



## THE USE OF COINTEGRATION AND ERROR CORRECTION MODELLING TO INVESTIGATE THE INFLUENCE OF DIABETES AND ASSOCIATED MEDICAL SERVICES EXPENDITURE ON ECONOMIC GROWTH IN MALAYSIA

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### ABSTRACT

*This paper reports on a frontier study undertaken to examine the influence of mortality rates due to diabetes (DBT) and medical services expenditure (EXP) on economic growth (RGDPP) in Malaysia. The results of the Johansen test for cointegration allowed the acceptance of  $r = 2$  as our estimate of the number of cointegrating equations among the three of variables. The negative sign of the residual in the estimated Error Correction Modelling (ECM) indicated the existence of a long-run equilibrium relationship among RGDPP, EXP and DBT, while the coefficient for error term implied that the system corrected its previous period disequilibrium due to positive or negative shocks in one period at an adjustment speed of 9.23 percent annually. These findings have substantive implications on the efforts to promote and achieve satisfactory health and wellness in Malaysia, and highlight a critical need for an effective long-term national strategy to resolve diabetes related economic issues. The results provide a useful foundation for a much needed national debate to review health-care spending in relation to choosing the best methods in reducing and alleviating diabetes and other chronic diseases such as cancer and cardiovascular disease. Additional priority areas that merit further study are highlighted to help in measuring and addressing the economic, human, and social costs of preventable chronic diseases and to identify opportunities to ameliorate these important aspects within the economy.*

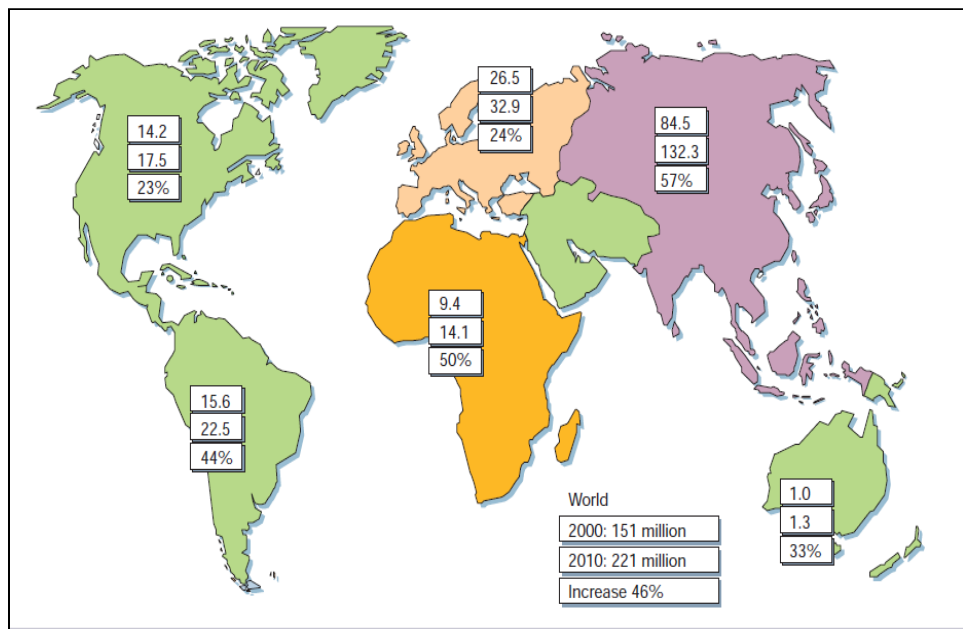
**Keywords:** Malaysia, diabetes, medical services expenditure, economic growth, cointegration and error correction modeling



## INTRODUCTION

Diabetes is a chronic disease that occurs in humans when the pancreas fails to produce sufficient insulin to absorb glucose from the blood. This condition can also develop when the body is unable to use the insulin it produces effectively. Insulin is a hormone made by the pancreas that enables cells to take in glucose from the blood, which is used for creating energy. Failure of the pancreas to produce insulin and/or failure of insulin to act properly leads to increased glucose levels in the blood, a condition associated with permanent and long-term damage to vital organs and tissues (IDF, 2013). In 2010, the world prevalence of diabetes affecting 285 million adults aged between 20 and 79 years was estimated at 6.4%, and this number is expected to rise to approximately 439 million (7.7%) adults by 2030. Experts forecast the number of diabetic adults to increase by 69% in developing countries and 20% in developed economies between 2010 and 2030 (Shaw *et al.*, 2010). The global number of people afflicted with diabetes rose from 151 million in 2000 to an estimated 221 million in 2010, a colossal increase of 46.4% (Fig. 1). This figure is further estimated to spiral to an alarming 300 million in 2025 (Zimmet *et al.*, 2001).

**Figure-1.** Numbers of people with diabetes (in millions) for 2000 and 2010 (top and middle values, respectively), and the percentage increase. Data adapted from ref. (Zimmet *et al.*, 2001).



Malaysia, a fast developing nation located in South-East Asia with an estimated population of 28 million people in 2012, is not immune to this pandemic. Malaysia's high-speed urbanisation and sedentary lifestyle are favorable environmental factors encouraging the rapid increase in the occurrence of diabetes and its resulting complications (Ismail *et al.*, 2000). The number of Malaysians afflicted with diabetes had almost doubled within a span of two decades from 6.3% in 1986 to 11.6% in 2010. By 2030, a total of 2.48 million Malaysians will be affected by the disease,

as predicted by the World Health Organisation (WHO) (Mafauzy, 2006). Already as of 30<sup>th</sup> April 2012, Malaysia has one of the world's highest numbers of diabetes cases among its population with 2.6 million registered patients. What is even more worrying is the equal number of Malaysian adults facing the risk of developing diabetes without even knowing it (WHO, 2013). The fast growing number of diabetes cases in Malaysia has resulted in substantial diabetes-associated mortality, disability, early retirement, and work absenteeism, which is likely to lead to lower labour productivity affecting economic growth. Against this backdrop, it is paramount to determine the relationship, if any, between the occurrence of diabetes and economic growth in Malaysia, which is the objective of the present study.

## REVIEW OF LITERATURE

### Diabetes and Its Economic Burden

The diabetes epidemic is a major predicament not only to the chronically afflicted patients, but also to the nation as it brings about adverse effects on its socioeconomic progress and development. Previous research has shown that diabetes affects patients, employers, and society by reducing employment, contributing to work loss and imposing health-related work limitations on those who remain employed (Bonow and Gheorghiade, 2004; Tunceli *et al.*, 2005). It is a costly disease both for the patient and the healthcare provider due to its chronicity and multi-organ involvement that requires an intensive treatment which in turn results in frequent visits and admissions to health facilities. High prevalence and higher rates of complications engender substantial negative implications on the economies (Ibrahim *et al.*, 2010). Although non-communicable, the chronic nature of the disease imposes a large economic burden on the national healthcare system. In 2010, healthcare spending on diabetes around the world accounted for 11.6% of the global total for healthcare expenditure, representing an estimated \$ 376 billion in US dollars. By 2030, this staggering figure is estimated to exceed USD490 billion (Zhang *et al.*, 2010).

To measure the economic burden brought about by diabetes within the local context, a survey of 253 patients was carried out at one public health clinic in the state of Selangor, Malaysia. Data were collected from the clinic to determine the amount expended by the government and patients for treating diabetes over a one-week duration. It was discovered that the annual direct cost borne by the government per diabetic patient was USD59.92, with an additional USD17.76 borne by the patients (Mafauzy, 2006). In a similar study done in another Malaysian state, the average cost for a diabetic patient was about USD363.13 per year, if treatment was sought in health clinics with specialist care. For treatment at health clinics without specialist care, the average cost was USD258.46 per year for one diabetic patient (Ibrahim *et al.*, 2010). Two separate but related studies performed in a teaching hospital revealed a total of USD696.31 spent on treating diabetic patients per admission (Roy *et al.*). In addition, the inpatient direct cost borne by the government for treating diabetic foot conditions was USD4,167.74 per patient per admission (Ibrahim *et al.*, 2010). Age and gender are among crucial factors influencing the amount spent on diabetic patients. More



than three-quarters of the global expenditure in 2010 was spent on diabetic patients aged between 50 and 80 years, and more money was spent on diabetes care for women than for men (Zimmet *et al.*, 2001; Tunceli *et al.*, 2005; Shaw *et al.*, 2010). Previous studies have also pointed to a large disparity in healthcare spending on diabetes between regions and countries. More than 80% of the global expenditure on diabetes was made in the world's richest nations, not in the low- and middle-income countries where 80% of diabetes cases occurred. The North American and Caribbean Region alone spent USD214 billion or 57% of the global total on diabetes in 2010. In marked contrast, the African Region spent in total USD1.4 billion on treating diabetes that equates to only 0.4% of the global total (Shaw *et al.*, 2010).

### Diabetes and Productivity

Diabetes influences the capacity of individuals and labour productivity in ways that adversely affect economic performance in the long run. Most people with diabetes in the developed world are below 65 years of age, whereas most of the diabetics in developing countries are between 45 and 64 years of age. This means that many diabetic individuals in developing nations will have to endure this condition during their most productive years (Bonow and Gheorghide, 2004). Asia's fast growing globalisation catalysed by its rapid economic development has marked economic and demographic transition in recent decades. The increase in population which occurred in tandem with economic growth has shifted the dietary patterns towards fast food and encourages sedentary life style. These are among the factors causing the sudden rapid increase of diabetic patients in Asia. The increasing burden of diabetes was predicted to cause substantial financial loss resulting from increased health care expenditure and lost productivity (Chan *et al.*, 2009). Among individuals with diabetes, the absolute probability of working is 4.4 percentage points less for women and 7.1 percentage points less for men relative to that of their counterparts without diabetes. Compared with individuals without diabetes, men and women with diabetes are 5.4 and 6 percentage points (absolute increase), respectively, more likely to have work limitations (Tunceli *et al.*, 2005).

The economic consequences of diabetic foot problems are major, both to society as well as to the patients and their families (Mazlina *et al.*, 2011). Diabetic complications have the potential to greatly impact the quality of life of patients with diabetes. One of the most frequently studied complications has been the effect of foot problems (Carrington *et al.*, 1996). Diabetic foot complications have been found to account for 12% of all diabetic hospital admissions in Malaysia. The resulting cost to society can be measured in direct costs attributed to treatment such as dressings or surgical procedures, as well as indirect costs in loss of productivity, social services, home care and quality of life (Ribu and Wahl, 2004). Mental health was also significantly affected although not as severely compromised as some of the components in physical health. Mental health component assesses the psychological distress, degree of happiness, limitations that emotional problems place on the extent of activities one is able to perform and general well-being. A possible explanation for the significantly poorer mental health state of patients with foot problems compared



to patients without foot problems is that patients with the former often experienced emotional uncertainty as to when or whether the foot problems will heal. Patients with foot associated diabetic conditions were also more likely to experience living restrictions and were found to have poorer psychosocial adjustments (Wändell and Tovi, 2000). When considered collectively, the aforementioned studies have provided important information on the impact and deleterious consequences of diabetes on affected patients and healthcare providers. However, there is a clear dearth in published information that provides empirical evidence on how diabetes affects a nation's long term economic growth. The present study, therefore, addresses this gap for Malaysia.

## DATA SOURCE AND METHODOLOGICAL FRAMEWORK

### Data Source

This study used annual data from the Malaysia Economic Statistics Time Series (2009 and 2011) and the Social Statistics Bulletin (1969-2010) published by the Department of Statistics, Malaysia. The variables under study are (i) per capita real gross domestic product (RGDPP), (ii) medical services expenditure (EXP), and (iii) number of deaths (mortality rates) due to diabetes (DBT). The empirical findings are derived from the 1970 – 2010 databases on these variables.

### Methodological Framework

The model that formed the basis for the study was adapted from the Keynesian approach (Solow, 1956), which emphasizes the role of four important sectors in the economy in stimulating economic growth, i.e. the household, government, corporate and export. This study, however, focused only on two of these sectors, namely the government and household, where the variable taken to represent the role of the government was allocation of money for medical services expenditure, while that representing the household sector was mortality rates due to diabetes. The latter representation was premised upon empirical evidence suggesting a strong impact of health and chronic illnesses on productivity (Beaglehole and Yach, 2003; Bonow and Gheorghide, 2004; Ghaffar *et al.*, 2004; Abegunde and Stanciole, 2006; Mafauzy, 2006).

To determine whether cointegration existed among economic growth, medical services expenditure and diabetes in Malaysia, the following model was used. The long-run relationship for the log transformed variables was specified as follows:

$$\ln RGDPP_t = \beta_0 + \beta_1 \ln EXP_t + \beta_2 \ln DBT_t + u_t \quad \text{Model (1)}$$

Where  $RGDPP_t$  represented the real gross domestic product per capita (RGDPP),  $EXP_t$  was expenditure of medical services;  $DBT_t$  was number of deaths (mortality rates) due to diabetes and  $u_t$  was the error term. Prior to conducting any test to identify the existence of a long-run relationship among the variables, the time series data needed to be verified for stationarity. A series is said to be stationary if the mean and variance of the series are independent of any specified time. It is very important to check on the stationary status of the data before estimating an econometric model in order to avoid spurious regression. This is because the use of non-stationary



data will automatically result in significant relationships among unrelated variables, although theoretically no such relationships exist. To check on the stationarity of time series, unit root test was employed. The main reasons for conducting unit root tests were to ascertain the order of integration crucial for setting up an econometric model from which inferences are made, and to take great care in finding exact critical values (Chan *et al.*), particularly as these unit root tests are motivated by economic theory which suggests that certain variables should be integrated, a random walk, or a martingale process (Sjö, 2008). The two unit root methods performed were the Augmented Dickey-Fuller (ADF) and the Phillips and Perron (PP) tests. The ADF test was performed to assess the degree of integration among the variables. The PP test has the advantage of providing robust estimates for small and moderate sample sizes and when the series has serial correlation and time-dependent heteroscedasticity (Phillips and Perron, 1988).

### **Johansen Cointegration Test and Error Correction Model**

The next steps after conducting unit root tests involved running the Johansen cointegration test (Johansen and Juselius, 1990) and estimating the Error Correction Model (ECM). An error correction model (ECM) was developed to estimate the speed at which the dependent variable returned to equilibrium after a change in the independent variables (Banerjee *et al.*, 2011). The speed was measured by percentage. In the error correction model employed in this study, the percentage change in real GDP per capita (RGDPP) was a function of the percentage change in medical services expenditure (EXP) and number of deaths due to diabetes (DBT) and the residuals lagged one period from the equation in level form. However, a prerequisite for developing an ECM was to test the long-run relationship among the variables included in Model (1). The cointegration procedure developed in Johansen (Johansen, 1991) and Johansen and Juselius (Johansen and Juselius, 1990) was employed to test the long run relationship in Model (1). Two types of the Johansen test were specified, one with trace and the other with eigenvalue. The null hypothesis for the trace test states that the number of cointegrating vectors is less than or equal to  $r$ , while the null hypothesis for the eigenvalue test is the number of cointegrating vector is equal to  $r$ . The null hypothesis is rejected when the test statistic is greater than the critical value. Rejecting the null hypothesis means there is a cointegration among the variables in the model, thus verifying that these variables have a long-run relationship (Sjö, 2008).

### **Discussion of the Empirical Results**

This section presents the initial results of estimating the impact of diabetes and medical services expenditure on economic growth in Malaysia. The sample period covers from 1970 to 2010. The Augmented Dickey Fuller (ADF) and Phillip-Perron (PP) unit root tests were performed to establish the stationarity of the series. The unit root test results shown in Table 1 indicate that the three variables in the model have unit root at level  $I(0)$ , but after the variables were converted into first difference, they became stationary,  $I(1)$ .



**Table-1.** ADF and PP Unit Root Test results

Variables	Augmented Dickey-Fuller (ADF) test statistics (with trend and intercept)		Phillips-Peron (PP) test statistics (with trend and intercept)	
	Level	First Difference	Level	First Difference
<i>ln RGDP</i>	-1.980	-5.523*	-2.119	-5.488*
<i>ln EXP</i>	-3.758	-6.519*	-3.666	-6.829*
<i>ln DBT</i>	-0.921	-6.466*	-1.206	-6.452*

(Notes: The symbol \* denotes that the variables are stationary at 1%, 5% and 10% levels)

For the purpose of the Ordinary Least Square (OLS) estimation, a model was developed as follows:

$$RGDP = \beta_0 + \beta_1 EXP + \beta_2 DBT + u \quad \text{Model (2)}$$

Table 2 illustrates the results for the Johansen test for cointegration. The trace statistic at  $r = 0$  was 61.1174, which exceeded its 5% critical value of 29.68. This finding shows that the null hypothesis of no cointegrating equations was rejected. Similarly, because the trace statistic at  $r \leq 1$  of 15.5031 exceeded its critical value of 15.41, we rejected the null hypothesis that there was one or fewer cointegrating equations. In contrast, because the trace statistic at  $r \leq 2$  of 0.8237 was less than its critical value of 3.76, we could not reject the null hypothesis that there were two or fewer cointegrating equations. We accepted  $r = 2$  as our estimate of the number of cointegrating equations among these three variables.

**Table-2.** Results for Johansen Tests for Cointegration

Trend: Constant			Number of obs = 38		
Sample: 1973-2010			Lags = 3		
Ho	H1	LL	Eigenvalue	Trace Statistic	5% Critical Value
$r = 0$	$r = 1$	-1079.3664	-	61.1174	29.68
$r \leq 1$	$r = 2$	-1056.5593	0.69892	15.5031	15.41
$r \leq 2$	$r = 3$	-1049.2196	0.32043	0.8237*	3.76
$r \leq 3$	$r = 4$	-1048.8077	0.02144		

(Notes: The symbol \* denotes that there are 2 or fewer cointegrating equations in the model)

As the variables were found to co-integrate, the next step was to run the Error Correction Model (ECM) for economic growth with the variables being kept stationary at first difference. Based on the ADF and PP test results, all three variables became stationary after the first differencing. An ECM estimates the speed at which a dependent variable returns to equilibrium after a change in an independent variable. In this study, ECM estimated the speed of change in economic growth as a result of the changes in medical services expenditure and mortality rates due to diabetes.

The ECM was specified as follows:

$$\Delta RGDP = \beta_3 + \beta_4 \Delta EXP + \beta_5 \Delta DBT + \beta_6 Ut - 1 + V \quad \text{(Model 3)}$$

Where  $\Delta RGDP$ ,  $\Delta EXP$  and  $\Delta DBT$  constituted the first differenced variables,  $\beta_3$  was the intercept,  $\beta_4$  and  $\beta_5$  were the short-run coefficients,  $\beta_6$  the coefficient for residual with one period lag,  $Ut-1$  the one period lag residual of Model (1) and  $V$  the white noise error term (which corrected the equilibrium).  $Ut-1$  is also known as equilibrium error term of one period lag. This  $Ut-1$  is an error



correction term that guides the variables (*RGDPP*, *EXP*, *DBT*) of the system to restore equilibrium or correct disequilibrium. The sign before  $\beta_6$  or the sign of the error correction term was found negative after estimation and the coefficient of  $\beta_6$  informed us of the rate at which it corrected the previous period disequilibrium of the system.

**Table-3.** Error Correction Model for Real Gross Domestic Product Per Capita (RGDPP)

Source	SS	Df	Ms	Number of obs	=	39
Model	980676.283	3	326892.094	F(3, 35)	=	1.50
Residual	7652060.06	35	218630.288	Prob > F	=	0.2328
Total	8632736.35	38	227177.272	R-squared	=	0.1136
				Adj R-squared	=	0.0376
				Root MSE	=	467.58
				Durbin Watson Statistics	=	1.788733
$\Delta$ RGDPP	Coef.	Std.Err.	T	P> t	95% Conf. Interval	
$\Delta$ EXP	.0001097	.0000945	1.16	0.253	-.0000821	0.0003016
$\Delta$ DBT	.2588309	.6059288	0.43	0.672	-.9712699	1.488932
$\Delta U(-1)$	-.0927838	.1021345	-0.91	0.370	-.3001279	.1145602
CONS	399.0132	84.9663	4.70	0.000	226.5224	571.5039

Table 3 shows the results of estimating the Error Correction Modelling (ECM) of Model (3). The short run coefficients for  $\beta_4$  and  $\beta_5$  were 0.0001 and 0.2588 respectively, which indicate that the coefficients for  $\Delta$ EXP and  $\Delta$ DBT were not significant since the  $p$ -values were greater than 0.05, but the negative sign of  $\beta_6$  (-0.0928) indicates that a long-run equilibrium characterized the relationship among the variables *RGDPP*, *EXP* and *DBT*. The coefficient for error term ( $\beta_6$ ) of -0.0928 implies that the system corrected its previous disequilibrium period due to positive or negative shocks in one period at an adjustment speed of 9.23 percent annually. The estimated Model (3) was not spurious as the value of R-squared (0.1136) was less than the Durbin Watson statistics (1.788773).

## CONCLUSION AND RECOMMENDATIONS

The findings have revealed that there existed a long-run equilibrium relationship among economic growth, medical services expenditure and mortality rates due to diabetes in Malaysia. The Johansen test for cointegration showed that at least two cointegrating equations from the developed model emerged. The three variables (*RGDPP*, *EXP* and *DBT*) were cointegrated and demonstrated a long-run equilibrium relationship as the residuals were found stationary. The model was a significant long-run model which indicated that long-run equilibrium relationships existed among these variables. The findings should be strongly considered as a relevant first informed contribution towards a much needed national debate on identifying best governance for health-care spending to alleviate chronic diseases. There is a dire need for a rigorous, long-term national commitment to the promotion of health awareness and well-being among Malaysians. Further research in related areas focusing on allied chronic conditions such as cardiovascular disease, cancer and others is necessary



in order to achieve a holistic understanding and appreciation of the critical parameters governing accurate measurement of economic, human, and social costs of preventable chronic diseases and identify opportunities to reduce or avoid them. The relative impact of poor lifestyle and diet, long working hours and associated stress on good health and well-being with nexus to economic growth must not be underappreciated.

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