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Forecasting on the long term sustainability of the employees provident fund in Malaysia via the Box-Jenkins' ARIMA model

Sallahuddin Hassan, Zalila Othman
School of Economics, Finance and Banking, Universiti Utara Malaysia, Malaysia

address: School of Economics, Finance and Banking, Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia

Abstract: This study employs the use of Box-Jenkins' ARIMA (1,1,0) model for the estimation and forecasts based on the annual data of EPF balances, which serve as a proxy to EPF sustainability, together with the yearly data of possible determinants namely investment earnings, nominal income, elderly population, life expectancy and mortality rate in Malaysia for the 1960 - 2010 and 2010 - 2014 periods, respectively. Amid a negative sentiment and conceivably bleak outlook on the long term EPF inadequacy to provide adequate incomes to elderly persons, the prognosis of this study instead reveals otherwise and is found to be in support for the long term prospect and sustainability of the EPF. With necessary improvements are underway to strengthen the performance of the administered EPF system, it is likely to believe that the EPF organization is committed to promoting its product as a more inclusive and equitable scheme in Malaysia.

JEL Classifications: E27, G23, H55

Keywords: ARIMA model, EPF, forecasting, long term sustainability
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1. Introduction

Employees provident fund (EPF), which is a compulsory savings scheme among the private and non-pensionable public sector employees, mainly aims to protect the rights of the employees to retirement savings and also to maximize the value of their savings for the post-employment financial security and well-being. Earnestly started with one main objective as the old age financial protection, the EPF has broadened its reasons thereafter in allowing for non-retirement withdrawals such as purchasing a house and financing higher education of children (Narayanan, 2002). Increasingly, the EPF faces tremendous challenges that have caused successive changes in its structure. Due to rising pre-retirement withdrawals, the EPF initiated its first reform in 1994 to separate a contributor's account into three accounts; Account I, II and III (holding 60, 30 and 10 percent of the member's balance, respectively), thus ensuring the major portion that is meant for retirement goes into Account I. However, the EPF members' accounts were subsequently restructured from three to two accounts in 2006 as part of the reform towards enhancing the overall efficiency and effectiveness of the EPF governance.

Concerning on the persistent rise in demands for pre-retirement withdrawals, this implies that a contributor's total balance being reserved for retirement deteriorates over time. For example, amid the total EPF savings of RM298.76 billion contributed by 6.04 million EPF active members, a surge in pre-retirement withdrawals from 1,949,606 applications in 2009 to 1,996,881 applications in 2010, constituting as an additional of 47,275 incoming forms within a year that summed up to RM26.4 billion in total, would be detrimental to the sustainable progress of the EPF system going forward (EPF, 2010). As a result, this may render to a fast depletion of the retirement fund especially in the absence of any prudent action besides considerable concerns are currently centered on declining dividend rates in the recent years that may raise the issues on financial prudence and profitability of the

EPF investment portfolio. Obviously, pre-retirement withdrawals do oppose the main objective of the EPF, that is, for old age financial protection. According to Bank Negara Malaysia (BNM) (2000), 81 percent of EPF contributors, who is aged 54, about to go into retirement in few years but only had balances of only RM30,000 or less. Surprisingly, such amount is barely sufficient to support an elderly person without other sources of wealth or income for a period of 14 - 19 years after retirement. In this respect, the restoration of EPF with its initial dedicative role to protect adequate savings for elderly persons is deemed necessary as suggested by Narayanan (2002).

Additionally, another concern may revolve around the issue of demographic transition and its potential effect on the social security system in Malaysia (Mohd, 2013). In response to the unavoidable challenges of rising elderly population, improving life expectancy and declining mortality rate apart from economic uncertainties, there are new improvements such as increasing diversification in potentially certified investments and improving a transparent governance of the EPF structure that need to be supplemented to the currently administered EPF system in Malaysia. As expected, such reform helps EPF becoming a more inclusive and equitable scheme that also takes into account on necessary measures of long term financial balance which no longer can cast a doubt on the long term financial performance and sustainability of the EPF.

2. Literature review

Pertaining to numerous forecasting methods out there, there is absence of empirical or concrete rules in-place that successfully derives the best forecasting model. Yet, the most acceptable and appropriate projected model is opted depending upon the one that is associated with the lowest errors being empirically observed in the model (Karin, 2011). With vast empirical studies on estimation and forecasting that are increasingly available thus far, there remains an uphill task on the crucial need to compare a significant difference between the errors from the adopted forecasting methods in respective studies.

Of the forecasting methods, Box-Jenkins' autoregressive integrated moving average (ARIMA) models, which have a high power of predictability with lower error, are popularly employed by many authors in their studies for estimation and forecasting purposes. For instance, the use of ARIMA models is prominently growing in the aspect of a country's macroeconomic performance namely domestic inflation. Meyler, Kenny and Terry (1998), who adopted ARIMA models in their studies, claimed that the model is feasibly adequate to forecast the inflation in Ireland. Similarly, their findings do match to some extent with Salam, Salam and Feridun (2007), who are in the other part of the world and also applied similar methods, unfolded the best model to forecast the inflation in Pakistan.

Furthermore, the application of ARIMA models is increasingly prevalent in the estimation and forecasting exercises especially in the medical procedures. Among others, Promprou, Jaroensutasinee and Jaroensutasinee (2006), who fitted the ARIMA models on the monthly data of dengue hemorrhagic fever cases in southern Thailand, revealed that the forecast curves were comparably close to the trend of actual figures and disclosed that the autocorrelation function (ACF) was insignificantly different compared to zero. Likewise, Li, Guo, Han, Zhang, Qi, Xu, Wei, Han and Liu (2012) concluded that the ARIMA models adequately describe the changes in hemorrhagic fever with renal syndrome (HFRS) frequency and these models can also be used for future forecasting that is tied to HFRS preventive control. In a similar vein, Moosazadeh, Nasehi, Bahrampour, Khanjani, Sharafi and Ahmadi (2014) proved that the Box-Jenkins and seasonal ARIMA (SARIMA) models are the appropriate tools to predict a growing incidence of tuberculosis cases in Iran.

On the contrary, there exist authors that have empirically indicated the evidence on the superiority of other regression models to outperform the ARIMA models in the estimation and forecasting purposes. One example is referred to Nanda (1988) that tested the forecasts based on the monthly milk procurement data by Amul Dairy from January 1965 to December 1975 via using two methods namely ARIMA models and regression models; ordinary least squares (OLS) and generalized least squares (GLS). From his finding, he established the empirical evidence on the shortcomings of the ARIMA models that were partially rooted from the characteristic of surrounding factors and the behaviour of the data. Also, he argued that lagged linear models; OLS and GLS were empirically favoured over the use of ARIMA models in terms of simultaneously analyzing various mixtures of the underlying key factors. Equivalently, Zhang, Zhang, Young and Li (2014) modeled and forecasted on the monthly data of nine types of infectious disease, which were obtained from a public health surveillance system in China, for the predication of future epidemic events. Based on three error measures; mean absolute error (MAE), mean absolute percentage error (MAPE) and mean square error (MSE), their findings unveiled that the support vector machine (SVM) outperforms the other methods namely ARIMA models and decomposition approach (e.g. regression and exponential smoothing) in terms of its effectiveness in the surveillance to predict the future epidemic events.

Notwithstanding, the use of ARIMA models, however, serves as a reliable benchmark to comprehend on the long term EPF sustainability in Malaysia, which is the topic of interest in this study, especially in the wake of rising elderly population, improving life expectancy and declining mortality rate in Malaysia over the years. Being as one of a kind thus far, the study is expected to set a precedent particularly in the Malaysia's financial security mainstream literature relating to the estimation and forecasting aspects.

3. Methodology

3.1. Data

Secondary data are utilized to forecast on the long term EPF sustainability between EPF balances and possible determinants namely investment earnings, nominal income, elderly population, life expectancy and mortality rate in Malaysia for the 1960 - 2014 period. The recent annual data on EPF balances (i.e. EPF contributions minus withdrawals) and investment earnings were collected from annual reports in the EPF's website whereas the older EPF balances and investment earnings (1980 and earlier) data are acquired from the National Archives of Malaysia in paper-based versions. The annual data on elderly population were obtained from the United Nation's World Population Prospects: The 2012 Revision Report. While the annual data on nominal income were taken from the website of Malaysia's Department of Statistics, the annual data on life expectancy and mortality rate were gathered from the World Bank's website. Fittingly, all variables were transformed into the logarithmic (log) form thereafter.

3.2 Model specification

Following several works of Mohd (2013), Samad and Mansor (2013), Ahmad and Sabri (2014), Asher and Bali (2015) and Jaafar and Daly (2016) particularly on the Malaysia's social protection system, the functional expression is hypothetically structured that can explain the long term EPF sustainability, which is proxied by EPF balances, is given as per Equation (1):

$$BALEPF = f(INVEARN, GDP, POP60, LIFEXP, MORT) \quad (1)$$

Then, Equation (1) is converted into the double natural log specifications as expressed in Equation (2) and becomes the empirical model for the study. Here, one benefit of the conversion is that the use of log form ascertains each series to possess stationary properties in its variance (Box & Jenkins, 1970 as cited in Makridakis & Hibon, 1997). Besides that, it enables for the statistical meanings of coefficients to be interpreted as the long run elasticity effects.

$$LBALEPF = \beta_0 + \beta_1 LINVEARN_t + \beta_2 LGDP_t + \beta_3 LPOP60_t + \beta_4 LLIFEXP_t + \beta_5 LMORT_t + \varepsilon_t \quad (2)$$

where $LBALEPF$ is natural log of EPF balances (in RM billion), $LINVEARN$ is natural log of investment earnings (in RM billion), $LGDP$ is natural log of nominal income (in RM billion), $LPOP60$ is natural log of elderly population (in percentage of total population), $LLIFEXP$ is natural log of life expectancy at birth (in total number of years) and $LMORT$ is natural log of under-five mortality rate (death per 1,000 live births). β_0 is a constant term and β_1 to β_5 are estimated parameters in the model. Also, t represents a time series data and ε_t is an error term.

3.3. Method of analysis

3.3.1 Box-Jenkins' autoregressive integrated moving average

In time series analysis, a systematic approach for forecasting is highly demanded. One feasible approach is via using the Box-Jenkins' ARIMA method that best fits to a particular time series and fulfills the parsimony principle. Since the Autoregressive Moving Average (ARMA) models do not adequately address non-stationary time series, the ARIMA model, which is a generalization of an ARMA model, treat non-stationary variables to become stationary series through a finite differencing of the data points (Box & Jenkins, 1970 as cited in Adhikari & Agrawal, 2013). The method involves four steps namely model identification, estimation, diagnostic checking and forecasting (Box & Jenkins, 1976 as cited in Bowerman, Richard & Koehler, 2005).

For identification, the use of two unit root tests; Augmented Dickey and Fuller (ADF) (1979) and the Phillips-Perron (PP) (1988) are used to check for the robustness of stationary results in the variables. Also, the samples of partial ACF (PACF) and ACF are technically referred in order to determine the optimal model parameters. In the estimation phase, the least squares method is employed for regression analyses between dependent and independent variables. Subsequently, the residuals of the estimated model are examined in the diagnostic checking exercises. Finally, the analyses on forecast errors and root mean squares errors (RMSE) are accordingly undertaken for the forecasting purpose.

4. Empirical results

As shown in Table 1, all variables are proven to have non-stationary properties at level. Due to their associated *p*-values that are over the 10 percent significance level, the null of a series to contain a unit root fails to be rejected. However, the variables are found to contain stationary properties after transforming all series into first-differenced variables. In turn, there is a tendency to reject the similar null and concludes that the fitted variables have become stationary series and are cointegrated of same order one, i.e. I(1) thereafter.

TABLE 1. RESULTS OF THE UNIT ROOT TESTS

VARIABLE	ADF		PP		CONCLUSION	
	LEVEL	FIRST DIFFERENCE	LEVEL	FIRST DIFFERENCE	ADF	PP
LBALEPF	-0.329 (0.988)	-3.768 (0.026)*	-0.035 (0.995)	-3.854 (0.021)*	I(1)	I(1)
LINVEARN	-0.566 (0.977)	-4.313 (0.006)*	-0.866 (0.952)	-7.303 (0.000)*	I(1)	I(1)
LGDP	-1.801 (0.691)	-5.593 (0.000)*	-1.977 (0.600)	-6.935 (0.000)*	I(1)	I(1)
LPOP60	-1.653 (0.748)	-3.609 (0.046)*	-0.079 (0.994)	-3.703 (0.031)*	I(1)	I(1)
LLIFEXP	-1.971 (0.593)	-4.539 (0.006)*	-2.394 (0.379)	-5.608 (0.000)*	I(1)	I(1)
LMORT	-1.875 (0.653)	-3.756 (0.027)*	-1.321 (0.872)	-4.416 (0.005)*	I(1)	I(1)

Note: Figures in the parentheses are p-values. * - shows that the null is rejected at the five percent significance level.

Moving on, a regression model for *LBALEPF* model is preliminarily estimated by using the historical data from 1960 to 2000 for a-41 year period prior to constructing any forecast in recent years i.e. over the 2000 - 2014 timeframe for a-15 year period. As exhibited in Table 2, the overall regression fit, which is measured by the R^2 value, implies a very tight fit reaching closer to the value of one that is characterized as a perfectly fitted line between dependent and independent variables.

TABLE 2. RESULTS OF THE ORDINARY LEAST SQUARE' REGRESSION

VARIABLE	COEFFICIENT	STANDARD ERROR	*T*-STATISTIC	*P*-VALUE
C	25.0468	3.6465	6.8688	0.0000*
LINVEARN	0.4856	0.0496	9.7966	0.0000*
LGDP	0.1966	0.0816	2.4099	0.0198*
LPOP60	0.1234	0.1795	0.6875	0.4950
LLIFEXP	-4.5405	0.8285	-5.4803	0.0000*
LMORT	-1.2645	0.1314	-9.6248	0.0000*
R^2	0.9993		Prob(*F*-statistic)	0.0000
Adjusted R^2	0.9992		Durbin-Watson statistic	0.4569

Note: * - indicates the null, H0: $\beta i = 0$ being rejected at the five percent significance level.

Among others, all variables, excluding *LPOP60*, are found statistically significant and positively and negatively related to *LBALEPF* with respective *t*-statistic figures that are over the value of two (in absolute term). However, it is noticeable that the low value of the Durbin-Watson *(DW)* statistic implies the presence of positive serial correlation in the residuals of the model.

To account for the presence of serial correlation, the original equation is subsequently modified by including the lags of the original explanatory variables. Alternatively, the inclusion of autoregressive (AR) and/or moving average (MA) terms in the estimated equation constitutes as one common method to compound the portion of serial correlation. Accordingly, the lagged terms have been removed from the equation and replaced thereafter with an AR(1) specification as displayed in Table 3.

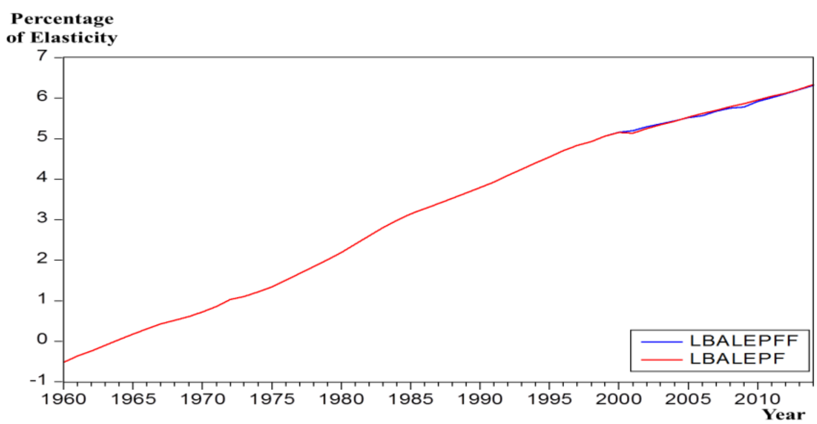
TABLE 3. RESULTS OF THE ORDINARY LEAST SQUARE' REGRESSION WITH AN AR(1) SPECIFICATION

VARIABLE	COEFFICIENT	STANDARD ERROR	*T*-STATISTIC	*P*-VALUE
C	-248.7554	53.8054	-4.6232	0.0000*
LINVEARN	0.2436	0.0543	4.4853	0.0000*
LGDP	0.0171	0.0580	0.2948	0.7694
LPOP60	-0.6546	0.3068	-2.1337	0.0381*
LLIFEXP	59.0637	12.4425	4.7469	0.0000*
LMORT	0.0657	0.2971	0.2213	0.8258
AR(1)	0.9398	0.0069	137.0569	0.0000*
R^2	0.9998		Prob(*F*-statistic)	0.0000
Adjusted R^2	0.9997		Durbin-Watson statistic	1.7300

Note: * - indicates the null, H0: βi = 0 being rejected at the five percent significance level.

Overall, the fitted AR(1) model is in proximity to the *DW* statistic of two thus reflecting that the series has no serial correlation and is comparable to the previously established lag one model. Eventually, the estimated model seems parsimonious and follows the mathematical form of the ARIMA (p, d, q) order. That is, it turns out to be ARIMA (1, 1, 0) order. As such, Figure 1 covers the combination of estimation and forecast timeframes that are put together, respectively, into a single graph for a-55 year period i.e. starting from 1960 to 2014.

FIGURE 1. ESTIMATION AND FORECAST OF LBALEPF, 1960 - 2014



Once the AR(1) model is determined given the observations of 1960 - 2000 period, the remaining observations for the 2000 - 2014 period are reserved in order to construct the model forecasts and to test for the accuracy of corresponding forecasts. That is, the outputs of the dynamic and static forecasts are illustrated in Figure 2 and Figure 3, accordingly.

FIGURE 2. DYNAMIC FORECAST ON THE PERCENTAGE CHANGES IN EPF BALANCES USING AR(1)

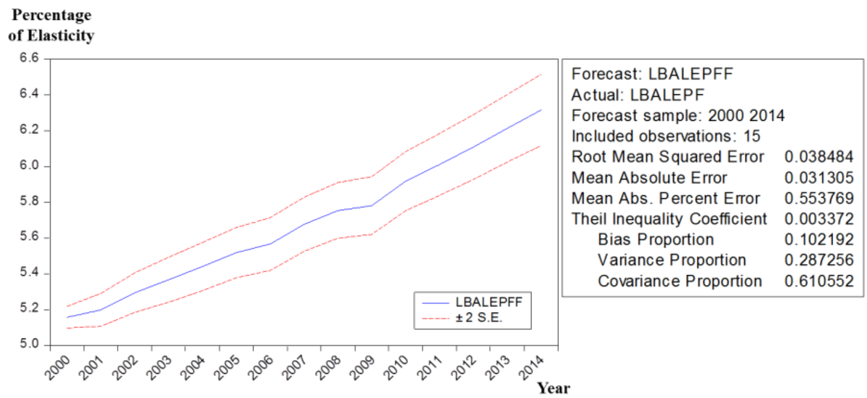
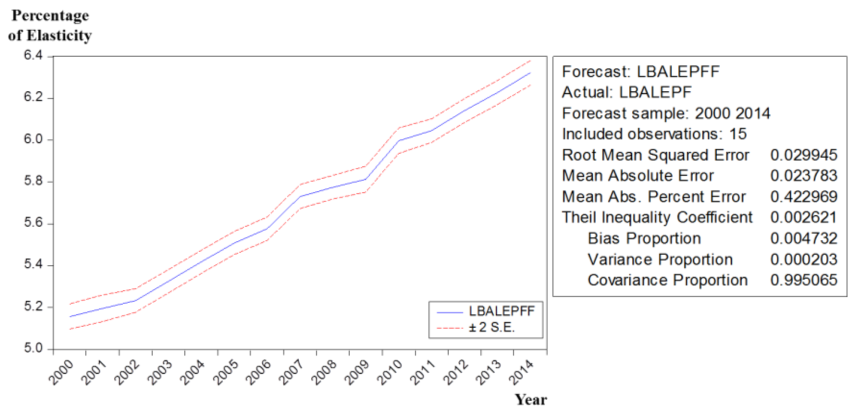


FIGURE 3. STATIC FORECAST ON THE PERCENTAGE CHANGES IN EPF BALANCES USING AR(1)



In both figures, the continuous line represents the corresponding forecast whereas the two dotted lines in every case indicate the confidence interval.

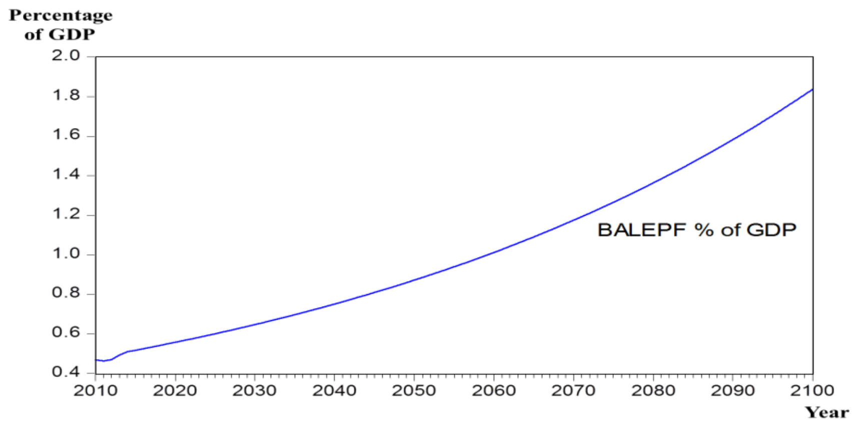
Empirically, the dynamic forecast in Figure 2 is inclined to be more stretchable than the static forecast in Figure 3, which signals for increasing forecast errors, upon the long term unconditional mean as the horizon increases. In other words, the stake is conceivably high when simulating the dynamic forecast with accuracy over an extended horizon due to involved assumptions and error bounds. Therefore, it is suggested that the static forecast from Figure 3 instead to represent the preferable benchmark for estimating errors and minimizing the impacts of such uncertainties.

As far as the forecast errors are concerned, the plot box of each case features other useful measures such as the square root of the mean squared error (RMSE), the MAE, the MAPE and Theil's *U*-statistic. While the first two forecast error statistics hinge upon the scale of the dependent variable, the latter two statistics are characterized as a scale invariant. In term of the interpretation, both RMSE and MAE criteria stipulate that the smaller the error, the better the forecasting ability of a model. Obviously, the static forecast in Figure 3 would lead to significantly better forecasting performance than the dynamic forecast in Figure 2.

Apart from that, the MAPE of the dynamic and static forecasts for *LBALEPF* in Figure 2 and Figure 3 are amounted to about 55.4 percent and 42.3 percent, respectively. In particular, this suggests that the model forecasts still have additional capacities to take up more variabilities coming from the out-of-sample part of data. Also, there is no sign of a perfect fit when the value is zero for both forecasts since their Theil inequality coefficients are posted with 0.0034 and 0.0026, accordingly. Additionally, pertaining to the decomposition of the forecast errors, the mean squared forecast error can be categorized into three proportions namely bias, variance and covariance. Here, the rule of thumb for the forecast to be classified as "good" is that most of the error bounds should be more concentrated on the covariance proportion rather than those to be in bias and variance proportions (Pindyck & Rubinfeld, 1991). Therefore, based on the summary statistics from Figure 2 and Figure 3, the static case stands out over the dynamic model to become the preferable forecast evaluation.

When looking into over an extended time horizon, i.e. between 2010 and 2100, the EPF balances, in percentage of GDP, are projected to remain on an upward trend annually as exhibited in Figure 4.

FIGURE 4. THE LONG TERM PROJECTION PATH OF EPF BALANCES-TO-GDP RATIO



Such pattern is expected to emerge due to rising optimisms on EPF contributions, which are heavily funded from the private sector i.e. both employers and employees, to gradually increase over time thus leaving a clear gap against EPF withdrawals. With the anticipation of future EPF balances to be on the increasing trend, this suggests that there is no pressing issue at present years concerning on the potential deterioration of the retirement fund and unsustainability of the EPF system over time. Therefore, the finding of this study is seen to challenge to some extent against currently established belief on the long term EPF inadequacy among some authors in respective studies such as Mohd (2013) and Jaafar and Daly (2016). Nevertheless, the prognosis of this study on future EPF balances as per Figure 4 may turn out otherwise depending upon the structural changes in EPF contributions and/or withdrawals schemes as the possible outcomes of worst case scenarios such as pessimisms on expected returns due to economic unfavourable conditions and stringent policy interventions gazetted by the government to optimally boost domestic consumption via making unprecedented EPF withdrawals since it is perceived to be the only key engine of economic growth while holding other key drivers to be constant throughout the observed timeframe.

5. Conclusion and policy implication

This paper employed the Box-Jenkins methodology on the ARIMA (1,1,0) order for the estimation and forecasts based on the annual data of EPF balances, which is a proxy to EPF sustainability, together with the annual data of possible determinants namely investment earnings, nominal income, elderly population, life expectancy and mortality rate in Malaysia for the 1960 - 2010 and 2010 - 2014 periods, respectively. Then, the forecasting exercise continues with the coming out of another set of prognosis (i.e. from 2010 to 2100) that looks into the arguably favourable perspective of the EPF sustainability over the long term.

Yet, there still exist lingering doubts on the long term EPF sustainability to fully commit with financial incomes provision to elderly population in the post-retirement periods. However, the long term projection path of EPF balances-to-GDP ratio in Figure 4 is empirically proven to be in favour of a positive sentiment that hypothetically suggests for the long run validation on the dual roles of the EPF being the financial security provider to elderly population after retirement and a key catalyst that produces substantial contributions to the country's ongoing economic development. Of which, the coverage on these designated roles of EPF both to the elderly population and the financial stimulus for spurring the country's economic development is elaborated in some studies such as Narayanan (2002) and Tan (2007). Notwithstanding, uncertainties, which cover both internal and external forces that may come into play, remain at their respective positions accordingly and continue to influence on the variations in EPF balances over the coming years. Therefore, new improvements are imperative to strengthen the performance of the existing EPF system. Such improvements, among others, may include initiatives to increase diversification in potentially certified investments and improve the degrees of efficient and transparent governance of the EPF structure. With the reform taking place accordingly, it is expected that the EPF organization progressively charts its pathway towards making its product a more inclusive and equitable scheme in Malaysia.

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