MACROECONOMIC UNCERTAINTY AND PRIVATE INVESTMENT: THE CASE OF POLAND

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Abstract

Analysis of investment decisions is an important macroeconomic subject due to the role of fluctuations in investments on the economic performance. It is argued that investment models need to take this effect into account if uncertainty has an impact on investment. Therefore, the effects of uncertainty on investments have recently been analyzed in the theoretical and empirical literature. While developing economies face more uncertainty than industrial countries do, most empirical studies consider the uncertainty-investment relationship for developed counties. In this paper, we analyzed the effect of the macro economic uncertainties on private investment in a developing county: Poland. We constructed a generalized autoregressive conditional heteroskedasticity (GARCH) model to measure uncertainties. Then, we employed the bound testing procedure to cointegration analysis. Since our findings indicate a long-term relationship of the variables, we adopt an error correction model to capture the dynamic relationship. Our estimates imply that the real exchange rate, inflation and growth uncertainties effect private investments negatively in Poland. Therefore, we can conclude that macroeconomic stabilization is a necessary condition for the continuity of investments in Poland.

***Keywords**:* Private Investment, Inflation Uncertainty, Exchange Rate Uncertainty, Bound Testing, Poland
JEL Classification: E2; E6

MAKRO EKONOMİK BELİRSİZLİK VE ÖZEL YATIRIMLAR: POLONYA ÖRNEĞİ

Öz

Yatırım kararlarının analizi, yatırımlardaki dalgalanmaların ekonomik performans üzerindeki etkileri nedeniyle önemli makro ekonomik konulardan biridir. Belirsizliğin yatırım kararları üzerinde etkisi varsa, yatırım modellerinin bu etkiyi dikkate almaları gerektiği ileri sürülmektedir. Bu nedenle, son zamanlarda belirsizliğin yatırımlar üzerindeki etkisi teorik ve ampirik literatürde analiz edilmektedir. Gelişmekte olan ülkeler, gelişmiş ülkelere göre daha fazla belirsizlik ile karşı karşıya olmalarına rağmen, belirsizlik ve yatırım ilişkisi üzerine mevcut literatürün çoğu gelişmiş ülkeleri ele almaktadır. Bu çalışmada gelişmekte olan bir ülke olan Polonya'da makro ekonomik belirsizliklerin özel yatırımlar üzerindeki etkisini analiz ettik. Belirsizliği ölçmek için genelleştirilmiş otoregresif koşullu değişen varyans (GARCH) modeli kurduk. Sonra eşbütünleşim analizi için sınır testi yaklaşımını uyguladık. Değişkenler arasında uzun dönemli ilişki bulunduğundan, dinamik ilişkiyi görmek için hata düzeltme modeli kullandık. Sonuçlarımız, Polonya'da reel döviz kuru, enflasyon ve büyüme belirsizliklerinin özel yatırımları negatif yönde etkilediğini göstermektedir. Böylece, Polonya'da makro ekonomik istikrarın yatırımları devamlılığı için gerekli bir koşul olduğu sonucuna vardık.

Anahtar Kelimeler: Özel Yatırımlar, Enflasyon Belirsizliği, Döviz Kuru Belirsizliği, Sınır Testi, Polonya
JEL Sınıflandırması: E2; E6

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1. Introduction

In the theoretical literature, it is argued that macroeconomic uncertainties can effect investments with different mechanisms. However, there is not any consensus on the direction of the effect of uncertainty on investments. Some papers state that *price uncertainty* may cause an increase in the expected profitability of the capital. Thereby the level of capital stock and investments will increase (see. Hartman, 1972; Abel, 1983; Lee, 2016). They assume that investors are risk-neutral. In other respect, Dixit and Pindyck (1994) argue that most of investment projects are irreversible. That is, once capital has been established, it is necessary to undergo a serious cost so that it can be used in a different project. Because of irreversibility and adjustment costs of investments that are under uncertainty, investors try to avoid taking wrong actions and prefer to wait until more information of the investment projects is revealed. This is called as the option value of waiting. In this case the downward adjustment may require a higher adjustment cost than the upward adjustment. How irreversibility changes the impact of uncertainty on investments depends on the competition-related or returns to scale-related assumptions (McDonald and Siegel, 1986; Pindyck, 1991). Another approach states that uncertainty increases default risks and this makes external financing more expensive, which can lead to investment contraction (Gilchrist et al., 2014). When investors avoid risk, uncertainty has a negative effect on investments (Zeira, 1990). In addition, the value of uncertainty might be important. The effect that is positive when uncertainty is low can be negative when the uncertainty exceeds a certain level (Sarkar, 2000). Shortly according to the assumptions, theoretical approaches foresee different relationships between uncertainty and investments, which is therefore an empirical question.

Macroeconomic uncertainties influence investment decisions by different ways. For example, exchange rate uncertainties make it difficult to predict the relative advantages of investing in traded or non-traded goods sectors. In addition, because the investment is highly depended on import content in developing countries, exchange rate uncertainty makes it difficult to estimate the cost of new investment for investors. Therefore, especially in developing countries where real exchange rates tend to exhibit higher volatility, increased real exchange rate uncertainty makes price signals less informative for profitable investment decisions and likely to complicate taking the right investment decisions. Pindyck and Solimano (1993) and Darby et al. (1999) argued that uncertainties in real exchange rates affect investments negatively. The degrees of openness of the economy and development level of the financial markets are some factors that affect this relationship. It is plausible that the impact is bigger in more open economies and economies with underdeveloped financial markets (see Easterly et al., 2000).

Investment decisions can be affected by uncertainty about different macroeconomic variables. For example, inflation generally seems as a general indicator of the macroeconomic situation of the country. Therefore, the inflation uncertainty may be regarded as an indicator of macroeconomic stability (Eberly, 1993). Many developing countries suffer from high and volatile inflation and it is expected that inflation uncertainties have a contractionary pressure on investment. That is why, investors may regard inflation uncertainty as the government's control over the economy is not strong and they perceived this case as risky, which makes investments reduce. Another view states that inflation and investment relationship is positive. In economies where inflation is high and prices are volatile, an increased marginal profitability of capital leads to an increase in investments. The change in output growth in developing economies also affects investments. Growth uncertainty represents the unpredictability of demand and it is likely to have an adverse effect on investment.

Since theoretical analyzes reveal different approaches to uncertainty and investment relationship, this paper analyzes the effect of real exchange rate, growth and inflation uncertainties on private investment in a developing country: Poland. Most studies about uncertainty and investment relationship focus on developed counties and cross-country analyzes. There is relatively less research about developing countries and country specific analyzes. However, developing economies face more macroeconomic uncertainty than industrial countries do. Uncertainty is a fundamental concern for these economies. In this sense, this study aims to contribute to the literature by analyzing the theoretically ambiguous uncertainty-investment relationship for a developing country: Poland.

Since 1989 Poland has been in progress of a transition to market economy from planned economy. Massive reforms were implemented to aim price and trade liberalization, macroeconomic stabilization, privatization, and institutional reforms. In 1990, price controls on most products were removed. In the new system, prices were to play an informational role to identify the real cost of capital. In 1991 the National Bank of Poland decided to abandon the fixed exchange rate regime and adopted the crawling peg instead. In 1998, central bank of Poland adopted inflation targeting and in 2000, central bank let the currency to float. Poland involved some international politics and economic organizations. In 1995, Poland became a member of World Trade Organization. In 1996, Poland joined the Organization of Economic Co-operation and Development (OECD) and in 2004 it ascended to full membership of the European Union (EU). In line with above developments, Poland's investment climate has improved. Since 2007, Poland's economy has grown over the EU's average growth rate. In this study we explore whether investors concern macroeconomic uncertainties in this one of the most dynamically growing developing economy.

The rest of the article organized as follows: In Section 2 we briefly provide an investment theory, introduce the literature and measuring uncertainty. Section 3 explains the methodology and data. Section 4 reports estimation and empirical results and Section 5 concludes the paper.

2. Macroeconomic Uncertainty and Investment

2.1. Investment Theory

According to Keynes (1936) investments can be explained by the marginal efficiency of capital and interest rate. The increase in the interest rate implies an increase in the opportunity cost of investments and this cause a decrease in investment. After Keynes, the investment theory was associated to growth models and this accelerator theory states that changes in the output linearly affects investments. According to this theory expectations have no role to determine investment. Another view, which is neoclassical approach, assert that desired level of capital stock depends on the level of output and the user cost of capital. However, the assumptions of this approach such as perfect competition and static expectations have been criticized. In another approach, Tobin (1969) was linked investment with the ratio of the market value of physical assets to its replacement cost. This is known as Tobin's q. When the ratio is higher than one, it implies that a firm earning a higher rate than its replacement cost, and firms decide to increase their investments. MacDonald and Siegel (1986), Dixit and Pindyck (1994) have emphasized that in the case of irreversibility, investments can be affected by uncertainty. Namely, when uncertainty increases, the option value of waiting rise and investors decide to delay their investments.

2.2. Literature Review

Empirical studies mainly focus on the effects of a single uncertainty indicator on investment. Papers that deal with uncertainties in the real exchange rate generally show that the uncertainty in the exchange rate has a constrictive effect on investment. For example, Serven (2003) uses a GARCH procedure to measure real exchange rate uncertainty and estimates the GMM system. He shows that exchange rate uncertainty negatively affects investments in 61 developing countries. In addition, Serven (2003) argues that there is a threshold effect, namely uncertainty has influence only if it exceeds a critical level. Darby et al. (1999) investigate five OECD countries using the Dixit-Pindyck model. They show that exchange rate volatility can have a negative impact on investment. Pradhan et al. (2004) shows that the real exchange rate uncertainty and investment relationship is inconclusive for four developing countries. Real exchange rate uncertainty is estimated by GARCH specification. They perform cointegration tests then they estimate an error correction model.

Byrne and Davis (2005) find that exchange rate volatility negatively effects the investment for a group of developed economies. They also use GARCH method as a measurement of uncertainty.

Besides the studies examining specifically exchange rate uncertainty and investment relationship, Serven and Solimano (1993) analyzed the impact of these uncertainty measures on private investment. They concluded that inflation and exchange rate uncertainties have a negative effect on investment. Similarly, Serven (1998) considers alternative measures of macroeconomic uncertainty (e.g. inflation, exchange rate, growth, terms of trade). Then he uses various panel data econometric methods to estimate investment equation and shows that macroeconomic uncertainty is affecting investments in developing countries negatively. Federer (1993) uses the risk premium to measure uncertainty. He estimates a neoclassical and Tobin's Q investment models. He also shows that macroeconomic uncertainty is effective in the negative direction on investments in US. Demir (2009) considers the effect of macroeconomic uncertainty and country risk on real investment. Inflation and real exchange rate uncertainties are measured by GARCH method. Then he estimates a GMM model. He finds that macroeconomic uncertainty significantly decreases the investment of industrial firms in three developing countries. Some papers analyzed the non-linear effects of uncertainty. Saman (2010) obtained uncertainty measure from a GARCH model. Then he used GMM estimation procedure and finds that inflation and exchange rate uncertainties reduce investment in Romania using linear model. He also shows that this relationship consistent with non-linear model. Lensink (2002) obtained uncertainty by the unconditional standard deviation of stock market returns. His research showed that in developed countries the effect of uncertainty on investments chances according to the size of the uncertainty. Accordingly, the low level uncertainty affects investments positively, while high uncertainty affects negatively.

2.3. Measuring Uncertainty

In the literature, different methods are used to measure uncertainty (see Lensink, 2002) and several sources of uncertainties are considered. One approach to measure macroeconomic uncertainty is using the conditional volatility of the variable. Another method of measuring uncertainty is using moving average based volatility (a measure of unconditional volatility). Evans (1991) states that some of the measures of variability are not a good indicator of uncertainty. Since economic agents use available information set to form their expectations, measure of variability should be identified conditionally on some information set. Therefore, it is not a suitable way to measure uncertainty by methods depending on using variability of observed variables. Recently to solve this issue empirical papers analyzing the impact of uncertainty have been modeling relevant variables as autoregressive conditional heteroscedasticity (ARCH) or generalized autoregressive conditional heteroskedasticity (GARCH) process. Byrne and Davis (2005) stated that GARCH model (which measures conditional volatility) emphasized periods of volatility, which might be expected to maximize uncertainty. In addition, Serven (1998) stated that conditional volatility provides the closest measure of uncertainty. Hence the advantages of the GARCH models can be summarized as follows (see Grier and Perry 2000): First, with these models, the variance of unpredictable innovations in variables can be estimated, which is a good indicator of the uncertainty. Secondly, the GARCH approach can be used to estimate the conditional mean and the conditional variance of variables simultaneously, which is more efficient than a two-step method (Hasanov, 2011). In the literature some studies focus aggregate uncertainty instead of individual uncertainty index. For example, Gan (2014) and Erdem and Yamak (2016) provide an aggregate uncertainty index reflecting the general macroeconomic uncertainty. Similarly, Atta-Mensah (2004) constructs an economic uncertainty index using estimated volatilities by the GARCH model. In addition to macroeconomic uncertainty, economic policy uncertainty is also considered and Baker et al. (2015) developed an index of economic policy uncertainty.

In this study, with regard to the source of uncertainty we consider the uncertainty of Euro (EUR)/Zloty (PLN) (unc_eur) and that of American Dollar (USD)/PLN (unc_usd) exchange rates, inflation uncertainty (unc_inf) and growth uncertainty (Unc_g). We chose to use the generalized autoregressive conditional heteroskedasticity (GARCH) approach for the above reasons to obtain each of the uncertainty variables. The variance of the unforeseen part of the GARCH model is taken as uncertainty:

$$y_t = \beta_0 + \sum_{j=1}^{q} \beta_j y_{t-1} + \varepsilon_t \quad (1)$$

$$h_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1}^2 \quad (2)$$

where y_t is the variable the volatility of which we desire to find, ε_t is stochastic processes with zero mean and h_t is its conditional variance. We estimate ARCH(1) and GARCH(1,1) models, then we chose GARCH model according to Akaike Information Criteria (AIC). Eq. (2) implies that the residuals of the inflation, real exchange rate and growth equations follow a GARCH(1,1) process provided by Bollerslev (1986). The above two-equation model was estimated to find each uncertainty variables. We take the conditional variances from Eq. (2) as a measure of uncertainty of y_t. The estimates can be seen from the Table 1. The residual diagnostic tests (Ljung-Box Q statistics) are provided in Table 2 and the estimates show that our models are satisfactory.

Table 1: **Results of GARCH Model**

	Estimates of the Exchange Rate Equation (EUR)	**Estimates of the Exchange Rate Equation (USD)**	**Estimates of the Growth Equation**	**Estimates of the Inflation Equation**
Constant	0.520*	0.034	2.003**	0.064
y_{t-1}	0.710*	0.922*	1.061*	1.360*
y_{t-2}	0.029	0.020	-0.054	-0.264
y_{t-3}	0.027	-0.198	-0.279	-0.067
y_{t-4}	-0.127	0.108	-0.409***	-0.470*
y_{t-5}		0.125	0.497**	0.482*
y_{t-6}			-0.091	-0.055
y_{t-7}			-0.111	-0.049
y_{t-8}				-0.279**
y_{t-9}				0.266*
Variance Equations				
α_0	0.001	0.001*	1.017	0.349**
α_1	0.304	-0.108*	0.024	0.495***
α_2	0.598**	1.099*	0.815**	-0.281

Note: *, ** and *** denote significance at 1%, 5% and 10% levels respectively.

Table 2: **Residual Diagnostic Tests of GARCH Model**

	Exchange Rate Equation (EUR)	Exchange Rate Equation (USD)	Growth Rate Equation	Inflation Rate Equation
Q_4	1.035	1.105	0.930	2.416
	(0.904)	(0.894)	(0920)	(0.660)
Q_{12}	7.293	11.559	7.929	5.885
	(0.838)	(0.482)	(0.791)	(0.922)
Q_4^2	6.651	1.049	2.929	3.323
	(0.156)	(0.902)	(0.570)	(0.505)
Q_{12}^2	10.129	4.898	7.571	11.833
	(0.605)	(0.961)	(0.818)	(0.459)

Notes: Q_4 is the fourth order Ljung-Box test for standardized residuals. Q_{12} is the 12th order Ljung-Box test for standardized residuals. Q_4^2 is the fourth order Ljung-Box test for squared standardized residuals. Q_{12}^2 is the 12th order Ljung-Box test for squared standardized residuals. p-values are provided in parenthesis.

3. Data and Methodology

In order to examine the relationship among three types of uncertainties and investment, we use quarterly data for the period of 1999:Q1-2014:Q4[2]. In Model 2, in addition to the real interest rate, we include the relative price of capital and domestic credit to private sector, which allow us to measure the cost of the capital. Hence we estimated the two models shown below:

$$I_t = f(I_{t-1}, r_t, rgdp_t, rgdp_{t-1}, unc_t) \qquad \text{(Model 1)}$$

$$I_t = f(I_{t-1}, r_t, rgdp_t, rgdp_{t-1}, relp_t, crd_t, unc_t) \qquad \text{(Model 2)}$$

where I is the private investment to GDP, r is the real interest rate, $rgpd$ is the log of current real GDP, unc the variables measuring the uncertainty. As an uncertainty measure, our model includes inflation uncertainty, growth uncertainty, and real exchange rate uncertainty. The nominal exchanges between EUR-PLN and USD-PLN are used in present analyze. To achieve the real exchange rate against EUR, the log of nominal exchange rate is multiplied by the Euro Area consumer price index and divided by the domestic price index. Similarly, we use United State consumer price index to measure the real exchange rate against USD. The real interest rate implies the cost of capital goods, and measured as $r = ln[(1+i)/(1+\pi)]$ where π is the inflation rate and i presents the nominal interest rate. A rise in the real interest rate reduces the demand for capital. Therefore the coefficient of the real interest rate is expected to be negative. Due to the accelerator effect, our model includes both the current and lagged values of real GDP. ($Real\ GDP = Nominal\ GDP/(GDPDeflator/100)$. We obtained all the above data from International Financial Statistics (IFS) published by International Monetary Fund (IMF). In Model 2, in addition, the investment function includes the relative price of capital ($relp = Investment\ Deflator/GPD\ Deflator$), which also measures the user cost of capital. When this cost is low, investments tend to increase and vice versa. We obtain this data from *Penn World Table* and we interpolate this data from annual to quarterly. Serven (1998) argued that since the interest rates on most of the emerging markets cannot be determined in the market, non-price rationing mechanism is used in these financial markets. In this sense, he suggests inclusion of domestic credit to private sector relative to nominal GDP variable to measure the tightness of credit market (crd). This data are taken from *World Development Indicators*. It is expected that an increase in the domestic credit to private sector affects investments positively.

4. Results

First, in order to establish a basis for further testing, each variable was tested for stationary. The results of the augmented Dickey–Fuller tests are presented in Table 3 and show that while investment, inflation uncertainty and growth uncertainty variables are $I(0)$, other variables are $I(1)$ and the first difference of all variables are $I(0)$. Next, we use the bound testing approach developed ARDL framework by Pesaran and Shin (1999) and Pesaran et al. (2001). This method allows us to see if there is a long-run relationship between variables we are dealing with. We choose this method because to use the conventional cointegration tests such as Engle and Granger (1987) and Johansen (1998) all-time series need to be integrated of order one. The bound testing approach, however, allows testing for cointegration among variables with different order of integration. Since in our models we have both I(0) and I(1) variables, bound testing methodology becomes the most useful approach.

[2] *A nominal exchange between EUR-PLN is available since 1999. The relative price of capital data is available until 2014. Therefore our paper covers the period of 1999-2014.*

Table 3: **ADF Test Results**

Variable	Level	First Difference
I	-3,602*	-2.586**
r	-1,970	-7.668*
rgdp	-1.735	-4.524*
relp	-1.511	-2.028**
crd	-2.186	-4.116*
unc_eur	-1.934	-8.204*
unc_usd	-1.447	-8.570*
unc_inf	-7,880*	-7.592*
unc_g	-5.350*	-7.841*

Note: * and ** denote rejection of the unit root null at %1 and %5 level respectively.

To conduct the bound test, following unrestricted error correction model (ECM) is used for Model 1 and Model 2 respectively.

$$\Delta I_t = \alpha_0 + \alpha_1 I_{t-1} + \alpha_2 r_{t-1} + \alpha_3 rgdp_{t-1} + \alpha_4 unc_{t-1} + \sum_{i=1}^{n} \alpha_5 \Delta I_{t-i} + \sum_{i=0}^{n} \alpha_6 \Delta r_{t-i} + \sum_{i=0}^{n} \alpha_7 \Delta rgdp_{t-i} + \sum_{i=0}^{n} \alpha_8 \Delta unc_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta I_t = \beta_0 + \beta_1 I_{t-1} + \beta_2 r_{t-1} + \beta_3 rgdp_{t-1} + \beta_4 relp_{t-1} + \beta_5 crd_{t-1} + \beta_6 unc_{t-1} + \sum_{i=1}^{n} \beta_7 \Delta I_{t-i} + \sum_{i=0}^{n} \beta_8 \Delta r_{t-i} + \sum_{i=0}^{n} \beta_9 \Delta rgdp_{t-i} + \sum_{i=0}^{n} \beta_{10} \Delta relp_{t-i} + \sum_{i=0}^{n} \beta_{11} \Delta crd_{t-i} \sum_{i=0}^{n} \beta_{12} \Delta unc_{t-i} + \gamma_t \quad (4)$$

where Δ denotes first differences of series, *n* shows the optimal lag length. We used the F-test to see if the lagged levels of the variables had a significant effect on the dependent variable. In this case, the null hypothesis in Equation (3) can be written as H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ against the alternative hypothesis that H_1: $\alpha_1 \neq 0$, $\alpha_2 \neq 0$, $\alpha_3 \neq 0$, $\alpha_4 \neq 0$. Similarly, the null hypothesis in Equation (4) is H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ against the alternative hypothesis that $\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0, \beta_5 \neq 0, \beta_6 \neq 0$. The test involves two groups of critical values, the first level refers to I(1), and the second level to the I(0) series. If we compute higher F-statistics than the upper critical values, we can reject the null hypothesis and conclude that there is cointegration.

Table 4 presents our findings from the bound test. Accordingly, we reject the hypothesis of no cointegration in each case. Thus, we see that there is a long-term relationship between the variables we have concerned. Next, to capture the dynamic relationship, we adopt an error correction model following Engle and Granger (1987). These models for Model 1 and Model 2 are as follows:

$$\Delta I = a_0 + a_1 \Delta I_{t-1} + a_2 \Delta r + a_3 \Delta rgdp + a_4 \Delta rgdp_{t-1} + a_5 \Delta unc\_i + a_6 EC_1 + \upsilon_1 \quad (5)$$

$$\Delta I = b_0 + b_1 \Delta I_{t-1} + b_2 \Delta r + b_3 \Delta rgdp + b_4 \Delta rgdp_{t-1} + b_5 \Delta relp + b_6 \Delta crd + b_7 \Delta unc_i + b_8 EC_2 + \upsilon_2 \quad (6)$$

where EC_1 and EC_2 are the error correction terms and υ_1 and υ_2 are the error terms. The error correction terms are obtained from the level relationship between dependent and all the independent variables in the model. According to Model 2, Equation 6 contains $relp$ and crd variables.

In Table 5 we see the estimation of the error correction model. In Panel A it can be seen that the real interest rate, in all cases, carries an expected sign. However it is statistically insignificant. For all cases, it seems that both the log of investment and the current GDP have a significant and positive effect. (The exception is the last equation of Model 2. In this case current GDP is insignificant). This is consistent with the theory of accelerator. Also, negative and significant error correction terms imply a mean reversion. The coefficients of lagged GDP are statistically insignificant. In Model 2 our estimates also include the relative price of capital, $\Delta relp$ and the ratio of domestic credit to private sector to nominal GDP, Δcrd, which are suggested by Serven (1998). It appears that the $\Delta relp$ is significant in two cases, but they have a wrong signs. Moreover, Δcrd has negative and statistically significant coefficient in three of four cases. However, the coefficients are very small.

Table 4: **F - Statistics for the Analysis of a Long Run Relationship in Equation (3) and (4)**

	Equation 3		**Equation 4**	
	Lap order *(n)*	**F-statistics**	**Lap order *(n)***	**F-statistics**
With unc_eur	1	6.34*	1	4.90*
With unc_usd	1	5.18**	1	4.08**
With unc_inf	2	3.79***	2	3.69**
With unc_g	1	4.42**	2	4.80*

Notes: *, ** and *** denote significance at 1%, 5% and 10% levels respectively. We compared the F -statistic with the critical bounds of the F-statistic provided in Pesaran, Shin, and Smith (2001), Table CI(iii) Case III. We use Akaike Information Criteria as lag length selection criteria.

Diagnostic tests are reported in Panel B. First we performed Ljung-Box tests for autocorrelation in the residuals and the results imply that estimated models are satisfactory. To test for the presence of serial correlation we reported the Lagrange Multiplier test statistic (LM). Except two cases, we could not reject the null hypothesis of no serial correlation. Then, we employed Breusch-Pagan-Godfrey test for heteroskedasticity of errors in regressions. According to test results heteroskedasticity is not a problem in our models. Finally, the plots of CUSUM and CUSUMQ test results for the stability of the ARDL model are presented in Graph 1. The results indicate that our models are stable over time since the plot of the CUSUM and CUSUMQ statistics fall inside the critical bounds presented straight lines.

It seems that the user cost of capital does not have a significant effect on investment. One possible reason may be capital market imperfections. That is, most of the new investments are not financed through credit; instead companies use their own funds (National Bank of Poland, 2005).

The main focuses of this study are the coefficients of primary measures of uncertainty. We consider three macroeconomic uncertainty indicators and our estimations imply that increase in the uncertainty of the EUR/PLN real exchange rate significantly reduces investment in Poland in both models. In addition, although we find negative coefficients for the uncertainty of the USD/PLN real exchange rate in both models, the coefficients are insignificant. It seems that, only the uncertainty stemming from fluctuations in the exchange rate of the EUR / PLN has a negative effect on private investments in Poland. This result is not surprising as it is considered that the European Union countries are the main economic partners of Poland.

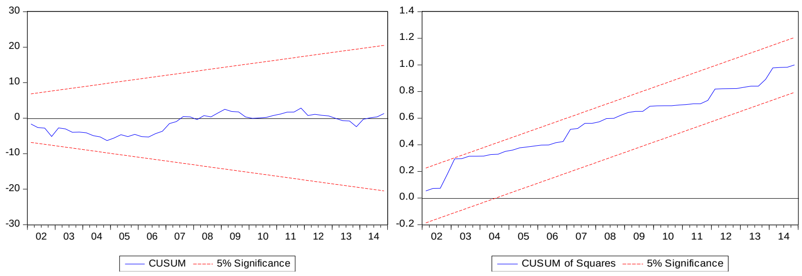
If we look at estimates of the effects of inflation and growth uncertainties on investment, we see the negative effect. To summarize the empirical findings, it has been shown that macroeconomic uncertainty indicators in Poland have a negative impact on investments.

Table 5: **Estimation of Equation (5) and (6)**

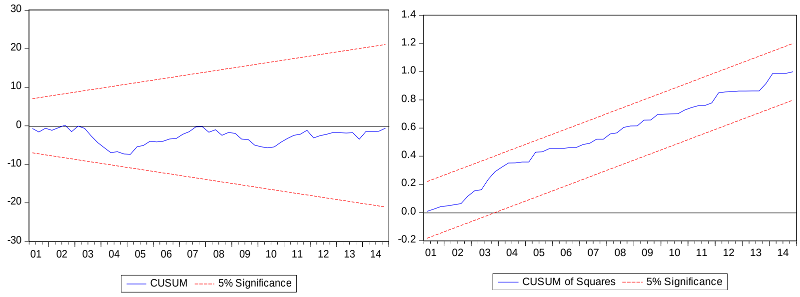
Variable	Equation 5 (Model 1)				Equation 6 (Model 2)			
	Equation 5:1	Equation 5:2	Equation 5:3	Equation 5:4	Equation 6:1	Equation 6:2	Equation 6:3	Equation 6:4
Panel A: Estimates								
Constant	-0.003	-0.003	-0.003	-0.002	-0.004	-0.002	0.001	0.001
ΔI_{t-1}	0.863*	0.980*	0.964*	0.936*	0.932*	1.074*	1.215*	1.173*
Δr	-0.044	-0.033	-0.044	-0.055	-0.032	-0.033	-0.085	-0.080
Δgdp	0.785**	0.918**	0.823**	0.752**	0.931**	1.025**	0.758***	0.609
Δgdp_{t-1}	-0.046	-0.249	-0.155	-0.118	0.122	-0.337	-0.660	-0.529
$\Delta relp$					-0.008	0.054	0.101**	0.106**
Δcrd					-0.0009***	-0.001***	-0.001	-0.001***
Δunc_eur	-0.223**				-0.305*			
Δunc_usd		-0.140				-0.219		
Δunc_inf			-0.005***				-0.006**	
Δunc_g				-0.028***				-0.022
EC	-1.041*	-1.103*	-0.979*	-0.981*	-1.202*	-1.232*	-1.245*	-1.264*
Panel B: Diagnostic Statistics								
F	15.671*	13.195*	11.452*	11.865*	13.265*	10.761*	10.337*	10.488*
LM	1.438	1.600	1.620	1.457	1.166	1.583	2.325**	2.541**
Adjusted R^2	0.60	0.55	0.51	0.52	0.63	0.56	0.55	0.55
Q_4	6.581	5.606	7.871	5.488	8.000	5.749	7.814	6.890
	(0.160)	(0.231)	(0.096)	(0.241)	(0.199)	(0.219)	(0.099)	(0.142)
Q_{12}	11.101	11.498	15.273	11.982	10.294	10.770	14.135	12.736
	(0.520)	(0.487)	(0.227)	(0.447)	(0.590)	(0.549)	(0.292)	(0.389)
Q_4^2	2.566	1.888	0.616	0.655	2.468	3.832	0.688	0.893
	(0.033)	(0.756)	(0.961)	(0.957)	(0.656)	(0.429)	(0.953)	(0.926)
Q_{12}^2	13.777	10.331	9.487	11.205	13.452	8.825	9.591	7.409
	(0.315)	(0.587)	(0.661)	(0.511)	(0.337)	(0.718)	(0.652)	(0.829)
Breusch-Pagan-Godfrey (p-values)	0.554	0.659	0.632	0.851	0.787	0.718	0.751	0.963

Notes: *, ** and *** denote significance at 1%, 5% and 10% levels respectively. Q_4 is the fourth order Ljung-Box test for standardized residuals. Q_{12} is the 12th order Ljung-Box test for standardized residuals. Q_4^2 is the fourth order Ljung-Box test for squared standardized residuals. Q_{12}^2 is the 12th order Ljung-Box test for squared standardized residuals. p-values are provided in parenthesis. LM is the Lagrange Multiplier statistic to test for autocorrelation. The null hypothesis of LM test is there is no serial correlation. For heteroskedasticity p-values of F statistics of Breusch-Pagan-Godfrey tests are presented. The null hypothesis of the Breusch-Pagan-Godfrey test is no heteroskedasticity. p-values show that we cannot reject the null hypothesis.

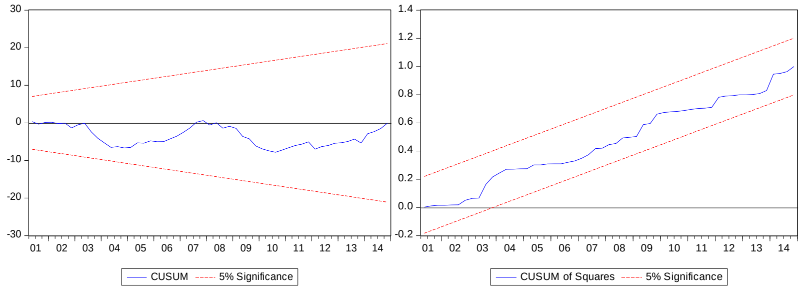
Graph 1: **CUSUM and CUSUMQ Tests**



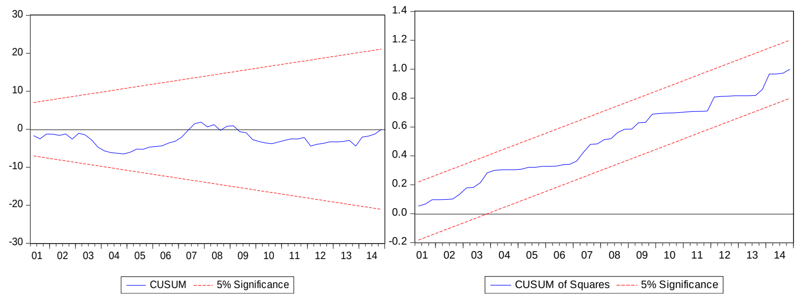
a. Plot of CUSUM and CUSUMQ Tests for Equation 5:1



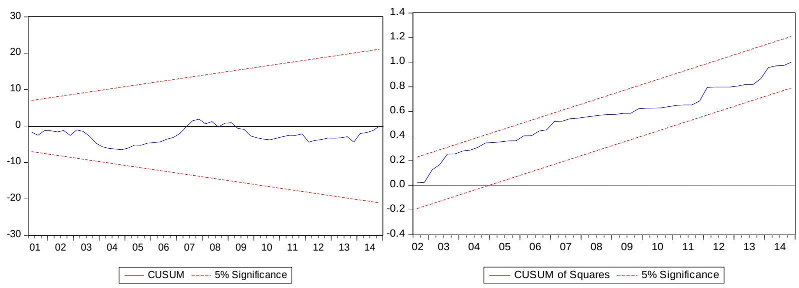
b. Plot of CUSUM and CUSUMQ Tests for Equation 5:2



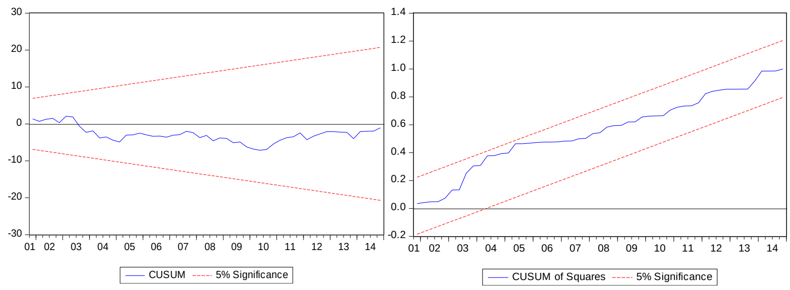
c. Plot of CUSUM and CUSUMQ Tests for Equation 5:3



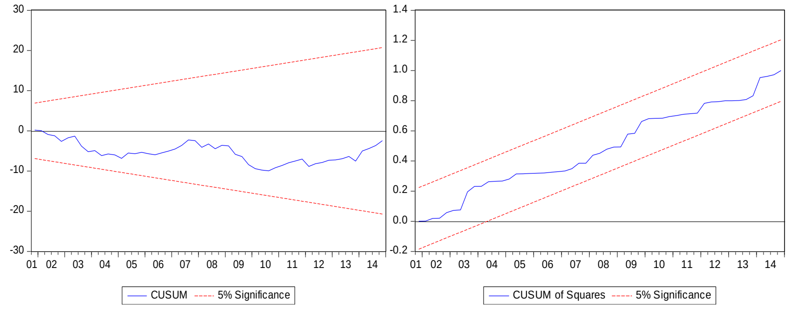
d. Plot of CUSUM and CUSUMQ Tests for Equation 5:4



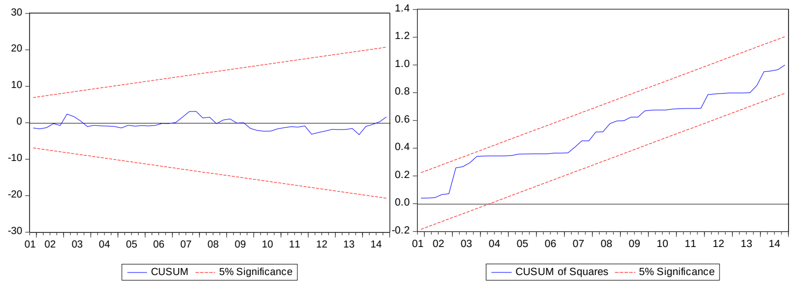
e. Plot of CUSUM and CUSUMQ Tests for Equation 6:1



f. Plot of CUSUM and CUSUMQ Tests for Equation 6:2



g. Plot of CUSUM and CUSUMQ Tests for Equation 6:3



h. Plot of CUSUM and CUSUMQ Tests for Equation 6:4

5. Conclusion

In the theoretical literature, there is no consensus on how the uncertainty affects investments, which is therefore an empirical issue. Most of the empirical papers on uncertainty and investment are focusing on developed countries. However, developing economies face more macroeconomic uncertainty than industrial countries do. In this paper we consider the impact of real exchange rate, growth and inflation uncertainties on private investment in a developing country: Poland. Our results show that EUR/PLN real exchange rate uncertainty reduces investment consistent with some earlier studies (e.g., Serven, 1998; Saman, 2010; Pradhan et al., 2004; Ghura and Grennes, 1993). Another uncertainty indicator is inflation uncertainty, and we see that inflation uncertainty depresses the private investment in Poland. In addition, we show that increase in the GDP growth uncertainty, which presents the unpredictability of demand, leads to a decrease in investment. Overall, as suggested by Serven (1998), our estimations point out to the fact that, the increase in the volatility of macroeconomic variables causes decrease in the information that market indicators provide investors. As a result, investors may decide to postpone their investment.

If it is accepted that one of the important objective of macroeconomic policy is to encourage investment, providing stability is as much of a priority issue as the level of variables such as interest rate or tax rates as suggested by Pindyck and Solimano (1993). According to our results, we can conclude that macroeconomic stabilization is a necessary condition for the continuity of investments in Poland. Therefore, stability should be one of the priorities of economic policy, especially when the importance of investments for economic performance is taken into account. In this study we consider linear relationship and the results may depend on the country specific conditions. Future research can consider other investment determinants and take into account nonlinear effect of uncertainty on investment for developing countries.

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