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The effects of transitory and permanent inflation uncertainty on investment in Ghana

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Abstract

We examined the effect of inflation uncertainty on domestic investment in Ghana using annual data for the period from 1963 to 2016. We decomposed inflation uncertainty into its transitory and permanent components in order to understand what component drives overall inflation uncertainty on investment. We found that, in the short run, while transitory inflation uncertainty affects investment in a differential manner, permanent inflation uncertainty affects investment negatively and insignificantly. The differential short-run effects of transitory inflation uncertainty on investment pass on to the long run as positive and significant effects. The negative short-run effect of permanent inflation uncertainty passes on to the long run insignificantly. Additionally, we found that total inflation uncertainty has differential short-run effects on investment, which passes on as negative and insignificant long-run effects. These results suggest that transitory inflation uncertainty tends to drive the differential short-run effects, while permanent inflation uncertainty drives the negative long-run effects. By decomposing uncertainty into transitory and permanent components, the overall dynamics of inflation uncertainty on domestic investment becomes clear. These findings are broadly consistent with the theoretical studies arguing that uncertainty may inhibit domestic investment. The findings suggest that counter inflationary policies should be more focused on moderating the volatility of inflation.

Keywords Transitory and permanent inflation uncertainty · Domestic investment · Ghana

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1 Introduction

This study examines the effects of inflation uncertainty on domestic investment in Ghana. Ghana has experienced three episodes of inflation uncertainty during the period from 1963 to 2016. The period between 1963 and 1987 was characterised by high-inflation uncertainty in the economy. From 1988 to early 2000, the inflation uncertainty was moderate. The period between 2000 to date may be best described as a period of low inflation uncertainty, barring an extreme case in 2003 (International Financial Statistics (IFS) 2017). Along with the movement of inflation uncertainty, the real investment showed an erratic and downward trend over this period (see Fig. 3 in the "Appendix"). Theories demonstrate that the impact of inflation uncertainty on investment is highly debatable. Some argue that inflation uncertainty may affect the stability of macroeconomic environment; therefore, it has a negative impact on investment expenditures (see McDonald and Siegel 1986; Pindyck 1991). In addition, inflation uncertainty may increase variation in relative price, thereby reducing the allocative efficiency of the price system (see Friedman 1977; Fischer and Modigliani 1978). On the contrary, Dotsey and Sarte (2000) argue that inflation uncertainty may increase investment via the channel of precautionary savings. Against this background, it will be interesting to understand the link between inflation uncertainty and investment. Several studies have examined the role of uncertainty on investment in the African and the Ghanaian context (see Aryeetey 1994; Serven 1997; Collier and Pattillo 2000; Ibrahim 2000; Lemi and Asefa 2003; Kumo 2006; Aysan et al. 2009). So far, none has decomposed uncertainty into its transitory and permanent components, when evaluating the effect of uncertainty on investment in these countries. In this paper, we study the effect of inflation uncertainty on domestic investment by decomposing total uncertainty into its transitory and permanent components. In doing so, we are able to establish the component of inflation uncertainty relevant to domestic investment. We are also able to tell the component of uncertainty which drives the inflation uncertainty–investment relationship in Ghana. Regarding policy implications, a significant result would imply that classical studies on the determinants of investment may be biased because most do not capture transitory and permanent uncertainty. Moreover, policies to enhance investment may better focus on the component of uncertainty which is more harmful to investment.

In addition to the impact of inflation uncertainty on investment, the effect of uncertainty in general on investment is highly inconclusive theoretically. According to Hartman (1972) and Abel (1985), high uncertainty enhances current levels of investment by competitive risk-neutral firms in their attempts to prevent uncertainty in the future. Also, Dixit and Pindyck (1994), using their theory of optimal inertia, have demonstrated that investors are generally reluctant to invest under uncertainty. In contrast, Pindyck (1988) and Bertola (1998) argued that high uncertainty slows down the investment process by risk-neutral firms. Other studies have shown that uncertainty may enhance or hurt investment under different conditions. Darby et al. (1999), extending Dixit and Pindyck (1994) framework, argued that if a firm's opportunity cost of waiting is lower than its present value or scrapping price, then the firm would not invest. Contrarily, the same firm would invest under lower uncertainty. Along a similar line of thought, Sarkar (2000) used the real option model of McDonald and Siegel (1986) and Dixit and Pindyck (1994) to show that uncertainty may be negatively or positively associated with investment. Moreover, Wong (2007) used investment timing instead of the probability of investment and demonstrated that higher uncertainty shortens the expected exercise time and thus enhances investment for safer projects. He concluded that the positive uncertainty–investment relationship is more likely for high-growth projects than for low-growth projects.

Empirically, most studies tend to find support for the negative effect of uncertainty. Aizenman (1992), for instance, has found that nominal uncertainty is more likely to discourage investment than real uncertainty. Bacchetta and Van Wincoop (2000) reported that the size of net capital flows is lower under unstable currency regime. Servén (2003) reported that investors are less motivated to invest in an economy with high uncertainty. Studies on uncertainty–investment link have shifted towards decomposing uncertainty into its transitory components. For example, Moore and Schaller (2002) reported that transitory and permanent changes in interest rates have different effects on US investment behaviour. Chadha and Sarno (2002) have found that the transitory component of price volatility tends to have a higher effect than the permanent component on US investment. Byrne and Davis (2004) found that temporary uncertainty is more important for investment. In a follow-up study, Byrne and Davis (2005) reported the same finding that temporary uncertainty is more important for investment.

As pointed out earlier, no study has looked at the effect of uncertainty on investment from this perspective in the African context. In order to arrive at a common ground, studies ought to probe the uncertainty–investment relationship from all angles or regions. The previous studies have only documented their evidence on advanced economies. However, do the previous findings hold under different economic setups? We may never know the answer until we probe other economies. Our study attempts to study the effect of transitory and permanent inflation uncertainty by focusing on a developing economy. The rest of our study is organised as follows. In the next section, we consider historical levels of inflation uncertainty in Ghana. Section 3 presents our empirical setup by specifying the empirical investment equations and elaborating on the data. Section 4 reports and discusses the empirical results obtained by taking the empirical investment specifications to the data. Section 5 concludes the paper.

2 Inflation uncertainty in Ghana

Figure 1 shows a year-on-year change in the consumer price index (CPI) from March 1963 to December 2016, with the CPI superimposed to show the trend in consumer prices. The CPI trend alone does not tell us much about inflation in the economy, other than revealing an upward trajectory in prices. From Fig. 1, it could be seen that the year-on-year percentage change in the CPI has sharp spikes during the 1970s

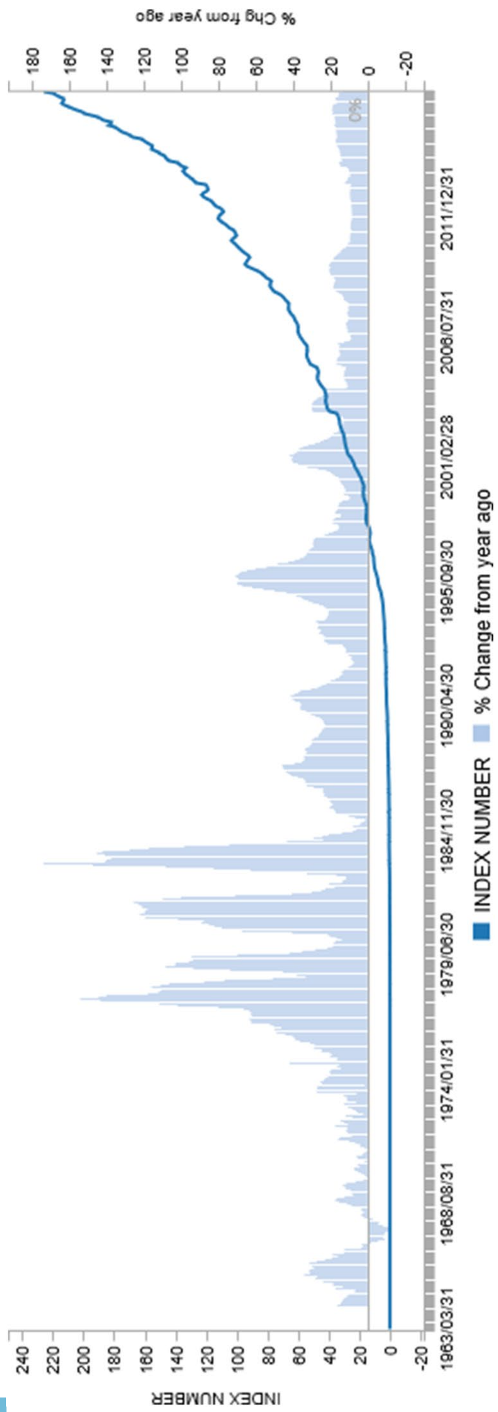

Fig. 1 Year-on-year percentage change in CPI for the period 1963:03 to 2016:12. *Source*: http://www.easydata.co.za/data/timeseries/IFS-165264___ZFM/. Accessed on 11 Apr 2017

and 1980s. Although, during the remaining period, there are sharp rises and falls in the year-on-year percentage change in the CPI and these are less pronounced. The changes in the CPI are particularly moderate from 2004 onwards. This marked the period of price stability in the economy (see Ocran 2007; Quartey 2010).

One way to understand the behaviour of inflation is by measuring its volatility or uncertainty. Uncertainty can be measured in various ways (see Kim 1993; Byrne and Davis 2004). In studying how inflation uncertainty relates to the level of inflation, Ball and Cecchetti (1990) decomposed uncertainty into short-term and long-term uncertainties. Chadha and Sarno (2002) followed suit when studying the effects of price volatility on investment. We follow this literature and decomposed inflation uncertainty into its permanent and transitory components using the component generalised autoregressive conditional heteroskedasticity (CGARCH) model. Although, there are various ways of decomposing inflation uncertainty (example, structural uncertainty, impulse uncertainty, steady-state inflation uncertainty, etc.), we prefer the CGARCH approach because it is the most convenient way of analysing the uncertainty–investment relationship within an autoregressive distributed lag (ARDL) framework. Besides, this approach has been used in Byrne and Davis (2005) to decompose exchange rate volatility in the G7 countries. The CGARCH can be used to model inflation uncertainty as follows:

$$\mathrm{INF}_t = f\left(\mathrm{INF}_{t-1};\gamma\right) + \varepsilon_t \tag{1}$$

where INF is inflation, $f(.)$ is the functional form of inflation assumed to be linear in parameters, INF_{t-1} is inflation at time $t-1$, and γ is a vector of parameters. ε_t is the error term which has a mean zero and a conditional variance of a known form σ_t^2. Equation (1) is specified in line with the inflation persistence literature (see Hamilton et al. 2016). The measure of inflation uncertainty is σ_t^2. The form of σ_t^2 has been at the centre of discussion in the heteroskedastic variance literature. In the CGARCH form proposed by Engle and Lee (1999), σ_t^2 is modelled as:

$$\sigma_t^2 - q_t = \bar{\omega} + \alpha_1\left(\varepsilon_{t-1}^2 - \bar{\omega}\right) + \beta_1\left(\sigma_{t-1}^2 - \bar{\omega}\right) \tag{2}$$

$$q_t = \alpha_0 + \rho\left(q_{t-1} - \alpha_0\right) + \varphi\left(\varepsilon_{t-1}^2 - \sigma_{t-1}^2\right) \tag{3}$$

where $\sigma_t^2 - q_t$ measures the transitory uncertainty, while q_t measures the permanent uncertainty. $\bar{\omega}$, α_0, α_1, β_1, ρ, and φ are parameters to be estimated. Transitory uncertainty converges to zero if $0 < \alpha_1 + \beta_1 < 1$, while permanent uncertainty converges to $\alpha_0/(1-\rho)$ if $0 < \rho < 1$. Permanent uncertainty is more persistent than transitory uncertainty. Therefore, $0 < \alpha_1 + \beta_1 < \rho < 1$. To ensure that the estimated uncertainty is non-negative, α_0, α_1, and β_1 must be positive and $\beta_1 > \varphi > 0$ (see Byrne and Davis 2005). The main distinction between the GARCH and CGARCH model is that the former assumes reversion to a constant mean $\bar{\omega}$, while the latter assumes reversion to a time-varying mean q_t. Hence, GARCH is a special case of CGARCH whereby $q_t = 0$ and Eqs. (2) and (3) become Eq. (2) without the q_t term (see Engle and Lee 1999).

Table 1 shows the estimates of the CGARCH model. In the mean equation, the lag of inflation is clearly an important predictor of current inflation. Similarly, the transitory component converges to zero since $0 < \alpha_1 + \beta_1 < 1$, while the permanent component converges to $\alpha_0/(1-\rho)$ since $0 < \rho < 1$. Table 2 shows the GARCH estimates. In this case too, the lag of inflation is an important predictor of current inflation. Moreover, the condition for convergence is met since $0 < \alpha_1 + \beta_1 < 1$. Finally, all the parameters of the CGARCH and GARCH models are statistically significant. Therefore, our indicators of uncertainty are reliably estimated.

In Fig. 2, we quantify the uncertainty of inflation in Ghana using the CGARCH estimates above. The advantage of the CGARCH model, in particular, is that it allows us to decompose total uncertainty in inflation into permanent and transitory uncertainties. The observed pattern in the year-on-year changes in the CPI as shown in Fig. 1 translates into inflation uncertainty. Note that inflation is measured as a first difference in the natural logarithm of CPI. From all three measures of inflation uncertainty—total, permanent, and transitory—it is evident that the highest uncertainty was recorded in 1974, followed by 1984, 1977, and 1979. The period between 1963 and 1987 was characterised by high-inflation uncertainty in the economy. From 1988 to early 2000, the inflation uncertainty was moderate. The period between 2000 to date may be best described as a period of low inflation uncertainty, barring an extreme case in 2003.

The high-inflation uncertainty between 1973 and 1979 is consistent with the oil price shock of 1973 whose effect lasted for the entire 1970s. The Arab–Israeli War led to an imposition of embargo of oil supply to the US and its allies by Arab members of the Organization of Petroleum Exporting Countries (OPEC), leading to severe oil supply shortages and hikes in oil prices (see Blinder 1979; Ikenberry 1986; Licklider 1988). Most economies around the world, including Ghana suffered from these oil supply shocks, which manifested in plant shutdowns and higher consumer prices.

Table 1 Component GARCH estimates—dependent variable is inflation (INF)

Variable	Coefficient	*z*-Statistic
Mean equation		
INF(− 1)	0.815	26.948***
Variance equation		
α_0	0.000	6.342***
ρ	0.986	334.058***
φ	0.032	3.778***
α_1	0.312	8.549***
β_1	0.397	6.467***

*** denotes 1% significant level

Table 2 GARCH estimates—dependent variable is inflation (INF)

Variable	Coefficient	*z*-Statistic
Mean equation		
INF(− 1)	0.763	38.167***
Variance equation		
α_0	0.000	14.049***
α_1	0.276	10.029***
β_1	0.712	39.884***

*** denotes 1% significant level

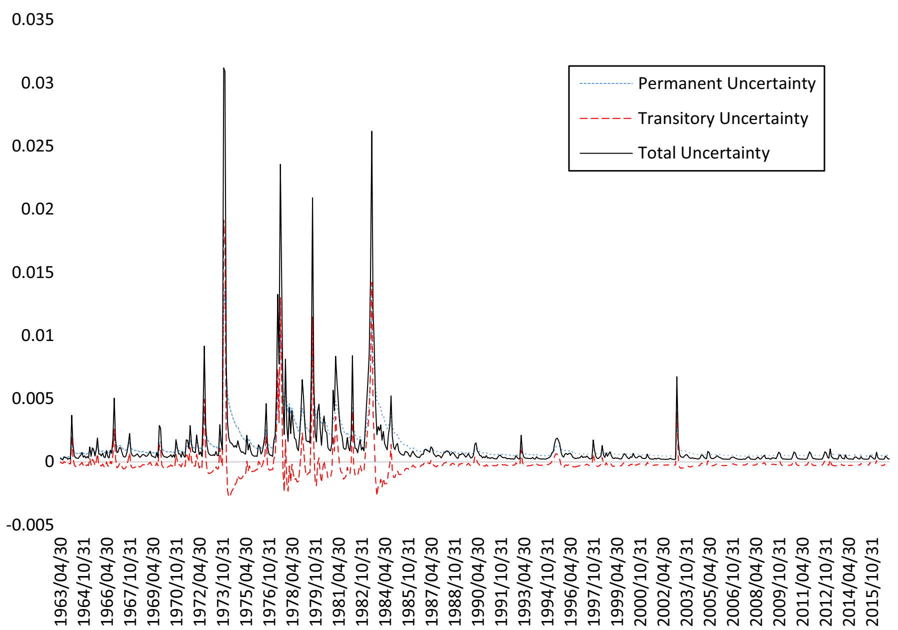

Fig. 2 Permanent, transitory, and total inflation uncertainty for the period 1963:03 to 2016:12. *Source*: Computed and plotted from the CGARCH model by authors

During this period, Ghana has undergone multiple changes in governments, particularly through coup d'états (see Owusu 1989). These events ultimately shaped inflation uncertainty dynamics in Ghana during this period. The high-inflation uncertainty recorded in 1984 preceded years of chronic drought (i.e. 1981 to 1983), food shortages, the repatriation of Ghanaians from Nigeria, and a low business confidence following the expropriation of private investments by the military governments (see Robertson 1983; Brydon 1985; Ofori-Sarpong 1986; Tabatabai 1988). The era of moderate and low inflation—that is, the 1990s and the 2000s—was aided by the country's return to democracy and peaceful transition of governments, the independence of the monetary authority, and the implementation of an inflation-targeting framework (see Crawford 2005; Ocran 2007; Quartey 2010; Heintz and Ndikumana 2011; Banya and Biekpe 2018). The uncertainty in inflation may have influenced domestic investment in one way or another. The rest of the paper attempts to empirically evaluate the magnitude and direction of the effect of inflation uncertainty in the country.

3 Empirical specifications and data

3.1 Empirical specifications

Following previous studies (see e.g. Darby et al. 1999; Byrne and Davis 2004), we model domestic investment as a function of income, the nominal interest rate, and measures of inflation uncertainty. Our investment specification takes the form:

$$\ln I_t = \phi_0 + \phi_1 Y_t + \phi_2 \ln r_t + \phi_3 \mathrm{TRAN}_t + \phi_4 \mathrm{PERM}_t + \mu_t \tag{4}$$

where I denotes domestic investment; Y denotes GDP growth rate; r denotes the nominal interest rate; TRAN and PERM denote, respectively, transitory and permanent inflation uncertainties as explained above; ln is the natural logarithm operator; ϕ is the coefficient of the model; μ is the white-noise error term; and t denotes the time subscript.

In theory, a positive growth in the real income is expected to create optimism among investors about the economy. Hence, domestic investment is expected to rise in reaction to a positive real income growth. The opposite holds for a negative real income growth. Therefore, ϕ_1 is expected to be positive. Other things unchanged, an increase in the interest rate should lead to an increase in the cost of capital or borrowing, and consequently, a decrease in the size of domestic investment (see Modigliani and Miller 1958; Das et al. 2014). From this point of view, the estimated value of ϕ_2 is expected to be negative. Generally, uncertainty may either harm or enhance domestic investment (see Hartman 1972; Abel 1985; Bertola 1998). Hence, the estimated ϕ_3 and ϕ_4 could be positive or negative.

The variables in Eq. (4) may be either $I(1)$ or $I(0)$ or a mixture. In that case, Eq. (4) may yield biased estimates. Taking advantage of the advances in econometrics, we re-specify Eq. (4) as a dynamic distributed lag model. In this form, we are able to differentiate short-run effects from long-run effects of inflation uncertainty on domestic investment, while at the same time report efficient estimates. The autoregressive distributed lag (ARDL) bounds testing approach developed in Pesaran et al. (2001) is the most suitable for re-specifying the investment function because, apart from allowing the variables to be either $I(1)$ or $I(0)$ or a mixture, it does well in small samples and does not require pretesting of the variables for unit roots. The dynamic specification of Eq. (4) is of the form:

$$\begin{aligned}\Delta \ln I_t = {} & \gamma_0 + \sum_{i=1}^{q} \gamma_{1i} \Delta \ln I_{t-i} + \sum_{i=0}^{q} \gamma_{2i} \Delta Y_{t-i} + \sum_{i=0}^{q} \gamma_{3i} \Delta \ln r_{t-i} + \sum_{i=0}^{q} \gamma_{4i} \Delta \mathrm{TRAN}_{t-i} \\ & + \sum_{i=0}^{q} \gamma_{5i} \Delta \mathrm{PERM}_{t-i} + \lambda_1 \ln I_{t-1} + \lambda_2 Y_{t-1} + \lambda_3 \ln r_{t-1} + \lambda_4 \mathrm{TRAN}_{t-1} \\ & + \lambda_5 \mathrm{PERM}_{t-1} + \varepsilon_t \end{aligned} \tag{5}$$

where ε, γ, and λ denote the white-noise error term, the short- and the long-run coefficients, respectively; Δ denotes the first-difference operator; and q is the maximum lag included in the model. The short-run effects of the variables on investment are the coefficients of the first-differenced variables. To arrive at the long-run effects of the variables on investment, we set the non-first-differenced lagged portion of Eq. (5) to zero and normalise λ_2 to λ_5 by λ_1.

For the estimates of Eqs. (4) and (5) to be reliable, the coefficients λ_1, λ_2, λ_3, λ_4, and λ_5 must be jointly significant. Stated in another way, the variables in Eq. (5) must be cointegrated in order to guarantee that the coefficients are efficiently estimated (see Iyke and Ho 2017a). This can be verified by testing the null hypothesis that $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$. Pesaran et al. (2001) derived two sets of critical values under this null hypothesis. Under the first set of critical values, the variables in Eq. (5) are assumed to be integrated of order zero, $I(0)$, while under the second set, they are assumed to be integrated of order one, $I(1)$. The presence of cointegration can be rejected if the calculated F-statistic is smaller than the first set of critical values. In the same vein, the presence of cointegration is accepted if the calculated F-statistic is greater than the second set of critical values. The test is said to be inconclusive if the calculated F-statistic lies in between both sets of critical values (see also Iyke and Ho 2017a).

3.2 Data

The empirical estimations are based on annual data covering the period 1963 to 2016. The period restriction is informed by the lack of consumer price index (CPI) data before 1963/03/31. The data on CPI comes from the International Financial Statistics (IFS) database compiled by the IMF. Inflation is defined as the first difference in the natural logarithm of the CPI from 1963/03/31 to 2016/12/31. We employed monthly data to measure inflation and consequently inflation uncertainty because there is evidence that uncertainty is better observed in data collected at higher frequency (see Bollerslev 1986). The family of GARCH models fits annual data poorly (Bollerslev 1986), making annual data inappropriate for measuring uncertainty. We calculated the measures of inflation uncertainty as discussed above (see also Byrne and Davis 2005). Because the obtained measures of uncertainty are at monthly frequency, we calculated their simple annual averages for each of the years. Domestic investment (I) is measured as gross capital formation (current US$) divided by GDP deflator.[1] Data for both gross capital formation (current US$) and GDP deflator are taken from the World Development Indicators (WDI). GDP growth rate, Y, is the annual percentage change in GDP obtained from the WDI. The interest rate, r, is measured as the central bank policy rate (end of period) from the IFS. Finally, note that quarterly data would have been preferable for the analysis. However, quarterly observations on investment and real income are not readily available, thereby restricting our choice to annual data. Table 3 shows the summary statistics of these variables. Figures 3, 4, and 5 in the "Appendix" show the visual graphs of real investment, GDP growth rate, and nominal interest rate, respectively. In the next section, we report and discuss the empirical results.

4 Empirical results

4.1 Transitory and permanent inflation uncertainty on investment

This section considers the effects of transitory and permanent inflation uncertainty on domestic investment. To do this, we utilised the ARDL approach presented

[1] Although it is preferable to measure domestic investment by the gross fixed capital formation, the data series are only available from 1983 onwards. Many important information would have been missed if we use this measurement. Therefore, we use gross capital formation which covers the period from 1963 to 2016, to measure domestic investment.

Table 3 Summary statistics

	ln*I*	*Y*	ln*r*	TRAN	PERM	VOL
Mean	20.276	1.453	2.775	0.000	0.001	0.001
Median	19.444	1.558	2.904	0.000	0.001	0.000
Maximum	25.827	2.642	3.807	0.003	0.005	0.008
Minimum	16.853	−0.997	1.504	−0.002	0.000	0.000
SD	3.030	0.667	0.679	0.001	0.001	0.002
Skewness	0.752	−1.775	−0.503	2.794	2.251	3.808
Kurtosis	2.043	7.574	2.196	14.437	6.937	17.675
Jarque–Bera	6.094	64.263	3.180	310.563	68.557	523.936
Probability	0.047	0.000	0.204	0.000	0.000	0.000
Sum	932.693	66.852	127.659	−0.007	0.050	0.045
Sum sq. dev.	413.199	20.015	20.725	0.000	0.000	0.000
Observations	46	46	46	46	46	46

Std. dev. and sum sq. dev. denote, respectively, standard deviation and sum of squared deviations. *TRAN*, *PERM*, and *VOL* denote, respectively, transitory, permanent, and total uncertainty. ln denotes the natural log operator

earlier. A desirable feature of the ARDL approach is that it does not require pre-testing of the variables to establish stationarity. In other words, the variables can be either $I(0)$, $I(1)$, or mixed integrated processes. Therefore, since the variables employed in this study are known to exhibit these integration properties, we do not test for unit roots. The error correction model in Eq. (5) is sensitive to lag choices (Pesaran et al. 2001). Hence, we followed Iyke and Ho (2017b) by limiting the maximum lag to four and used the Akaike information criterion (AIC) to choose the optimal lags for each variable. To proceed with the estimation of the coefficients in the model, we first tested for cointegration. The results of the ARDL bound test for cointegration show that the calculated F-statistic for Eq. (5) is 4.136, which is higher than the upper-bound critical values reported by Pesaran et al. (2001, p. 300) in Table CI (iii) Case III for five variables (i.e. $k=5$). We conclude that the variables are cointegrated. The estimated short- and long-run results are reported in Table 4. The optimal ARDL model selected based on the AIC is ARDL(1, 3, 0, 3, 0). Table 4 is made up of three parts. The first, second, and third parts report the long-run estimates, the short-run estimates, and the diagnostic tests,[2] respectively.

Looking at the results in Table 4, it is evident that the ARDL is correctly specified. That is, the model is structurally stable, and there is no serial correlation and functional misspecification as shown by the relevant diagnostic tests reported at the bottom of Table 4 and Fig. 6a, b in the "Appendix". The short-run results indicate

[2] These tests are the Lagrange multiplier (LM) test, Ramsey's regression equation specification error test (RESET), the cumulative sum of recursive residuals (CUSUM) test and the cumulative sum of squares of recursive residuals (CUSUMSQ) test, respectively (see Breusch 1978; Brown et al. 1975; Godfrey 1978; Ramsey 1969).

Table 4 Transitory and permanent inflation uncertainty and investment

Variable	Coefficient	*T*-Statistic
Long-run results dependent variable is lnI		
Y	0.341	2.716***
lnr	− 1.415	− 3.837***
TRAN	4331.391	2.532**
PERM	− 736.423	− 1.673
Short-run results dependent variable is lnΔI		
Δ*Y*	0.046	4.567***
Δ*Y*(− 1)	− 0.004	− 0.357
Δ*Y*(− 2)	− 0.023	− 2.364**
Δln*r*	− 0.316	− 2.129**
ΔTRAN	113.376	1.511
ΔTRAN(− 1)	− 497.323	− 4.945***
ΔTRAN(− 2)	− 212.887	− 3.285***
ΔPERM	− 79.459	− 1.178
Constant	4.500	5.094***
ECM	− 0.160	− 5.281***

F-Statistic	LM	ARCH	RESET	CUSUM	CUSUMSQ
Diagnostics					
4.136	3.939(0.140)	0.644(0.422)	2.703(0.158)	S	S

** and *** denotes 5% and 1% significant levels, respectively. *P* values for the diagnostic tests are in the parentheses. S denotes stable. *TRAN*, *PERM* denote, respectively, transitory and permanent uncertainty

that while transitory inflation uncertainty has differential effects on investment, the permanent inflation uncertainty affects it negatively and insignificantly. The differential effects of transitory inflation uncertainty on investment in the short run turn to be positive in the long run. The negative effect of permanent inflation uncertainty on investment in the short run passes on to the long run, although insignificantly. Our findings are similar to Byrne and Davis (2004), who document a negative long-run effect of permanent inflation uncertainty on investment. We may conclude that inflation uncertainty has asymmetric effect on domestic investment in Ghana, since the sizes of the transitory and permanent effects both in the short and the long run are different. Interest rate has a negative effect on investment in the short run which passes on to the long run. This finding is also supported by the one documented by Byrne and Davis (2004). Finally, both the short- and the long-run estimates suggest that income growth rate affects investment positively. Iyke and Ho (2017b) report a contrasting finding. The source of this difference may be attributed to the fact that their study is based on a shorter sample and this may have distorted the precision of their coefficient estimates.

4.2 Total inflation uncertainty on investment

In the previous section, our aim was to find out how investment reacts to transitory and permanent uncertainty. Here, we attempt to assess how investment reacts to overall inflation uncertainty. We measured total inflation uncertainty as the annualised conditional variance of a GARCH(1,1) model using the first difference in the natural log of monthly CPI from 1963/03/31 to 2016/12/31.[3] After limiting the maximum lag to four, we found that the preferred ARDL specification to be ARDL(1, 3, 0, 4). The specification is reliable because the coefficient of the error correction term suggests convergence, and there is no serial correlation and functional misspecification as shown by the relevant diagnostic tests (see bottom of Table 5 and Fig. 7a, b in the "Appendix"). The main results are presented in Table 5. These results generally mirror the one shown in Table 4 in that inflation uncertainty appears to have differential effects on investment in the short run and a negative effect in the long run. Again, these results are consistent with the findings of Byrne and Davis (2004). In line with the previous results, interest rate appears to have a negative and significant effect on investment both in the short and the long run. Finally, income growth rate has a positive and significant effect on investment both in the short and the long run.

4.3 Sensitivity analysis

This section tests whether the results are sensitive to the presence of structural breaks. During the study period, there had been a series of international and domestic events, such as the oil supply shocks, global financial crisis, changes in governments, etc. that may affect the path of the variables in our model. Therefore, we estimate the following equation with the inclusion of a dummy variable, DUM, to capture the presence of structural breaks:

$$\begin{aligned}\Delta \ln I_t = {} & \gamma_0 + \gamma_1 \mathrm{DUM}_t + \sum_{i=1}^{q} \gamma_{2i} \Delta \ln I_{t-i} + \sum_{i=0}^{q} \gamma_{3i} \Delta Y_{t-i} + \sum_{i=0}^{q} \gamma_{4i} \Delta \ln r_{t-i} + \sum_{i=0}^{q} \gamma_{5i} \Delta \mathrm{TRAN}_{t-i} \\ & + \sum_{i=0}^{q} \gamma_{6i} \Delta \mathrm{PERM}_{t-i} + \lambda_1 \ln I_{t-1} + \lambda_2 Y_{t-1} + \lambda_3 \ln r_{t-1} + \lambda_4 \mathrm{TRAN}_{t-1} \\ & + \lambda_5 \mathrm{PERM}_{t-1} + \varepsilon_t \end{aligned} \tag{6}$$

Equation (6) is similar to Eq. (5), except we include the variable DUM as a dummy variable to capture the presence of structural breaks. For the model containing the transitory and permanent inflation uncertainty, the preferred specification using the AIC is ARDL(1, 3, 2, 3, 2), which is different from the one in Table 4. The results obtained using this ARDL specification is shown in Table 6. The results are in general consistent with the main results. Although the impacts of permanent inflation on investment in the short run differ, both results are insignificant. Considering the model with total inflation uncertainty, the preferred specification using the AIC

[3] See Byrne and Davis (2005) and Iyke and Ho (2017b) for a similar measure for the real exchange rate.

Table 5 A GARCH measure of inflation uncertainty and investment

Variable	Coefficient	*T*-Statistic
Long-run results dependent variable is lnI		
ln*Y*	0.334	3.672***
ln*r*	−1.388	−4.059***
VOL	−116.060	−0.595
Short-run results dependent variable is ln∆I		
∆ln*Y*	0.040	4.321***
∆ln*Y*(−1)	−0.010	−0.785
∆ln*Y*(−2)	−0.027	−2.488**
∆ln*r*	−0.300	−1.848*
∆VOL	−4.812	−0.219
∆VOL(−1)	−9.508	−0.364
∆VOL(−2)	51.926	2.041**
∆VOL(−3)	72.662	3.013***
Constant	4.822	4.599***
ECM	−0.177	−4.760***

F-Statistic	LM	ARCH	RESET	CUSUM	CUSUMSQ
Diagnostics					
4.271	3.659(0.161)	1.259(0.262)	1.857(0.181)	S	S

*, ** and *** denote 10%, 5%, and 1% significance levels, respectively. *P* values for the diagnostic tests are in the parentheses. S denotes stable. *VOL* denotes total uncertainty

is ARDL(1, 3, 0, 4), which is the same as the one in Table 5. Therefore, the results are highly similar. Clearly, the inclusion of structural breaks has inconsequential impact on the inflation uncertainty–investment relationship reported in Tables 4 and 5. In other words, the findings presented earlier are robust to alternative specifications of the investment function (Tables 6 and 7).

4.4 A synthesis of the findings

We set out to examine the effects of transitory and permanent inflation uncertainty on domestic investment. By deriving transitory and permanent inflation uncertainty from a CGARCH model and using the ARDL framework, we found that, in the short run while transitory inflation uncertainty has differential effects on investment, the permanent inflation uncertainty affects it negatively and insignificantly. We also found that the differential effects of transitory inflation uncertainty on investment in the short run turn to positive in the long run. Moreover, we found that the negative effect of permanent inflation uncertainty on investment in the short run passes on to the long run, although insignificantly. Our findings are broadly in line with those of Chadha and Sarno (2002) and Byrne and Davis (2004).

Byrne and Davis (2004), in particular, document a negative effect of permanent inflation uncertainty on investment. We also found similar result in the main and the

Table 6 Transitory and permanent inflation uncertainty and investment with structural breaks

Variable	Coefficient	*T*-Statistics
Long-run results dependent variable is lnI		
Y	0.250	2.445**
ln*r*	− 1.335	− 6.476***
TRAN	2317.405	1.850*
PERM	− 533.681	− 1.916*
DUM	− 1.126	− 4.131***
Short-run results dependent variable is lnΔI		
Δ*Y*	0.055	5.412***
Δ*Y*(− 1)	0.003	0.256
Δ*Y*(− 2)	− 0.028	− 2.983***
Δln*r*	− 0.186	− 1.239
Δ*lnr*(− 1)	0.415	2.529**
ΔTRAN	1.770	0.027
ΔTRAN(− 1)	− 675.407	− 5.194***
ΔTRAN(− 2)	− 355.972	− 3.992***
ΔPERM	85.528	1.130
ΔPERM (− 1)	175.729	2.467**
ΔDUM	− 0.372	− 2.243**
Constant	6.696	6.022***
ECM	− 0.240	− 6.172***

F-Statistic	LM	ARCH	RESET	CUSUM	CUSUMSQ
Diagnostics					
5.429	2.119(0.347)	0.533(0.465)	0.215(0.646)	S	U[a]

** and *** denotes 5% and 1% significant levels, respectively. *P* values for the diagnostic tests are in the parentheses. S denotes stable. U denotes unstable. TRAN, PERM denote, respectively, transitory and permanent uncertainty

[a]Although the CUSUMSQ slightly deviates from the upper bound, later on it returns completely inside the critical bounds. See Fig. 8a and b in the "Appendix" for the plots of CUSUM and CUSUMSQ

alternative models. In addition, Byrne and Davis (2004) found transitory uncertainty to be more important for investment in their study. We found transitory and permanent uncertainty to be equally relevant for investment. Our results may have differed from theirs because they studied the US, a vastly advanced economy, while we study Ghana, a developing economy. The US has a well-developed market, whose economic agents are expected to better differentiate between transitory and permanent uncertainty and thus respond to speedy flow of information. A permanent inflation uncertainty is expected to persist; hence, agents in a well-developed market factor this in their investment decisions as expected. In contrast, Ghana has a less-developed market with high information asymmetry. The economic agents in the Ghanaian market may, therefore, have recognition lags, in terms of distilling permanent uncertainty from transitory uncertainty, which in turn reflects in their investment decisions. Their response to permanent inflation uncertainty is expected to be very slow, and hence

Table 7 A GARCH measure of inflation uncertainty and investment with structural breaks

Variable	Coefficient	*T*-Statistics
Long-run results dependent variable is lnI		
ln*Y*	0.332	3.445***
ln*r*	− 1.435	− 4.063***
VOL	− 120.558	− 0.615
DUM	− 0.783	− 2.029*
Short-run results dependent variable is lnΔI		
Δln*Y*	0.041	4.390***
Δln*Y*(− 1)	− 0.010	− 0.773
Δln*Y*(− 2)	− 0.029	− 2.596**
Δln*r*	− 0.254	− 1.501
ΔVOL	− 5.020	− 0.229
ΔVOL(− 1)	− 10.637	− 0.406
ΔVOL(− 2)	51.787	2.036**
ΔVOL(− 3)	76.266	3.128***
DUM	− 0.255	− 1.438
Constant	4.918	4.662***
ECM	− 0.180	− 4.823***

F-Statistic	LM	ARCH	RESET	CUSUM	CUSUMSQ
Diagnostics					
4.396	3.235(0.198)	1.454(0.228)	1.852(0.182)	S	S

*, ** and *** denote 10%, 5%, and 1% significance levels, respectively. *P* values for the diagnostic tests are in the parentheses. S denotes stable. *VOL* denotes total uncertainty. See Fig. 9a and b for the plots of CUSUM and CUSUMSQ

indicating why permanent uncertainty has insignificantly negative or even positive effect in the short run. Once the economic agents digest the information, permanent inflation uncertainty displays a negative impact on investment in the long run.

As a complement to the transitory and permanent inflation uncertainty estimates, we examined the effect of total inflation uncertainty on domestic investment. By measuring total inflation uncertainty using the conditional variance of a GARCH(1,1) model of inflation, we found that total inflation uncertainty has differential effects on investment in the short run. In the long run, however, the effect is negative and insignificant. These results are generally consistent with the theoretical predictions that uncertainty may be harmful to investment. The effects of total inflation uncertainty on investment suggest that transitory inflation uncertainty drives the short-run effects, while permanent inflation uncertainty tends to drive the long-run effects. Therefore, by decomposing uncertainty into transitory and permanent, we tend to understand the overall dynamics of inflation uncertainty on domestic investment better.

From a theoretical point of view, the relevance of transitory uncertainty for investment in the short run may stem from the fact that it influences uncertainty about the future levels of inflation, which in turn leads to short-term speculative pressures. In general, such short-term pressures should lead to lower investment in the short run as they are normally linked with rising costs of capital (i.e. real interest rates). Our results appear to confirm these theoretical predictions. Further, our results appear to support the interest rate channel because the interest rate enters into the specifications significantly. Clearly, uncertainty in the economy inhibits investment through rising interest rate. In addition, uncertainty in the economy drives investment through rising incomes since income growth enters into the specifications positively and significantly.

5 Conclusion

Domestic investment plays a critical role in the economy by boosting the growth of output, the size of income, employment, public expenditure on essential services, among others. Theoretical and empirical studies have been devoted to establishing the primary determinants of investment. Uncertainty, in particular, has been one such key determinant of investment as established in the recent literature. However, the direction of its impact on investment has remained an inconclusive debate both in theory and empirics. The recent empirical interest in the role of uncertainty in investment has shifted towards decomposing uncertainty into temporary and permanent uncertainty. These studies have mostly considered uncertainty in the advanced economy context. Our study focuses on a developing economy by narrowing down uncertainty into inflation uncertainty. Specifically, we decomposed inflation uncertainty into transitory and permanent uncertainty in order to understand what component drives overall inflation uncertainty on investment in this economy. We derived transitory and permanent inflation uncertainty from a CGARCH model. And by using the ARDL framework to specify the investment model, we found that, in the short run while transitory inflation uncertainty has differential effects on investment, the permanent inflation uncertainty affects it negatively and insignificantly. The differential short-run effects of transitory inflation uncertainty on investment turn to positive in the long run, consistent with previous findings. Moreover, the negative short-run effect of permanent inflation uncertainty passes on to the long run, although insignificantly. We then examined the effect of total inflation uncertainty on domestic investment by measuring total inflation uncertainty using the conditional variance of a GARCH(1,1) model of inflation. We found that total inflation uncertainty has differential short-run effects on investment. In the long run, the effect of total inflation uncertainty on investment is negative and insignificant. The effects of total inflation uncertainty on investment suggest that transitory inflation uncertainty tends to drive the short-run effects, while permanent inflation uncertainty drives the long-run effects. Therefore, by decomposing uncertainty into its transitory and permanent components, we tend to understand the overall dynamics of inflation uncertainty on domestic investment better. Overall, our findings tie with theoretical studies which argued that uncertainty may enhance domestic investment in the short run and harm investment in the long run. Since the results mainly suggest that inflation uncertainty actually harms investment in the long run, this means that counter inflationary policies should probably focus on moderating the volatility of inflation. Regime shifts may be an important driver of inflation uncertainty (i.e. inflation uncertainty could be subject to regime switching between periods of low- or high inflation), which may in turn influence the uncertainty–investment relationship. Although, the exploration of such dynamics appears interesting, this paper has not done so. Perhaps, future studies may consider examining this possibility.

Appendix

See Figs. 3, 4, 5, 6, 7, 8, and 9.

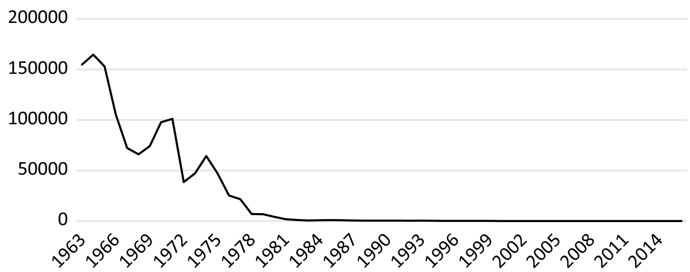

Fig. 3 Real investment for the period 1963 to 2016. *Source*: Authors compilation

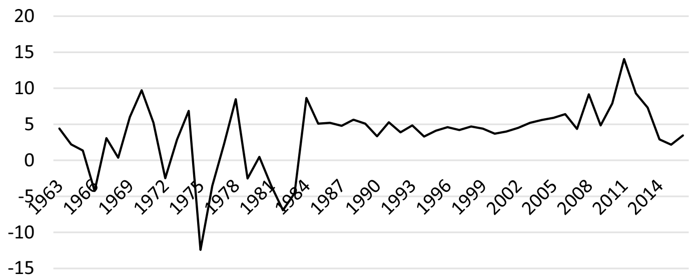

Fig. 4 GDP growth rate for the period 1963 to 2016. *Source*: Authors compilation

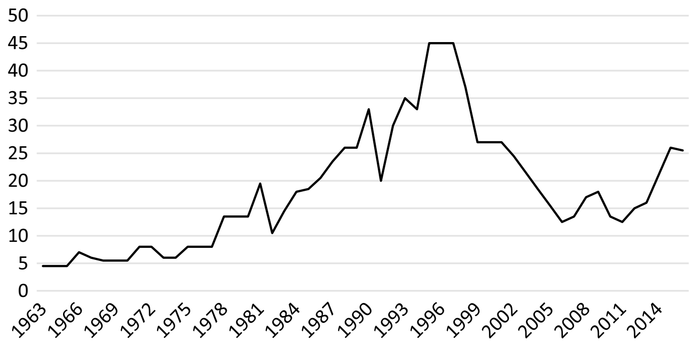

Fig. 5 Nominal interest rate for the period 1963 to 2016. *Source*: Authors compilation

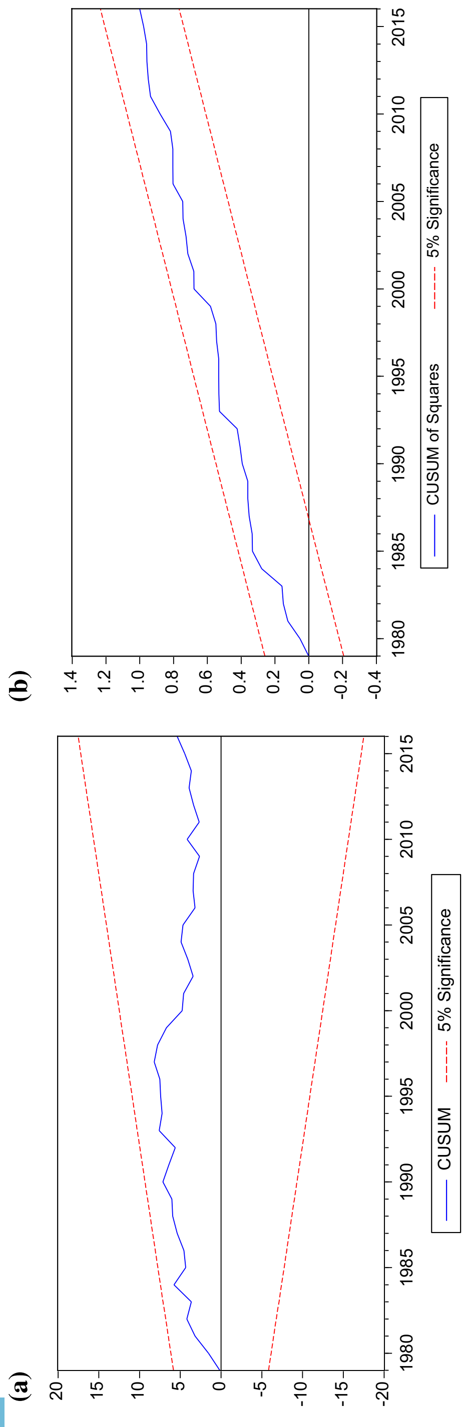

Fig. 6 **a** The plot of cumulative sum of recursive residuals. **b** The plot of cumulative sum of squares of recursive residuals

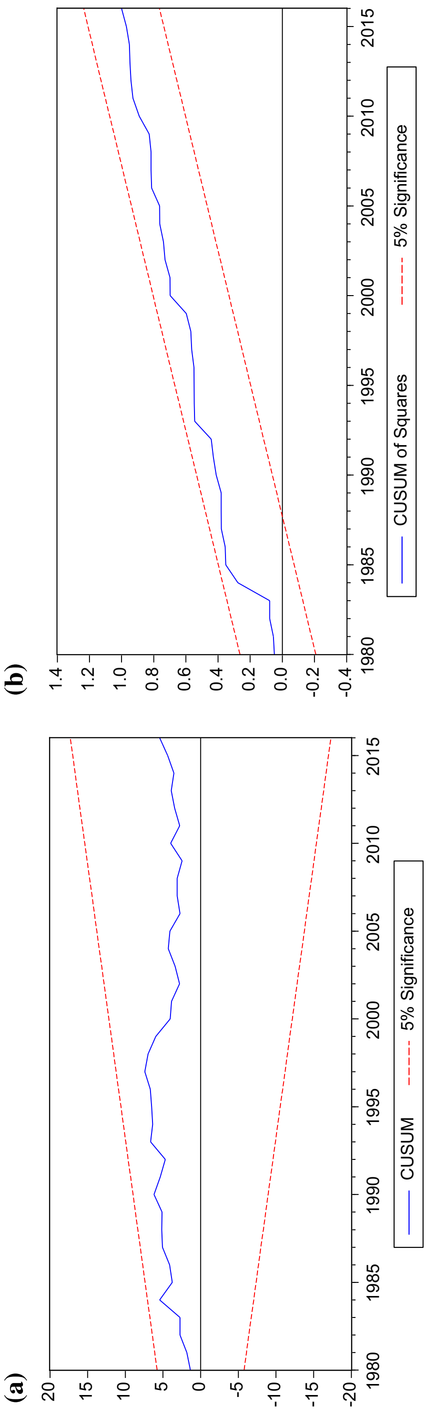

Fig. 7 **a** The plot of cumulative sum of recursive residuals. **b** The plot of cumulative sum of squares of recursive residuals

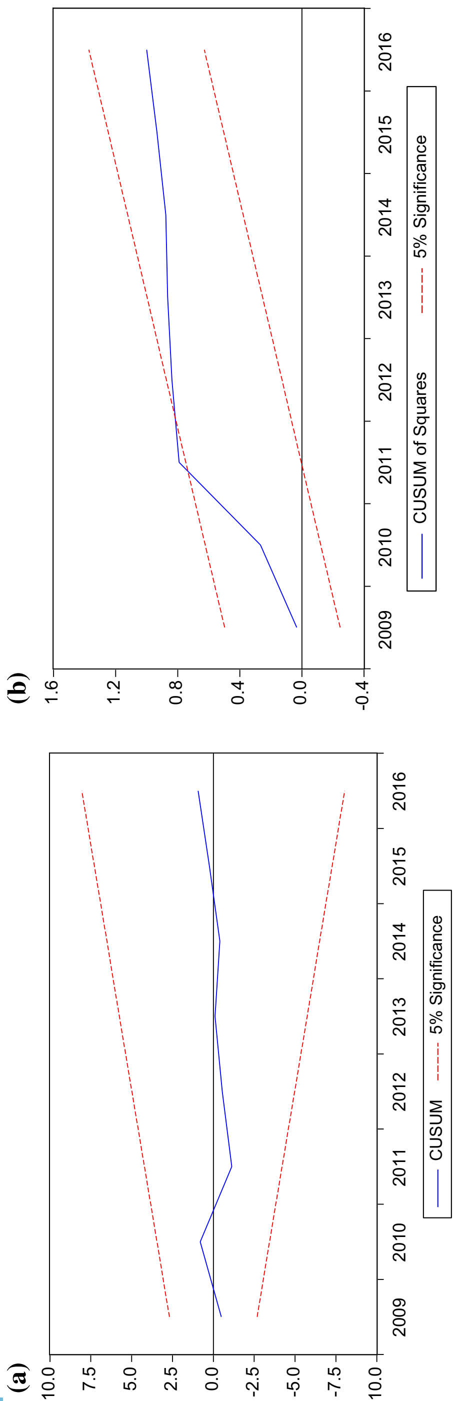

Fig. 8 **a** The plot of cumulative sum of recursive residuals. **b** The plot of cumulative sum of squares of recursive residuals

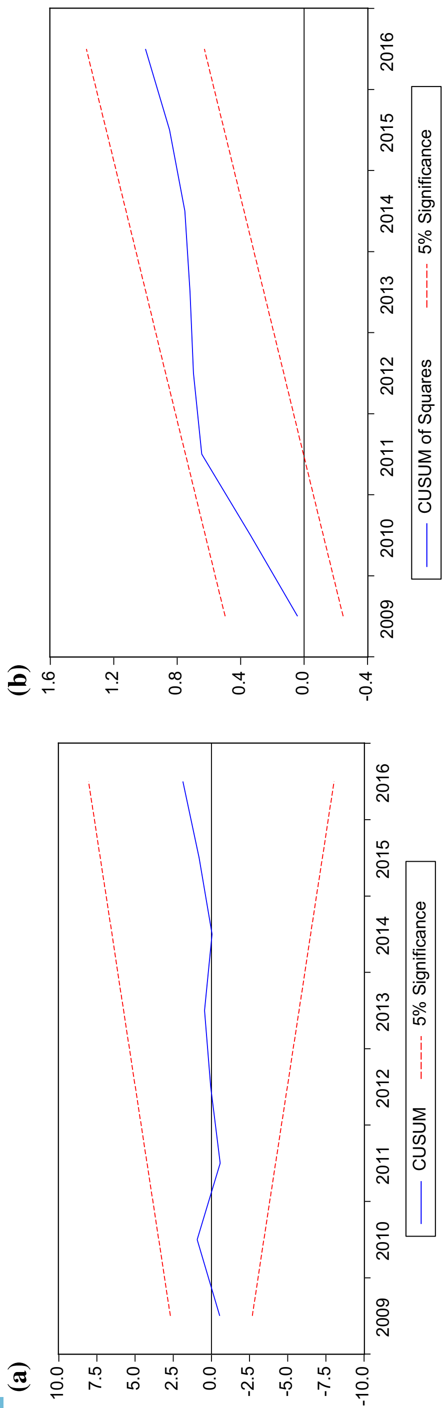

Fig. 9 **a** The plot of cumulative sum of recursive residuals. **b** The plot of cumulative sum of squares of recursive residuals

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