expenditure has varied with average life expectancy. Therefore, a positive elasticity value of 0.5, for instance, implies that a percentage increase in average life expectancy is associated with half a percentage increase in public health expenditure. An elasticity of 1.33 implies that every percentage increase in average life expectancy is associated with a 1.33 percentage increase in public health expenditure, and so forth. Similar to other regression based analyses that have explained the variation in public health expenditure across countries [see Milne and Molana (1991), Hitiris and Posnett (1992), Hansen and King (1996), Gerdtham *et al*. (1992), Newhouse (1977)], this study will estimate and evaluate the functional relationship between public health expenditure, GDP and other non-income explanatory variables.

Data sources

The study utilised secondary, yearly data covering the period from 1995 to 2012. The data on public health expenditure was sourced from the Financial and Fiscal Commission (FFC) database. Data on average life expectancy was sourced from the MRC database. It is based on the average life expectancy at birth indicator which accounts for a wide spectrum of mortality rates and prevalence distribution of health states in the population. Data on medical inflation (based upon a 2000 base of 100) and GDP (at constant 2005 prices) were obtained from Statistics South Africa (STATSSA).

Econometric results and discussion

As a preliminary step to empirical analysis, the study commences by investigating the integration properties of the series. This is done in order to establish the presence of unit roots in the data and to apply appropriate modelling procedures. That is, in establishing whether the variable is stationary or non-stationary, it is important to test for the presence of unit roots in order to avoid a spurious regression (Harris, 1995). By differencing data to remove the non-stationary (stochastic) trend, spurious regression problem can be avoided. While there are several ways for testing the presence of unit roots in the data, this study utilises the Augmented Dickey-Fuller (ADF) approach to test the null hypothesis that a series contain a unit root against the alternative of stationarity. Following from Gogfrey and Treymayne (1998), Handa and Ma (1989) and Muscatelli and Hurn (1992), the ADF test was employed to this end and the results are summarised in the table below.

Table 1. Summary of Augmented Dickey-Fuller (ADF) unit root test on time series.
Tabela 1. Sumário do Augmented Dickey-Fuller (ADF) teste de raízes unitárias em séries de tempo.

Series	Levels	First differences
HCF	-1.139	-5.627***
LEX	-2.573	-5.901***
GDP	-2.261	-2.725*
MEDIC_INFL	-3.499*	

Notes: critical values taken from MacKinnon (1991) response surface of critical values of ADF Test; asterisks (*) indicate significant coefficients: (*) statistically significant at 10% level; (**) statistically significant at 5% level; and (***) statistically significant at 1% level.

The results of the Augmented Dickey-Fuller test, reflected in Table 1 above, suggest all model variables are of unit roots in levels, except for MEDIC_INFL. This means that the non-stationary variables had to be differenced. Further tests indicate that the non-stationary variables are stationary after the first differencing, suggesting differenced stationary series of order one, I(1). That is, the logarithms of PHE, LEX and GDP are I(1) and MEDIC_INFL is I(0). Eventually, all non-stationary variables became stationary after taking the first difference.

In order to establish a long-run relationship between PHE and other selected variables a cointegration regression analysis is applied, whereby the residuals obtained from the ordinary least squares estimation were subjected to unit root analysis. Based on the Angle-Granger (1987) cointegration test, the results suggest that the residuals from the regression were stationary, hence cointegrated. The results of the cointegration analysis are presented in Table 2 below.

Table 2. Cointegration test on residuals of HCF, GDPR, LeX and Medic_Infl.
Tabela 2. Teste de cointegração dos resíduos HCF, GDPR, LeX and Medic_Infl.

	t-Statistic (ADF test on residuals)	Decision
South Africa	-4.465*	Cointegrated

Notes: the critical values for the Engle-Granger cointegration test on regression residuals at 1%, 5% and 10% are -5.7869, -4.76352 and -4.2891, respectively; (*) indicate parameters are significant at 10% level; (**) significant at 5% level; and (***) significant at 1% level.

The results presented in the table above indicate a cointegrating regression, suggesting the existence of a long-run relationship between PHE, GDP, LeX, and Medic_Infl in South Africa. Hence we can conclude that, for South Africa, these variables share the same long run properties. This is indicative of the ability by GDP, inflation and increased human longevity to influence public health funding.

Since the model has been found to reflect a cointegrating regression, the model can be estimated using ordinary least squares (OLS) without any further adjustment to yield consistent estimates. Table 3 presents the coefficient estimates of the model based on the OLS estimation of the relationship between public health expenditure and the selected variables.

Table 3. OLS estimates of the relationship between PHE and GDP, LeX, Medic_Infl.
Tabela 3. Estimativas de MQO da relação entre PHE e GDP, LeX, Medic_Infl.

Dependant variable: Public health expenditure (PHE_t)	South Africa
Constant	-49.99***
	3.68
Economic output (GDP)	3.71***
	(0.16)
Life expectancy	1.87***
	(0.56)
Medical inflation	0.20*
Summary statistics	
Adjusted R^2	0.98
F-statistic	261.96
Prob (F-statistic)	0.00
Number of observations	18
Estimation method	OLS

Notes: (*) statistically significant at 10% level; (**) statistically significant at 5% level; and (***) statistically significant at 1% level.

The regression yield an impressive adjusted R^2, implying that the regressors account for approximately 98 per cent variation in public health expenditure. The estimated coefficients are fairly robust, significant and of the expected signs. In the first instance, the elasticity of GDP is 3.71 (significantly above one at the 1% level) which mean that a one percentage increase in GDP will give a 3.71 percentage rise in aggregate public health expenditure. Furthermore, since the income elasticity of health care spending obtained exceeded unity, health care is deemed a luxury good in South Africa. This indicates an increased marginal preference to spend on health care and is suggestive of the willingness by government to prioritise the health care sector.

This reaffirms the conclusion by Hansen and King (1996) that most estimates of income elasticity of health care spending obtained have exceeded unity.

With regards to medical inflation, health care is usually considered to be relatively inelastic with respect to consumer price (Gerdtham *et al*., 1992). Hence the inelastic coefficient value of 0.20 in respect of medical inflation is in line with empirical findings. This implies that an increase in medical inflation results in a small percentage increase in the health budget. This is true for South Africa where MTEF budgets in the public health sector have been adjusted by the conventionally low CPI inflation which has consistently remained below medical inflation.

As mentioned, our parameter of primary interest in this study is the elasticity of public health expenditure in respect of average life expectancy. The value and the sign of this coefficient is important since it will address the critical question of how public health expenditure will react to an increase in life expectancy (i.e. population ageing). The estimated coefficient was found to be significant and of the expected sign with an elasticity value of 1.87. Since this value is above 1 in absolute terms (i.e. elastic), this implies that a significant growth in health expenditure have been explained by the accumulative effects of ageing population over time. This means that an increase in the average life expectancy has resulted in a higher percentage increase in the budget for public health care. Between 2009 and 2014, life expectancy in South Africa has increased from 53 years to 57 year and this have a significant impact on health budgets given the fact that as people live longer, they are expecting to be given unconditional access public health care. These results strongly confirmed that health care expenditure for the elderly increase with age, given the fact that health care expenditures increase with closeness to death (Yang *et al*., 2003).

This is also reaffirmed by Gray (2005) who was able to show that an increasing elderly population was the main reason for the upsurge in inpatient care expenditures and ultimately long-term health care expenditure. As a result in the UK, for instance, the government have incorporated greater longevity and proximity to death into health care expenditure projections as part of the long-term health spending requirements (Wanless, 2002). Projections by the OECD of the impact of population ageing on public expenditures suggest that population ageing will create an increase in age-related social expenditures from an estimated 19 per cent of GDP in 2000 to almost 26 per cent of GDP by 2050, with health care expenditure accounting most of the increase (Dang *et al*., 2001).

This is suggestive of the potential that the public health care budget has to deliver and address the burden of disease. Consequently, this also indicative of the growing concerns that, in South Africa, public health is consuming more in resources without the concomitant increase in output of service provision and hence raising suspicion of technical inefficiencies that might be embedded in this sector. According to the study on Financing Health Services in Developing countries by Zere (2000), inefficiency was identified as one of the major problems in the African health care system apart from access and equity. Furthermore, evidence emerging from other studies suggests that there is wide prevalence of technical inefficiency in hospitals and other health facilities in South Africa (Zere *et al*., 2001). In South Africa, much of the attention by policy makers,

donors and health care researchers has been on health sector reform and mobilisation of additional resources to address inequity and access to health care. However, it is also equally important that the efficiency with which these resources are used is investigated and addressed.

The current real increases in health budgets are an attempt to respond to the needs of the health sector and to deal with the main causes of the burden of disease. However despite these interventions, the life expectancy rate has shown an increasing trend over time. This means that public health expenditure will have to increase significantly over the next decade as people live longer and expecting to be given unconditional access public health care. This implies that, any formal structure or system for delivering health care will eventually be confronted with the inevitable situation of a limited amount of resources to serve a growing patient population. This has a potential to change the demographic landscape of South Africa, challenging the way in which public health care is to be funded.

Table 4. Results of error correction model diagnostic testing.
Tabela 4. Resultados do modelo de diagnóstico de correção de erros.

Dependant variable: DLN_PHE_t	Coefficient
EC $term_{t-1}$	-1.21***
	(-6.79)
DLN_PHE(-3)	-0.31***
	(-2.30)
DLN_GDP(-1)	1.12*
	(-1.84)
Adjusted R^2	0.80

Diagnostic Tests[#]

	H_0	p-value	Conclusion
Jarque-Bera	Normality of residuals	0.999	Normality of residuals
Ljung-Box Q	No auto-correlation	0.804	No auto-correlation present
Breusch-Godfrey LM Test	No auto-correlation	0.983	No auto-correlation present
ARCH-LM	No heteroskedasticity	0.515	No heteroskedasticity present
White	No heteroskedasticity	0.235	No heteroskedasticity present
Ramsey RESET	No misspecification	0.720	No misspecification

Notes: (*) statistically significant at 10% level; (**) statistically significant at 5% level; (***) statistically significant at 1% level; t-statistics are in brackets; ([#]) reject H_0 if p-value < α : where $\alpha = 0.05$.

With regards to the results of the error-correction model, the error correction term is significant at 1% level of significance and has a speed of adjustment coefficient value of -1.21 (Table 4). This coefficient indicates that public health expenditure adjusted relatively faster to changes to the underlying equilibrium relationship since the parameter estimate, ε_{t-1}, shows that 1.21 percentage of disequilibrium is removed in each period. In addition, the diagnostic tests reveal that the estimated model is correctly specified and conform with the statistical assumptions of the classical linear model. The diagnostic checks performed include the Jarque-Bera test for normality in the residuals; the Ljung-Box Q test of no autocorrelation in residuals; a Breusch-Godfrey LM test for serial autocorrelation; an ARCH-LM test for no autoregressive conditional heteroscedasticity, White's test for heteroscedasticity and Ramsey's RESET test of misspecification. Based on the tests performed, the results show that the model do not have problems of misspecification, serial correlation and heteroscedasticity.

Also, the results of the normality test show that the residuals are normally distributed with a zero mean and variance. These results suggest that the estimated regression model is well specified and generally conforms to economic theory and the assumptions underlying our modelling procedures.

Conclusion and recommendations

Despite the rising allocations and progress made with the delivery of public health services, the South African health care system continues to be challenged by the large burden of disease. Life expectancy has increased over the past years. This has a direct impact on increased public health expenditures. Furthermore, despite real increases in health budgets that have been noted recently, the upward increasing trend in life expectancy rate implies that public health expenditure will have to increase quite significantly over the next decade as people live longer and expecting to be given unconditional access to public health care. If sustained this may potentially change the demographic landscape of South Africa, challenging the way in which public health care is to be funded.

One of the main conclusions that emerge from this study is the strong positive relationship between public health expenditure and real GDP, as reported in previous studies. The high income elasticity coefficient above unity is suggestive that health care is a luxury good in South Africa, and hence government's willingness to prioritise the health care sector.

Regarding the other non-income variables, the coefficient for medical inflation is relatively small and inelastic. This is also consistent with previous empirical findings as suggested by Gerdtham *et al*. (1992) that increases in medical inflation result to smaller changes in health expenditure. The findings further confirm that public health expenditure and life expectancy are positively correlated, in South Africa during the period of 1995 to 2012. The elasticity coefficient of life expectancy was found to be elastic with the value 1.87, implying that a significant growth in health budgets have been explained by longevity accumulation impacts over time. This demonstrates the impact of the accumulative effects of ageing population on health expenditure over time.

While the results of this analysis may demonstrate the importance of GDP, life expectancy and medical inflation as determinants of public health expenditure, differences in health outcomes and funding levels across districts necessitates the need to go beyond the current national level analysis. Additional research is therefore needed to assess the levels allocative and operational efficiency of health facilities across districts for optimum policy conclusions. In the absence of sufficient study data the use of Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) to address some these specific questions is recommended.

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