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Dynamic Relationship between Inflation Uncertainty and Private Investment in Iran: An Application of VAR-GARCH-M Model

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Abstract

This paper empirically investigates the relationship between CPI inflation uncertainty, and private investment in the Iranian economy from 1988 to 2010 by using quarterly data. We employ a bivariate VAR(5)-GARCH(1,1)-in-mean with diagonal BEKK model to discover in a unified framework how are the interactions between the variables. In the model, conditional variance of inflation and private investment are interpreted as inflation and private investment uncertainties, respectively. Our empirical finding shows that, 1) there are bidirectional mean spillovers between inflation and private investment, 2) private investment uncertainty affects private investment negatively, 3) private investment uncertainty doesn't affect inflation, 4) inflation uncertainty affects inflation positively, and 5) inflation uncertainty affects private investment negatively, supporting Pindyck (1982, 1988, 1991), Caballero (1991), Ferderer (1993a), Caballero and Pindyck (1996).

Keywords: Inflation Uncertainty, Private Investment Uncertainty, Bivariate GARCH Model.

JEL Classification: C22; E22, E31

1. Introduction

In the last two decades, there has been increasing interest in empirical research relating to economic growth in Iran because one of the most important purposes in Iran's 20-year vision plan is achieving the highest position in economic growth and development. Therefore, identifying the effective variables to obtain these goals has been considered in Iran's growth literature (see, e.g. Taghavi and Mohammadi, 2006; Delavari, et al., 2008; Komijani and Nazari, 2009). Investment plays an important role in the economic growth of a country as it raises the production capacity of the economy and promotes technological progress through embodiment of

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new techniques. Investment in Iran has twofold: government investment and private investment. The government investment depends on the oil export revenue and foreign exchange earnings, but the resource to finance government investment is uncertain because of the fluctuations in the oil price. Therefore, the much attention to private investment growth is necessary. In recent years a few papers constructed a large set of possible explanatory variables and used regression analysis to identify the variables which have a statistically significant impact on private investment (see, e.g.; Gharavi Nakhjavani, 2003; Eghbali et.al, 2004; Abbasinezhad and Jabal Ameli, 2006; Keshavarzian and Ziae Bigdeli, 2006; Shokri et.al, 2007; Kazerouni and Ebghaei, 2008; Mousavi Jahromi and Zayer, 2008; Rezaei, 2010; among others). One of the important variables that affect private investment is inflation. There are a lot of different theoretical descriptions that are explained the relationship between inflation and private investment in literature. For example, endogenous growth theory announced that the relationship between inflation and investment is negative because inflation leads to reduction in capital accumulation and growth rate through diminishing rate of return (Gultekin, 1983 and Boyd et al., 1996). Therefore, the adverse impact of inflation on financial market is directly translated into reduction in investment (Xu, 2000). Inflation can prevent investors to invest because of lacking confidence in long-term treaties in the stock market (Iqbal and Nawazi, 2010). Valadkhani (2004) claimed that inflation in Iran decreases the value of money and this makes people reluctant to deposit their funds in the banking system because of its low returns. This makes people more incentive to invest in unproductive activities such as the black market for foreign currencies, gold coins, cars, money laundering because of their higher returns in short periods. This mechanism causes to decrease in the necessary funds for investment purposes in the banking system.

Also, inflation uncertainty is the most important factor, after the product, affecting private investment (Zelekha, 2010). Theoretical literature emphasizes the importance of the effects of inflation uncertainty on investment. (see, e.g., Hartman (1972), Abel (1983), Pindyck (1982, 1988, 1991), Caballero (1991), Ferderer (1993a), Caballero and Pindyck (1996), Abel et al. (1996), among others). For example, a convex profit function to prices in perfect competition firms increased investment under price uncertainty environment (Abel, 1983). Dahmarde and Bashiri (2012) defined uncertainty as a phenomenon that decreases the predictability of

the domestic macroeconomic environment. This uncertainty leads to nominal long-term debt return combined with very high risk that causes high expected nominal returns for investors, therefore it causes an increase in long-term interest rates. Also, inflation uncertainty leads to the uncertain future payments; for example, it can make employers and workers uncertain about future salaries, and it also can make owners and tenants anxious about the future permissions. Uncertainty spreads to other economic variables such as reduction of the ability of consumers and producers in making the right decision and encourages them to finance investment resources with certain long-term interest rates to avoid the increased risk of short-term interest rates. Another sphere of influence of uncertainty on the firm is for allocating part of their resources to predict future inflation, and therefore forecast high risks and further inflation. All these factors distort resource-allocation and decrease investment and output growth (Montiel and Serven, 2004). Hellerstein (1997) stated that Inflation uncertainty in the financial market increases the risk associated with the investment which translated into reduction in economic activities and investment. Dahmarde and Bashiri (2012) (as cited in Easterly and Schmidt-Hebbel, 1991) suggested that a competitive and stable macroeconomic environment characterized by low and stable internal and external deficits, low inflation and real depreciation of the exchange rate are conducive to higher growth led by significant private investment. However, in empirical evidence with other countries data, this relationship has been mixed, at best (See e.g., Zeira (1990), Driver and Moreton (1991), Caballero (1991), Ferderer (1993b), Aizenman and Marion (1993), George and Morisset (1995), Leahy and Whited (1995), Glezakos and Nugent (1997), Caruso (2001), Mazeda Gil (2004), Da Silva Filho (2007), Zelekha (2010) and Fischer (2011). Mixed results are related to assumptions on market competitiveness, risk neutrality, symmetry/asymmetry of investment adjustment costs and entrepreneurial attitudes toward risk (Caballero, 1991; Abel and Eberly, 1994). Zeira (1990) showed the extent of investors' risk aversion, the concavity of the utility function, the convexity of the profit function, and the distribution of risk cause to different effects of uncertain relative prices on investment. Uncertainty tends to raise investment through the convexity of the profit function but it discourages investment due to investors' risk aversion (see, e.g., Serven, 1998).

In the empirical side, there are a lot of empirical investigations about macroeconomic variables and investment under uncertainty with Iranian data in the literature (see, e.g. Daroughe and Mohammadi, 2005; Gaskar et al., 2007; Moradpour et al., 2008; Ahangari and Saadatmehr, 2008; Kazerouni and Doulati, 2008; Esmaeilzadeh Maghari, 2009; Heidari and Hashemi, 2011; among others). The most important feature of Iranian empirical studies is that none of them considers the effect of inflation uncertainty on private investment. The next important drawback of these studies to investigate macroeconomic uncertainties and investment is that, they have used a univariate GARCH specification for estimation of the uncertainties. As Dahmarde and Bashiri (2012) expressed, univariate models do not allow studying the joint determination of more than one series. This is a remarkable vacuum of study, as there is a vast theoretical literature that emphasizes the importance of the simultaneous effects of the series (see, e.g. Brooks, 2002, Tsay, 2005, Minović, 2007, among others), and to the best of our knowledge, there is not any empirical study on assessing the relationship between inflation, investment and their respective uncertainties with Iranian data.

We use a VAR type GARCH-M (VAR-GARCH-M) with a diagonal BEKK model to investigate the relationship between the conditional means and conditional variance of inflation and private investment in Iran to estimate a time-varying variance-covariance matrix simultaneously. Thus, the hypotheses that we are going to test with Iranian data are as follows:

- There are bidirectional mean spillovers between inflation and private investment.
- Investment uncertainty affects investment negatively.
- Investment uncertainty affects inflation positively.
- Inflation uncertainty affects inflation positively.
- Inflation uncertainty affects investment negatively.

The rest of the paper is structured as follows. Section 2 outlines our econometric model. Section 3 discusses the data. Section 4 presents and interprets our main results, and finally, section 5 concludes the paper.

2. The Model

We apply a BGARCH-in-Mean (BGARCH-M) with a diagonal BEKK model to estimate the relationships between inflation and private investment and their respective uncertainties simultaneously. In the

applied BGARCH-M models, the dependent variables in the mean equations are the inflation and the private investment. The explanatory variables will contain variables that could help predict private investment and inflation in mean equations and their uncertainty measures in variance equations. The first step to model a BGARCH model to simultaneously estimate the conditional means, variances, and covariances of variables is specifying the mean equation by testing for serial dependence in the data under consideration (Dahmarde and Bashiri, 2012). Estimates of the mean and variance-covariance equations for inflation and private investment are as follows:

$$\begin{bmatrix} y_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \sum_{i=1}^{5} \begin{bmatrix} \phi_{i1} & \phi_{i2} \\ \phi_{i3} & \phi_{i4} \end{bmatrix} \begin{bmatrix} y_{t-i} \\ \pi_{t-i} \end{bmatrix} + \begin{bmatrix} \rho_1 & \rho_2 \\ \rho_3 & \rho_4 \end{bmatrix} \begin{bmatrix} h_{1t} \\ h_{2t} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \end{bmatrix} du1995\ q2 + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix} = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1t-1} \\ \varepsilon_{2t-1} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t-1} \\ \varepsilon_{2t-1} \end{bmatrix}' \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix}$$
$$+ \begin{bmatrix} b_{11} & 0 \\ 0 & b_{22} \end{bmatrix}' \begin{bmatrix} h_{11t-1} & h_{12t-1} \\ h_{21t-1} & h_{22t-1} \end{bmatrix} \begin{bmatrix} b_{11} & 0 \\ 0 & b_{22} \end{bmatrix} \quad (2)$$
$$\varepsilon_t \mid \psi_{t-1} \approx N(0, H_t)$$

Where y_t , π_t denote private investment and inflation, respectively. The residuals, $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$, are innovation (disturbance) vector that assumed to be normally distributed with a time varying conditional variances. H_t is a conditional variance-covariance matrix that is always positive definite, in which $h_{1,t}$ and $h_{2,t}$ are the conditional variance of the residual term taken as private investment uncertainty and inflation uncertainty at time t, ψ_{t-1}represents the information set at time $t-1$, A and B as diagonal matrices are 2×2 (see, e.g., Heidari and Bashiri, 2011).

We use this log-likelihood function to estimate the parameters of the BGARCH models of *BEKK* specifications:

$$l(\theta) = -\frac{TN}{2}\log 2\pi - \frac{1}{2}\sum_{t=1}^{T}(\log|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t) \quad (3)$$

Where θ denotes all the unknown parameters to be estimated, N is the number of series in the system and T is the number of observations and other notations are defined before (see, e.g., Heidari and Bashiri, 2011).

3. Data

In our empirical analysis we use the Consumer Price Index (CPI) and the Private Investment for Iran, respectively. The data have quarterly frequency and range from 1980:Q1 to 2010:Q4. Inflation is measured as follows: (see, e.g. Asteriou, 2006).

$$\pi_t = (\ln cpi_t - \ln cpi_{t-1}) \times 400 \qquad (4)$$

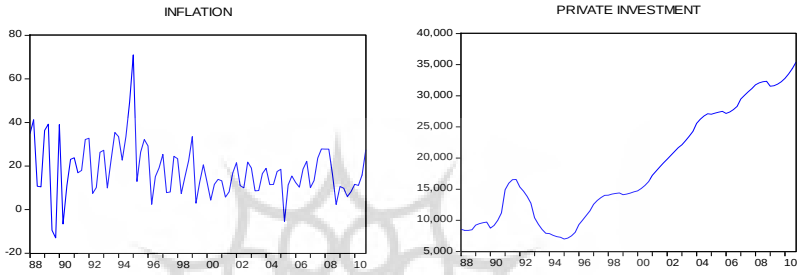

Figure 1 shows the inflation and private investment in the Iranian economy during 1988-2010.
Source of the data: Central Bank of Iran

Figure1: Inflation and Private Investment in the Iranian Economy

Figure 1 shows that private investment level seems to have a time trend. Therefore we propose to use differential of logarithmic private investment as private investment growth, instead of its level. The summary statistics for the data are given in Table 1. The large value of the Jargue-Bera statistic for inflation and private investment growth implies a deviation from normality at 5% level of significance.

Table 1: Summary Statistics for Iranian Inflation and Investment

	Private Investment Growth	Inflation
Mean	5.696710	17.90114
Median	6.831478	16.01043
Maximum	115.6341	71.05508
Minimum	-81.12525	-13.03819
Std. Dev.	22.89697	12.63333
Skewness	0.341249	0.820494
Kurtosis	9.815568	5.599371
Jargua-Bera	179.8514	36.22335
Probability	0.0000	0.0000

Source: Authors calculation

Following Dahmarde and Bashiri (2012), we employ several tests such as Augmented Dicky Fuller (ADF), Phillips-Perron (PP), Ng-Perron (2000) and Kwiatkowski et al. (1992)-(KPSS) tests to determine stationary properties of the series. The Results of these standard unit root tests aren't the same. As Heidari and Bashiri (2012) expressed, In Iran, there have been many unusual policy changes and/or external shocks to the economy which results in the occurrence of multitude of structural breaks in the variables under consideration. The results of these tests aren't true by taking these structural breaks.

To carry out the structural in the variables, we use the endogenously determined multiple break tests introduced by Bai and Perron (1998 and 2003). The results show that using most of these tests, we have breaks in the mean of the series under considerations. So, to determine stationary properties of the series we use unit root with structural break tests like Zivot and Andrews (1992) and Lee and Strazicich (2004) tests. Tables 2 and 3 present the results of Zivot and Andrews (1992) and Lee and Strazicich (2004) unit root tests, respectively.

Table 2: Zivot and Andrews (1992) Unit Root Test Results

Variables	TB	T_{ZA}	Result
Private Investment Growth	1995q2	-4.037578	I(1)
Inflation	1995q4	-4.957421	I(1)

Note: 1) The critical values for ZA test at levels 1%, 5% and 10% are -5.57, -5.08 and -4.82, respectively (Zivot and Andrews, 1992).
2) Source: Authors calculation

Table 3: Lee and Strazicich (2004) Two Structural Break Unit Root Test Results

Variable	TB1	TB2	K	t-statistic	Result
Private Investment Growth	1990Q4	1995Q2	8	-11.1848	I(0)
Inflation	1995Q1	1999Q3	5	-7.0126	I(0)

Note: 1) The critical values at 1, 5, 10% are -5.823, -5.286 and -4.989, respectively (Lee and Strazicich, 2004)
2) Source: Authors calculation

In 1995, oil revenues declined. This external shock to the economy along with the government's inability to control the changes in exchange rate and increased government spending, resulted in the occurrence of structural breaks in the variables. The results reveal in Table 2 that in the presence of two structural breaks, the null of unit root is rejected for at the 5% level of significance.

4. Estimation Results

We use a VAR (5)-GARCH-M model by using the information Schwarz criterion to determine the number of lags to estimate the relationships between inflation and private investment growth and their respective uncertainties simultaneously. The method for the estimation of the parameters is the maximum log-likelihood with BEKK approach. The estimated bivariate BEKK model is reported in Table 4.

However, the coefficient of conditional variance of inflation in the mean equation is positive and significant, which means that inflation uncertainty affects the level of inflation. This result supports Cukierman and Meltzer (1986) and Cukierman (1992) hypothesis that increases in inflation uncertainty raise the optimal inflation rate by increasing the incentive for the policy maker to create inflation surprises.

Moreover, our empirical finding shows that inflation uncertainty affects on the private investment growth inversely, supporting Pindyck (1982, 1988, 1991), Caballero (1991), Ferderer (1993a), Caballero and Pindyck (1996), hypothesis. This is in line with the result is in line with Zeira (1990), Driver and Moreton (1991), Ferderer (1993b), Aizenman and Marion (1993), Caruso (2001), Da Silva Filho (2007), Zelekha (2010) and Fischer (2011) among others, where they find a negative relationship between inflation uncertainty and investment for different countries. Our results suggest that the inflation uncertainty seems to become an impediment to the private investment growth.

Therefore, the negative effect of inflation uncertainty on the private investment implies than in Iranian economy inflation uncertainty, because of instability of policies, reduces the information content of prices, distorts relative prices and long run contracts, and therefore lowers economic efficiency and investment.

Table 4: Estimated parameters of Bivariate BEKK model

	Coefficient	Std. Error	z-Statistic	Prob.
μ_1	-4.100207	2.085443	-1.966109	0.0493
ϕ_{11}	0.600884	0.041544	14.46362	0.0000
ϕ_{12}	-0.043987	0.046303	-0.949971	0.3421
ϕ_{21}	0.126441	0.023387	5.406381	0.0000
ϕ_{22}	0.007109	0.039432	0.180274	0.8569
ϕ_{31}	0.103101	0.024547	4.200195	0.0000
ϕ_{32}	-0.002112	0.040205	-0.052534	0.9581
ϕ_{41}	-0.220463	0.025601	-8.611346	0.0000
ϕ_{42}	-0.072591	0.038629	-1.879183	0.0602
ϕ_{51}	0.025240	0.016362	1.542609	0.1229
ϕ_{52}	-0.206441	0.035316	5.845477	0.0000
ρ_1	-0.002289	0.000262	-8.733877	0.0000
ρ_2	-0.006228	0.002762	-2.255032	0.0241
λ_1	6.508810	1.503898	4.327958	0.0000
μ_2	23.35171	3.035154	7.693746	0.0000
ϕ_{13}	0.091193	0.021680	4.206345	0.0000
ϕ_{14}	0.207266	0.084057	2.465782	0.0137
ϕ_{23}	-0.089793	0.020490	-4.382248	0.0000
ϕ_{24}	-0.309627	0.068032	-4.551179	0.0000
ϕ_{33}	0.041985	0.024544	1.710597	0.0872
ϕ_{34}	0.042188	0.054271	0.777363	0.4369
ϕ_{43}	0.116575	0.020390	5.717362	0.0000
ϕ_{44}	0.300967	0.050079	6.009835	0.0000
ϕ_{53}	-0.197274	0.037393	-5.275652	0.0000
ϕ_{54}	-0.169244	0.046797	-3.616556	0.0003
ρ_3	0.000678	0.000171	3.965177	0.0001
ρ_4	0.016551	0.004391	3.769357	0.0002
λ_2	-11.64297	2.069149	-5.626937	0.0000
c_{11}	7.978866	2.175857	3.666999	0.0002
c_{12}	10.90572	2.534940	4.302161	0.0000
c_{22}	14.90623	4.561384	3.267917	0.0011
a_{11}	1.787320	0.192242	9.297230	0.0000
a_{22}	0.845813	0.116260	7.275170	0.0000
b_{11}	-0.002734	0.021277	-0.128507	0.8977
b_{22}	0.522179	0.064695	8.071363	0.0000

Source: Authors calculation

Our empirical evidence also shows that private investment growth uncertainty has a negative and significant effect on the private investment growth. This result means that private investment growth uncertainty affects the level of private investment, reversely.

The empirical evidence shows that investment uncertainty affects the level of inflation. This result means that rises in investment uncertainty increases inflation in the Iranian economy.

And finally, the coefficient of inflation with 4 and 5 lag in the mean equation is negative and significant, which means that inflation affects the private investment growth, reversely. As Valadkhani, (2004) expresses the rate of inflation has been used as a proxy for the nominal interest rate by Pesaran (1995) in his estimation of the real money balances for Iran and Khayum (1991) used price index as a proxy for the rate of interest in the context of developing countries

Equation 1 shows that these models allow for dynamic dependence between the volatility of the series under consideration. Figures 2 and 3 show the conditional covariance and variance of inflation and private investment growth. It can be seen from the behavior of conditional covariances (Figure 2) that correlation between inflation and private investment growth is unstable over the period of 1990-2000.

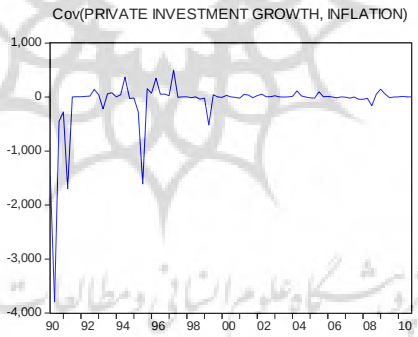

Figure 2: Estimated conditional covariance for investment and inflation

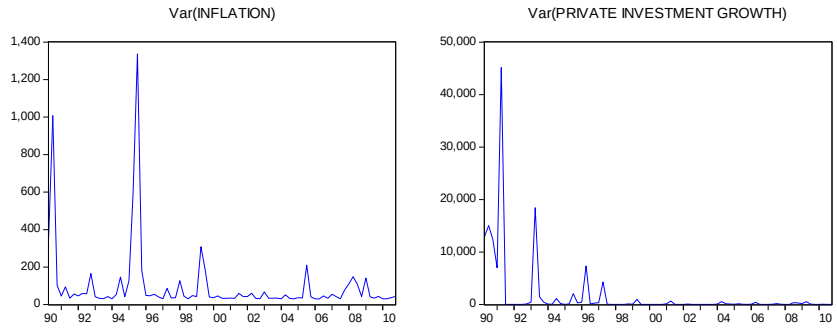

Figure 3: Estimated conditional variances of investment and inflation

On the other hand, it has been frequently observed that volatility changes over time. We found that private investment growth is more volatile than inflation. In the model, estimated conditional variance of private investment growth has the greatest peak at the time. As Valadkhani (2004) expresses higher inflation rates can discourage investors to obtain real assets. Under inflationary circumstances, the value of money deteriorates and it causes little incentive for people to deposit their funds in the banking system. This is the case particularly in Iran since nominal interest rates profit rates for term deposits and saving accounts are kept artificially low. Therefore, agents tend to invest in unproductive activities such as buying/selling foreign currencies, gold coins, cars, money laundering. It is interesting to recognize an increase in the growth of the consumer price index and its uncertainty under these circumstances are conjectured to produce a decline in the propensity to save as measured by funds flowing through financial intermediaries. This leads to a reduction in the funds deposit for investment through the banking system.

5. Summary and Conclusion

This paper empirically investigates the relationship between CPI inflation, inflation uncertainty, and private investment in Iranian economy from 1988 to 2010 by using quarterly data. We employ a bivariate VAR (5)-GARCH(1,1)-in-mean model to discover in a unified framework how are the interactions between the variables. The method for the estimation of parameters is a maximum log-likelihood with the diagonal BEKK approach. In the model, conditional variance of inflation and private investment growth are interpreted as inflation and private investment

growth uncertainties, respectively. From this empirical analysis, the authors conclude that, 1) there are bidirectional mean spillovers between inflation and private investment, 2) private investment growth uncertainty affects private investment growth negatively, 3) private investment growth uncertainty affects inflation positively, 4) inflation uncertainty affects inflation positively, this result supports Cukierman and Meltzer (1986) and Cukierman (1992) hypothesis, and 5) inflation uncertainty affects private investment growth negatively, supporting, Pindyck (1982, 1988, 1991), Caballero (1991), Ferderer (1993a), Caballero and Pindyck (1996). This result is in line with Zeira (1990), Driver and Moreton (1991), Ferderer (1993b), Aizenman and Marion (1993), Caruso (2001), Da Silva Filho (2007), Zelekha (2010) and Fischer (2011) among others. Therefore, in Iranian economy inflation uncertainty, because of instability of policies, reduces the information content of prices, distorts relative prices and long run contracts, and therefore lowers economic efficiency and investment. Therefore, creation of a stable macroeconomic environment by government encourage private investment.

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