Revisiting the health-income nexus in Malaysia: ARDL cointegration and Rao's F-test for causality

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REVISITING THE HEALTH–INCOME NEXUS IN MALAYSIA: ARDL COINTEGRATION AND RAO'S F-TEST FOR CAUSALITY

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ABSTRACT

This study re-visits the health-income nexus for Malaysia using alternative econometric techniques which addressed on the small sample problem. This study covers the annual sample period of 1970 to 2009. Based on the appealing small sample properties, we applied the bounds testing approach to cointegration and the system-wise Rao's F-test with bootstrap simulation procedure in this study. The bounds test suggests that health care expenditure and real income are moving together in the long-run. In addition, the long-run income elasticity is also estimate using four long-run estimators, namely OLS, DOLS, FMOLS, and ARDL. Interestingly, the entire long-run estimators suggest that the long-run income elasticity is more than unity. Therefore, our findings support the health care luxury hypothesis in Malaysia. From policy view point, the system-wise Rao's F-test reveals strong unilateral causality running from real income to health care expenditure in Malaysia.

JEL Classification Codes: C22; I10
Keywords: Cointegration, Causality; Health-income nexus; Malaysia; Rao's F-test

1. INTRODUCTION

After the seminal papers by Mushkin (1962) and Newhouse (1977), voluminous of empirical studies have attempted to investigate the health care expenditure and income (e.g., Hansen and King, 1996; Clemente et al, 2004). These seminal papers articulated that health is a capital and hence investment on health is a prominent source for income growth. In addition, the income elasticity should be positive and greater than unity (see also Gerdtham et al., 1992; Murray et al., 1994).[1] Ironically, the existing research efforts failed to provide a clear picture of income elasticity of the demand for health care as well as the direction of causality between health care expenditure and income.[2] In practice, some empirical studies found that income growth Granger-cause health care expenditure to change (Rao et al., 2008). While, some published articles argued that health care expenditure induces income growth to change (Mushkin, 1962; Grossman, 1972).

[1] However, there are some studies such as Parkin et al. (1987) and Blomqvist and Carter (1997) claimed that income elasticity is positive but slightly below unity.
[2] Devlin and Hansen (2001) found that the direction of causality between health care expenditure and income is inconclusive among 20 OECD countries. Rao et al. (2008) also finds similar results for the Association of South East Asia Nations (ASEAN).

Retrospectively, there are magnitude of empirical works have done on this topic, and the studies also varied widely in terms of scope of study and methodology. However, most of them focused on developed countries by using a panel data analysis (e.g., Roberts, 1999; Freeman, 2003; Gerdtham and Lothgren, 2000; Sen, 2005; Wang and Rettenmaier, 2007). Therefore, a country-specific study on developing countries such as Malaysia is relatively scarce. To the best of our knowledge, only few studies such as Rao et al. (2008), Samudram et al. (2009), and Tang (2009) have investigated the health-income nexus for Malaysia using the cointegration and causality tests. However, the empirical evidence between health care expenditure and real income for Malaysia remains controversial. For example, Rao et al. (2008) used the annual data from 1981 to 2005 to analyse the causal relationship between health care expenditure and real income in five ASEAN countries using the standard Granger causality tests. In general, the causality results are mixed among five ASEAN countries. Specifically, the study observed that there is bilateral causality between health care expenditure and real income in Indonesia and Thailand, while only unilateral causality running from real income to health care expenditure was detected in Malaysia and Singapore. Nevertheless, the causal relationship between health care expenditure and income is neutral for the Philippines. Apart from that, Samudram et al. (2009) examined the long-run as well as the causal relationship between health care expenditure and real income in Malaysia using the cointegration tests alone. For the sake of brevity, the study covered the annual sample from 1970 to 2004 and they found that health care expenditure and real income are positively related in the long-run. In addition, they also surmised that health care expenditure and real income are bilateral causality in Malaysia. Subsequently, Tang (2009) used the annual data from 1960 to 2007 to re-assess the relationship between health care expenditure and real income in Malaysia. Unfortunately, the author found that health care expenditure and real income are not cointegrated, but the author found the evidence of two-ways causality between the variables.

The major problems with much of the earlier studies on Malaysia can be classified into two parts. First, they failed to provide true causal relationship because the variables are not cointegrated and they used inappropriate methodology. For example, Rao et al. (2008) and Tang (2009) found some evidence of causality, but their results showed that the variables are not cointegrated.[3] Moreover, Samudram et al. (2009) obtained the causality results by using cointegration test which is inappropriate because the presence of cointegrating relationship does not necessarily imply the direction of causality. Therefore, causality results provided by earlier studies may not exhibit the true causal relationship and may also be meaningless for both the economists and policymakers. Extracting the true causal relationship is important not just for understanding the flows, but it is also important for determining appropriate policy (Deaton, 1995). Second, as far as we know, no empirical work thus far had paid tribute on income elasticity of the demand for health care in Malaysia. Understanding of income electricity of the demand for health care is required to determine whether health care in Malaysia is a necessity or luxury goods. Additionally, it is directly link to the future formulation of health care financing, the development of health care services, and growth policies in Malaysia. If health care is necessity goods, government intervention on health care system is required; otherwise the *invisible hand* or market determination system may work better. Motivated by the lacunas in this topic, this study attempts to re-investigate the relationship between health care expenditure and real income in Malaysia.

This study fills the lacuna with various ways. First, we apply the bounds testing approach for cointegration to determine the presence of a long-run equilibrium relationship

[3] Masih and Masih (1998) noted that the Granger causality test is strictly represents correlation rather than causality if the variables are not cointegrated.

between health care expenditure and real income in Malaysia. Second, we employ the system-wise Rao's F-test in association with the residuals-based bootstrap simulation procedure to test for causality between health care expenditure and income. The choice of these econometric tests is motivated by two factors. At best, these methods are applicable and valid even when the variables are stationary at different orders (Pesaran et al, 2001; Dolado and Lütkepohl, 1996). In addition, these methods have superior properties in small samples (Pesaran and Shin, 1999; Shukur and Mantalos, 2000). Therefore, the findings of this study may avoid the size distortion and low power problems in testing the health-income relationship for Malaysia.

The remaining of this paper is organised as follows. The next section will briefly explain the data source and econometric techniques use in this study. Section 3 will report the empirical finding of this study and finally Section 4 will present the concluding remarks.

2. DATA AND METHODOLOGY

This study uses the secondary annual data of real health care expenditure, real Gross Domestic Product (GDP). This study covers the annual sample from 1970 to 2009. The data is collected from Asian Development Bank, *Key Indicators* (KI) and the Malaysian Economic Reports. The GDP deflator (2000 = 100) is used to derive the real term.

There is an abundance of econometric methods designed for testing the cointegrating relationship. Nevertheless, we use the bounds testing approach (Pesaran et al., 2001) within the autoregressive distributed lag (ARDL) framework because of its superior performance in small sample.[4] In addition, it is applicable irrespective of whether the underlying explanatory variables are purely $I(0)$, purely $I(1)$, or mutually cointegrated. In other words, this cointegration approach released the assumption of uni-formally $I(1)$ process. To perform the ARDL cointegration test, Pesaran et al. (2001) suggested to estimates the following unrestricted error-correction model (UECM).

$$\Delta \ln HCE_t = \alpha_0 + \theta_1 \ln HCE_{t-1} + \theta_2 \ln Y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta \ln HCE_{t-i} + \sum_{j=0}^{k} \phi_i \Delta \ln Y_{t-j} + \varepsilon_t \quad (1)$$

Here Δ is the first difference operator and ln denotes the natural logarithm. $\ln HCE_t$ is the real health care expenditure, $\ln Y_t$ is the real income and ε_t is the disturbance term. To test the presence of cointegrating relationship, we can apply the standard F-test on the lagged level variables coefficients $[\theta_1, \theta_2]$. If the calculated F-statistic is exceeds the critical values, we reject the null hypothesis of no cointegration $[\theta_1 = \theta_2 = 0]$. Otherwise, no meaningful long-run relationship can be formed from between these variables.

Subsequently, we proceed to determine the direction of causality between health care expenditure and income using the causality method advocated by Dolado and Lütkepohl (1996). Shukur and Mantalos (2000) examined the size and power of eight generalisations of tests for the Granger-causality in the augmented-VAR system. In short, the Monte Carlo experiment exhibited that the performance of modified Wald tests is poor in small sample, and amongst eight tests under consideration the system-wise Rao's F-test demonstrate the best performance in small sample (see also Hatemi-J and Shukur, 2002). Given the small

[4] Interested readers may consult Pesaran and Shin (1999), Panopoulou and Pittis (2004), and Caporale and Pittis (2004) for Monte Carlo evidence on the performance of the bounds testing approach in comparison with other cointegration tests.

sample size of this study (T = 40 observations), the system-wise Rao's F-test is uses for the Granger causality. Consider the following augmented-VAR system with $p = (k+1)$ lag structure:

$$z_t = a_0 + A_1 z_{t-1} + \cdots + A_p z_{t-p} + \upsilon_t \tag{2}$$

Where $A_p = (n \times n)$ dimensional matrix of parameters for p lag structure, while z_t, υ_t and a_0 consists of m-dimensional vectors. The disturbances term υ_t are assumed to be spherically distributed and white noise. Next, we partition z_t into two sub-vectors z_t^1 and z_t^2 as given below:

$$z_t = \begin{bmatrix} z_t^1 \\ z_t^2 \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} A_{11,1} & A_{12,1} \\ A_{21,1} & A_{22,1} \end{bmatrix} \times \begin{bmatrix} z_{t-1}^1 \\ z_{t-1}^2 \end{bmatrix} + \cdots + \begin{bmatrix} A_{11,p} & A_{12,p} \\ A_{21,p} & A_{22,p} \end{bmatrix} \times \begin{bmatrix} z_{t-p}^1 \\ z_{t-p}^2 \end{bmatrix} + \begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix} \tag{3}$$

From the above augmented-VAR system, z_t^2 Granger-causes z_t^1 if the null hypothesis $A_{12,p-1} = 0 \forall_{p-1}$ is rejected, while $A_{21,p-1} \neq 0 \forall_{p-1}$ exhibit that z_t^1 Granger-causes z_t^2. Before defining the system-wise Rao's F-test, let us define:

$\mathrm{Z} := (z_1, \ldots, z_T)$ $\quad (k \times T)$ matrix,

$\mathrm{B} := (a, A_1, \ldots, A_p)$ $\quad (k \times (kp+1))$ matrix,

$$W_t := \begin{bmatrix} 1 \\ z_t \\ z_{t-1} \\ \vdots \\ z_{t-p+1} \end{bmatrix} \quad ((kp+1) \times 1) \text{ matrix,}$$

$W := (W_0, \ldots, W_{T-1})$ $\quad ((kp+1) \times T)$ matrix,

and

$\varpi := (\varepsilon_1, \ldots, \varepsilon_T)$, $\quad (k \times T)$ matrix

Based on the above notations, the augmented-VAR(p) system can be written compactly as follow:

$$\mathrm{Z} = \mathrm{B}W + \varpi \tag{4}$$

The estimated $(k \times T)$ matrix of the disturbances term from the unrestricted and restricted regression model (4) can be denoted as $(\hat{\varpi}_{UR})$ and $(\hat{\varpi}_R)$, respectively. Then the variance-covariance matrix of the estimated residuals are generated by $\mathrm{H}_{UR} = \hat{\varpi}'_{UR} \hat{\varpi}_{UR}$ and $\mathrm{H}_R = \hat{\varpi}'_R \hat{\varpi}_R$. Ultimately, the system-wise Rao's F-test statistics for Granger causality can be calculated by the following equation:

$$RAO = (\phi/q)\left(U^{1/s} - 1\right) \tag{5}$$

Where, $s = \left[\left(q^2 - 4\right)\Big/\left(k^2\left(G^2+1\right)-5\right)\right]^{1/2}$, $\Delta = T - \left(k\left(kp+1\right) - Gm\right) + \frac{1}{2}\left[\left(G-1\right)-1\right]$, $\phi = \Delta s - r$, $r = q/2 - 1$, and $U = \det \mathrm{H}_R / \det \mathrm{H}_{UR}$. $q = Gm^2$ is the number of restrictions imposed by the null hypothesis, G is the p restriction in Equation (2) and finally m is the dimension of the sub-vector z_t^1. RAO statistic is approximately distributed as $F\left(q, \phi\right)$ under the null hypothesis, and reduces to the standard F-statistic when $k = 1$.

3. EMPIRICAL FINDING

We employed three unit root tests, namely Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwaitkowski-Phillips-Schmidt-Shin (KPSS) to inspect the degree of integration for each series. The unit root tests results are reported in Table 1. Overall, three unit root tests consistently suggest that the variables are integrated at different order, but none of the variables is integrated higher than order one process or beyond. Since the findings presents non-uniform order of integration, the bounds testing approach to cointegration is very suitable in comparison to the conventional cointegration tests (e.g., Engle and Granger, 1987).

Table 1: The results of unit root tests

Variables	ADF	PP	KPSS
$\ln HCE_t$	–4.761 (3)***	–2.998 (3)	0.071 (1)
$\Delta \ln HCE_t$	–4.620 (3)***	–4.294 (5)***	0.059 (5)
$\ln Y_t$	–2.265 (0)	–2.131 (1)	0.127 (4)*
$\Delta \ln Y_t$	–4.319 (0)***	–4.302 (1)***	0.070 (1)

Note: The asterisks *** denotes the significant level at 1 per cent. The figure in the parenthesis is the optimal lag order for ADF test, or bandwidth for PP and KPSS unit root test determine by Bartlett Kernel Newey-West bandwidth. The unit root tests specification was determined by the procedure suggested by Enders (2004).

Given the unit root results are in favour of ARDL cointegration test, we next employed the AIC statistic to determine the optimal lag structure for the ARDL model because of its best performance in small sample (Lütkepohl, 1991). The AIC statistics suggest that ARDL[3, 1] is the best model and the selected lag structure is also in tandem with the conventional wisdom that optimal lag for annual data should range between 1 to 3 years (see Enders, 2004). Additionally, numbers of diagnostic tests were conducted on the final ARDL model to ensure that the selected model is correct and valid. The Jarque-Bera normality test cannot reject the null hypothesis of normality, indicating that the estimated residuals are normally distributed. Hence, the conventional tests statistics such as t-statistic and F-statistics are valid. Moreover, the Breusch-Godfrey Lagrange Multiplier (LM) test and also the Autoregressive Conditional Heteroskedasticity (ARCH) LM test exhibit that the model is free from autocorrelation and heteroskedasticity problems up to first and second orders. In addition, the Ramsey RESET test indicates that the selected ARDL model is also free from the specification error problem.

Table 2: The results of cointegration test

Calculated F-statistic for bounds test		
$F\left(\ln HCE \mid \ln Y\right)$	9.999***	
#Critical values bounds (F-test):		
Significance Level	Lower $I(0)$	Upper $I(1)$
1 per cent	7.625	8.825
5 per cent	5.260	6.160
10 per cent	4.235	5.020
Conclusion:	Cointegrated	

Note: *** denote significance at the 1 percent level. # Unrestricted intercept and trend (k = 1, T = 40) critical values are obtained from Narayan (2005).
R-squared: 0.551; Adjusted R-squared: 0.438;
F-Statistic: 4.900 (0.001); Jarque-Bera: 1.600 (0.449);
Ramsey RESET [1]: 0.121 (0.727), [2]: 1.986 (0.370);
Breusch-Godfrey LM test [1]: 0.006 (0.939), [2]: 0.044 (0.978);
ARCH LM test [1]: 0.330 (0.566); [2]: 0.525 (0.770)
[ ] refer to the diagnostics tests order; ( ) refer to the p-values

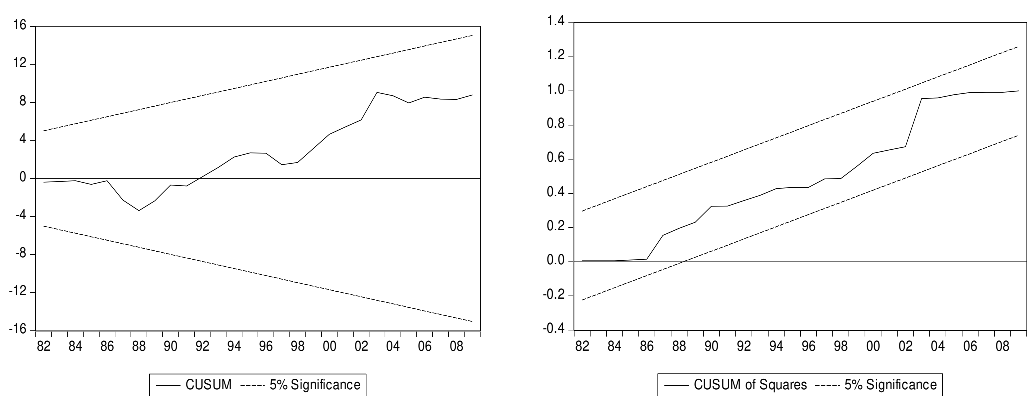

Figure 1: *The plots of CUSUM and CUSUM of Squares statistics*

In the same caveat of analysis, the plots of CUSUM and CUSUM of statistics in Figure 1 illustrate that the estimated parameters are stable over the analysis period. Finally, the results of bounds testing approach to cointegration together with the diagnostic tests are reported in Table 2. To test for the presence of cointegrating relationship between health care expenditure and real income in Malaysia, a joint significance F-test was conducted on the lagged level variables in Equation (1). The calculated F-statistics [9.999] is greater than the 1 per cent upper bounds critical values [8.825] simulated by Narayan (2005). Contrary with the findings of Rao et al. (2008) and Tang (2009), we found that health care expenditure and real income in Malaysia are cointegrated and there must be a long-run meaningful relationship. Once the variables are found to be cointegrated, the short- and long-run income elasticities of the demand for health care should be estimated. We employed four different cointegrating estimators to estimate the long-run elasticities of health care expenditure function. Among them are the Autoregressive Distributed Lag (ARDL) approach suggested by Pesaran and Shin (1999), the Ordinary Least Squares (OLS) approach suggested by Engle and Granger (1987), the Fully-Modified OLS (FMOLS) approach suggested by Phillips and Hansen (1990) and the Dynamic OLS (DOLS) approach suggested by Stock and Watson (1993). The reason for doing this is to examine the robustness of the estimation results and also to provide more efficient results in our relatively small sample study.

Table 3: The results of long-run elasticities

No.	Cointegrating estimators	Cointegrating vector	
		$\ln Y_t$	Constant
1.	Pesaran et al. (2001) – ARDL	1.394***	–10.967***
2.	Engle and Granger (1987) – OLS	1.336***	–10.202***
3.	Phillips and Hansen (1990) – FMOLS	1.383***	–10.762***
4.	Stock and Watson (1993) – DOLS	1.329***	–10.091***

Note: The asterisk *** denotes the significant level at 1 per cent level. (1) ARDL – Autoregressive Distributed Lag; (2) OLS – Ordinary Least Squares; (3) FMOLS – Fully Modified OLS; (4) DOLS – Dynamic OLS

Table 3 shows the long-run income elasticities of the demand for health care in Malaysia. We notice that all four cointegrating estimators provide very similar long-run elasticities results and hence the estimated results are robust. To be more specific, all the estimated coefficients are statistically significant at the 1 per cent level and they also have the correct signs. On average, the long-run income elasticity is greater than unity and range from 1.33 to 1.39. For example, a 1 per cent increase in real income increases health care expenditure in Malaysia by more than 1.3 per cent. Apparently, our findings support the presence of luxury health care hypothesis in Malaysia, meaning that change of health care expenditure is faster than real income growth. This result is corroborated to the findings of Gerdtham et al. (1992) and Murray et al. (1994).

Table 4: The results of Granger causality test (Rao's F-test)

	Null Hypothesis	
	$\ln Y_t \nrightarrow \ln HE_t$	$\ln HE_t \nrightarrow \ln Y_t$
Rao's F-statistics	8.265*	5.179
Bootstrapped p-value	0.0580	0.1810
Bootstrapped critical values		
5 percent	8.649	8.711
10 percent	7.163	6.779

Note: The asterisks * denotes the significant level at 10 per cent. $\nrightarrow$ represent "does not Granger-cause". The system-wise AIC was used to determine the best lag order. The bootstrap is based on 1000 replication.

The presence of long-run relationship did not imply a direction of causality, but it confirmed that testing for Granger causality is meaningful and not just a predictability test (Masih and Masih, 1998). From policy view point, the direction of causality between health care expenditure and real income has important policy implication. Table 4 presents the Granger causality tests based on the leveraged bootstrapped simulation approach of the system-wise Rao's F-test and *p*-values. From the causality results, we found that for the null hypothesis of real income does not Granger-causes health care expenditure, the *p*-value for the system-wise Rao's F-test statistic is less than 0.10. This exhibits that the null hypothesis can be rejected and there is Granger-causality running from real income to health care expenditure in Malaysia. Nevertheless, the *p*-value for the null hypothesis of health care expenditure does not Granger-causes real income is more than 0.10. This indicates that the null hypothesis cannot be rejected and no evidence of Granger causality running from real health care expenditure to real income. Overall, our findings suggest unilateral causality running from real income to real health care expenditure rather than reversal causation. Apparently, our empirical result is contrary with the finding of Samudram et al. (2009) and Tang (2009), who found evidence of bilateral causation based on the cointegration and/or MWALD causality tests. There are at least three potential explanations of why our causality results differ from those suggested by Samudram et al. (2009) and Tang (2009). First, we employed different time span of data. Second, we used the system-wise Rao's F-test rather than MWALD test because Shukur and Mantalos (2000) demonstrated that for small sample analysis the MWALD test may suffer from the size distortion and low power. Third, the presence of cointegration is not a proper indicator of the direction of causality. Therefore, our causality test results are valid, albeit different direction of causality has occurred.[5]

4. CONCLUDING REMARKS

The objective of this study is to re-investigate the relationship between health care expenditure and real income in Malaysia using the more robust econometric methods. This study employed the annual sample from 1970 to 2009 to achieve the objective of this study. The results of the bounds testing approach to cointegration revealed that real health care expenditure and real income in Malaysia are cointegrated. Four long-run estimators were employed to estimate the long-run income elasticity of the demand for health care. Interestingly, all four long-run estimators' consistently show that income elasticity is greater than unity, implying that health care in Malaysia is a luxury good. In our empirical analysis, we also ascertain the direction of the causality between health care expenditure and real income. The system-wise Rao's F-test reveals unilateral causality running from real income to health care expenditure, but no evidence of reversal causality. This affirms that the real income is a prominent source for health care expenditure in Malaysia rather than the other way around.

[5] One may suspect that the income elasticity and also the causal relationship between health care expenditure and real income may be varied over time either due to omission of relevant variables and/or structural breaks. To overcome the sceptical, we re-estimate the long-run income elasticity and also the causality test with the recursive regression procedure to affirm the results (see Tang, 2008). Remarkably, the recursive regression results makes no different where the long-run income elasticity and also the causality inferences are stables over the respective sample period. To conserve space, the results are not reported here, but it is available upon request.

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