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Reconciling the Mixed Weak Form EMH Findings on the ZSE – Evidence of Evolving Efficiency (1994-2013).

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Abstract
The empirical findings on Zimbabwe Stock Exchange (ZSE) weak-form efficiency since the 1993 stock market liberalisation have been mixed, indicating some changes in weak-form efficiency and its dependency on the tests and methodology used. This research investigated the evolution of ZSE weak-form efficiency over the period 1994 to 2013. A sample of twenty (20) continually listed stocks and the Industrial and Mining Indices were analysed using three approaches namely the; Augmented Dickey-Fuller (ADF), dummy variable; Chow Test and Kalman Filter estimation. Findings show that, Zimbabwe Stock Exchange data violates the Augmented Dickey-Fuller (ADF) random walk test, despite the Kalman Filter estimation graphs indicating continual but unstable efficiency while the hypothesis of constant efficiency was rejected under the CHOW and Dummy variable tests based on the industrial index and 20 continually listed counters over 1994 – 2013. Turbulences in ZSE efficiency under the Kalman filter estimation graphs were observed during the period just after the currency revaluation of 2006; the period just after the multi-currency adoption (dollarisation) in 2009, and a few other systemic firm specific experiences in between, suggesting that the degree of efficiency has been unstable from 1994 to 2013. The observed weak-form efficiency is in line with emerging markets evidences and reveals the effectiveness of the measures undertaken by the ZSE to ensure that investors stay up to date with information affecting stock prices. Investors and financial theorists are urged to keep track of the time-varying nature of weak-form efficiency on the ZSE for use in investment strategies and stock selection methods. AMH's evolving market efficiency was found to reconcile the mixed weak-form efficiency conclusions of prior researchers on the ZSE over the years 1994 – 2013

Key Words: Adaptive Market Hypothesis, Random Walk, Weak-form Efficiency, dummy variable, Chow Test, Kalman Filter, ZSE.

1.1 Introduction

The ZSE has been a preferred capital market in the SADC region outside of South Africa due to the more than a century of trading on the stock exchange (since 1896). The ZSE enjoyed attention since its liberalisation in 1993 where individual foreign investor thresholds were set at 10% and collective foreign ownership at 40% in a listed company. The stock exchange also faced a number of economic conditions and regulations. Five key phases are of note when considering the ZSE over the period 1993 to 2013 namely the early post ZSE liberalisation of years 1993 to 1997, the early years of the ZWD currency crisis, drought and trade deficit 1998-2001, high inflation years 2002 to 2006, hyperinflation years 2007 to 2008 and the years post dollarisation of the economy from January 2009. The high inflation period of 2002-2008 characterised by currency revaluations through removal of zeros. Zimbabwe adopted the use of multiple currencies in the year 2009 and the ZSE resumed on 19 February 2009 using the United States Dollars (USD) (ZSE Handbook, 2010). In light of this, it becomes imperative that the ZSE be given a test of evolving efficiency to determine how far it has come in terms of drifting towards efficiency.

Research findings on weak-form efficiency in emerging and frontier capital markets have not been encouraging (Degutis and Novickytė, 2014). Empirical literature provides mixed evidence of ZSE weak-form efficiency with; Magnusson and Wydick (2002), Simons and Laryea (2005), Jefferis and Smith (2005), Smith (2008), Sunde and Zivanomoyo (2008), Mazviona and Nyangara (2013) and Chowa *et al*. (2014) finding it to be a weak form inefficient. On the other hand, Jefferis and Okeahalam (1999b), Appiah-Kusi and Menyah (2003) and Mlambo and Biekpe (2007) concluded that the ZSE is weak-form efficient. This indicates the change in weak-form efficiency over time and the dependence of weak-form efficiency tests on the methodology used (Fama 1998; Lim and Brooks 2011). Traditional tests on the ZSE examine whether it is or is not weak-form efficient in the absolute sense, by assuming that the level of market efficiency remains constant throughout the entire estimation period. Such tests do not account for the evolution of efficiency over time. Thus the possibility of time-varying weak-form market efficiency on the ZSE has been neglected by previous researchers, and this study aims to overcome this problem by revealing a clearer picture of the evolution of efficiency on the ZSE.

Yen and Lee (2008) demonstrated that the EMH no longer has the strong level of support it received during the 1960s, but instead has come under relentless attack from the school of behavioural finance (BF) in the 1990s. Lo (2008) highlight that critics found anomalies and behaviours that could not be explained by the EMH and thus, argued that investors are often if not always irrational, exhibiting predictable and financially ruinous behaviour. Frankfurter (2007) and Lo (2008) present the key EMH critics from proponents of behavioural finance as; overconfidence, overreaction, loss aversion, herding, psychological accounting, miscalibration of probabilities, hyperbolic discounting and regret.

Fama (1998) reviewed two models of behavioural finance, namely the BSV by Barberis, Shleifer and Vishney (1998) and the DHS by Daniel, Hishleifer and Sabramanyam (1997), put forward to explain how the judgement biases of investors lead to over-reaction/under-reaction to market events. Fama (1998) emphatically disagreed with the new models based on their failure to produce rejectable predictions that capture the menu of anomalies better than market efficiency. An empirical adjudication by Frankfurter (2007) concluded in favour of the EMH and reduced the BF to a mere anomaly similar to Ball and Brown (1968)'s post-earnings announcement drift (PEAD) due to the following three fundamental flaws.

1. It does not amount to a comprehensive methodology, a clear combination of ontology (what is to be known), and epistemology (how it is to be known).
2. Its empirical evidence is almost exclusively event-studies.
3. Its structure, with the exception of some basic assumptions regarding investors' behaviour, is the same as the EMH and its aim is the exclusive discreditation of the EMH.

Lo (2004) attempts to reconcile the opposing camps by proposing an evolutionary alternative to market efficiency termed the Adaptive Markets Hypothesis (AMH). The AMH by Lo (2004, 2011) states that prices reflect as much information as dictated by the combination of environmental conditions and the number and nature of 'species' in the economy. Lo (2008) asserts that the AMH has been able to reconcile many of the apparent contradictions between efficient markets and behavioural exceptions with the market efficiency condition viewed as a characteristic that varies continuously over time and across markets (Lim and Brooks 2011). Given the notable impact of the political and economic environment in the host country on the capital markets, a pioneer application of the AMH on the ZSE was deemed necessary in reconciling the mixed results on random walk tests in published literature despite AMH being a new paradigm is still under development (Lo 2008).

1.2 Purpose of the Study

This study performs a number of tests for the evolution of efficiency on twenty selected stocks and the Mining and Industrial Indices from the Zimbabwe Stock Exchange. The research also conducts preliminary tests that seek to identify whether the necessary conditions for fitting an AR (1) model have been met. The investigation covers the period from January 1994 to December 2013. A number of evolving weak form efficiency studies have been focused on Western economies and very few have been performed on African countries. The rest of this paper is structured as follows: Section 2 reviews the literature on the evolution of weak-form efficiency. Section 3 presents the data and the methodology employed to investigate the evolution of weak-form efficiency. Section 4 discusses the findings and Section 5 concludes the study.

2 Review of Related Literature

2.1 Evidence of Market Efficiency Evolution under the AMH

As markets operate and market microstructures develop, they are likely to become more efficient and this is possible given the rapidly growing emerging markets, as well as continually changing regulations and structures across the global stock exchanges (Zalewska-Mitura and Hall, 1998). Conventional efficiency tests have employed tests which lead to the inference that a stock market either is or is not at all weak-form efficient and thus, gradual changes in efficiency are not captured. This 'all or none' perspective tends to ignore the tendency for markets to cyclically move between efficiency and inefficiency in response to institutional, regulatory and technological factors (Chordia and Shivakumar, 2005). Transformation in the economic system encourages financial relationships and markets to change (Hall and Urga, 2002; Kvedaras and Basdevant, 2002) and raises the need to employ other techniques that allow integrating the structural change more explicitly.

The opening of the domestic stock market to foreign investors has been found to lead to a general increase in stock market efficiency (Kim and Singal, 2000a, 2000b; Fuss, 2005) despite neutral and mixed results from Maghyereh and Omet (2002) and Nguyen and Fontaine (2006). Studies conducted on the African market efficiency since the mid-1990s to date have so far shown that the efficiency of a market is affected by the stage of development of the market, implying that older markets are more likely to be efficient than newer markets (Jefferis and Smith, 2005). With more than a century in existence and two decades post-liberalisation, the ZSE can be expected to be tending towards efficiency, at least in the weak-form, despite the lack of consensus among researchers. This research circumvents the arguments of Lim and Brooks (2011) and Lo (2008) on the dependence of weak-form efficiency tests on the methodology used by presenting the first attempt to test for the change in weak-form efficiency over time on the ZSE.

2.1 Causes of Changes in Market Efficiency

The adoption of an electronic trading system, thereby replacing physical trading floors is widely believed to improve stock market efficiency through speedy operations and activities of exchanges, reduced costs, elimination of trade intermediation and ease of extending trading days and hours (Naidu and Rozeff, 1994). Modernisation of exchanges through electronic trading have resulted in no improvement in weak-form efficiency in some cases, despite documented increased liquidity and volatility. Automation can cause liquidity to decrease because it does not allow a direct negotiation between traders for important transactions and does not therefore allow them to preserve a certain control on trading conditions. Furthermore, the popular implementation of a Price Limits System has led to decreased efficiency in some markets due to lack of equilibrium (Naidu and Rozeff, 1994; Smith *et al.*, 2002).

Various studies have found changes in the regulatory structure to influence market efficiency in the expected directions (Antoniou *et al.*, 1997; Groenewold *et al.*, 2004; Hung, 2009). The interplay between liquidity and trading costs has led to enhanced informational efficiency in Kyle's (1985) model. Complimentary findings by Gu and Finnerty (2002) and Lim and Brooks (2011), observed that the USA market has exhibited a positive relationship between technological advances and improvements in market efficiency. Vogel (2010) asserts that the occurrence of a market crash or a financial crisis is another possible contributing factor of market inefficiency, as the resulting increased volatility in prices of financial assets induces some barrier in the reflection of full information and multiples. However, Hoque *et al.* (2007) found no significant effect of a crisis on weak-form efficiency of eight emerging Asian stock markets using the variance ratio (VR) test.

2.2 Review of Modelling the Evolution of Weak-form Efficiency

The possibility of evolving weak-form market efficiency has received increasing attention in recent years, with researchers using various techniques in search of its evidence. Emerging literature employs a state space model to capture the time-varying weak-form stock market efficiency. The state space form is widely used to represent dynamic systems with the advantage of allowing unobserved/state variables to be incorporated into, and estimated along with the observable model. The most common techniques used to model the evolution of weak-form efficiency described in this section are; the time-varying autoregressive model, the GARCH-M model and the time-varying variance ratio approach.

Time-Varying Autoregressive Model

Emerson *et al.* (1997) and Zalewska-Mitura and Hall (1998) formalized the use of a time-varying autoregressive model as a test of evolving efficiency, using the Kalman (1960) filter technique to track the changing degree of market efficiency over time, and this framework was followed in the studies of Lo (2004), Ito and Sugiyama (2009) and Ito *et al.* (2013). The AR model allows one to at least check for weak-form efficiency and it is able to detect changes in efficiency over time by performing the Chow Tests on the model slope coefficients. The time-varying AR coefficients can be estimated by applying Kalman smoothing, the OLS or Generalised Least Squares (GLS).

The time-varying parameter GARCH-M

The Generalized Autoregressive Conditional Heteroskedasticity in Mean (GARCH-M) model, was implemented by Emerson *et al.* (1997), Zalewska-Mitura and Hall (1998), Hall and Urga (2002), Jefferis and Smith (2005) and Abdmoulah (2009). This model works in three dimensions by checking for weak-form efficiency, detecting changes in efficiency over time and within stochastic series models the time-varying variance of the error process in a systematic way with NIID (normal, identical and independent distribution) properties (Emerson *et al.*, 1997; Hall and Urga, 2002). The model uses the standard Kalman Filter approach with a measurement equation in the slope parameter estimation and maximum likelihood methods.

Time-varying Variance Ratio (VR) Statistic

Kvedaras and Basdevant (2002) developed and subsequently applied the methodology to track the changing degree of stock market efficiency in the three Baltic States, namely Estonian, Latvian, and Lithuanian stock exchange market indices. The time-varying variance ratio allows getting a heteroskedasticity-robust inference without specifying a certain structure of conditional heteroskedasticity and enables the evaluation of different structures of autocorrelation. The variance ratio test makes use of the fact that the variance of a random walk process increases linearly with time, so that the q period variance of the IID residuals is equal to q times the variance of it.

3 Methodologies for Testing for Evolving weak form Efficiency on the ZSE

The search for evolving efficiency was meant to give an exhaustive longitudinal view of ZSE efficiency post its liberalisation of 1993 so as to reconcile the mixed ZSE weak form efficiency findings by prior researchers. The evolving efficiency tests were done over both ZWD and USD periods in an attempt to overcome the biases associated with the sample period and methodology used (Fama, 1998; Lim and Brooks, 2011).

The sample period was divided into the ZWD period (January 1994 to December 2006) and the USD period (February 2009 to December 2013) and hence the sample period January 1994 to December 2013 could not be treated as one. The data was split into equal non-overlapping four year Phases (I, II, III and IV) following Kvedaras and Basdevant (2002) so as to make comparisons between the phases as shown in Table 2. The first Phase I represents the early years post ZSE liberalisation of until the ZWD currency crisis of the close of 1997. Phase II extends from the currency crisis to the beginning of rising inflation in 2001. Phase III represent a period of pronounced inflationary pressures and currency depreciation. The last Phase IV falls in the USD dispensation characterised with recovery and stability. The years 2007 to 2008 were excluded due to high to hyperinflation which made the data unreliable (IMF, 2009) and the distortions from the use of the OMIR (Chowa *et al.*, 2014).

Table 1: ZSE Market Phases for Time Varying efficiency Tests

Currency Regime	**Market Phase**	**Market Phase Timing**	
		Start Date	**End Date**

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ZWD	Phase I	3 January 1994	31 December 1997
	Phase II	1 January 1998	31 December 2001
	Phase III	1 January 2002	31 December 2006
USD	Phase IV	19 February 2009	31 December 2013

The investigation on how the level of efficiency of the ZSE has evolved was based on 931 observations of weekly log returns for the closing industrial and mining indices and 20 individual counters' price data from 3 January 1994 to 31 December 2013. The selected 20 counters were continually listed on the ZSE and gave complete data over the whole period out of the average number of 50 listed counters.

The Augmented Dickey-Fuller (ADF) (1979) test for a unit root with trend and intercept was done first to ensure that every variable is stationary as in Chiwira and Muyambiri (2012) and Gimba (2012). Following the procedures in Kvedaras and Basdevant (2002) the data were tested for normality and autocorrelations before testing for stability of weak-form efficiency and modelling time-varying efficiency using Kalman Filters and plotting evolving efficiency graphs and test for changes in autoregressive coefficients using Dummy Variability. The Chow Test which requires one continuous sample period (Ito and Sugiyama, 2009; Ito *et al.*, 2013) was performed on the three phases of the 'longer' ZWD and period only.

3.1 Model for Time-Varying Efficiency

Assuming that the weekly closing prices and indices follow a log-normal distribution, weekly return for the prices and indices were computed as in as in (Abdmoulah, 2009; Patel *et al.* 2012):

$$r_t = ln\left(\frac{P_t}{P_{t-1}}\right)$$

Where, r_t is the weekly returns index at time *t*, P_t is the closing market price at time *t* and P_{t-1} is the closing market price at time *t-1*.

Hall and Urga (2002) highlight that weak form efficiency hypothesis implies an unpredictable market with no profit opportunities which are based on the past movement in asset prices. This view is best captured by a simple regression of AR(1) form following the methodology outlined in Hall and Urga (2002), Abdmoulah (2009) and Ito *et al.* (2013) as shown by equation 3.1, with weak form efficiency implying that $\beta_i = 0, for\ \forall i > 0$.

$$r_t = \beta_0 + \sum_{i=1}^{p} \beta_i r_{t-i} + e_{t,} \qquad e_t \sim N(0, \sigma^2) \qquad 3.1$$

where:

- r_t is the weekly returns on index at time *t*;
- β_0 is the intercept for the mean equation;
- β_i is the slope coefficient of the return at time *t-i*;
- e_t are uncorrelated error terms for all *t*.
- *i* = period *i*

The corresponding forms of time varying equations that explicitly allows for the changing parameters which may be present presented in Emerson *et al.* (1997) and Zalewska-Mitura and Hall (1998), Hall and Urga (2002), Ito and Sugiyama (2009) and Ito *et al.* (2013) has the form of equation 3.2. The time subscripts allow the parapeters to vary over time.

$$r_t = \beta_{0t} + \sum_{i=1}^{p} \beta_{it} r_{t-i} + e_{t,} \qquad e_t \sim N(0, \sigma^2) \qquad 3.2$$

Hypothesis testing for parameter constancy under the Chow Test and the dummy variable approach is done on the slope coefficient β_{it} , used as a measure of weak-form efficiency and is specified as follows.

H_0: $\beta_{it} = \beta_i$ for all *t*, i.e., ZSE efficiency is constant throughout the estimation period.

The Ordinary Least Squares (OLS) methodology is employed to fit the AR(1) model when comparing different sub-periods. Rejection of H_0 leads to the search for time-varying efficiency in order to capture the gradual changes in efficiency based on Kalman smoothing. A binomial test was followed in drawing statistical inferences and interpretation of results.

3.2 The Chow Test

The Chow Test was used to test for structural change on whether regression coefficients remain unchanged in different sub-periods using the *F*-test[1], usually used to test the ratio of variances for populations that are assumed to have a normal distribution. To test whether there is a structural change in the relationship between the regress and the regressors, the test compares the residual sum of squares from a regression run on the entire data set with the total of residual sum of squares resulting from separate regressions on the sub-groups within the sample believed to have different parameters. If the two values are close, the parameters are stable thus, the same parameters are appropriate for the entire data set. The Chow Test for a structural change was implemented only for Phases I, II and III over the period 3 January 1994 to 31 December 2006 and was derived from equation 3.2 following Chordia and Shivakumar (2005) and Abdmoulah (2009) as follows.

Phase I: (*i* =1, *t* =1) $\quad r_t = \beta_{01} + \beta_{11} r_{t-1} + e_t, \quad$ 3.3
Phase II: (*i* =1, *t* =2) $\quad r_t = \beta_{02} + \beta_{12} r_{t-1} + e_t, \quad$ 3.4
Phase III: (*i* =1, *t* =3) $\quad r_t = \beta_{03} + \beta_{13} r_{t-1} + e_t, \quad$ 3.5

We have:

H_0: $\beta_{0i} = \beta_0$, $\beta_{1i} = \beta_1$, for the three phases, *i* = 1, 2, 3

That is, the same parameters are appropriate for the entire data set, and

H_1: at least one of the $\beta_{ji} \neq \beta_j$, for *j*=0,1

That is, at least one parameter differs within the three sub-periods.

[1] F-test procedure used is quite robust against departures from normality and homogeneity of variance

Hence H_0 implies that for the entire period:

$$r_t = \beta_0 + \beta_1 r_{t-1} + e_t, \ \ e_t \sim NIID(0, \sigma^2) \qquad 3.6$$

Regression equation 3.6 assumes that there is no structural change over the three sub-periods and therefore estimates the AR(1) model for the entire time period, that is, β_0 and β_1 are assumed to be constant.

The ordinary least squares (OLS) method in Brooks (2008) was used to fit the regressions 3.3 up to 3.6 in E-views 6.0 in order to get the residual sum of squares for each ZWD era and for the entire period. The idea behind the Chow Test is that if there is no structural change (that is, all phases regressions are essentially the same), then the residual sum of squares (RSS) of the entire period should not be significantly different from the total of the RSS of each phase $(RSS_{n_1} + RSS_{n_2} + RSS_{n_3})$, where the number of observations: n_1=207, n_2=206 and n_3=259, for the Phases I, II and III respectively) based on equation 3.7. Thus, the test statistic is:

$$\frac{[RSS-(RSS_{n_1}+RSS_{n_2}+RSS_{n_3})]/k}{[RSS_{n_1}+RSS_{n_2}+RSS_{n_3}]/(n_1+n_2+n_3-2k)} \sim F_{(k,n_1+n_2+n_3-2k)} \text{ , If } H_0 \text{ is true,} \quad 3.7$$

Where *k* is the number of parameters being estimated, which is =2 (i.e. β_{0i} and β_{1i}) in this case.

The p-value is computed and if it is less than the 5% level of significance, H_0 is rejected hence the same parameters are not appropriate for the entire sample period. The conclusion in such a case would be that there has been a significant change in the parameters of the regression equation within the sub-periods implying that efficiency on the ZSE is time-varying. However, while the use of the Chow Test can suggest that there is parameter instability, it does allow one to carefully model the parameter of interest - it may be the intercept term, β_0, or the regression coefficient, β_1 and to shed more light, dummy variables are used to shed more light on the structure of the parameters.

3.3 Testing Changing Market Efficiency Using Dummy Variables

Dummy variables provide a more direct way of examining the stability of weak-form efficiency. This method is suitable when it is thought that the slope coefficient is likely to change in response to changes in circumstances as observed on the ZSE over the period 1994-2013. This method makes use of the time varying AR model of Zalewska-Mitura and Hall (1998), Ito and Sugiyama (2009) and Ito *et al.* (2013) despite keeping the the slope coefficient constant for a given phase. The basic model uses the same AR (1) model of returns expressed by equation 3.6. The coefficient β_1 is believed to be different in each sub-period (i=1, 2, 3 and 4) because of changes in the economic and financial environment, and such changes were modelled in this research by including a slope dummy variable in Misrosoft Excel Spreadsheets regression in the following manner:

$$r_{it} = \beta_0 + \sum_{i=1}^{n} \beta_i D_i r_{it-1} + e_t, \qquad 3.8$$

Where:

- $D_1 = 1$, for sample observations from phase 1 and 0 otherwise
- $D_2 = 1$, for sample observations from phase 2 and 0 otherwise
- $D_3 = 1$, for sample observations from phase 3 and 0 otherwise
- $D_4 = 1$, for sample observations from phase 4 and 0 otherwise

The effect of including a slope dummy variable is that a different β_i is estimated for each sub-period *i*. The β_is' in this research have been estimated using the OLS method. The null hypothesis is:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 \quad 3.9$$

That is, the same coefficient β_1, is appropriate for the entire data set, implying a constant efficiency (Hall and Urga, 2002; Abdmoulah, 2009).

3.4 The Kalman Filter Estimation Approach

The mixed empirical findings on ZSE weak-form efficiency over 1994 to 2013 prompted the need to investigate the evolution of efficiency over the two different currency periods using the Kalman filter estimation graphs. The Kalman Filter approach has been widely used to capture gradual changes in parameter values in a model (Emerson *et al.*, 1997; Zalewska-Mitura and Hall, 1998; Kvedaras and Basdevant, 2002; Ito and Sugiyama, 2009; Abdmoulah, 2009). The technique is suitable when the state variables are Markovian processes and gives optimal results in practice and can easily be formulated and implemented given a basic understanding and measurement equations need not be inverted. The two assumptions behind the Kalman Filter estimation are that the model used to predict the 'state' is assumed to be a linear function of the measurement and the model error and the measurement error (noise) is Gaussian with zero mean. This research used a state-space representation of the dynamics of the time-varying parameter AR(1) model of the form:

$$r_t = \beta_0 + \beta_{1t} r_{t-1} + e_t, \qquad e_t \sim N(0, \sigma^2) \quad 3.10$$

$$\beta_{1t} = \beta_{1t-1} + v_t, v_t \sim N(0, \sigma_v^2) \quad 3.11$$

Equation 3.10 is known as the measurement or observation equation and equation 3.11 is known as the state (or transition) equation. The state equation describes the dynamics of the coefficient β_{1t}, which is assumed to follow a vector AR(1) process. The disturbance vectors, e_t and v_t are assumed to be independent white noise processes. The goal of the Kalman Filter approach is to estimate the parameters β_0, σ^2 and σ_v^2 and make inferences about the state vector β_{1t}, thus,giving a clear (graphical) picture of the gradual changes in market efficiency.

4 Results

4.1 Descriptive Statistics for the ZSE

This section presents results from the longest ZSE time series based on the 20 continuously listed counters and the industrial and mining indices. The descriptive and basic statistics relating to the weekly returns for each counter and the Mining and Industrial Indices for ZWD era January 1994 to December 2006 and USD era February 2009 to December 2013 are shown in

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Tables 2 and 3 in APPENDIX I. The sample means of returns are all positive in ZWD era, but in USD era only 9 out of 20 counters (45%) and the Industrial Index have positive mean returns. The measure of skewness indicates that 80% of the counters and both indices in ZWD era have positively skewed returns whilst only 20% of the counters and the Mining Index in USD era have positively skewed returns.

This can be explained by the high inflation levels in ZWD era which lead to higher nominal returns since this study has used nominal instead of 'real returns' adjusted for inflation. In addition, the measure of kurtosis shows that all counters and both indices in both ZWD and USD regimes are more 'peaked' than the normal distribution leptokurtic (kurtosis >3). The coefficient of skewness shows that the ZWD returns were positively skewed in most counters while the USD ones were mostly negatively skewed relative to a normal distribution. The Jarque-Bera test rejects the null hypothesis of 'a normaly distributed data series' for both ZWD and USD returns even at the 1% level of significance. The fact that return series reject the assumption of normality and this is consistent with the presence of nonlinearity effects.

4.2 ADF for Unit Root Tests on the ZSE

The results of ADF tests with trend and intercept for unit root in Table 4 in APPENDIX I, rejects the null hypothesis that returns are non-stationary i.e. have a unit root for all counters and both indices in both ZWD and USD eras. This confirms that all series tested are stationary and thus, useful for further statistical analysis.

4.3 Autocorrelation Tests for the ZSE

The Ljung-Box tests on the level series with p lags Q(p), for up to 10 lags was done to prove the robustness of the above results. The choice of 10 lags was meant to allow for comparisons between the ZWD and USD periods and is in between Kvedaras and Basdevant (2002) who used Q(7) and Abdmoulah (2009) and Chiwira and Muyambiri (2012) who used (16) and took into consideration the Q(12) used in Gursory *et al.*, (2008). Q(10) were assumed to be $\chi^2(10)$ distributed under the null of no serial autocorrelation. The null hypothesis for no serial auto-correlation is rejected in both ZWD and USD trading, suggesting that the stocks and indices are weak-form inefficient. The results presented in Tables 5 and 6 in APPENDIX I show that, based on the Q-statistic, 11 (55%) of the counters reject the random walk model in ZWD era, while all counters are in violation of the random walk in USD era. The autocorrelation test results also indicate that the number of stocks rejecting the null hypothesis of no autocorrelations significantly increases from ZWD to USD era from 55% to 100%, which suggests that the level of efficiency actually deteriorated after the currency reform of 2009, contrary to expectations.

Results from Tables 5 and 6 indicates that the ZSE is not weak-form efficient based on the 'all or nothing' autocorrelation test methodology and warrants the need to search for evolutionary nature of efficiency using methods in the following sub sections.

4.4 Kalman Filter Graphs for the ZSE

The Kalman Filter evolving efficiency graphs in APPENDIX II, show that during the currency crisis of the late 1997, 30% of the counters and the mining index recorded a drop in the level of weak-form efficiency, namely Astra, Border, Hippo, TSL, Colcom and Mash, whilst 10% of the counters and the industrial index recorded an improvement in the level of weak-form efficiency, namely Ariston and Meikles. Thus, the null hypothesis that the crisis had no effects on efficiency can be rejected since more than 5% of counters were affected.

The five-year high, inflation period of 2002-2006 brought about increased turbulence in first order autoregressive coefficients in the majority of the stocks. The period just after the 2006 currency revaluation, August to December 2006 was followed by worsening efficiency in 40% of the stocks. These are Ariston, Border, Delta, Hippo, Natfoods, PG, Truworths and TSL. Furthermore, the market correction period just after dollarisation 19 February to 20 April 2009 saw 55% of the stocks and the industrial index significantly deviating from weak-form efficiency whilst the remaining 45% and the Mining Index stayed efficient. Those that worsened in efficiency namely; BAT, Border, Cafca, Delta, Edgars, Mash, Natfoods, NTS, Truworths, TSL and Willdale.

The Kalman Filter method with evolving efficiency graphs shown in APPENDIX VII indicates insignificant deviations from the random walk model with the zero value of the first order autoregressive coefficient being largely contained in all confidence interval graphs except for a few turbulent periods.

4.5 The Chow Test for the ZSE

The Chow Test results in Table 7 reveal some structural breaks in most (17) of the 20 stocks tested as well as in both indices over the 3 market phases (Phases I, II and III) in the period January 1994 to December 2006. The remaining 3 stocks reported stability or no structural change in efficiency estimates over the market phases. Using the Binomial test, the conclusion at the 5% level of significance is that efficiency is not stable or there is a structural change on the ZSE over the sample period as more than 1 counter has a significant p-value. The Chow test result for the ZWD era indicate that ZSE market fundamantals and efficiency were non static over the three key phases of the early post ZSE liberalisation (1994 to 1997), the early years of the ZWD currency crisis 1998-2001 and the high inflation years 2002 to 2006.

4.6 The Dummy Variable Test for the ZSE

The outcome of the dummy variable test was done through spreadsheet implementation of equation 3.14 under the null hypothesis of equality of slope coefficients as specified in equation 3.15 as $H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4$, which represents the stability of weak form efficiency. The test excluded the period just after currency revaluation (removal of three zeros on the ZWD) August 2006 to December 2006 and the market correction period just after dollarisation 19 February 2009 to 20 April 2009. Table 8 in APPENDIX I, shows that the stability of weak-form efficiency fails in all the phases the null hypothesis is rejected in 12, 11 and 15 counters for the Phases I, II, III and IV. The binomial test at the 5% level of significance corresponds to just one counter at most out of 20 rejecting the null hypothesis of no significant difference between the pairs; (β_1 *vs*

β_2) (β_2 *vs* β_3) and (β_3 *vs* β_4). Thus, based on the binomial test, the level of ZSE weak-form efficiency is unstable as it is not the same over the four market phases.

5 Discussion on Evolving ZSE Efficiency

Evolving efficiency tests were intended to capture the gradual nature of weak-form efficiency due to changes in the stock market operating environment. While the autocorrelations test results suggest that most of the counters and both indices are inefficient, the Kalman Filter state-space estimation graphs in APPENDIX II suggest otherwise. The Kalman Filter state-space estimation graphs time paths of β_{1t} and their 95% confidence were found to be largely not significantly different from zero for all the counters and both indices, which is consistent with weak-form efficiency properties. This is in line with results by Appiah-Kusi and Menyah (2003), Mlambo and Biekpe (2007), and Jefferis and Okeahalam (1999a) who reported that the ZSE is weak-form efficient. The ZSE efficiency worsened during the 1997 ZWD currency crisis, the start of high inflation and OMIR use around 2004, the August 2006 ZWD currency revaluation and the dollarisation of ZSE trading in February 2009. This contrasts the findings of Hoque *et al.* (2007) who found the efficiency of selected Asian stock markets unchanged pre and post financial crisis. Thin trading and the trend reinforcing nature of the high returns during the year 2009 of 124.40% for the industrial index as the bourse was recovering from a low base might have resulted in price momentum predictability and short-tern bursts of weak-form inefficiencies.

The conflicting results from the ADF test, Autocorrelation test, Chow Test and the dummy variability test, against the Kalman Filters estimation graphs indicate unstable efficiency in all four phases and suggest dependence of efficiency estimations upon the estimation method used as suggested by Lim and Brooks (2011). The observed varying levels of efficiency for all stocks led to the rejection of the null hypothesis of constant efficiency in line with Chordia and Shivakumar (2005). Thus, the ZSE efficiency has been evolving (Lo, 2004), with the market trending on both efficiency and inefficiency, thereby giving an explanation for the contrasting findings on ZSE efficiency researches over the past two decades whereby, Magnusson and Wydick (2002), Simons and Laryea (2005), Jefferis and Smith (2005), Smith (2008), Sunde and Zivanomoyo (2008) and Mazviona and Nyangara (2013) finding it to be a weak-form inefficient. The currency induced instabilities experienced by Zimbabwe over the past two decades however make it impossible for the ZSE efficiency trajectory to be clearly defined.

6 Conclusion

The research unearthed the evolving nature of ZSE market efficiency, due to the 1997 ZWD currency crisis, the start of high inflation and OMIR use around 2004, the August 2006 ZWD currency revaluation and the 2009 dollarisation of trading, thereby reconciling the mixed weak-form EMH efficiency conclusions of prior researchers on the ZSE over the years 1994 to 2013.
The AMH results are very much in line with those postulated by the Adaptive Markets Hypothesis (AMH) of Lo (2004, 2008) which implies a considerably complex market dynamics, with cycles as well as trends, panics, manias, bubbles, crashes, and other phenomena that are routinely witnessed in natural market ecologies. This research provides some insight into the new paradigm of evolving efficiency that is still in its infancy. The conclusion is that the ZSE is a

typical FM that exhibit non constant efficiency for the vast majority of the sample period with the exception of a few times for a few counters, and the efficiency level is rather unstable over time, negatively reacting to contemporaneous crises. It is recommended that academic evidence of ZSE weak-form efficiency be treated within the evolutionary spectrum in light of the prevailing environment as suggested by Lo (2004).

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APPENDICES

APPENDIX I: Tables of Results

Table 2: Descriptive Statistics for ZWD era (January 1994 to December 2006)

Counter	Mean Return	Minimum	Maximum	Standard deviation	Skew	Kurtosis	Jarque-Bera Statistic	p-value
Afdis	0.0182	-0.9694	0.5521	0.1308	0.00	7.16	488.29	0.00
Ariston	0.0191	-0.3871	1.0704	0.1360	2.26	12.60	3,174.13	0.00
Astra	0.0144	-1.2528	1.2528	0.1574	0.05	14.74	3,888.79	0.00
BAT	0.0198	-1.3394	1.7047	0.1518	2.48	38.63	36,510.32	0.00
Border	0.0169	-0.6286	0.6931	0.1083	0.99	8.57	984.68	0.00
Cafca	0.0158	-0.6763	0.6225	0.1335	0.73	5.38	220.18	0.00
Colcom	0.0172	-0.6931	0.7050	0.1337	0.43	5.29	168.40	0.00
Delta	0.0182	-0.4555	0.7221	0.1098	1.09	6.06	398.60	0.00
Edgars	0.0185	-0.3997	0.5108	0.1151	0.78	3.88	90.81	0.00
Hippo	0.0198	-0.6313	0.7185	0.1205	1.11	7.31	662.81	0.00
Mash	0.0157	-1.4663	1.8971	0.1845	1.24	23.53	12,057.70	0.00
Meikles	0.0210	-0.3185	0.7386	0.1055	1.91	8.90	1,390.55	0.00
Natfoods	0.0188	-0.5754	0.7577	0.1365	0.49	5.44	194.86	0.00
NTS	0.0135	-2.4361	1.0498	0.1874	-2.66	47.24	56,004.15	0.00
PG	0.0148	-1.0296	1.4628	0.1800	0.98	10.49	1,690.79	0.00
Radar	0.0182	-7.2282	7.4265	0.4231	0.55	265.76	1,947,552.91	0.00
Truworths	0.0144	-2.0477	2.4361	0.2154	-0.37	48.22	57,703.79	0.00
TSL	0.0168	-0.4434	0.9808	0.1352	1.29	7.33	715.72	0.00
Willdale	0.0096	-1.7636	0.8855	0.1881	-1.83	23.31	12,010.55	0.00
Zimpapers	0.0188	-1.0986	1.4069	0.1951	1.02	8.73	1,042.25	0.00
Industrial Index	**0.0187**	**-0.3402**	**0.6368**	**0.0985**	**1.66**	**7.32**	**837.85**	**0.00**
Mining Index	**0.0171**	**-0.2583**	**0.4837**	**0.0726**	**1.20**	**5.81**	**385.09**	**0.00**

Table 3: Descriptive Statistics for USD era (February 2009 to December 2013)

Counter	Mean Return	Minimum	Maximum	Standard deviation	Skew	Kurtosis	Jarque-Bera Statistic	p-value
Afdis	0.0045	-0.6931	0.4700	0.1077	-0.79	12.61	1,000.85	0.00
Ariston	-0.0032	-1.3863	0.7885	0.1938	-1.20	12.48	1,007.20	0.00
Astra	0.0020	-0.2877	0.3221	0.0751	0.64	6.79	168.82	0.00
BAT	0.0098	-0.7828	0.5596	0.1105	-1.10	14.19	1,371.47	0.00
Border	-0.0016	-1.3863	1.3863	0.1881	-0.42	26.60	5,877.38	0.00
Cafca	0.0082	-1.3863	1.6094	0.1716	1.18	46.47	19,979.81	0.00
Colcom	-0.0012	-0.8473	0.4055	0.1187	-1.39	11.70	879.50	0.00
Delta	0.0061	-0.4055	0.3930	0.0685	0.14	13.13	1,082.94	0.00
Edgars	-0.0020	-0.6931	0.8109	0.1496	-0.23	8.06	272.54	0.00
Hippo	0.0019	-1.9253	0.4274	0.1507	-7.99	106.60	115,834.38	0.00
Mash	-0.0017	-0.9163	0.5878	0.1314	-1.51	14.22	1,422.26	0.00
Meikles	-0.0066	-1.2040	0.5500	0.1217	-3.31	38.48	13,735.19	0.00
Natfoods	0.0125	-0.3001	0.3102	0.0829	0.71	2.90	21.31	0.00
NTS	-0.0055	-2.3026	0.6931	0.2307	-4.44	44.42	18,918.80	0.00
PG	-0.0182	-1.6094	0.9163	0.2333	-0.81	12.94	1,068.98	0.00
Radar	-0.0052	-1.3218	0.7621	0.2029	-0.61	9.17	417.36	0.00
Truworths	0.0029	-2.3026	0.8755	0.2063	-5.34	62.96	39,098.94	0.00
TSL	0.0080	-2.3026	1.2528	0.2272	-4.03	51.44	25,420.26	0.00
Willdale	-0.0036	-1.0986	1.0986	0.2421	-0.24	6.30	117.31	0.00
Zimpapers	-0.0072	-2.8134	1.1394	0.2509	-5.18	64.10	40,484.82	0.00
Industrial Index	**0.0027**	**-0.3502**	**0.2550**	**0.0475**	**-0.63**	**18.99**	**2,713.00**	**0.00**
Mining Index	**-0.0031**	**-0.4085**	**0.3629**	**0.0847**	**0.34**	**4.62**	**32.56**	**0.00**

Note: A significant p-value (<.01, 0.05) indicates the rejection of the null hypothesis of normality at the 1% and 5% level respectively.

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Table 4: ADF Unit Root Test (with Trend and Intercept)

Counter:	**ADF test statistic**	
	ZWD era (Jan 1994 to Dec 2006)	**USD era (Feb 2009 to Dec 2013)**
Afdis	-25.467	-17.656
Ariston	-16.375	-18.443
Astra	-28.969	-17.431
BAT	-27.275	-17.350
Border	-13.926	-18.470
Cafca	-23.871	-24.919
Colcom	-24.642	-12.962
Delta	-25.824	-15.030
Edgars	-25.652	-14.597
Hippo	-15.371	-15.688
Mash	-29.588	-14.495
Meikles	-24.295	-20.086
Natfoods	-25.982	-16.932
NTS	-29.793	-22.699
PG	-28.616	-15.124
Radar	-11.425	-19.235
Truworths	-28.588	-13.528
TSL	-24.174	-26.000
Willdale	-27.052	-20.151
Zimpapers	-20.404	-10.048
Industrial Index	**-22.932**	**-13.858**
Mining Index	**-14.117**	**-15.327**

Notes: The 1% critical values of the ADF tests are -3.9717 for ZWD era and -3.9949 for USD era.

- A significant test statistic indicates the rejection of the null hypothesis of non-stationarity.

Table 5: Autocorrelation Tests for ZWD era

Counter	**Autocorrelation coefficients at lag**									**Q-statistic**	**p-value**
	1	**2**	**3**	**4**	**5**	**7**	**8**	**9**	**10**		
Afdis	0.03	0.07	0.01	-0.05	-0.07	0.05	0.01	-0.02	0.01	11.63	0.31
Ariston	0.03	0.11	-0.03	0.00	-0.07	-0.04	-0.05	0.03	-0.09	22.16	0.01
Astra	-0.10	0.07	0.06	0.03	-0.05	-0.07	0.06	0.04	-0.07	24.46	0.01
BAT	-0.03	0.05	0.00	0.00	0.01	-0.04	-0.04	-0.02	0.02	5.55	0.85
Border	0.21	0.21	0.11	0.11	0.06	0.02	0.10	0.04	0.01	85.78	0.00
Cafca	0.10	0.07	-0.01	0.05	0.04	0.02	0.05	-0.02	0.01	17.66	0.06
Colcom	0.07	-0.06	-0.01	0.02	0.03	0.00	0.02	0.03	-0.02	9.01	0.53
Delta	0.02	0.07	0.13	-0.05	-0.04	-0.02	-0.01	0.00	-0.05	21.24	0.02
Edgars	0.03	0.11	0.00	0.03	-0.07	-0.02	-0.06	0.02	0.03	17.55	0.06
Hippo	0.15	0.14	0.08	0.06	0.00	0.01	0.06	0.06	0.08	43.97	0.00
Mash	-0.12	0.01	0.00	-0.01	0.09	0.04	-0.04	0.06	-0.04	31.34	0.00
Meikles	0.08	0.00	0.07	-0.09	0.02	0.06	0.03	0.02	0.00	16.62	0.08
Natfoods	0.02	0.02	0.02	0.04	0.02	0.00	0.01	0.02	0.04	5.81	0.83
NTS	-0.13	0.03	-0.03	-0.02	-0.07	-0.01	0.00	0.06	0.02	20.42	0.03
PG	-0.08	0.10	0.01	0.02	-0.04	0.00	-0.04	0.06	0.00	24.37	0.01
Radar	0.03	0.01	0.00	0.00	-0.01	-0.01	-0.02	0.00	0.01	135.08	0.00
Truworths	-0.09	0.09	0.00	-0.08	0.02	-0.03	-0.04	0.03	0.02	34.49	0.00
TSL	0.09	0.02	-0.01	-0.08	0.01	0.01	0.02	0.01	0.13	31.43	0.00
Willdale	-0.04	-0.03	-0.05	-0.01	-0.06	-0.11	0.04	0.04	-0.04	17.56	0.06
Zimpapers	0.01	-0.10	-0.02	-0.03	-0.04	0.01	0.05	0.02	-0.02	11.63	0.31
Industrial Index	**0.16**	**0.12**	**0.09**	**0.04**	**0.10**	**-0.01**	**0.10**	**0.10**	**0.07**	**57.06**	**0.00**
Mining Index	**0.18**	**0.23**	**0.12**	**-0.01**	**-0.07**	**-0.08**	**0.06**	**0.05**	**0.01**	**77.28**	**0.00**

Table 6: Autocorrelation Tests for USD era

Counter	Autocorrelation coefficients at lag									Q-statistic	p-value
	1	2	3	4	5	7	8	9	10		
Afdis	-0.11	0.14	-0.02	0.14	-0.03	-0.06	-0.20	0.01	-0.21	101.07	0.00
Ariston	-0.13	-0.19	-0.02	-0.04	-0.08	-0.02	0.06	-0.13	-0.06	58.78	0.00
Astra	-0.10	-0.05	-0.03	0.03	-0.25	0.06	-0.08	-0.03	0.05	61.37	0.00
BAT	-0.04	-0.02	-0.05	0.04	-0.03	-0.15	-0.05	-0.07	-0.06	33.84	0.00
Border	-0.15	0.06	-0.18	0.04	0.01	-0.02	-0.03	-0.04	-0.07	48.43	0.00
Cafca	-0.30	0.07	-0.04	0.09	0.03	0.07	-0.13	0.09	-0.08	100.90	0.00
Colcom	-0.07	-0.05	0.01	-0.07	0.07	0.06	-0.05	-0.14	-0.15	74.90	0.00
Delta	0.14	0.03	0.07	-0.04	-0.14	-0.25	-0.11	-0.01	-0.03	89.44	0.00
Edgars	0.08	0.09	0.02	-0.04	-0.08	-0.22	-0.06	0.07	0.01	95.62	0.00
Hippo	0.01	-0.15	-0.07	0.06	-0.04	0.04	0.13	-0.20	-0.07	74.82	0.00
Mash	0.01	-0.17	-0.11	-0.03	0.00	-0.01	-0.13	-0.08	-0.04	51.97	0.00
Meikles	0.00	0.10	0.04	-0.03	0.06	0.02	-0.10	-0.13	-0.27	83.59	0.00
Natfoods	-0.03	0.19	0.08	0.15	0.26	0.08	0.07	0.08	0.14	119.00	0.00
NTS	-0.34	0.02	0.25	-0.20	0.18	0.06	0.02	-0.23	0.15	294.83	0.00
PG	-0.07	-0.22	-0.08	0.14	-0.13	0.17	-0.02	-0.15	-0.06	108.97	0.00
Radar	-0.20	-0.06	0.07	-0.14	0.08	0.01	-0.02	-0.09	0.05	57.17	0.00
Truworths	-0.24	0.17	-0.20	0.27	-0.23	-0.20	0.11	-0.08	-0.03	211.12	0.00
TSL	-0.45	-0.07	0.42	-0.40	0.23	0.11	-0.05	-0.29	0.11	513.54	0.00
Willdale	-0.22	0.05	-0.07	-0.08	0.05	-0.09	0.06	0.06	-0.06	56.95	0.00
Zimpapers	-0.07	-0.32	-0.02	0.05	0.00	0.13	-0.11	-0.11	0.01	131.46	0.00
Industrial Index	**0.30**	**0.21**	**0.20**	**-0.06**	**-0.05**	**-0.25**	**-0.24**	**-0.24**	**-0.15**	**259.38**	**0.00**
Mining Index	**0.05**	**0.07**	**0.10**	**-0.03**	**0.08**	**-0.09**	**0.00**	**-0.10**	**-0.04**	**36.65**	**0.00**

Note: A significant p-value of <0.05, indicates the rejection of the null hypothesis of no autocorrelations.

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Table 7: The Chow Test for ZWD Phases I, II, III

Counter:	RSS	RSS_{n_1}	RSS_{n_2}	RSS_{n_3}	F-statistic	P-value
Ariston	12.442	1.035	1.175	10.112	3.247	0.04
Border	7.575	0.766	1.884	4.603	14.816	0.00
Hippo	9.591	1.843	0.841	6.611	10.631	0.00
TSL	12.269	0.758	2.377	8.853	7.806	0.00
Afdis	11.560	1.325	3.508	6.351	11.236	0.00
BAT	15.532	0.965	8.278	5.458	18.868	0.00
Colcom	12.027	1.132	2.351	8.091	13.084	0.00
Delta	8.139	0.467	1.329	6.110	9.864	0.00
Edgars	8.943	0.787	1.794	6.158	7.804	0.00
Meikles	7.468	1.281	0.855	5.212	5.472	0.00
Natfoods	12.591	1.178	2.931	8.159	8.786	0.00
Truworths	31.082	2.162	3.542	24.833	5.954	0.00
Zimpapers	25.734	3.464	4.289	17.364	8.208	0.00
Astra	16.567	0.979	6.448	8.701	9.093	0.00
Cafca	11.941	1.824	1.643	7.915	16.425	0.00
Mash	22.693	1.392	3.066	17.655	8.768	0.00
NTS	23.317	0.791	5.472	16.883	2.473	0.09
PG	21.720	0.759	5.215	15.018	11.580	0.00
Radar	120.927	2.024	2.624	115.928	0.976	0.38
Willdale	23.852	1.402	3.205	19.196	0.688	0.50
Industrial Index	**6.397**	**0.487**	**1.069**	**4.572**	**14.639**	**0.00**
Mining Index	**3.447**	**0.230**	**0.491**	**2.630**	**9.580**	**0.00**

Note: A significant p-value of < 0.05 indicates the rejection of the null hypothesis of same parameters for the entire data set.

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Table 8: Dummy Variability of Efficiency (January 1994 to December 2013)

Counter:	β_1	**Std Error (β_1)**	β_2	**Std Error (β_2)**	β_3	**Std Error (β_3)**	β_4	**Std Error (β_4)**
Afdis	0.075	0.070	-0.187	0.068	0.084	0.065	-0.118	0.064
Ariston	-0.018	0.069	-0.023	0.069	-0.009	0.067	-0.137	0.064
Astra	-0.027	0.070	-0.220	0.068	-0.078	0.065	-0.099	0.064
BAT	0.117	0.068	-0.224	0.068	0.186	0.064	0.141	0.063
Border	0.151	0.069	-0.030	0.070	0.273	0.063	0.057	0.064
Cafca	-0.156	0.069	-0.146	0.067	0.172	0.064	-0.159	0.063
Colcom	0.117	0.069	-0.031	0.070	0.033	0.065	-0.104	0.063
Delta	0.231	0.068	-0.121	0.070	-0.029	0.066	0.052	0.062
Edgars	-0.119	0.069	0.020	0.070	0.021	0.065	-0.065	0.064
Hippo	-0.061	0.070	-0.062	0.070	0.173	0.064	0.001	0.063
Mash	-0.174	0.069	-0.274	0.067	-0.130	0.065	-0.267	0.062
Meikles	0.088	0.069	0.053	0.070	-0.008	0.065	-0.082	0.059
Natfoods	0.040	0.070	-0.052	0.070	0.035	0.065	-0.194	0.063
NTS	-0.033	0.070	-0.188	0.069	-0.140	0.065	-0.347	0.060
PG	0.204	0.067	-0.310	0.066	-0.006	0.065	-0.099	0.061
Radar	-0.104	0.069	-0.150	0.069	0.027	0.065	-0.233	0.062
Truworths	0.080	0.070	-0.026	0.069	-0.122	0.065	-0.239	0.061
TSL	0.122	0.069	-0.001	0.069	0.063	0.065	-0.149	0.057
Willdale	-0.028	0.069	-0.011	0.070	-0.033	0.065	-0.147	0.064
Zimpapers	-0.115	0.069	-0.213	0.068	0.067	0.065	-0.277	0.062
Mining Index	**0.249**	**0.067**	**0.063**	**0.070**	**0.168**	**0.065**	**0.038**	**0.061**
Industrial Index	**0.265**	**0.070**	**-0.043**	**0.070**	**0.137**	**0.064**	**0.079**	**0.057**

Note: A significant p-value of < 0.05 indicates the rejection of the null hypothesis of same parameters for the entire data set.

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APPENDIX II: Evolving efficiency graphs

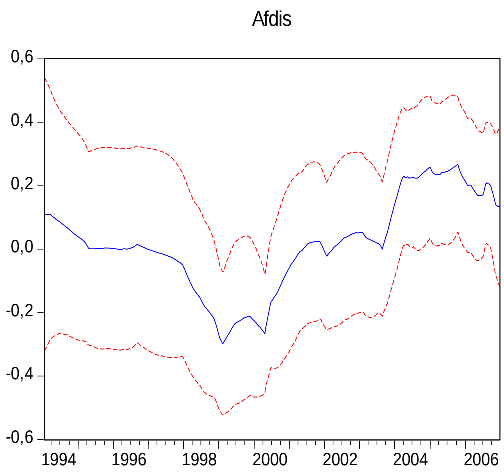
(Time paths of estimated β_{1t})

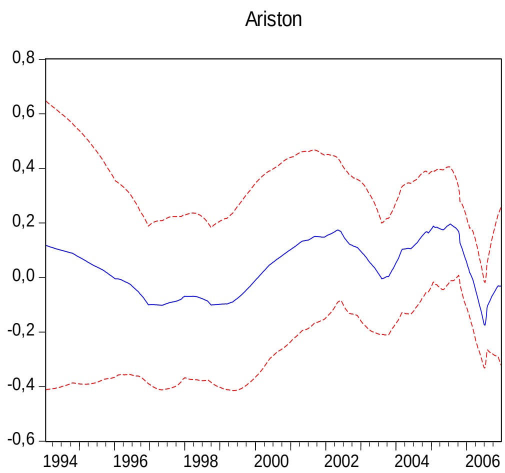
Key:

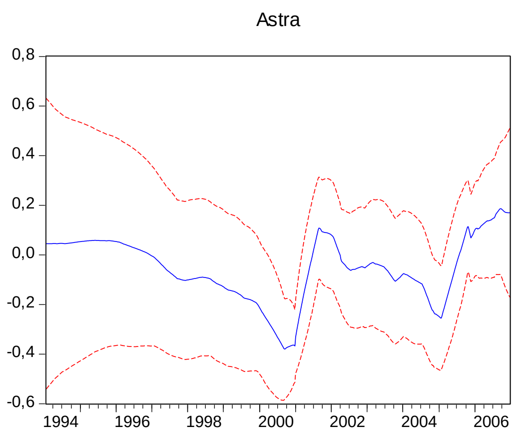
β_{1t}

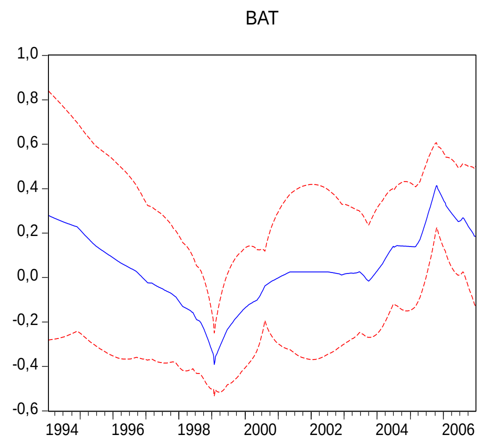
95% Confidence Limits

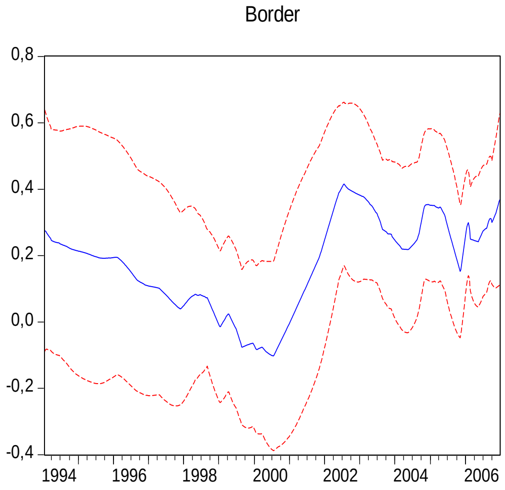
ZWD period:







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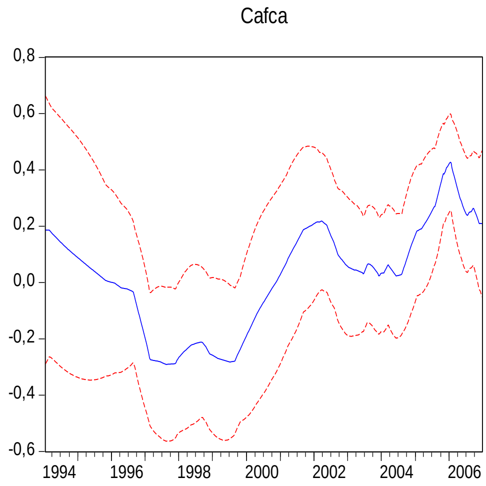
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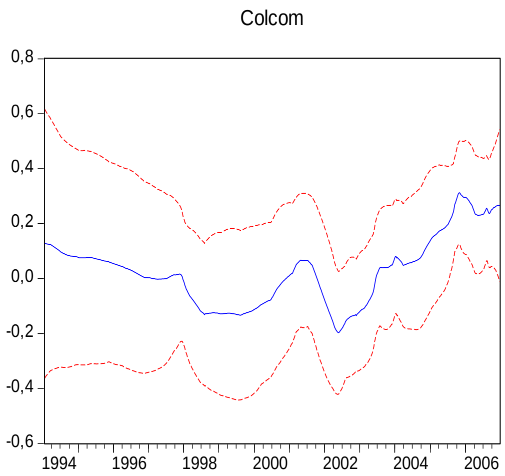
1994 1996 1998 2000 2002 2004 2006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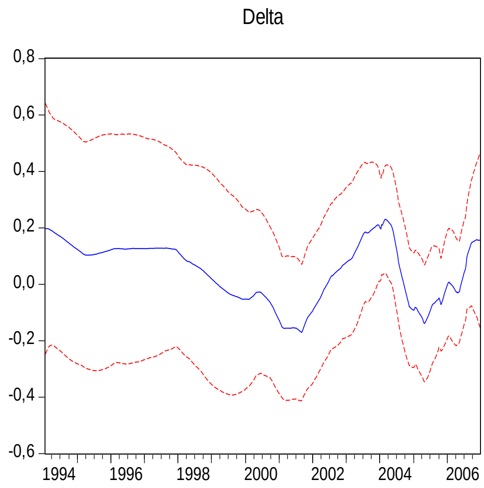
1994 1996 1998 2000 2002 2004 2006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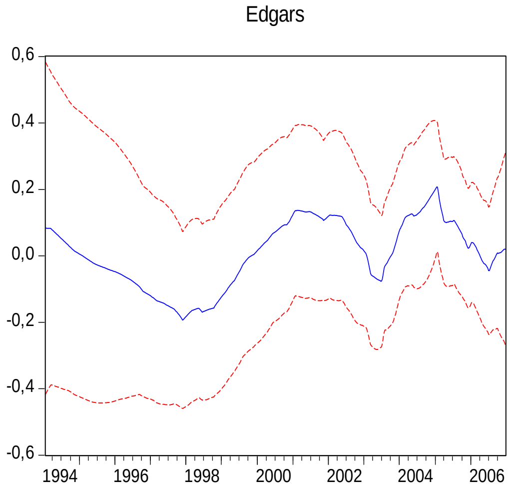
1994 1996 1998 2000 2002 2004 2006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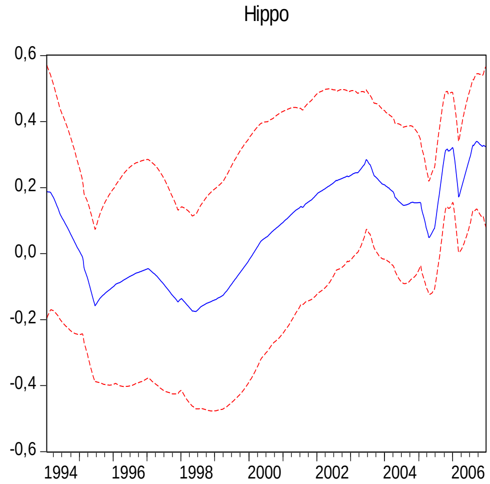
1998
2000
2002
2004
2006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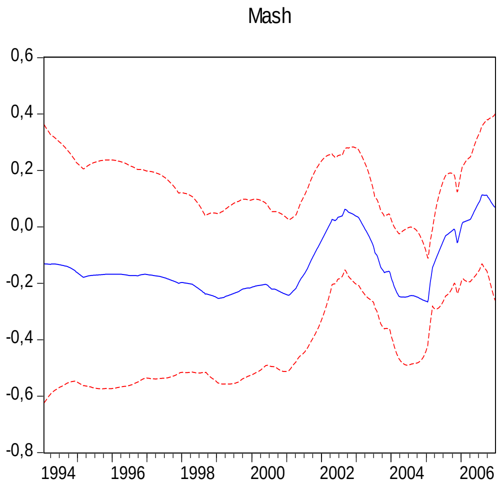
1998
2000
2002
2004
2006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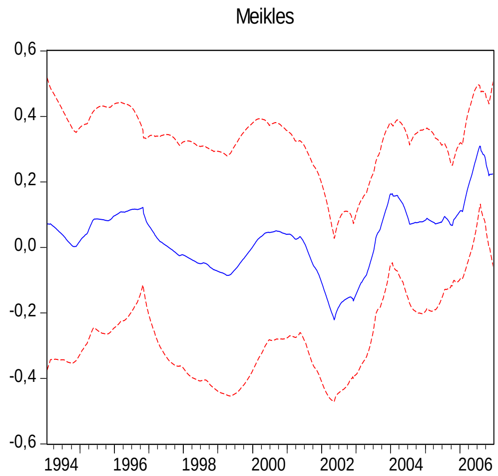
2002
2004
2006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1996
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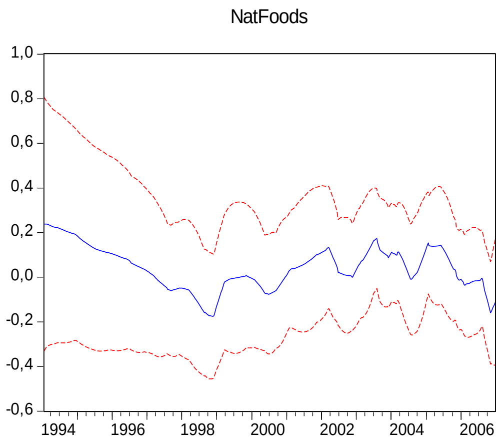
2002
2004
2006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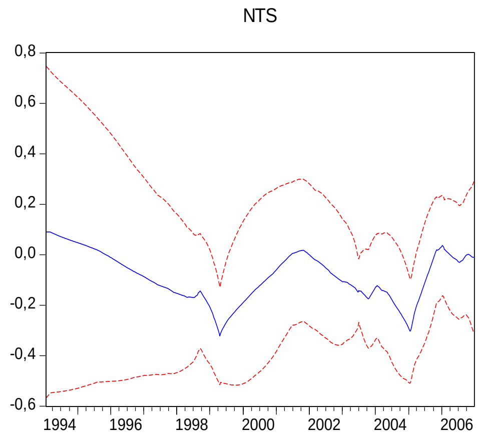
1998
2000
2002
2004
2006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1994
1996
1998
2000
2002
2004
2006

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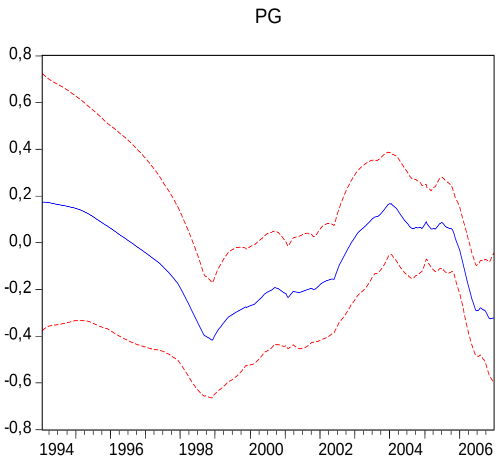

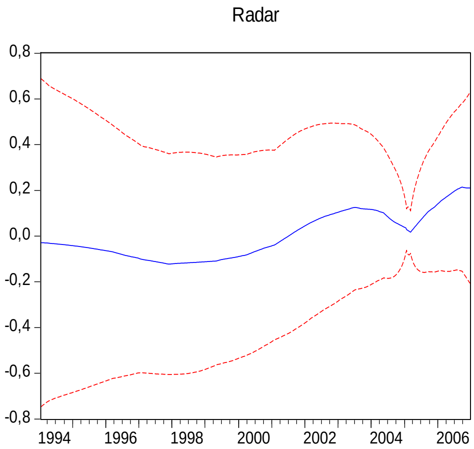

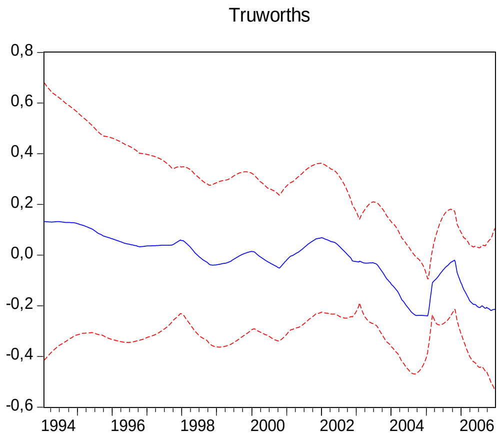

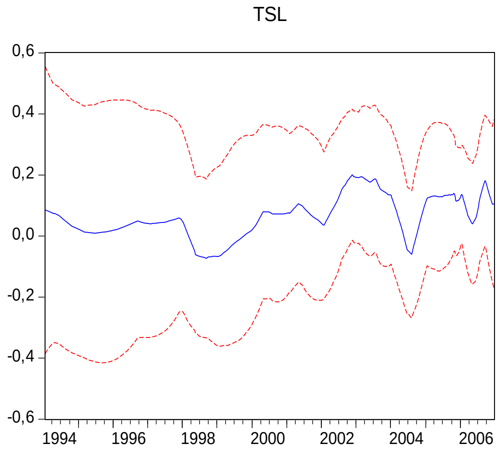

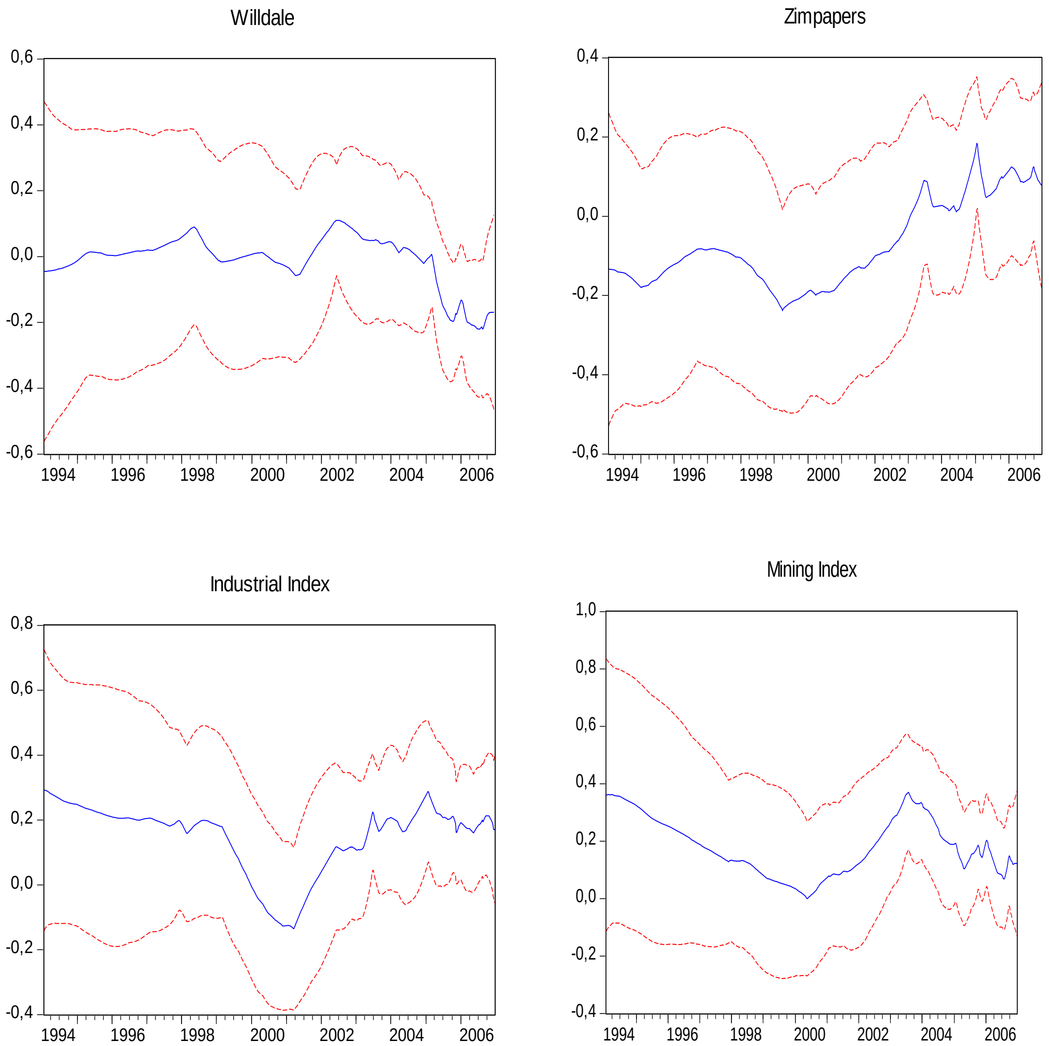
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Zimpapers
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1994 1996 1998 2000 2002 2004 2006
Industrial Index
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1994 1996 1998 2000 2002 2004 2006
Mining Index
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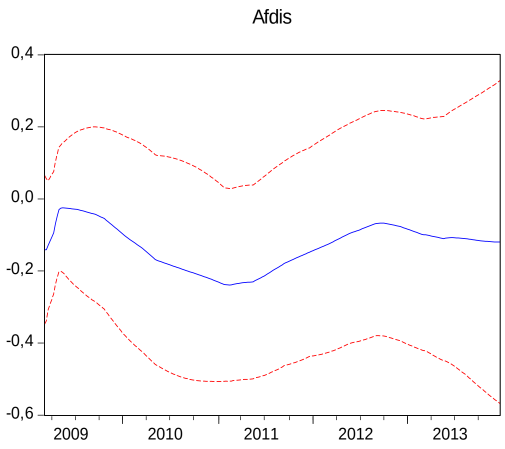
1994 1996 1998 2000 2002 2004 2006

USD period: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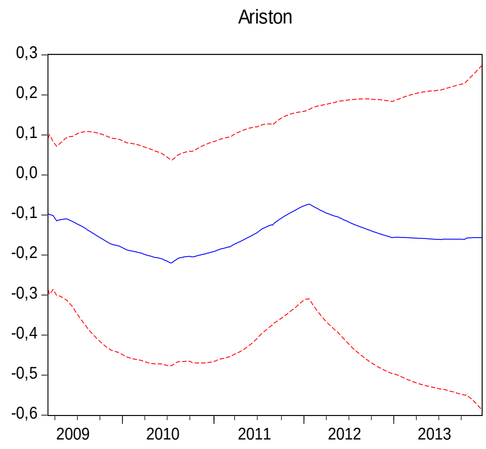
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2012
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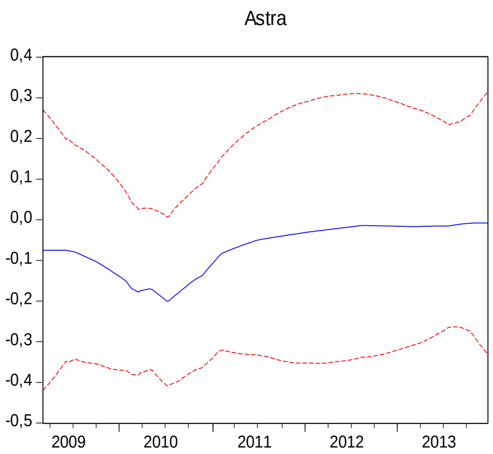
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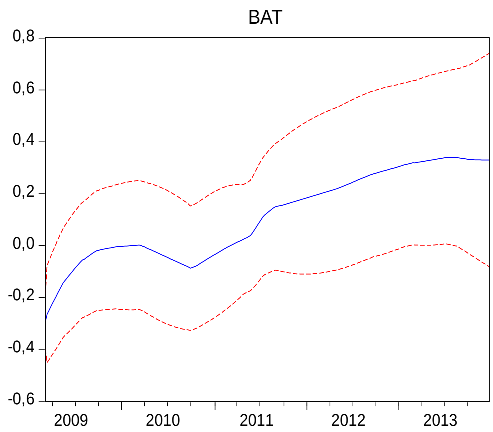
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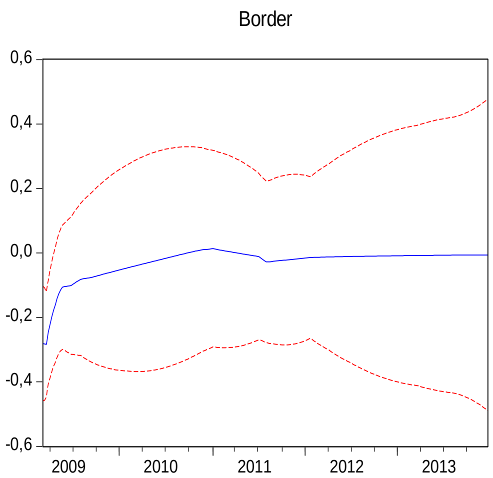
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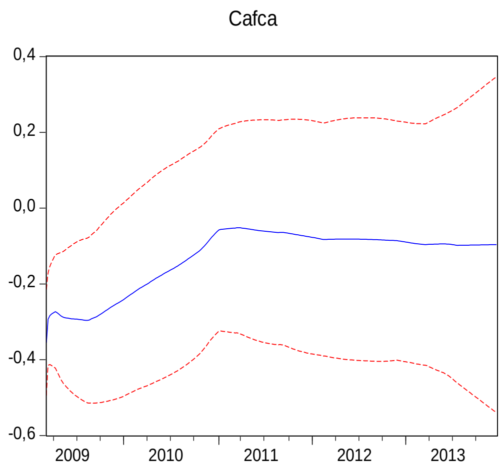
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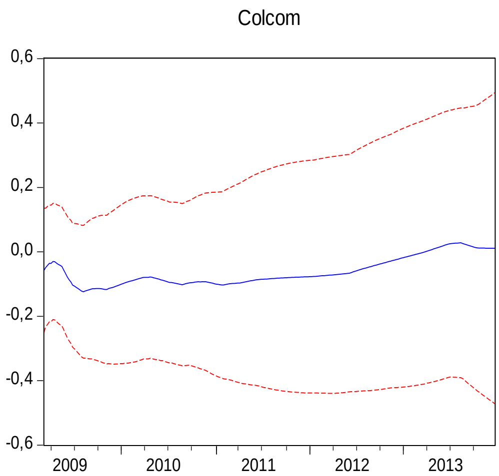
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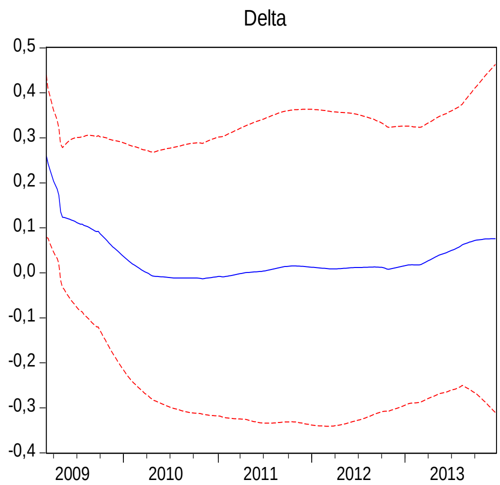
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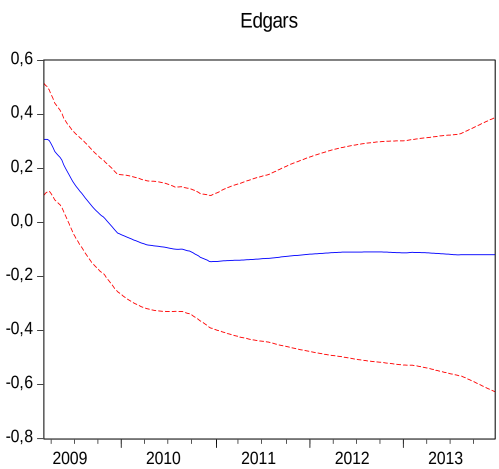
2012
2013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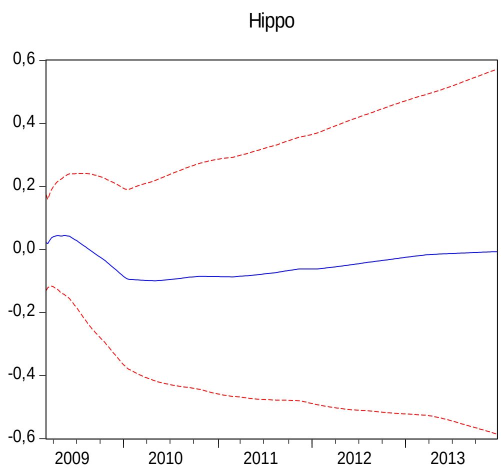
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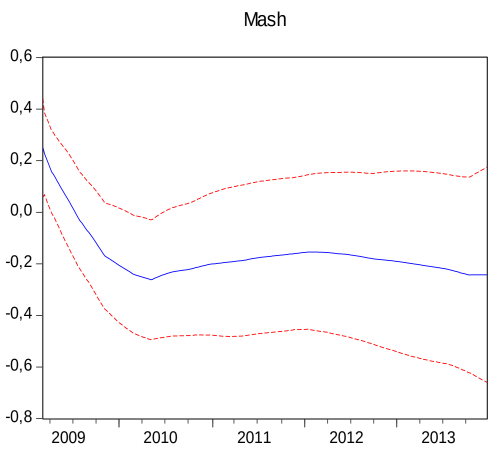
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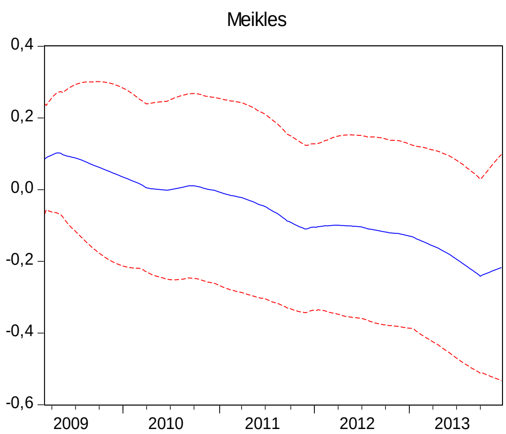
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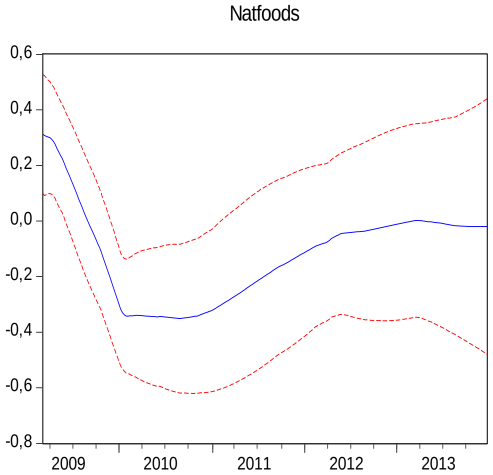
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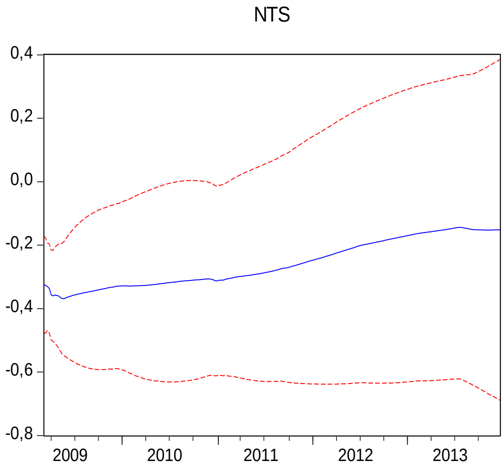
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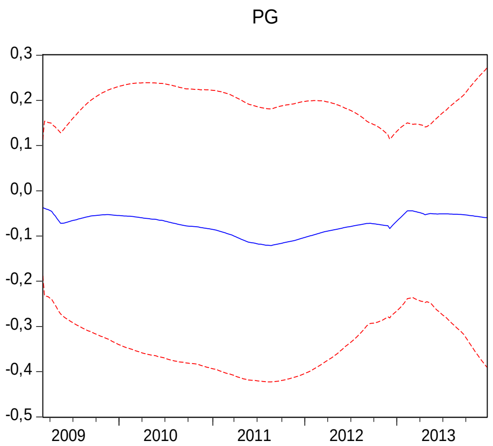
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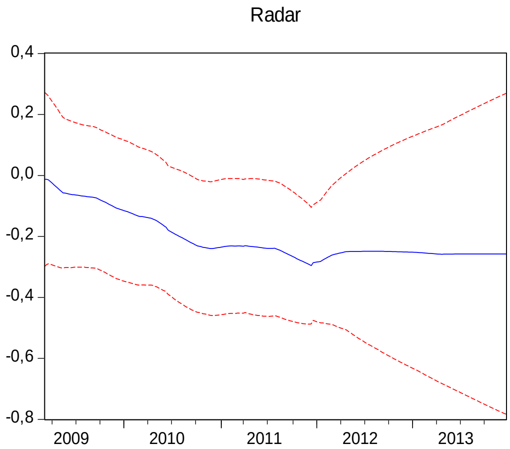
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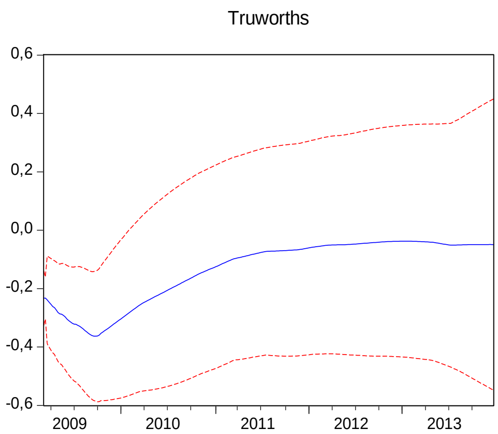
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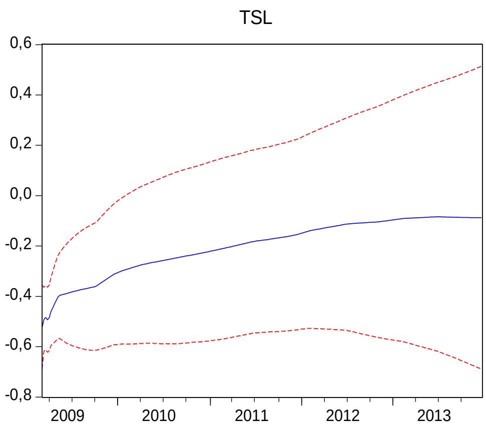
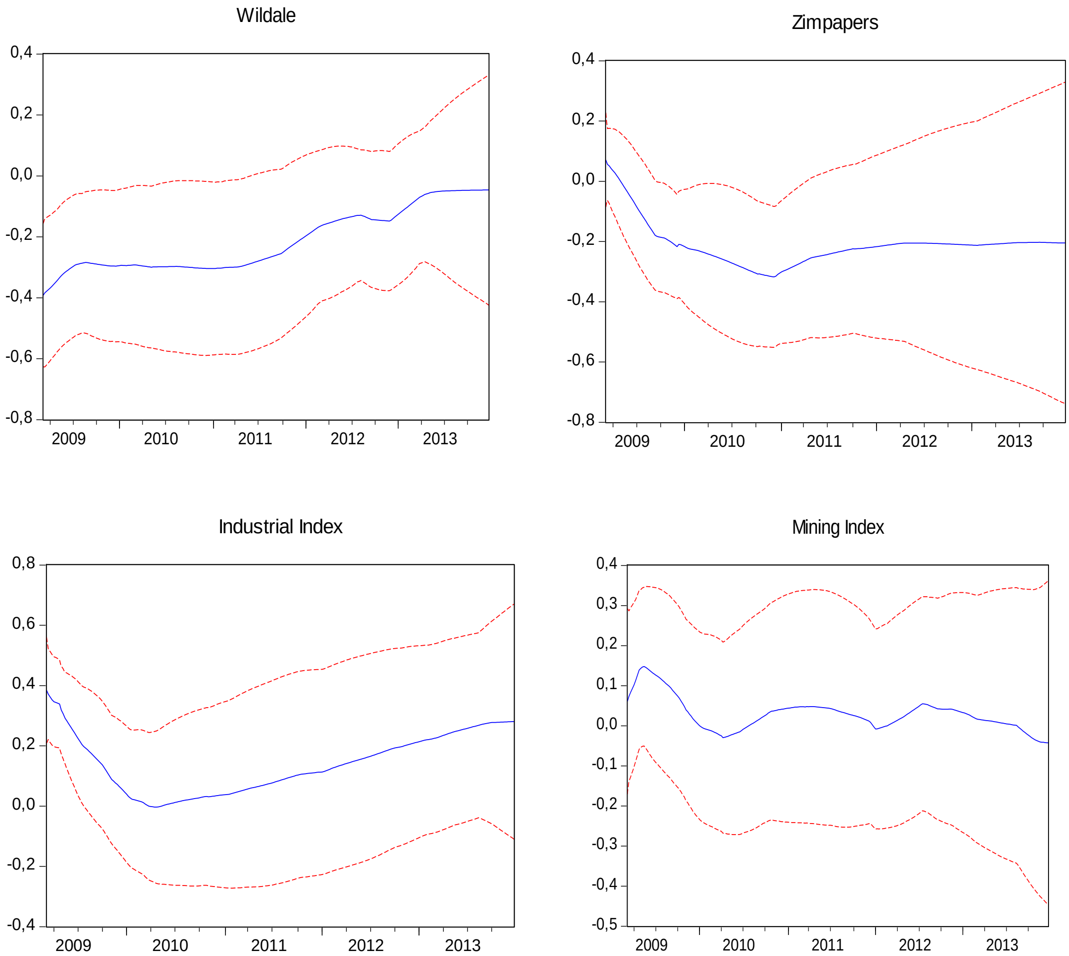
2009
2010
2011
2012
2013


TSL
0,6
0,4
0,2
0,0
-0,2
-0,4
-0,6
-0,8
2009
2010
2011
2012
2013



*State space estimation generated in Eviews 6.0.