Exchange rate uncertainty and domestic investment in Ghana

Bernard Njindan Iyke1* and Sin-Yu Ho2

Abstract: The impact of exchange rate uncertainty on domestic investment remains a topical issue in international finance. The existing studies based on macro- or micro-level data have produced mixed findings leaving the issue widely open for further investigation. We revisit this issue at the macro-level by differentiating the short-run impacts of exchange rate uncertainty from long-run impacts. Using annual data for Ghana covering the period 1980–2015, we found that exchange rate uncertainty has differential impacts on domestic investment in the short run. That is, while the current level of uncertainty enhances investment, previous levels of uncertainty dampen investment. In the long run, exchange rate uncertainty has a positive impact on domestic investment. These findings are robust to alternative specifications of our model.

1. Introduction
Modern economies favour flexible over fixed exchange rate arrangements. The commonly practised flexible exchange rate arrangement is the managed-float or dirty-float, whereby monetary authorities allow the value of local currency against foreign ones to be determined by market forces, and occasionally intervene during periods when the currency deviates from its equilibrium. This exchange rate arrangement creates volatilities or uncertainties in the real exchange rate. In the literature, it

ABOUT THE AUTHORS
Bernard Njindan Iyke is with the Department of Finance, Deakin University in Australia where his research presently focuses on topics at the intersection of corporate finance and asset pricing. Previously, he was with the Department of Economics, University of South Africa where he focused on topics in macro and international economics.

Sin-Yu Ho is with the Department of Economics, University of South Africa where she focuses on issues relating to development finance, stock markets, emerging markets and developing countries.

PUBLIC INTEREST STATEMENT
Modern economies have favoured flexible exchange rate arrangements over fixed ones. As a result, exchange rates have become more volatile or uncertain. Uncertainty may cause investors to invest more or less depending on their preference towards risk. This paper explored the short- and long-run effects of exchange rate uncertainty on domestic investment in Ghana for the period 1980 to 2015. It found that uncertainty has differential effects on investment in the short run. Specifically, while the current level of uncertainty enhances investment, previous levels of uncertainty hurt it. In the long run, exchange rate uncertainty only enhances investment. These findings imply that policymakers should be more concerned about short-term uncertainty which could hurt investment in the country.
has been established that real exchange rate uncertainty can produce undesirable consequences. For example, Caballero and Corbo (1989) and Chowdhury (1993) have found that increases in real exchange rate uncertainty have significantly negative effects on export. Exchange rate uncertainty may also pass-through to prices of goods and services, thereby introducing price uncertainty, which affects domestic investment positively or negatively. On the one hand, Hartman (1972) and Abel (1985) argue that the high price uncertainty may promote current levels of investment by competitive risk-neutral firms in their attempt to prevent uncertainty in the future. On the other, Pindyck (1988) and Bertola (1998) demonstrate that high uncertainty reduces the investment process by risk-neutral firms.

Other theoretical models demonstrate the impact of exchange rate uncertainty on investment. Dixit and Pindyck (1994), using their theory of optimal inertia, show that investors are generally hesitant to invest under uncertainty. By extending the Dixit and Pindyck (1994) framework, Darby, Hallett, Ireland, and Piscitelli (1999) demonstrate that if a firm’s opportunity cost of waiting is lower than its present value or scrapping price, the firm will not invest. However, under lower uncertainty, the same firm will invest. This suggests that uncertainty may promote or hurt investment. By estimating an aggregate investment function for France, Germany, Italy, UK and US, Darby et al. (1999) found that investment increases if exchange rate uncertainty is lowered. Similarly, Sarkar (2000), using the real option model of McDonald and Siegel (1986) and Dixit and Pindyck (1994), demonstrate that uncertainty may be negatively or positively associated with investment. Wong (2007) followed Sarkar (2000) by re-examining the effect of uncertainty on investment. However, unlike Sarkar (2000), Wong (2007) used investment timing instead of the probability of investment. He found that higher uncertainty shortens the expected exercise time and thus, enhances investment for relatively safe projects. This positive uncertainty-investment nexus is more likely for high growth projects than for low growth projects.

In his empirical study, Aizenman (1992) shows that nominal exchange rate uncertainty is more likely to discourage investment than real uncertainty. Also, Bacchetta and van Wincoop (2000) found that the size of net capital flows is higher under a more stable exchange rate regime. In addition, Servén (2003) stated that investors will be less motivated to invest in an economy with high exchange rate uncertainty. He found that the impact of real exchange rate uncertainty on investment in developing countries depends on their degree of openness to trade. More open developing countries suffer more from real exchange rate uncertainty than less open ones. In a recent study, Bahmani-Oskooee and Hajilee (2013), using a sample of 36 countries, found that exchange rate uncertainty has significant short-run effects on domestic investment in 27 of the 36 countries. They also found that the short-run effects are translated into the long-run effects in only 12 countries.

Owing to the fact that domestic investment is essential for achieving sustainable economic growth, full employment, intensive poverty reduction and income equality, we re-assess the impact of real exchange rate uncertainty on domestic investment by focusing on Ghana, a developing country currently experiencing slow economic growth. Apart from Bahmani-Oskooee and Hajilee (2013), the previous studies failed to differentiate long-run impacts of exchange rate uncertainty from short-run impacts. We focus on Ghana for two main reasons. Firstly, apart from Kyereboah-Coleman and Ayigbe-Tettey (2008), who examined the impact of real exchange rate volatility on foreign direct investment (FDI) in Ghana, no study focuses specifically on the impact of exchange rate uncertainty on domestic investment. Secondly, Ghana has experienced episodes of frequent real depreciations (undervaluations), and appreciations (overvaluations) thereby, providing an excellent case study for examining the exchange rate uncertainty-domestic investment relationship. From 1957–1982, the country practised a fixed exchange regime, which led to an overvalued Cedi, deteriorating economic performance, excessive import of finished goods, falling domestic investment and balance-of-payment crisis (see
Baffoe-Bonnie, 2004; Iyke & Ho, 2017). To realign the exchange rate, Ghana undertook a series of devaluation exercises between 1983–1986 under the Economic Recovery Programme and the Financial Sector Adjustment Programme (Baffoe-Bonnie, 2004; Iyke & Ho, 2017). From 1986 onwards, Ghana gradually shifted from a fixed exchange regime to a managed-float regime (see Iyke & Ho, 2017). Ever since the managed-floating regime replaced the fixed exchange regime, the country’s currency, the Cedi, became volatile. Hence, we aim to assess how the volatility in the Cedi has influenced domestic investment in the country. Ideally, our data should have started from 1986, when the country officially started shifting from a fixed exchange regime to a managed-float regime, in order to avoid regime-shifts from influencing the empirical results. However, this will shorten the data size and bias the coefficient estimates. Nevertheless, the empirical result presented does not show evidence of structural instability. Therefore, regime-shifts do not appear to be driving the results.

As a preview of our results, we found that exchange rate uncertainty has differential impacts on domestic investment in the short run. In other words, the short-run results suggest that, while the current level of uncertainty enhances investment, previous levels of uncertainty dampen investment. In the long run, exchange rate uncertainty has a positive impact on domestic investment. These findings appear to be robust to alternative specifications of the model. We then offered some explanations of these results. The rest of the paper is organised as follows. Section 2 presents the methodology. Section 3 reports the empirical results. Section 4 concludes the paper.

2. Methodology

2.1. Empirical specifications
We closely follow the literature and formulate domestic investment as a function of real domestic income, the nominal interest rate and the real exchange rate (see Bahmani-Oskooee & Hajilee, 2013). We then include a measure of real exchange rate uncertainty in order to examine whether uncertainty influences domestic investment. Ghana’s investment model will be of the form:

$$\ln I_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 r_t + \alpha_3 \ln \text{RER}_t + \alpha_4 \text{VOL}_t + \mu_t,$$

where $I$ is a measure of domestic investment; $Y$ is the real income, which is measured as real GDP; $r$ is the nominal interest rate; RER is the real effective exchange rate between Ghana and the rest of the world—an increase in RER denotes real appreciation and a decrease real depreciation of the Ghana Cedi; VOL is a measure of real exchange rate uncertainty to be explained later; ln is the natural logarithm operator; $\alpha$ are the coefficients of the model; $\mu$ is the white-noise error term; $t$ denotes the time subscript.

In line with the theory, positive growth in the real income should create optimism among investors regarding the economy, thereby, leading to a boom in domestic investment. The reverse is true, other things unchanged. Hence, we expect $\alpha_1$ to be positive. An increase in the nominal interest rate should raise the cost of borrowing and decrease the level of investment in economy. The estimated value of $\alpha_2$ should be negative. Changes in the real exchange rate have an ambiguous effect on domestic investment (see Alexander, 1952). Hence, the value of $\alpha_3$ could be either positive or negative. Finally, like the real exchange rate, exchange rate uncertainty could be either conducive or harmful to investment (see Abel, 1985; Bertola, 1998; Hartman, 1972; Servén, 2003). Therefore, the expected sign of $\alpha_4$ could be either positive or negative.

To differentiate short-run impact from long-run impact of exchange rate uncertainty on domestic investment, we reformulate Equation (1) as an error correction model. Although, other error correction mechanisms exist in the literature, Pesaran, Shin, and Smith (2001) proposes we use the ARDL bounds testing approach to reformulate Equation (1). This approach is empirically useful in our case because it does well in small samples and it does not require pretesting of the variables for unit roots. The ARDL specification of Equation (1) will be of the following form:
where $\epsilon_t$, $\beta$ and $\delta$ are the white-noise error terms, the short-run and the long-run coefficients of the model, respectively; $\Delta$ is the first-difference operator; and $q$ is the maximum lag of the model. The short-run impacts of the variables on domestic investment are the coefficients of the first-differenced variables. For their long-run impacts on domestic investment, we set the non-first-differenced lagged component of Equation (2) to zero and normalised $\delta_2$ to $\delta_5$ on $\delta_1$.

The reliability of the estimates of Equations (1) and (2) are contingent on the joint significance of the coefficients $\delta_1, \delta_2, \delta_3, \delta_4$ and $\delta_5$. In other words, the variables in Equation (2) should be cointegrated in order to ensure that the coefficients are efficiently estimated. We can verify the existence of cointegration by testing the hypothesis that $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$. Pesaran et al. (2001) calculate two sets of critical values under this null hypothesis. The first set of critical values are calculated by assuming that the variables in Equation (2) are integrated of order zero, $I(0)$, while the second set are calculated by assuming that they are integrated of order one, $I(1)$. We can reject the presence of cointegration if the calculated $F$-statistic is smaller than the first set of critical values. Similarly, we fail to reject the presence of cointegration if the calculated $F$-statistic is larger than the second set of critical values. The test is inconclusive if the calculated $F$-statistic lies in-between both sets of critical values.

2.2. Data

The results presented in what follows are based on an annual data covering the period 1980–2015. The restriction of data to this period is due to lack of observations on the real effective exchange rate (RER) before 1980. More importantly, Ghana began its roadmap to trade and exchange rate liberalisation from 1983. Therefore, the exchange rate is unlikely to be volatile before 1983, since the exchange regime then was largely fixed (see Baffoe-Bonnie, 2004; Iyke & Ho, 2017). The RER is the real effective exchange rate index (2010 = 100) taken from the International Financial Statistics (IFS) database compiled by the IMF. We constructed our main measure of real exchange rate uncertainty, VOL, out of the log of RER spanning the period 1980:01–2015:12. Following other studies such as West and Cho (1995), and Bahmani-Oskooee and Xi (2011), VOL is calculated as the monthly conditional variance of GARCH (1, 1). The yearly average of this monthly index is used as VOL. To ensure that our results are not sensitive to the choice of the real exchange rate uncertainty measure, we calculated another measure, VOL SD, and used it in the empirical analysis as a robustness check. The nominal interest rate, $r$, is measured as the 91-day Treasury bill rates. Data on this variable for the period 1987–2015 is taken from the Bank of Ghana’s Monetary Time Series Data. Since observations are not available for this variable during the period 1980–1987, we supplement this period with Central Bank Policy Rates taken from the IFS. The summary statistics of these variables are shown in Table 1. In what follows, we report and discuss the empirical results.

\[
\Delta \ln I_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i} \Delta \ln I_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta \ln Y_{t-i} + \sum_{i=0}^{q} \beta_{3i} \Delta r_{t-i} + \sum_{i=0}^{q} \beta_{4i} \Delta \ln RER_{t-i} \\
+ \sum_{i=0}^{q} \beta_{5i} \Delta VOL_{t-i} + \delta_1 \ln I_{t-1} + \delta_2 \ln Y_{t-1} + \delta_3 r_{t-1} + \delta_4 \ln RER_{t-1} + \delta_5 VOL_{t-1} + \epsilon_t, 
\]
3. Empirical results

3.1. The main results

The ARDL approach does not require pretesting of the variables to establish stationarity. The variables can be either I(0), I(1) or mixed-integrated processes. Since the variables considered here are known empirically to exhibit these integration properties, we do not test for unit roots. Because the results in the error correction model in Equation (2) are sensitive to lag choices, we followed the literature and restricted the maximum lag in the model to four and used the Akaike information criterion (AIC) to select the optimal lags to be included for each variable (see Bahmani-Oskooee & Hajilee, 2013; Halicioglu, 2007; Tang, 2007). The estimated short- and long-run results following these restrictions are reported in Table 2. The selected model is ARDL (1, 3, 2, 4, 3). The bottom of Table 2 displays the diagnostic tests. The model must pass these tests in order for the coefficients to be reliable. The diagnostic tests are: The LM, RESET, BPG, CUSUM and CUSUMSQ tests. These tests suggest that there is structural stability, no serial correlation and heteroscedasticity, and no functional mis-specification of the investment model, implying that the results are reliable. Also, the estimated error correction term is negative and statistically significant, indicating the presence of cointegration. The presence of cointegration is further supported by the calculated $F$-statistic, which is greater than the upper bound critical values at 1%.3

Now let us examine the coefficient estimates. The short-run results show that real exchange rate uncertainty has differential impacts on domestic investment. While the current level of uncertainty enhances investment, previous levels of uncertainty dampen investment. However, in the long run, uncertainty has a positive impact on investment. Considering the other variables, real income has a persistent positive impact on domestic investment in the short run. The impact is reversed in the long run. The nominal interest rate has negative impact on investment in the short run, but a positive impact in the long run (see, also, Beccarini, 2007). Also, while the real exchange rate has differential effects on investment in the short run, its effect is negative on investment in the long run. This means that, in the short run, real depreciation of the Ghana Cedi may either enhance investment or harm it. However, in the long run, depreciations are conducive for domestic investment in the country. Finally, each year, a disequilibrium in domestic investment is correct at a rate of 89.6%.

### Table 1. Summary statistics

| Statistic | ln $I$ | ln $Y$ | $r$ | ln RER | VOL | VOL SD |
|-----------|-------|-------|-----|-------|-----|-------|
| Mean      | 1.212 | 10.244| 23.812 | 2.232 | 0.266 | 1.481 |
| Median    | 1.324 | 10.219| 21.775 | 2.088 | 0.1017 | 1.250 |
| Maximum   | 1.502 | 10.667| 47.880 | 3.563 | 2.763 | 3.802 |
| Minimum   | 0.528 | 9.9214 | 9.600 | 1.841 | 0.000 | 0.645 |
| Std. dev. | 0.263 | 0.223 | 10.410 | 0.418 | 0.626 | 0.712 |
| Skewness  | −1.259 | 0.370 | 0.794 | 1.899 | 2.795 | 1.614 |
| Kurtosis  | 3.535 | 2.036 | 3.018 | 5.713 | 10.034 | 5.131 |
| Jarque-Bera | 9.941 | 2.217 | 3.783 | 32.698 | 121.120 | 22.463 |
| p-value   | 0.006 | 0.330 | 0.150 | 0.000 | 0.000 | 0.000 |
| Sum       | 43.661 | 368.795 | 857.250 | 80.357 | 9.603 | 53.335 |
| Sum sq. dev. | 2.438 | 1.741 | 3793.535 | 6.138 | 13.753 | 17.748 |
| Observations | 36 | 36 | 36 | 36 | 36 | 36 |

Notes: Std. dev. and Sum sq. dev. denote, respectively, standard deviation and sum of squared deviations. ln denotes the natural log operator.
3.2. Sensitivity analysis

Are the above results robust to: (i) an alternative maximum lag, (ii) the choice of optimal lags for each variable, (iii) the measure of real exchange rate uncertainty, or (iv) a different estimation approach? We attempt to verify this question in this section. First, let us consider the results when we reduced the maximum lags to be included in the model from four to two. We used the AIC to select the optimal lags for each variable. The preferred model, in this case, is ARDL (1, 1, 0, 1, 0). The results are reported in Table 3. Looking at the diagnostic tests reported at the bottom of the table, it is clear that there is structural stability, no serial correlation and heteroscedasticity, and no functional misspecification of the investment model. Moreover, the error correction term indicates cointegration and convergence. These results are therefore, reliable. The current level of exchange rate uncertainty has a positive impact on domestic investment in the short run, similarly to the main results. In addition, the exchange rate uncertainty improves investment in the long run, consistent with the main results. Real income has a positive influence on domestic investment in the short run, but an insignificant impact in the long run. Both nominal interest rate and real exchange rate have no impact on domestic investment in the short run. However, in the long run, their impacts on domestic investment look identical to those reported in Table 2, namely: nominal interest rate affects domestic investment positively, while real exchange rate affects it negatively. Importantly, the reduction in the maximum number of lags allowed in the model did not affect the results much.

Now, what happens if we maintain the restrictions in Table 2 but select the optimal lags using the SIC? These results are reported in Table 4. Here the preferred model is ARDL (1, 1, 0, 1, 0). The results differ from the one using the AIC [ARDL (1, 1, 0, 1, 0)]. Obviously, the information criterion matters when determining the optimal lags for each variable in the model. Again, considering the diagnostic tests reported at the base of Table 4, it is clear that there is structural stability, no serial correlation and heteroscedasticity, and no functional misspecification of the investment model. Similarly, the calculated F-statistic shows evidence in support of cointegration, while the error correction term indicates convergence. Hence, these results are also reliable. The results suggest that exchange rate uncertainty has differential effects on domestic investment in the short run. The current level of exchange rate uncertainty has a positive influence on domestic investment, while the previous level
### Table 3. Results based on ARDL model restricted to two lags

| Lag | 0 | 1 | 2 |
|-----|---|---|---|
| **Selected model:** ARDL (1, 1, 0, 1, 0) | | | |
| **Short-run** | | | |
| Δln I | | | |
| Δln Y | 2.756 [3.094] | | |
| Δr | 0.001 [0.956] | | |
| Δln RER | −0.120 [−1.663] | | |
| ΔVOL | 0.144 [3.342] | | |
| ECM(−1) | −0.649 [−5.104] | | |
| **Long-run** | | | |
| Constant | 1.722 [5.110] | | |
| ln Y | 0.011 [0.060] | | |
| r | 0.004 [1.995] | | |
| ln RER | −0.798 [−3.160] | | |
| VOL | 0.256 [1.820] | | |
| **Diagnostics** | | | |
| Adj. R² | | | |
| F-statistic | 4.297 | 0.343 (0.563) | 3.004 (0.181) | 7.879 (0.343) | \( S \) \( S \) |

Notes: The values in the block parentheses are the \( t \)-statistics. \( p \)-values for the diagnostic tests are in the parentheses. \( S \) denotes stable.

### Table 4. Results based on optimal choice of lags using SIC

| Lags | 0 | 1 | 2 | 3 | 4 |
|------|---|---|---|---|---|
| **Selected model:** ARDL (1, 3, 1, 4, 2) | | | | | |
| **Short-run** | | | | | |
| Δln I | | | | | |
| Δln Y | 4.287 [4.265] | 2.197 [1.808] | 3.460 [3.036] | | |
| Δr | −0.000 [−0.259] | | | | |
| Δln RER | −0.855 [−7.188] | 0.420 [2.172] | 0.864 [4.889] | 0.090 [1.780] | |
| ΔVOL | 0.156 [1.926] | −0.281 [−3.685] | | | |
| ECM(−1) | −0.830 [−7.427] | | | | |
| **Long-run** | | | | | |
| Constant | 9.816 [7.427] | | | | |
| ln Y | −0.713 [−2.487] | | | | |
| r | 0.004 [2.918] | | | | |
| ln RER | −1.705 [−4.304] | | | | |
| VOL | 0.514 [2.726] | | | | |
| **Diagnostics** | | | | | |
| Adj. R² | | | | | |
| F-statistic | 8.825 | 0.081 (0.778) | 3.181 (0.206) | 7.730 (0.934) | \( S \) \( S \) |

Notes: The values in the block parentheses are the \( t \)-statistics. \( p \)-values for the diagnostic tests are in the parentheses. \( S \) denotes stable.
of uncertainty hurts it. In the long run, uncertainty enhances investment. Real income has a positive and persistent impact on domestic investment in the short run, but this becomes negative in the long run. Nominal interest rate has no impact on domestic investment in the short run. However, it has a positive impact on investment in the long run. Real exchange rate has differential effects on investment in the short run but its effect on investment in the long run is negative. Overall, these results are similar to the main results.

Will the results change if we use a different measure of real exchange rate uncertainty? To answer this question, we calculated an alternative measure of uncertainty using the annualised standard deviation method. We derived the annualised standard deviation of the log of monthly real effective exchange rate. We denoted this variable as VOL_SD and maintained the restrictions imposed on Equation (2) in Section 3.2. The estimates are reported in Table 5. The preferred model, in this case, is ARDL (2, 4, 3, 1, 4). As with the other results, there is structural stability, no serial correlation and heteroskedasticity, and no functional misspecification of the investment model, implying the estimates are reliable. Real exchange rate uncertainty has differential effects on domestic investment in the short run. In the long run, however, its effect is positive. Real income has differential effects on investment in the short run. It has no impact on investment in the long run. Similarly, nominal interest rate has differential effects on investment in the short run. In the long run, nominal interest rate has no impact on investment. Real exchange rate has a negative effect on domestic investment in the short and long run.

As an additional robustness check, we re-estimated the investment function using the vector error-correction modelling (VECM) approach. Unlike the ARDL approach, the VECM approach includes the same number of lags for each variable in the model. So, to avoid overfitting the investment function, we included a maximum of two lags for each variable in the model. The reliability of estimates obtained from this approach depends on the assumptions that the variables are cointegrated, there is not serial correlation and heteroskedasticity, the residuals are normally distributed, and that the specification is structurally stable. To ensure that these assumptions are fulfilled we performed a number of diagnostic tests. The results are shown at the bottom of Table 6. From these results, it is

| Lag | 0   | 1   | 2   | 3   | 4   |
|-----|-----|-----|-----|-----|-----|
| Short-run |     |     |     |     |     |
| ∆ln I | 0.244 [1.723] |     |     |     |     |
| ∆ln Y | 3.590 [3.493] | −2.117 [−1.803] | 2.006 [1.963] | −3.162 [−3.815] |     |
| ∆r | 0.000 [0.410] | −0.001 [−0.663] | −0.004 [−3.482] |     |     |
| ∆ln RER | −0.634 [−5.427] |     |     |     |     |
| ∆VOL_SD | 0.014 [0.422] | −0.001 [−0.042] | 0.091 [3.461] | −0.036 [−1.579] |     |
| ECM(−1) | −0.902 [−5.660] |     |     |     |     |
| Long-run |     |     |     |     |     |
| Constant | 0.180 [4.498] |     |     |     |     |
| ln Y | 0.203 [1.327] |     |     |     |     |
| r | 0.006 [3.973] |     |     |     |     |
| ln RER | −0.461 [−2.515] |     |     |     |     |
| VOL_SD | 0.160 [2.749] |     |     |     |     |
| Diagnostics |     |     |     |     |     |
| Adj. R² | 0.921 |     |     |     |     |
| F-statistic | 4.900 |     |     |     |     |
| RESET | 0.017 [0.896] |     |     |     |     |
| LM | 4.237 [0.120] |     |     |     |     |
| BPG | 15.744 [0.610] |     |     |     |     |
| CUSUM | S |     |     |     |     |
| CUSUMSQ | S |     |     |     |     |

Notes: The values in the block parentheses are the t-statistics. p-values for the diagnostic tests are in the parentheses. S denotes stable.
clear that the variables are cointegrated, there is no serial correlation and heteroscedasticity, the errors are normally distributed, and the function is structurally stable. Therefore, the corresponding coefficient estimates shown at the upper part of Table 6 are reliable. Looking at Table 6, we gather that both the short- and the long-run results are similar to those reported in the tables above. Real exchange rate uncertainty has differential impacts on domestic investment in the short run. In the long run, however, uncertainty has a positive impact on investment. Regarding the remaining variables, real income has a positive impact on investment in the short run, which reverses in the long run. The nominal interest rate has a negative impact on investment in the short run, which reverses in the long run. The real exchange rate has a negative impact on investment in the short run, which passes on to the long run. Finally, each year, a disequilibrium in domestic investment is correct at a rate of 83.0%.

In sum, the effect of exchange rate uncertainty on domestic investment appears to be robust to these alternative specifications. The results are generally consistent with existing studies such as Aizenman (1992), Wong (2007), and Bahmani-Oskooee and Hajilee (2013).

### 3.3. A synthesis of the main findings

Overall, the evidence brought forth in the empirical analysis suggests two things. Firstly, real exchange rate uncertainty has differential impacts on domestic investment in the short run. Specifically, the current level of uncertainty enhances investment, while the previous levels of uncertainty dampen investment. Secondly, real exchange rate uncertainty has a positive impact on investment in the long run. These conclusions are not at odds with the literature. The direction of the impact of real exchange rate uncertainty on investment remains divisive in theory. The direction can be positive or negative depending on the underlying assumptions regarding adjustment costs (see Dixit & Pindyck, 1994),

| Table 6. Results based on a VECM approach |
|------------------------------------------|
| Lags | 1 | 2 |
| Model: VECM(2) |
| Short-run |
| ΔlnI | 0.223 [2.189] | 0.288 [1.415] |
| ΔlnY | 2.903 [2.568] | 1.889 [0.452] |
| Δr | -0.001 [-0.531] | -0.003 [-1.343] |
| ΔlnRER | -0.528 [-2.657] | -0.355 [-1.071] |
| ΔVOL | 0.158 [2.148] | -0.008 [-0.238] |
| ECM(−1) | -0.830 [-2.658] |
| Long-run |
| Variable | Coefficient |
| Constant | 0.022 [0.606] |
| lnY | -0.777 [-3.874] |
| r | 0.005 [3.122] |
| lnRER | -1.729 [-6.139] |
| VOL | 0.891 [5.091] |
| Diagnostics |
| Adj. R² | 0.558 |
| χ² | 338.014 |
| LM | 22.254 |
| Joint JB | 8.422 |
| Stability | S |
| Trace | 19.574 |
| Max-eigen | 12.368 |
| Notes: χ² is the χ² statistic for the heteroscedasticity test, LM is the Lagrange multiplier statistic for serial correlation test, Joint JB is the joint Jarque-Bera statistic for the normality test, Stability denotes the status of the model based on the inverse roots of an autoregressive characteristic polynomial function (see Iyke, 2015). Trace and Max-Eigen are, respectively, the Trace and the Maximum eigen-value statistics for the Johansen cointegration test. S denotes stable.
risk-aversion (see Zeira, 1990), the degree of industry competition (see Caballero, 1991). Hartman (1972) and Abel (1985) document the fact that in the short run the current level of uncertainty enhances investment. According to these studies, uncertainty may promote the current level of investment by competitive risk-neutral firms in their attempts to prevent uncertainty in the future. An alternative explanation regarding the positive relationship between investment and real exchange uncertainty has been provided by Darby et al. (1999). In their study, they demonstrated that if a firm’s opportunity cost of waiting is higher than its present value or scrapping price, the firm will still invest under uncertainty. Along this line of reasoning, according to Wong (2007), higher uncertainty shortens the expected exercise time and thus, enhances investment for relatively safe projects. Furthermore, studies such as Cushman (1985, 1988), Sarkar (2000) have documented evidence in support of a positive relationship between exchange rate uncertainty and investment. The previous levels of uncertainty may affect investment negatively because if investors perceive that the uncertainty will persist, they will lower their investment portfolios (see Bertola, 1998; Jeanneret, 2007; Pindyck, 1988; Wong, 2007). Often, their reactions to exchange rate uncertainty may not be quick due to factors such as production and delivery delays, recognition lag, among other factors (see, Magee, 1973). Hence, although the impact of previous level of uncertainty on investment may be negative, this impact may also be weak. Finally, the positive impact of uncertainty on investment in the long-run is consistent with Cushman (1988), Wong (2007) and Bahmani-Oskooee and Hajilee (2013).

A caveat applies to our findings. Our measure of domestic investment—gross capital formation as a percentage of GDP—does not distinguish investment by foreign investors from domestic investors. Hence, it is complicated isolating the specific effects of local and foreign investors’ reactions to uncertainty. In reality, foreign and local investors perceive and react to uncertainty differently. This may be attributed to the fact that while foreign investors are less susceptible to nominal illusions including those induced by uncertainty owing to alternative investment avenues available to them, the same cannot be said for domestic investors. Therefore, a better measure of domestic investment, which explicitly controls for investment activities undertaken by foreign investors, would reveal a cleaner investment-uncertainty relationship. However, a measure of domestic investment, which purges foreign investor activities is not obtainable at least for the period considered in the study. In fact, World Bank argues that the quality of the data on our proxy for domestic investment (i.e. gross capital formation as a percentage of GDP), depends on the quality of government accounting systems, “which tend to be weak in developing countries” (World Bank, 2017). This reinforces the argument that it is difficult to obtain a near perfect measure of domestic investment in Ghana. In sum, although we presented dynamic links between domestic investment and uncertainty, it is important to understand these links beyond the face value of our empirical results. A better measure of domestic investment could provide interesting policy insights.

4. Conclusion
Apart from determining the direction of trade (i.e. exports and imports), the real exchange rate also performs a greater role in the movement of capital. The real exchange rate performs these roles by influencing other prices and returns to investment. Modern economies have adopted free-floating currencies with the aim of achieving market efficiency. However, floating currencies are susceptible to large appreciations or depreciations, introducing exchange rate risks and uncertainties. How do these uncertainties influence investment? Previous studies found that exchange rate uncertainty may promote or harm domestic investment—in fact, sometimes, these studies are inconclusive. Also, the extant literature tends to focus on the short-run effects of exchange rate uncertainty on investment, thereby neglecting the long-run effects. We re-visit the impacts of exchange rate uncertainty on investment by differentiating short-run impacts from long-run impacts. By focusing on Ghana due to reasons stated in the introduction of this paper, and using annual data covering the period 1980–2015, we found that exchange rate uncertainty has differential impacts on domestic investment in the short run. That is, while the current level of uncertainty enhances investment, previous levels of uncertainty dampen investment. In the long run, exchange rate uncertainty has a positive impact on domestic investment. These findings are robust to alternative specifications of our model.
Although, uncertainty may not be generally conducive for economic activities as documented extensively in various studies, our findings suggest that it may enhance domestic investment in particular. Policy-makers could be more concerned about short-term uncertainty, which appears to harm investment in Ghana. Besides, it is possible that this evidence may extend to developing countries with similar economic, political, demographic and institutional fundamentals like Ghana. Hence, the policy implication of our findings may carry over to such countries. A caveat of the evidence present in our study is that the dynamic links documented between investment and uncertainty may not be complete. This is because our measure of domestic investment, gross capital formation as a percentage of GDP, does not explicitly differentiate the quantity of investment attributable to foreign and local investors. Hence, the heterogeneous reaction of foreign and local investors to uncertainty is not purged from the investment-uncertainty nexus. While it is complex to control for the contribution of foreign investors to domestic investment in the present study due to lack of data, things may change in the future.

Acknowledgment
We thank Antonio David and two anonymous referees for their two rounds of comments which improved the paper substantially. We take full responsibility for any remaining errors.

Funding
The authors received no direct funding for this research.

Author details
Bernard Njindan Iyke¹
E-mails: benitoflex@gmail.com, bnjindan@deakin.edu.au
Sin-Yu Ho²
E-mails: hosy@unisa.ac.za, alicehosinyu@gmail.com

¹ Department of Finance, Deakin Business School, Deakin University, 221 Burwood Highway, Melbourne Burwood Campus, Victoria 3125, Australia.
² Department of Economics, University of South Africa, P.O. Box 392, UNISA 0003, Pretoria, South Africa.

Citation information
Cite this article as: Exchange rate uncertainty and domestic investment in Ghana, Bernard Njindan Iyke & Sin-Yu Ho, Cogent Economics & Finance (2017), 5: 1362157.

Notes
1. The Cedi was the official name of Ghana’s currency from 1965 until 2007 when it was renamed the Ghana cedi (see Dzokoto, Mensah, Twum-Asante, & Opere-Henaku, 2010).
2. These tests are, respectively, Ramsey’s Regression Equation Specification Error Test (RESET), the Lagrange Multiplier (LM) test, the Breusch-Pagan-Godfrey test for heteroscedasticity, the Cumulative Sum of Recursive Residuals (CUSUM) test and the Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) test (see Breusch, 1978; Breusch & Pagan, 1979; Brown, Durbin, & Evans, 1975; Godfrey, 1978; Ramsey, 1969).
3. The F-statistic is compared to Table CI (iii) Case III: Unrestricted intercept and no trend of Pesaran et al. (2001, p. 300) for four independent variables (i.e. k = 4).
4. We found evidence in support of at most two cointegration relationships among the variables using the Trace and Maximum eigen-value tests.

References
Abel, A. B. (1985). A stochastic model of investment, marginal Q and the market value of the firm. International Economic Review, 26, 305–322. https://doi.org/10.2307/2526585
Aizenman, J. (1992). Exchange rate flexibility, volatility, and domestic and foreign direct investment. International Monetary Fund Staff Papers, 39, 890–922. https://doi.org/10.2307/3658425
Alexander, S. S. (1952). Effects of a devaluation of trade balance. International Monetary Fund Staff Papers, 2, 263–278. https://doi.org/10.2307/3662618
Bacchetta, R. & van Wincoop, E. (2000). Does exchange-rate stability increase trade and welfare? American Economic Review, 90, 1093–1109. https://doi.org/10.1257/aer.90.5.1093
Baffoe-Bonnie, J. (2004). Dynamic modelling of fiscal and exchange rates policy effects in a developing country: A non-structural approach. Journal of Economic Studies, 31, 57–75. https://doi.org/10.1080/14647770310010516260
Bahmani-Oskooee, M., & Hajilee, M. (2013). Exchange rate volatility and its impact on domestic investment. Research in Economics, 67(1), 1–12. https://doi.org/10.1016/j.rie.2012.08.002
Bahmani-Oskooee, M., & Xi, D. (2011). Exchange rate volatility and domestic consumption: A multisupply analysis. Journal of Post Keynesian Economics, 34, 319–330. https://doi.org/10.2753/PKE0160-3477340207
Beccarini, A. (2007). Investment sensitivity to interest rates in an uncertain context: Is a positive relationship possible? Economic Change and Restructuring, 40, 223–234. https://doi.org/10.1016/j.sit.2004-007-9025-1
Bertola, G. (1998). Irreversible investment. Research in Economics, 52, 3–37. https://doi.org/10.1006/rece.1997.0153
Breusch, T. S. (1978). Testing for autocorrelation in dynamic linear models. Australian Economic Papers, 17, 334–355. https://doi.org/10.1111/j.1467-8454.1978.tb00635.x
Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroskedasticity and random coefficient variation. Econometrica, 47, 1287–1294. https://doi.org/10.2307/1911963
Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the constancy of regression relations over time. Journal of the Royal Statistical Society, Series B, 37, 149–163.
Caballero, R. (1991). On the sign of investment-uncertainty relationship. American Economic Review, 81, 279–288.
Caballero, R. J.; Corbo, V. (1989). The effect of real exchange rate uncertainty on exports: empirical evidence. The World Bank Economic Review, 3, 263–278. https://doi.org/10.1093/wber/3.2.263
Chowdhury, A. R. (1993). Does exchange rate volatility depress trade flows? Evidence from error- correction models. Review of Economics and Statistics, 75, 700–706. https://doi.org/10.2307/2110025
Cushman, D. O. (1985). Real exchange rate risk, expectations, and the level of direct investment. Review of Economics and Statistics, 67, 297–307. https://doi.org/10.1093/wber/3.2.263
Cushman, D. O. (1988). Exchange rate uncertainty and foreign direct investment in the United States. Weltwirtschaftliches Archiv, 124, 322–336. https://doi.org/10.1007/BF02706782

Dorby, J., Hallett, A. H., Ireland, J., & Piscitelli, L. (1999). The impact of exchange rate uncertainty on the level of investment. The Economic Journal, 109, 55–67. https://doi.org/10.1111/ecoj.1999.109.issue-454

De Vita, G., & Abbott, A. (2004). Real exchange rate volatility and US exports: An ARDL, bounds testing approach. Economic Issues, 9, 69–78.

Dixit, A., & Pindyck, R. (1994). Investment under uncertainty. Princeton, NJ: Princeton Press.

Dzokoto, V. A. A., Mensah, E. C., Twum-Assante, M., & Opare-Henaku, A. (2010). Deceiving our minds: A qualitative exploration of the money illusion in post-redenomination Ghana. Journal of Consumer Policy, 33, 339–353. https://doi.org/10.1007/s10603-010-9144-3

Godfrey, L. G. (1978). Testing against general autoregressive and moving average error models when the regressors include logged dependent variables. Econometrica, 46, 1293–1301. https://doi.org/10.2307/1913829

Halicioglu, F. (2007). The J-curve dynamics of Turkish bilateral trade: A cointegration approach. Journal of Economic Studies, 34, 103–119. https://doi.org/10.1108/01443580710745362

Hartman, R. (1972). The effect of price and cost uncertainty on investment. Journal of Economic Theory, 5, 258–266. https://doi.org/10.1016/0022-0531(72)90105-6

Iyke, B. N. (2015). Electricity consumption and economic growth in Nigeria: A revisit of the energy-growth debate. Energy Economics, 51, 166–176. https://doi.org/10.1016/j.eneco.2015.05.024

Iyke, B. N., & Ho, S. Y. (2017). The real exchange rate, the Ghanaian trade balance, and the J-curve. Journal of African Business, 18, 380–392. https://doi.org/10.1080/15289162017.1315706

Jeanneret, A. (2007). Foreign direct investment and exchange rate volatility: A non-linear story. SSRN e-Library.

Kyme, J. R. (2007). Foreign direct investment and exchange rate volatility: A non-linear story. SSRN e-Library.

Kyereboah-Coleman, A., & Agirey-Tettey, K. F. (2008). Effect of exchange-rate volatility on foreign direct investment in Sub-Saharan Africa: The case of Ghana. The Journal of Risk Finance, 9, 52–70. https://doi.org/10.1080/15265940810842410

Magee, S. P. (1973). Currency contracts, pass-through, and devaluation. Brookings Papers on Economic Activity, 1, 303–325. https://doi.org/10.1007/2534091

McDonald, R. L., & Siegel, D. (1986). The value of waiting to invest. Quarterly Journal of Economics, 101, 707–727. https://doi.org/10.1111/j.1468-0297.1986.tb05420.x

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approach to the analysis of level relationships. Journal of Applied Econometrics, 16, 289–326. https://doi.org/10.1002/1099-1050(200105)16:3<289::AID-JAE1050>3.0.CO;2-6

Pindyck, R. S. (1988). Irreversible investment, capacity choice, and the value of the firm. American Economic Review, 78, 969–985.

Ramsey, J. B. (1969). Tests for specification errors in classical linear least squares regression analysis. Journal of the Royal Statistical Society Series B, 31, 350–371.

Sarkar, S. (2000). On the investment-uncertainty relationship in a real options model. Journal of Economic Dynamics and Control, 24, 219–225. https://doi.org/10.1016/S0165-1889(99)00005-6

Servén, L. (2003). Real-exchange-rate uncertainty and private investment in LDCs. Review of Economics and Statistics, 85, 212–218. https://doi.org/10.1162/rest.2003.85.3.212

Tong, T. C. (2007). Money demand function for Southeast Asian countries: An empirical view from expenditure components. Journal of Economic Studies, 34, 476–496. https://doi.org/10.1108/014435807107830952

West, K. D., & Cho, D. (1995). The predictive ability of several models of exchange rate volatility. Journal of Econometrics, 69, 367–391. https://doi.org/10.1016/0304-4076(94)01654-I

Wong, K. P. (2007). The effect of uncertainty on investment timing in a real options model. Journal of Economic Dynamics and Control, 31, 2152–2167. https://doi.org/10.1016/j.jedc.2006.07.002

World Bank. (2017). Gross capital formation (% of GDP). Retrieved from https://data.worldbank.org/indicator/NE.GDI.TOTL.Z

Zeira, J. (1990). Cost uncertainty and the rate of investment. Journal of Economic Dynamics and Control, 14, 53–63. https://doi.org/10.1016/0165-1889(90)90005-2

© 2017 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.

You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.