

1 *Article*

2 Investigate the Co-Movement Relationship between 3 Medical Expenditure and GDP in Taiwan – Base on 4 Wavelet Analysis

5 Hsin-pei Hsueh ¹, Chien-Ming Wang ^{2,*}, Cheng-Feng Wu ³ and Fangjhy Li ^{1,*}6 ¹ School of Finance, Hubei University of Economics, China7 ² School of Economics and Trade, Hubei University of Economics, China8 ³ School of Business Administration, Hubei University of Economics, China

9 * Correspondence: cmwang8@gmail.com(C-M.W); fangjhy@hbue.edu.cn(F.L.)

10

11 **Abstract:** The universal health insurance system in Taiwan was formed with good intentions
12 to help vulnerable groups. However, the possibility of bankrupting the system due to wasted
13 medical resources. In this study, using the medical expenditures of the Taiwanese
14 Government and gross domestic product (GDP) as variables, the wavelet analysis method
15 was used to empirically study the correlations and leading-lagging relationships in quarterly
16 data in the period from 1996 to 2016. In addition, the dependent population of the insured
17 was used as the control variable. This population had no income and had high medical
18 demands. Results: After the dependent population was included as a control variable, there
19 was a period of low-frequency (one to four years short-term) linkage correlation, as well as
20 a period of high-frequency (four to eight years long-term) linkage correlation. In addition,
21 for more than eight years, there was also a high degree of linkage correlation, indicating that
22 the linkage between medical expenditures and GDP occurred over the long term. Moreover,
23 since medical expenditures positively affected GDP, one-way causality was observed.
24 However, after 2008, regardless of whether a long or short term was examined, there was
25 almost no linkage correlation. Before 2008, the medical expenditures of the government
26 were positively correlated with economic growth; i.e., they enhanced economic growth. But,
27 after 2008, this effect had already disappeared. The universal health insurance system has
28 long been denounced as a waste of medical resources, and the waste must be immediately
29 stopped. The government urgently needs to find a new solution.

30 **Keywords:** gross domestic product; medical expenditures; Wavelet analysis; co-movement
31 relationship; health insurance
32

33 1. Introduction

34 In Taiwan's universal health insurance system, the insured include all nationals and
35 foreigners who have residence permits, and the policy was formed with good intentions to
36 help vulnerable groups. It also allowed people with major illnesses and chronic diseases to
37 no longer worry about huge medical expenses. The universal health insurance system was
38 enacted by the Kuomintang Government after a vote. At one time, more than eight million
39 retired elderly people, children, housewives, unemployed, and other uninsured people could
40 all receive health insurance and have healthcare security. Internationally, the medical health
41 insurance system in Taiwan had also received wide acclaim, and the domestic populace's
42 degree of satisfaction with it was higher than 70%. Social incidents in the past, such as acute
43 or critical illnesses that necessitated patients raising money or in which the long-term medical
44 expenses of the patients with chronic illnesses harmed the families, all came to an end.

45 The universal health insurance system has long been denounced as a waste of medical
46 resources, and the waste must be immediately stopped. The health insurance system was
47 formed with good intentions to help vulnerable groups and patients who have acute, critical,
48 and chronic illnesses so that they do not need to worry about treating their illnesses. Insurance
49 was originally designed to transfer risk and prevent losses that are caused by accidents or
50 diseases.

51 However, since universal health insurance was implemented in 1995, the finances of the
52 program have been observed to shift from bad to worse. Because the number of unnecessary
53 and repeated visits to hospitals and clinics has increased. It is critical to emphasize that
54 medical attention should be sought only when there is a need.

55 The convenience of medical treatment in Taiwan resulted in increasingly high
56 government medical expenditures, wasted medical resources, and problems related to health
57 insurance restructuring. These issues were all denounced by the people, and the possibility
58 of bankrupting the system was raised. Therefore, the Taiwanese Government urgently needs
59 to consider improvements to this system.

60 2. Literature Review

61 In the foreign literature, early studies on the effect of government medical expenditures on gross
62 domestic product (GDP) were mainly concentrated on the relationship between medical
63 expenditures and GDP. Moreover, most of the studies supported that government medical
64 expenditures and GDP growth were positively correlated. Abel-Smith (1963, 1967) was the first to
65 discover that the ratio of medical expenditure to GDP was positively correlated with GDP. Thus,
66 higher GDP resulted in a higher ratio of medical expenditures to GDP, indicating that GDP was an
67 important factor that determined government medical expenditures. Later, the study by Kleiman
68 (1974) showed that government revenues also had a significant effect on government medical
69 expenditures and that per capita GDP (Newhouse, 1969) was also a major influencing factor of
70 government medical expenditures. Many subsequent empirical studies also came to this conclusion.
71 For example, Gbesemete and Gerdtham (1992) found that, in some African countries, per capita GDP
72 was the biggest factor influencing per capita medical expenditures. The analysis by Hitris and Posnett
73 (1992) on the Organization for Economic Cooperation and Development (OECD) countries also found
74 that there was an extremely strong correlation between per capita GDP and medical expenditures,
75 and Gyimah-Brempong (1998) drew the same conclusion in a subsequent study.

76 When studying the effects of government medical expenditures on economic development, most
77 scholars believed that government medical expenditures had a positive effect on GDP growth.
78 Gerdtham (1992) found that in some OECD countries, per capita income had a significant and
79 positive effect on government medical expenditures. Azeem (2009) studied Pakistan and found that
80 increasing medical expenditures could increase economic development. Gerdtham and Löthgren
81 (2000) used the unit root test to conduct a cointegration analysis of 21 OECD countries and find the
82 long-term relationship between medical expenditures and GDP.

83 In studies that targeted the relationship between GDP and government medical
84 expenditures, some scholars found that government medical expenditures had neither a
85 significant influence on nor a negative correlation with GDP growth. Hansen and King (1996)
86 analyzed 20 OECD countries from 1960 to 1987 and found that there was no long-term relationship
87 between medical health insurance expenditures and GDP in OECD countries, thereby not supporting
88 the effect of GDP on medical health insurance expenditures. Devlin and Hansen (2001) similarly
89 used 20 OECD countries from 1960 to 1987 to test the Granger causality between medical
90 health insurance expenditures and GDP and found that six countries had no evidence to
91 support that there was causality between the two. In eight countries, medical health insurance
92 expenditures affected GDP; in another eight countries, GDP affected medical health
93 insurance expenditures; and in two countries, the two affected each other.

94 There were also a few scholars who supported that the two were negatively correlated. For
 95 example, Mohapatra et al. (2011) used data from 16 main Indian states to divide government medical
 96 expenditures into profitable and capital-related medical expenditures. The results revealed that there
 97 was no influence on the national economy, but there was an effect on the states—capital government
 98 medical expenditures were found to affect the states' long-term GDP development.

99 3. Research Method and Data

100 In this paper, we introduce the wavelet analysis method used in this study to verify the linkage
 101 between the medical expenditures of the Taiwanese Government and gross domestic product (GDP).

102 3.1. Research Method

103 Wavelet analysis is a mathematical tool that has emerged in the last decade. Wavelet analysis,
 104 also known as wavelet transform. Wavelet analysis proposed the concept of Haar in 1910. Then the
 105 French physicist J. Morlet improved the traditional Fourier transform in 1984 to analyze the local
 106 properties of seismic waves. This wavelet signal was used to introduce signal analysis and
 107 decompose signals. The wavelet transform is the result of wavelet analysis. Then physicist A.
 108 Grossman began to study Morlet's scaling and $\left\{a - \frac{1}{2}\Psi\left(\frac{x-b}{a}\right); a, b \in R\right\}$ translation system for a certain
 109 function, which is the beginning of wavelet analysis. After that, it became an important discovery
 110 and breakthrough after 1822 "Fourier Transformation" analysis quickly applied to many fields.

111 However, "Fourier Transformation" cannot identify the structural mutation of the time series at
 112 the local frequency, and thus lacks good time domain localization properties; in addition, the Fourier
 113 transform requires the time series to have good stability. The economic and financial time series are
 114 mostly unsteady.

115 The wavelet transform can overcome the shortcomings of the Fourier transform, and it has also
 116 evolved. Because of the time domain and frequency domain localization properties, it can be superior
 117 to the "Fourier Transformation" in dealing with non-stationary (non-stationary) time series and time
 118 domain frequency domain localization information. It can be used to analyze irregular waveforms
 119 and to better deal with time series information for structural abrupt changes in non-stationary (non-
 120 stationary) time series.

121 The following are four wavelet analysis tools, continuous wavelet transform, wavelet power
 122 spectrum, wavelet correlation and phase difference.

123 3.1.1. Continue Wavelet Transform

124 Continuous wavelet transform can construct time-frequency signals with good time domain and
 125 frequency domain localization. The information that is difficult to see in the time series is revealed in
 126 the time domain and the frequency domain. The wavelet transform has (1) discrete wavelet transform
 127 and (2) continuous wavelet transform. The discrete wavelet transform is a special case, which is not
 128 introduced. The introduction is mostly continuous wavelet transform used on financial data.

129 It can be listed as follows:

$$130 W_x(\tau, s) = \int_{-\infty}^{+\infty} \chi(t) \psi_{\tau, s}^*(t) dt$$

131 Here * represents a complex conjugate, ie $\psi_{\tau, s}^*(t)$ is a complex conjugate function of the
 132 $\psi_{\tau, s}$ function, and $\psi_{\tau, s}$ is the base wavelet function.

133 As mentioned above, it is a sequence of functions obtained by the mother wavelet function after
 134 the warping translation. Use $\psi(t)$ to represent the mother wavelet function, and the base wavelet
 135 function $\psi(t)$ and the mother wavelet function $\psi(t)$ can be listed as:

$$136 \psi_{\tau, s} = \frac{1}{\sqrt{s}} \psi\left(\frac{t - \tau}{s}\right)$$

137 s is parameter table mother wavelet expansion; τ parameter table mother wavelet translation; $\frac{1}{\sqrt{s}}$
 138 factor corresponds to the frequency. Different values of s will produce different mother wavelet
 139 functions: $s > 1$ is the mother wavelet narrow; $s < 1$ is the mother wavelet width. The narrow
 140 mother wavelet is for the high-frequency part with a short duration in the sequence, and the wide
 141 mother wavelet has a good expression for the low-frequency part with longer duration in the
 142 sequence. Since s and τ values change continuously, $\psi(t)$ is called continuous mother wavelet
 143 function, and $W_x(\tau, s)$ is called continuous wavelet transform function.

144 3.1.2. Wavelet Power Spectrum

145 The wavelet power spectrum (Wavelet Power Spectrum) of a single time series $\chi(t)$ becomes
 146 the wavelet self-power spectrum, which is used to measure the volatility of $\chi(t)$ in the time domain
 147 and frequency domain combination, as follows:

$$148 \sigma_\chi^2 = \int_0^{+\infty} \int_{-\infty}^{+\infty} |W_\chi(\tau, s)|^2 \frac{d\tau ds}{s^2}$$

149 Since Hudgins et al. (1993) introduced the cross-wavelet transform of two time series for the first
 150 time, the cross-wavelet power spectrum of the two time series $\chi(t)$ and $y(t)$ is defined as The
 151 wavelet self-power spectral product of $\chi(t)$ and $y(t)$, namely: $|W_{x,y}(\tau, s)|^2 = |W_x(\tau, s)|^2 |W_y^*(\tau, s)|^2$.
 152 The cross-wavelet power spectrum can be used to measure the local co-shift between $\chi(t)$ and $y(t)$
 153 in the combination of time domain and frequency domain.

154 3.1.3. Wavelet Coherency Coefficient

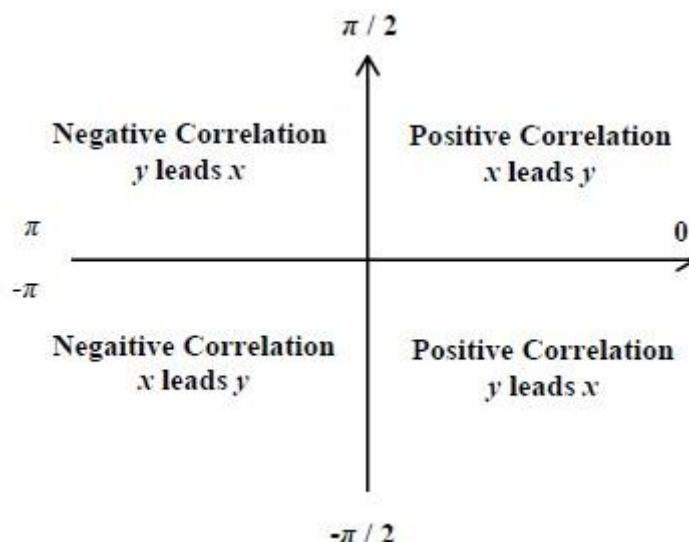
155 Based on the wavelet power spectrum, the ratio between the cross-wave power spectrum of the
 156 time series $\chi(t)$ and $y(t)$ and the respective wavelet power spectra can be further used to measure
 157 the ratio between $\chi(t)$ and $y(t)$. The local correlation in the time domain and the frequency domain
 158 is called the wavelet correlation coefficient, which is represented by $R_n^2(s)$:

$$159 R_n^2(s) = \frac{|S(s^{-1}W_{x,y}(\tau, s))|^2}{S(s^{-1}|W_x(\tau, s)|^2)S(s^{-1}|W_y(\tau, s)|^2)}$$

160 In the above formula, S is a smoothing factor for performing time-frequency normalization
 161 processing. The value of $R_n^2(s)$ is between 0 and 1. When $R_n^2(s)$ is equal to 1, it means that $\chi(t)$ and
 162 $y(t)$ are completely correlated; when $R_n^2(s)$ is equal to 0, it means $\chi(t)$ and $y(t)$ There is no
 163 connection between them.

164 3.1.4. Phase Difference

165 The following figure shows the leading edge (causal) relationship of the phase difference
 166 diagram:



167

168

Figure 1. Phase Difference Icon.

169 In Bloomfield et al. (2004), it is proved that the phase difference between the time series $\chi(t)$
 170 and $y(t)$ can be used to measure the lead-lag relationship between the two at a specific time
 171 frequency. The phase difference is defined as the ratio of the imaginary part \Im to the real part \Re
 172 of the cross wavelet power $W_{xy}(\tau, s)$, expressed as follows:

$$173 \quad \phi(\tau, s) = \tan^{-1} \left(\frac{\Im \{ (W_{xy}(\tau, s)) \}}{\Re \{ (W_{xy}(\tau, s)) \}} \right)$$

174 $\phi(\tau, s) \in [-\pi, \pi]$ represents the correlation between $\chi(t)$ and $y(t)$ at a particular frequency:

175 (1) When $\phi(\tau, s) \in (0, \frac{\pi}{2})$, then $\chi(t)$ and $y(t)$ are positively correlated, and $\chi(t)$
 176 leads $y(t)$.

177 (2) When $\phi(\tau, s) \in (\frac{\pi}{2}, \pi)$, then $\chi(t)$ and $y(t)$ are negatively correlated, and $y(t)$
 178 leads $\chi(t)$.

179 (3) When $\phi(\tau, s) \in (0, -\frac{\pi}{2})$, then $\chi(t)$ and $y(t)$ are positively correlated, and $y(t)$
 180 leads $\chi(t)$.

181 (4) When $\phi(\tau, s) \in (-\frac{\pi}{2}, -\pi)$, $\chi(t)$ and $y(t)$ are negatively correlated, and $\chi(t)$
 182 leads $y(t)$.

183 (5) When $\phi(\tau, s) = 0$, then $\chi(t)$ and $y(t)$ exhibit a complete positive correlation, ie,
 184 have covariance.

185 (6) When $\phi(\tau, s) = \pi$, then $\chi(t)$ and $y(t)$ exhibit a complete negative correlation.

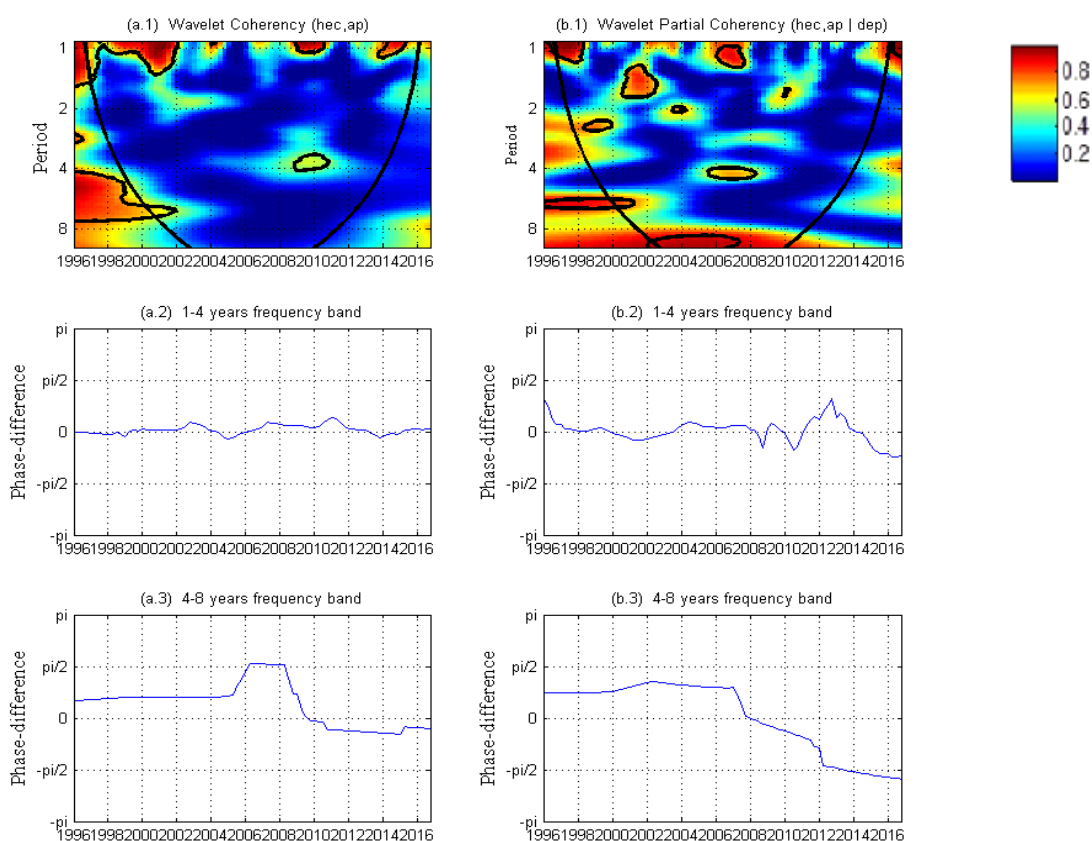
186 3.2. Data

187 Taiwan was used as the sample country in this study. Health insurance and medical expense
 188 expenditures and GDP were used as the variables, and the dependent population of the insured was
 189 used as the control variable. The dependent population was all spouses and immediate relatives who
 190 were not employed, most of which were underage children and retired elderly people 65 years of age
 191 or above. This population has no income and accounts for a high proportion of medical expenditures.

192 The data period was from the first quarter of 1996 to the fourth quarter of 2016, which resulted in a
 193 total of 84 quarters of data. The GDP data were sourced from the Directorate General of Budget,
 194 Accounting, and Statistics of Taiwan, which is a branch of the Executive Yuan, and the data on health
 195 insurance and medical expense expenditures and the dependent population of the insured were
 196 sourced from the Bureau of National Health Insurance of Taiwan.

197 4. Empirical Results

198 The following are wavelet analysis between health insurance medical expenditures in Taiwan
 199 and GDP.



200

201 **Figure 2.** Linkage analysis between health insurance medical expenditures in Taiwan and GDP with
 202 the control variable of the dependent population.

203 Results: Before the control variable was included, the whole sample period had only high-
 204 frequency (one-year short-term) linkage correlation, and the high-frequency (four- to eight-
 205 year long-term) effect was very weak.

206 After the control variable was included, there was low-frequency (one- to four-year short-
 207 term) linkage correlation, and there was two-way causality. The high-frequency effect (four
 208 to eight years or more than eight years) had a high degree of linkage correlation, and there
 209 was one-way causality in which medical expenditures positively affected GDP. However,
 210 after 2008, regardless of whether the correlation was long or short term, there was almost no
 211 linkage correlation. Therefore, the Taiwanese Government should consider the
 212 appropriateness of medical expenditures.

213 As shown in Figure(a.1), in terms of the correlation between Taiwan's health insurance medical
 214 expenditures and GDP, short-term (one to four years) effects were found from 1997 to the end of 1999,

215 at the end of 2001, and from 2009 to the middle of 2010. In 2014, there was a significant positive
216 correlation (correlation coefficient > 0.7), and the significant correlation was within one year (an
217 extremely short-term frequency). There was a long-term (four- to eight-year) positive correlation only
218 in 2001 (correlation coefficient > 0.4), and there was no linkage correlation for the rest of the period.

219 After adding the control variable, as in Figure (b.1), short-term (one to four years) effects were
220 found from 1997 to the end of 1999, in the middle of 2000 and 2002, and from 2006 to the third quarter
221 of 2007, and there was a more significant positive correlation (correlation coefficient > 0.6). Positive
222 long-term (four to eight years and more than eight years) correlations were found in 2000 and from
223 2002 to the beginning of 2008 (correlation coefficients > 0.7 and 0.5 , respectively). After 2008, there
224 was almost no linkage correlation in the long or short term.

225 In Figure (a.2), short-term (one to four years) effects were found from 1997 to the end of 1999,
226 and at the end of 2001, medical expenditures were positively correlated and covaried with GDP. From
227 2009 to the middle of 2010, medical expenditures and GDP were positively correlated, and medical
228 expenditures led GDP. In 2014, medical expenditures were positively correlated and covaried with
229 GDP, and the period of the significant correlation was within one year (an extremely short-term
230 frequency).

231 For Figure (a.3), the long-term (four to eight years) phase difference showed that there was a
232 positive correlation (correlation coefficient > 0.4) only in 2001, and medical expenditures led GDP.

233 After including the control variable of the dependent population, in Figure (b.2), in the short
234 term (one to four years) from 1997 to the end of 1999, medical expenditures were positively correlated
235 and covaried with GDP. From the middle of 2000 to the middle of 2002, medical expenditures and
236 GDP were positively correlated, and medical expenditures led GDP (medical expenditures positively
237 affected GDP). From 2006 to the third quarter of 2007, medical expenditures and GDP were positively
238 correlated with medical expenditures leading GDP. Therefore, the short-term (one to four years)
239 phase difference showed that the two had mutual causality. After 2008, there was almost no linkage
240 correlation.

241 In Figure (b.3), positive long-term (four to eight years and more than eight years) correlations
242 were found in 2000 and from 2002 to the beginning of 2008, and medical expenditures led GDP. After
243 2008, there was almost no linkage correlation, regardless of long or short term.

244 To summarize, for the whole sample period, the correlation between medical expenditures and
245 GDP was positive.

246 The short-term (one to four years) phase difference showed that before including the control
247 variable, medical expenditures and GDP were positively correlated, and there was covariation or a
248 positive correlation with medical expenditures leading GDP. After including the control variable,
249 medical expenditures and GDP were positively correlated and had mutual causality.

250 The long-term phase difference (four to eight years and more than eight years) showed that
251 regardless of whether the control variable was included, medical expenditures and GDP were
252 positively correlated with medical expenditures leading GDP. However, after the control variable
253 was added, there was almost no linkage correlation after 2008, regardless of the time period (long or
254 short term).

255 5. Conclusions

256 The economic growth rate of Taiwan has recently decelerated. In particular, since 1980, the mean
257 real GDP growth rate has decreased, and the growth rate of medical expenditures has peaked. The
258 empirical results showed that before 2008, increasing medical expenditures for the Taiwan
259 Government would increase Taiwan's GDP. Medical expenditures are government expenditures, but
260 those applying for medical expenses were the major public and private hospitals, regional hospitals,
261 private clinics, etc. Medical expenditures ultimately increased GDP, which may have been influenced
262 by differences between the inflated reported figures and differences in drug prices. Furthermore, the
263 profit gaps between various medical units were very large. Therefore, high medical expenditures can
264 result in economic benefits.

265 Before 2008, Taiwan did not have a relative increase in medical expenditures when only GDP
 266 increased (the economic environment improved); instead, medical expenditures increased Taiwan's
 267 GDP. Moreover, the GDP growth that was caused by high medical expenditures was truly caused by
 268 wasted domestic fund transfers in which the government and its citizens supported the profits of the
 269 medical industry by increasing the industry's surpluses or undeserved profits due to wasted medical
 270 resources. However, after 2008, this effect had already disappeared. The health insurance system
 271 restructuring in 2008 may be one of the reasons.

272 The universal health insurance system has long been denounced as a waste of medical resources,
 273 and the waste must be immediately stopped. The health insurance system was formed with good
 274 intentions to help vulnerable groups and patients who have acute, critical, and chronic illnesses so
 275 that they do not need to worry about treating their illnesses. All people should be willing to help
 276 others. Insurance was originally designed to transfer risk and prevent losses that are caused by
 277 accidents or diseases. Because there are no longer paid health insurance premiums, the number of
 278 unnecessary and repeated visits to hospitals and clinics has increased. It is critical to emphasize that
 279 medical attention should be sought only when there is a need.

280 **The empirical results showed that prior to 2008, the medical expenditures of the government**
 281 **were positively correlated with economic growth; i.e., they enhanced economic growth. If reduced**
 282 **medical expenditures were recommended at this time to balance the profits and losses in the**
 283 **health insurance system, GDP growth would have also decreased synchronously. However, after**
 284 **2008, this effect disappeared, and there was no longer any linkage correlation between medical**
 285 **expenditures and GDP. The continued expansion of medical expenditures no longer increased**
 286 **GDP in Taiwan. Therefore, the government should adopt corresponding measures to prevent**
 287 **wasted medical resources and explore the effectiveness of the health insurance system after the**
 288 **health insurance restructuring in 2008 as well as the installation of the present health insurance**
 289 **system. This work provides corresponding thoughts and recommendations for the Taiwanese**
 290 **Government.**

291 **The Taiwanese Government should reconsider the appropriateness of the current health**
 292 **insurance system; revise the items that are covered by health insurance, such as copays for doctor's**
 293 **visits and the health checkup cycle; eliminate repetition and waste; and update other response**
 294 **measures, which have become pressing policy issues.**

295 References

- 296 Abel-Smith B. (1963) Paying for Health Services. *World Health Organisation*, Public Health
 297 Papers.
- 298 Abel-Smith B. (1967) An International Study of Health Expenditure. *World Health*
 299 *Organisation*, Public Health Papers.
- 300 Azeem Qureshi M.(2009) Human development, public expenditure and economic
 301 growth: a
 302 system dynamics approach. *International Journal of Social Economics*, 36(1-2): 93-
 303 104.
- 304 Devlin, N. and Hansen, P. (2001) Health Care Spending and Economic Output Granger
 305 Causality. *Applied Economics Letters* , 8, 561-564.
- 306 Fernando Pueyo. (2006) Investigating the Relationship Between Health and Economic
 307 Growth: Empirical Evidence from a Panel of 5 Asian Countries. *Journal of Asian*
 308 *Economics*, 21 (4):104-111.
- 309 Gbesemete K P(1992), Gerdtham U G. Determinants of Health Care Expenditure in
 310 Africa: a Crosssectional Study. *World Development*, 20(2):303-308.

- 311 Gerdtham UG, J Sjøgaard ,B Jönsson ,et al. (1992)A pooled crosssection analysis of the health
312 care expenditures of the OECD countries. Springer Netherlands,1-287.
- 313 Gerdtham, U.G. & M. Löthgren. (2000).On Stationarity and Cointegration of International
314 Health Expenditure and GDP. *Journal of Health Economics*, 19(4), 461-475.
- 315 Gyimah-Brempong K. (1998) The political economy of budgeting in Africa 1971-1991.
316 *Journal of Public Budgeting, Accounting & Financial Management*,4(4): 590-616.
- 317 Hansen, P. and King, A. (1996) The Determinants of Health Care Expenditure A
318 Cointegration Approach. *Journal of Health Economics*, 15, 127-137.
- 319 Hitiris T, Posnett J.(1992) The Determinants and Effects of Health Expenditure in Developed
320 Countries. *Journal of HealthEconomics*,11 (2):173-181.
- 321 Kleiman E. (1974) The Determinants of National Outlay on Health. *The Economics of Health*
322 *and MedicalCare*, Londn.
- 323 Mohapatra S, Mishra P.(2011)Composition of Public Expenditure on Health and Economic
324 Growth: A Cointegration Analysis andCausality Testing. *IUP Journal of Public*
325 *Finance*,9(2):30-43.
- 326 Newhouse J P. (1969) Toward a Theory of Nonprofit Institutions: An Economic Model of
327 a Hospital. *The American EconomicReview*,60(1):64-74.