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MODELLING THE INFLATIONARY PROCESSES. A CASE STUDY OF AZERBAIJAN: A VECTOR ERROR CORRECTION MODEL

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МОДЕЛИРОВАНИЕ ИНФЛЯЦИОННЫХ ПРОЦЕССОВ. ПРАКТИЧЕСКИЙ ПРИМЕР АЗЕРБАЙДЖАНА: ВЕКТОРНАЯ МОДЕЛЬ КОРРЕКЦИИ ОШИБОК

This study investigates the transmission channels of inflationary processes in Azerbaijan through VECM model. The results in this study introduce that NEER effects on inflationary processes significantly in the short run and long run relationship. Additionally money aggregate (M2) impact an increase effects on inflation in the short run relationship. Results of VECM estimation show that in the short-run and long run M2 effect on inflation. So, macroeconomic indicator GDP mitigates the inflationary processes pressure in the short run and long-run. So, in accordance with theory, error correction term is negative sign. It points out the long-run relation of this model. The lagged values of the CPI influence the volatility of inflation over time with significant inertia of about 0.45%. Inflation expectations about future price levels significantly influenced the volatility of inflation. According to the theory, error correction term is negative sign. VECM model estimate results show that the speed of adjustment of consumer price index to the long-run equilibrium direction is about 0.18. The sign of error correction term is negative and this is significant. It means that if inflation exceeds its long-run equilibrium by 1(one) percentage point, e.g. because of temporary shocks, 18percent of this deviation is adjusted for every month, so that it takes about six months for inflation return to its long-run steady state.

Это исследование посвящено изучению каналов передачи инфляционных процессов в Азербайджане через VECM модели. Результаты этого исследования показывают, что НЭОК (номинальный эффективный курс) воздействует на инфляционные процессы значительно в краткосрочной и долгосрочной перспективе. Кроме того, денежный агрегат (M2) влияет на увеличение инфляции в краткосрочной перспективе. Результаты оценки VECM показывают, что в краткосрочной и долгосрочной перспективе M2 оказывает влияние на инфляцию. Таким образом, макроэкономический показатель ВВП снижает влияние инфляционных процессов в краткосрочной и долгосрочной перспективе. Таким образом, в соответствии с теорией, термин исправление ошибок является отрицательным знаком. Это указывает на долгосрочную взаимосвязь этой модели. Отставание значения ИПЦ влияет на волатильность инфляции с течением времени со значительной инерцией около 0,45%. Инфляционные ожидания в отношении будущих ценовых уровней существенно повлияли на волатильность инфляции. Согласно теории, срок для исправления ошибок является отрицательным знаком. Результаты оценки VECM модели показывают, что скорость корректировки индекса потребительских цен в долгосрочной перспективе равновесного состояния примерно равна 0,18. Знак коррекции ошибок в перспективе отрицательно, и это имеет большое значение. Это означает, что если инфляция превышает долгосрочного равновесия на 1 (один) процентный пункт, например, из-за временных потрясений, 18 процентов этого отклонения корректируется для каждого месяца, так что она занимает около шести месяцев для инфляции при возвращении к своему долгосрочному равновесному состоянию.

Key words: Inflationary process, VECM, cointegration, impulse response function, money aggregate.

Transmission effects of factors over inflationary processes are determined in response-impulse functions. So, response-impulse reaction of CPI is significantly higher to the change happened in CPI and NEEM. The response impulse of CPI to the change in NEEM is observed the growing tendency up to six periods after change then it goes down.

Introduction

Whole governments, private sectors and banking sectors in the world make their decision for the short-term and long-term position over the macro-econometric modeling. This modeling enables them to perceive the processes occurred in the real time. The economy in the country is subjected various shocks such as economic policy shocks and behavioral shocks which influences the national economy and causes systematical effects. So, it needs to understand the economic processes that may influence mode of life and economic growth. The main elements of economic processes are inflationary processes. So, as a result of adverse condition in inflationary process every one can feel the negative effects of this one. In order to prevent from these adverse circumstances it necessities to model the inflationary processes and investigate the matters in the short-run and long-run relationship. Consequently, from here comes the importance of building VECM model to study the relationship between key macroeconomic variables and forecast their behavior regarding economic policy changes. VECM model enable us to get information about the short-run and long-run adjustment to the changes in the variables included to the model through estimating the parameter measuring the short-run and long-run term. As this model is dynamic and forecasting model, it is useful to predict the changes in future. Because, economic theory does not provide sufficient information on the dynamic features of the relationship between variables.

Determining the determinants of inflationary processes those may cause in short-run and long run period, the speed of adjustment inflation rate to the long-run equilibrium, transmission channel effects of the variables explaining impulse response functions are attempted to investigate in this study. The study aimed to provide of forecasting inflation by applying Vector Error Correction Model (VECM) model and investigate the dynamic property of the model using variance decomposition and impulse response functions. An inflation forecast is important in monetary policy. As the main purpose of the Central Bank of Azerbaijan is to maintain the price stability in the country, inflationary processes investigation assumes a great importance. VECM approach is assuming the existence of co-integration vectors defining the long-run relation among the variables and the deviation or gap from the long-run relation influences the speed of inflation adjustment.

1. Methodology and data

Cointegrating factors introduced by Granger are commonly used in macroeconomic modeling through the vector error correction model (VECM). The VECM representation of a dynamic system is acquired as a simple rearrangement of the vector autoregressive (VAR) model advocated by Sims (Damodar N Gujarati, 2004). According to Christopher Sims in case of true simultaneity among the set of variables, all these ones should be treated on a equal conditions. That is to say there shouldn't be any a priori differentiation between endogenous and exogenous variables. If cointegration was detected between series we know that there exists long-term equilibrium relationship between the variables, we implement VECM model in order to evaluate short run properties of the cointegrated series. In case of no cointegration VECM is not reqiured. In that case we can directly employ the Granger test to identify the causal links between variables (Fadli Fizari Abu Hassan Asari,Nurul Syuhada Baharuddin, Nurmadihah Jusoh, Zuraida Mohammad, Norazidah Shamsudin and Kamaruzaman Jusoff, 2011). So, VECM is a kind of VAR model used with cointegration restrictions. In this condition it is expedient to use the unrestricted VAR model. Cointegration between CPI_t, GDP_t , $M2_t$, $CPI_t$and $NEEM_t$ imply that error correction terms may appear in a model relating ΔCPI_t to ΔGDP_t, $\Delta M2_t$, and $\Delta NEEM_t$. (Jeffreey M, 2000,). In VECM cointegration rank shows the number of cointregrated vectors. In this case VAR model can be specified as follows:

$$CPI_t = \propto + \sum_{j=1}^{k} \beta_j M_{t-j} + \sum_{j=1}^{k} \gamma_j NEEM_{t-j} + \sum_{j=1}^{k} \tau_j GDP_{t-j} + u_{1t}$$

$$M_{2t} = \delta + \sum_{j=1}^{k} \theta_j CPI_{t-j} + \sum_{j=1}^{k} \tau_j GDP_{t-j} + \sum_{j=1}^{k} \gamma_j NEEM_{t-j} + u_{2t}$$

$$GDP_t = \omega + \sum_{j=1}^{k} \theta_j CPI_{t-j} + \sum_{j=1}^{k} \beta_j M_{t-j} + \sum_{j=1}^{k} \gamma_j NEEM_{t-j} + u_{3t}$$

$$NEEM_t = \varphi + \sum_{j=1}^{k} \theta_j CPI_{t-j} + \sum_{j=1}^{k} \beta_j M_{t-j} + \sum_{j=1}^{k} \tau_j GDP_{t-j} + u_{4t}$$

where the $u`s$ are stochastic error terms called impulses or innovations or shocks in the VAR. (Damodar N Gujarati, 2004)

A VAR model is employed for stationary variables. Whereas, whether there is non-stationary variables in that case their differences are used to avoid from the spurious regression. It is in fact that the most economic variables are unit root. That is to say the most of these ones are non-stationary times-series. Therefore, it needs to develop the non-stationary times series theorem. Engel and Granger show that linear combination of non-stationary variable can be stationary. It determines the long-run relationship among the variables (F.Engle & C.W.J. Granger)

Determining the whether the variable are cointegrating or not is the main task in building the VECM model. As mentioned above VECM is a kind of VAR model. In this type of models are determined with restrictions of cointegrations. So, it can be called as RVAR model.

In generally VECM model contains both long-run and short-run relations among variables set in vector Y. Based on above mentioned inflation in Azerbaijan can be estimated by using the VECM which can be specified as follows:

$$\Delta x_t = \phi(L)\Delta x_t + x_t'\delta + \varepsilon_t$$

Here, $x_t = (CPI_t, M_{2t}, GDP_t, NEEM_t)$is vector of variables. $\phi(L)$ — coefficients matrix (matrices) for lag

operators L. Whereas, δ — co-integration vectors capturing long-run information among the variables. The matrix δ is error correction coefficients. (Fahad Alturki, 2010). These parameters measure the speed of adjustment to the long-run equilibrium. In our study it means that if inflation exceeds its long-run equilibrium 1 percentage point because of temporary shock, error correction coefficient shows how of this deviation is adjusted for every month and so that how long period it takes about inflation to return its long-run equilibrium. Other words if the money aggregate level is 1(one) percent higher than the equilibrium level in one month it will cause inflation by error correction coefficient in the following month. While money growth doesn't have the significant direct impact on a inflation its effect is transmitted through the error correction mechanism. (Emilio Sacerdoti, October 2001,Washington). Matrix δ is the long-run coefficients. It is a vector of cointegrated parameters. In such models the short and long-run parameters are estimated simultaneously. (Abu N. M. Wahid, 2011)

It should be stated that one of the VECM properties and generally VAR model is the ability to investigate the effects of shocks on endogenous variables and its transmission. Sims suggests impulse response functions for determining of unpredictable policy shocks on macro variables. We used in this study IRF to show the reaction of one variable to change in other ones in stochastic form. So, in VAR model with setting all of variable in one side of an equation and other side include the stochastic elements. EC (error correction) terms are the stochastic error terms, called impulses or innovations or shocks in the language of VAR. (Damodar N Gujarati, 2004)

The data in this research CPI (Consumer Price index), M2 (money aggregate), GDP (Gross Domestic Product), NEEM (Nominal Effective Exchange Rate) are obtained from the statistics bulletin of Central Bank of the Republic of Azerbaijan. The statistic data covering the period from April, 2011 until October 2014 is used on monthly basis. (Azerbaijan, 2011-2014)

2. Empirical analysis and results.

2.1. Unit root tests

Before modeling the CPI, it is useful to determine the orders of integration for variables included into VECM model. The most frequently used unit root test is based on the Augmented Dickey-Fuller test. This parametric approach originally proposed by Dickey and Fuller. (Dickey, "Distribution of the estimators for autoregressive time series with a unit root", 1979) (Dickey, "Likelihood ratio statistics for autoregressive time series with a unit root", 1981). As shown in Table 1 we use augmented Dickey Fuller Test (ADF) and Phillips-Perron statistics to identify the whether the variables are stationary or not. In other words, it tests whether all variables are non-stationary at their level and become stationary at

Table.1: Results of stationarity tests

Variables	ADF	Phillips-Peron	Decision
log(CPI)	-1,8207	-2,180965	I(1)
Δlog(CPI)**	-3,90564	-3,905638	
log(M2)	-2,85777	-6,633549	I(1)
Δlog(M2)**	-6,5325	-9,633966	
log(GDP)	-3,49737	-3,333486	I(1)
Δlog(GDP)**	-7,06195	-13,05603	
log(NEEM)	-3,35031	-3,360108	I(1)
Δlog(NEEM)**	-4,60428	-4,6132	

Note. D represents the first difference operator and log is logarithm. Critical values ADF test. 1%=3.5885.Philips-Peron 1%=3.58851. (**)-indicates that significant at 1%.

Table.2: Johansen Hypothesized cointegrating relations(trace statistic)

No. of CE(s)	Eigen value	Trace Statistic	0,05 Critical Value	Prob.**
None *	0,528189	70,75642	47,85613	0,0001
At most 1 *	0,401327	38,45584	29,79707	0,004
At most 2 *	0,215273	16,39515	15,49471	0,0365
At most 3 *	0,129653	5,971112	3,841466	0,0145

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level.

Table.3: Johansen Hypothesized cointegrating relations(Maximum Eigen value)

No. of CE(s)	Eigen value	Max-Eigen Statistic	0,05 Critical Value	Prob.**
None *	0,528189	32,30057	27,58434	0,0115
At most 1 *	0,401327	22,06069	21,13162	0,0369
At most 2 *	0,215273	10,42404	14,2646	0,1855
At most 3 *	0,129653	5,971112	3,841466	0,0145

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level.

Table.4.Vector Error Correction Model Estimates results.

	ΔlogCPI	ΔlogGDP	ΔlogM2	ΔlogNEEM
EC(-1)	-0,183139	3,397098	0,223302	0,331664
	[-3.69784]	[2.32330]	[0.91794]	[2.62172]
ΔlogCPI(-1)	0,45716	-3,295365	0,199148	0,188146
	[2.99613]	[-0.73152]	[0.26572]	[0.48273]
ΔlogCPI(-2)	0,179783	-6,399024	-0,76351	-0,670142
	[1.10411]	[-1.33108]	[-0.95462]	[-1.61119]
ΔlogGDP(-1)	-0,013359	-0,321906	0,002802	0,005802
	[-2.43617]	[-1.98835]	[0.10403]	[0.41424]
ΔlogGDP(-2)	-0,014053	-0,045467	0,020089	0,006578
	[-2.67569]	[-0.29322]	[0.77873]	[0.49033]
ΔlogM2(-1)	0,02593	-2,401713	-0,423921	0,053393
	[2.36468]	[-1.86224]	[-1.97572]	[0.47851]
ΔlogM2(-2)	0,032599	-3,804366	-0,32911	-0,01539
	[2.72556]	[-2.86804]	[-1.49131]	[-0.13410]
ΔlogNEEM(-1)	-0,169538	8,154115	0,374638	-0,224345
	[-2.36277]	[3.84911]	[1.06297]	[-1.22402]
ΔlogNEEM(-2)	-0,101872	3,298875	0,102855	-0,01359
	[-1.41842]	[1.55577]	[0.29156]	[-0.07408]
C	-0,000111	0,142931	0,032646	0,000927
	[-2.07346]	[3.21769]	[4.41749]	[0.24132]
R-squared				
Adj. R-squared	0,481356	0,480139	0,011463	0,147277
F-statistic	5,228034	5,207472	1,052825	1,786804
Akaike AIC	-7,365147	-0,594764	-4,181843	-5,489551
Schwarz SC	-6,951417	-0,181033	-3,768112	-5,07582

Table 5: Diagnostic tests			
	Tests	**F-statistics**	**Probability**
1	Normality		
	Jarque-Bera statistic	0.342	0.842
2	Serial correlation	0.7788	0.468
	Breusch-Godfrey serial correlation LM test		
3	Autoregressive conditional heteroscedasticity		
	ARCH LM test	0.0615	0.8055
4	Heteroscedasticity		
	Breusch-Pagan-Godfrey	0.9811	0.4885

their first differences. It was found that all variables of the study exhibit unit root process mostly at the 1% level of significance.

2.2. Johansen's Test for Cointegration

As we have more than two variables in the model, there is a possibility of having more than one co-integrating vector. By it means that the variables in the model might form several equilibrium relationships. In order to find out how many cointegrating relationships exist among variables requires the use of Johansen's methodology. Similar to Engle-Granger approach Johansen's approach requires all variables in the system are integrated in the same order 1 (Johansen, 1991). The factors impacting the inflation in the long-run econometric models participate with their own units. Consequently in most cases it depends on the time. As a rule these factors are non-stationary times series which reflect itself the long run change trends. These relations are estimated on basis of standard deviations and afterwards time series having close relations are chosen. In econometrics while the time series are changing with zero or close to zero standard deviation and synchronously changeable are called as joint series or cointegrated series(Hasanli, March 2008).

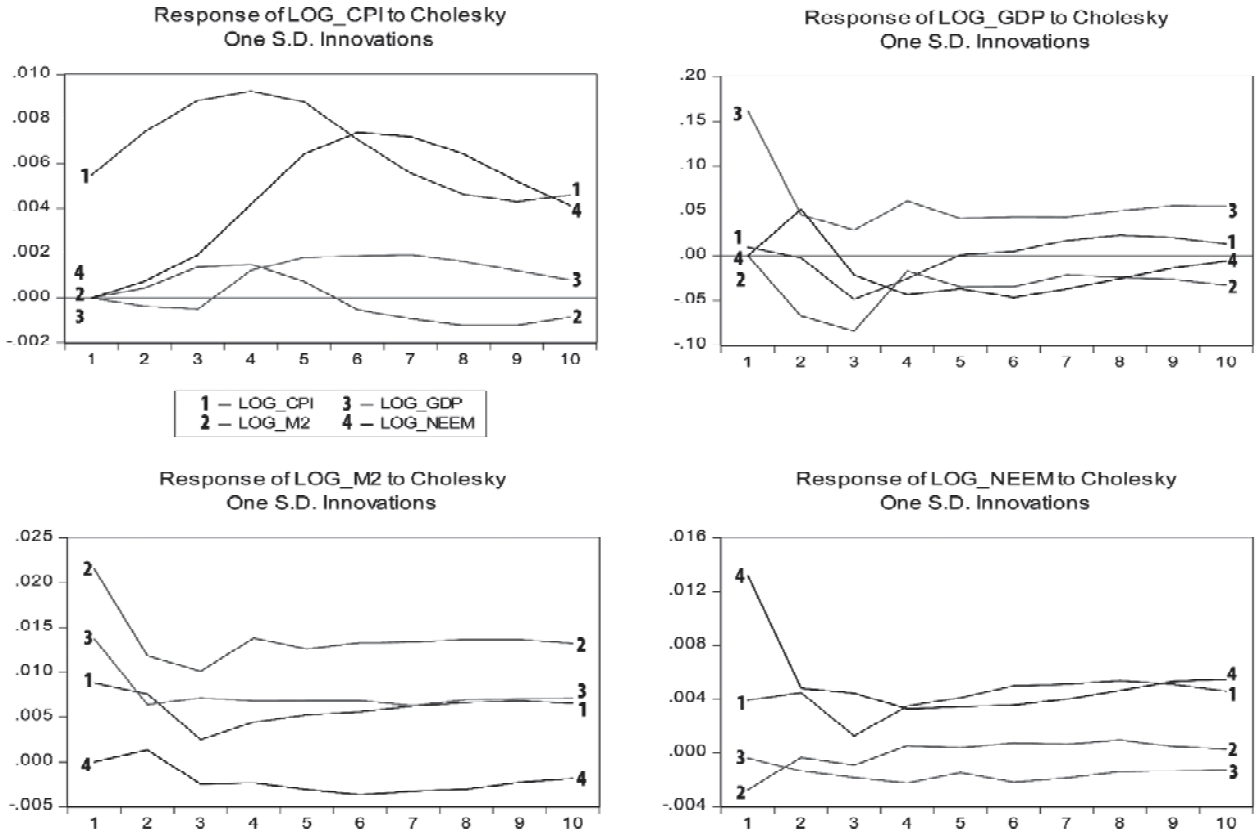
Trace statistics shows four cointegrating equations. Whereas max-eigen value test shows that there are two cointegrating equations in the analysis.

2.3. Estimation of Vector Error Correction Model.

Having determined that the variables are non-stationary at their levels but stationary after differencing once and they are co-integrated, we can build a Vector Error Correction Model (VECM).

The terms is derived from long-run equation introduces us information about speed of adjustment of inflation to its long-run equilibrium. It gives us the proportion of disequilibrium errors accumulated in the previous months those are corrected in the current month. VECM model results show that the speed of adjustment of consumer price index to the long-run equilibrium direction is about 0.18. As shown in the result the sign of error correction term is negative and this result is significant. It means that if inflation exceeds its long-run equilibrium by 1(one) percentage point, e.g. because of temporary shocks, 18percent of this deviation is adjusted for every month, so that it

Figure.1. Impulse Response of Inflation to Shocks: VECM Analysis



takes about 6(six) months for inflation return to its long-run steady state. Model shows that NEEM influences CPI significantly. F-statistics shows that model is significant.

From the standpoint of econometric theory there are may be serial correlation due to ARCH effect. Therefore in time series analyses, especially those involving financial data it should be tested for ARCH effect before accepting the Durbin-Watson statistics. (Damodar N Gujarati, 2004).

Above mentioned diagnostic test shows that, there is no ARCH effect in this model. In order to investigate whether there is heteroscedasticity problem in the estimated model or not, we apply to Breusch-Pagan-Godfrey test and determine that there is no heteroscedasticity. LM test indicates that VECM doesn't subject to serial correlation. (see.Table5).

3.3. Impulse responsiveness in Vector Error Correction Model.

Impulse response function (IRF) is a shock to a VECM system. Impulse responses determine the responsiveness of endogenous variable in the model when a shock is done to error term (EC-1). Shock is applied to each variable to see their effects in VECM system. So, the impulse response function traces out the response of the dependent variable in the VECM system to shocks in the error term such as EC-1. The IRF points out the impact of such shocks over several months in the future.

We can see from above depicted impulse response graphs that a shock put to error terms responded differently by each variable. So, while response impulse of CPI to NEEM is increasing trend up to 6months, after then the responsiveness goes down gradually (see.Figure1 and Table.6). It is obvious that response impulse function reaches its maximum responsiveness level only in the sixth month after happening the shocks (such as oil revenue shocks, innovation shocks etc.). Responsiveness of CPI to previous period CPI value is increasing up to 4th month after shock. But then it goes down. Although it goes down the increasing trend is observed in 10th period.

Conclusions

Results of Vector Error Correction Model in this study reveal that NEEM influences on inflationary processes significantly in the short run and long run relationship. As well as VECM estimates show that money supply (M2) impacts an increasing effect on inflation in the short run and long run too. So, macroeconomic indicator GDP mitigates the inflationary processes pressure in the short run and long-run. The lagged values of the CPI influence the volatility of inflation over time with significant inertia of about 0.45%. Current expectations about future price levels significantly influenced the volatility of inflation. According to the theory, error correction term is negative sign. VECM model results show that the speed of adjustment of consumer price index towards the long-run equilibrium direction is about 0.18. The sign of error correction term is a negative and this is significant. It means that if inflation exceeds its long-run equilibrium by 1(one) percentage point, e.g. because of temporary shocks, 18percent of this deviation is adjusted for every month, so that it takes about 4(four) months that the inflation will return to its long-run steady state.

Transmissions of inflationary processes are depicted in response-impulse functions. So, response-impulse reaction of CPI is significantly higher to the change in CPI and NEEM and it lasts several periods. The response impulse of CPI to the change in NEEM goes on the growing tendency up to six periods after change then it goes down. Investigating the responsiveness of CPI to the NEEM is very important to be aware of responsiveness duration and make the effective decisions in monetary policy.

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