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Impact of Inflation Uncertainty on the Prices of Industrial Products

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Abstract: Inflation rate in Iran has been a growing concern and gradually has become the country's economic problems. Despite the intense struggle, the rate of inflation in Iran has been growing during this time. The growth of Industrial production rate has been increased. This study compared the influence of price indices for agricultural and industrial products by inflation uncertainty using time series data 1974-2007. The inflation uncertainty is estimated by using GARCH models. The desired model using vector auto regression (VAR) was evaluated. Impulse response functions (IRF) and variance decomposition has also been checked. Results from the VAR test in the industry section indicate that the industrial added-value, real exchange rate variable, the volume of liquidity and inflation uncertainty are in positive relation with the price index industrial products. Impulse response functions in industrial sector have been studied to the incoming shocks of all variables. The variance decomposition results indicate that in a short, middle and long period of time, most contributions of fluctuations for industrial products' price index are followed by the industrial products price and they were about respectively, 72%, 55% and 50%. The results show that the inflation uncertainty variable along with other variables has a significant impact on industrial products' price, especially in a long term. Thus, in studies which analyze the behavior of industrial products' prices and affecting factors, the inflation uncertainty variable should be considered along with other variables.

JEL: C13 · C53 · E31
Key words: Inflation uncertainty · Industrial prices · GARCH model · Vector Auto Regression model (VAR) · Johansson integration

INTRODUCTION

Industry is one of the important and vital parts of each economy for growth and development, which is the target of most communities including developing countries. For many years, economic growth and development in developing countries was followed up through this sector to solve problems and to expend many costs [1]. In most developing countries, the fundamental and structural constraints in the supply side economics are major concerns that limit supply growth and cause the emergence of inflation pressures [2]. Inflation imposes costs on a society. The harmful effects of inflation include: redistributing the income in favor of asset owners and detriment of wage and salary, increasing the inflation rates and volatility in macroeconomic, shortening the time horizon of decision making, reducing capital investment in manufacturing activity and, as a result, decreasing the economic growth [3]. Inflation is often being considered as a measure of overall macroeconomic situation and macroeconomic instability and uncertainty [4]. Therefore, several studies have been performed in this field. Such as [5] discussed the effect of increased production of agriculture, industry and services on inflation in Iran. The results show that for the control of inflation in Iran, it is essential that government's economic policies pay more attention to the prices and expand production in agriculture and services sectors [6] examined the effect of government's credit policy in industry sector along with monetary and fiscal policies. The results suggest that there is a strong and stable positive relationship between bank credits and industry value added that represents excessive dependent industrial production to this governmental policy variable. [7] examined the link between inflation and inflation uncertainty using Granger causality test indicates that inflation leads to

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higher inflation uncertainty in Iran but the reverse relationship is not significant [8]. Used quarterly data in multivariate EGARCH models. This study found that both inflation uncertainty and output uncertainty had negative and significant effects on output growth. The study also found that inflation uncertainty and the inflation level had both declined since the adoption of a formal inflation-targeting monetary policy in Australia. [9] Studied the causal relationships between inflation, output growth and uncertainty for the Turkish economy based on the system-GARCH methodology. The estimation results revealed that policies aiming at reducing inflation would lead to a more efficient functioning of the price system and this would contributed to the real output growth. [10] investigated the behavior of Japanese stock market volatility with respect to a few macroeconomic variables including gold price, crude oil price and currency exchange rates (Yen/US$). The results showed that macroeconomic variables used in this study had no impact on the volatility of Japanese stock markets and the simplest GARCH (1, 1) model yielded the best result.

The aim of this study is to investigate the impact of industrial products prices on inflation uncertainty and demonstrate that the industrial product prices are affected by inflation uncertainty. Therefore, the macroeconomic variables and vector autoregressive model (VAR) are used for this study. The data used are annual dating from 1974 to 2007. The results are estimated by EVIEWS6.0

MATERIALS AND METHOD

Structural and theoretical models are generally used to predict the time series. Structural models are based on the theory of single-equation regression models and simultaneous equations, while non-theoretical models are not based on the theory and the future behavior of variables and are determined by their past behavior plus the error term that is not predictable. These models include the ARIMA[1], AR[2], MA[3] (Box-Jenkins technique is used) and VAR[4] models [11].In order to measure and estimate the inflation uncertainty (IU) variable, the Generalized Autoregressive Conditional Heterokedasiticy (GARCH) model has been used. The conditional variance of the error term follows an ARIMA process. Here q is the rank of moving average ARCH and p is the rank of Autoregressive GARCH. The GARCH (p,q) can be written as follows: [12]

$$y_t = x_t'\gamma + \varepsilon_t \tag{1}$$

$$\sigma^2_t = \omega + \alpha_i\varepsilon^2_{t-i} + \beta_j\sigma^2_{t-j} \tag{2}$$

y_t is the dependent variable in period t, x_t is the dependent variable in period t and ε_t is the residual in the period t.

The equation (1) is a conditional mean model, as a function of exogenous variables with the disturbance. Since the variance of each period is forecast by a prior period it is called the conditional variance. The conditional variance equation (2) is a function of the followings:

- Average ω
- News about volatility in the last period, which is delayed by residual of squares variable obtained from the equation ε^2_{t-i}. This statement is called ARCH.
- Forecasting variance of last period σ^2_{t-i}. This component is called a GARCH.

The necessary condition for positivity of conditional variance is that all the coefficients should be positive.

$$a_i > 0 \quad \forall i = 1,2,...,p \tag{3}$$

$$\beta_j > 0 \quad \forall i = 1,2,...,q \tag{4}$$

And also should have: $\omega > 0$. Sufficient conditions for the GARCH (p,q) for being weak stationary is that:

$$\sum_{i=1}^{p}\alpha_i + \sum_{i=1}^{q}\beta_j < 1 \tag{5}$$

If the shocks are unstable then the model will provide a sufficient condition [13]. In order to evaluate the inflation uncertainty variable, the model is estimated in different states using the Box-Jenkins method and the best optimal lag is obtained by using Akaike information criterion. The optimal lag is chosen by taking into account the lowest obtained Akaike information criteria. Vector autoregressive method is an option along Box-Jenkins's methods that is similar to simultaneous equations. The simultaneous equations method was severely criticized by Christopher Sims and VAR option was proposed by Sims (1980). Sims believes that this theory cannot provide enough limitation for identification of structural models [14]. In VAR model, there are some endogenous variables that each of them was explained by

[1] Auto Regressive Integrated Moving Average.

[2] Auto Regressive.

[3] Moving Average.

[4] Vector auto regressive.

their past values and the values with interruption of all other endogenous variables models. The two time series x_t and Y_t for two variables will be as follows: [15]

$$X_t = a_0 + \sum_{j=1}^{k} B_j X_{t-j} + \sum_{i=1}^{n} \delta_j Y_{t-i} + u_{1t} \quad (7)$$

$$Y_t = a_0 + \sum_{j=1}^{k} A_j X_{t-j} + \sum_{i=1}^{n} \lambda_j Y_{t-i} + u_{2t} \quad (8)$$

VAR model is estimated by OLS model and the results of this model depend on entered variables and lag length. In connection with the stationary of variables, the non-stationary variables existence intensifies the likelihood for the existence of spurious regression and cointegration relationships. Therefore, in the VAR model that contains a series of non-stationary, existence of cointegrated vectors should be tested. In order to estimate the model by using vector autoregressive (VAR), the stationary state must be considered first: 1. if the variables are stationary at the level, variables of the model will be explained. 2. If the variables are stationary at the first difference, then the VAR model, as was said earlier, will be explained. Then, the cointegration will be reviewed by Johansson test [16]. For this purpose, we use Johansson cointegration method. Model VAR in (8) with m variables is written like this:

$$Y_t = \delta + A_1 Y_{t-1} + \ldots + A_k Y_{t-k} + v_t = \delta + \sum_{j=1}^{k} A_j Y_{t-j} + v_t \quad (8)$$

$$Y_t = \sum_{j=1}^{k} A_j Y_{t-j} + v_t \quad (9)$$

To simplify the formula, the intercept is removed. Also assumed that all variables have one or zero order cointegration. This sample:

$$\Delta Y_t = BY_{t-1} + \sum_{j=1}^{k-1} B_j Y_{t-j} + v_t \quad (10)$$

is written as:

$$B = -(I - A_1 - A_2 - \ldots - A_k) \quad (11)$$

$$B_j = -(A_{j+1} - A_{j+2} - \ \ldots - A_{j+k}) \quad j = 1,2,3,\ldots,k-1 \quad (12)$$

Sample (12) is like ECM model where if all variables have cointegration order one, ΔY_{t-j} variables will be static. Now by assuming the existence of cointegration between variables and being BY_{t-i} as stationary, a consistent pattern can be estimated. In recent years, inflation uncertainty has been used as an indicator to show the status of macroeconomic instability. This has been due to the influence of variables from various sectors of the economy including the price indices of products and from the state of economic instability and fluctuation in prices. The study investigates the relationship between the price index of industrial products and uncertainty. A remarkable aspect of this study is that such a study has never been conducted before. With regard to research goals and internal and external reviews of studies performed, the desired pattern can be specified as follows:

$$LN(IND) = \beta_0 + \beta_1 LN(INVID) + \beta_2 \mathrm{LN}(OPEN) + \beta_3 \mathrm{LN}(RER) + \beta_4 \mathrm{LN}(M_2) + \beta_5 \mathrm{LN}(CPI) + IU + u \quad (13)$$

The variables are:
IND: Industrial product price index, the indicator measures the amount of output from the manufacturing, mining, electric and gas industries, INVID: value added of industries, The value added of an industry, is the contribution of a private industry or government sector to overall GDP and OPEN: degree of trade openness index. To determine the degree of openness index, the basic indicators have been used as follows: [17]

$$\mathrm{OPEN} = \frac{IM + EX}{GDP} \quad (14)$$

IM and EX and GDP, respectively, represent the total amount of imports, exports and GDP.

RER: real exchange rate. In this study, the country's real exchange rate is determined by notion's purchasing power parity (PPP). For this purpose, the following equation is used: [17]

$$RER = ER \times \frac{WPI}{CPI} \quad (15)$$

The WPI is the wholesale price index out of the country and as a close approximation; the wholesale price index of the America has been used instead. CPI is the consumer price index and ER is the exchange rates in the market. RER indicates the real exchange rate. M2: the volume of money liquidity, where liquidity is the sum of volume of money and quasi money. CPI: consumer price index. IU: the inflation uncertainty variable. Related data have been calculated and estimated using time series data of industrial products price index (IND). For this purpose, the Generalized Autoregressive Conditional Heteroskedastic model (GARCH) has been used.

Table 1: The results of stationary of variables

Variable	status	Observed value at level	Critical value at level	Observed value at 1st difference	Critical value at 1st difference
Log ind	intercept	-1.20	–3.46*		–3.46*
			–2.59**		–2.59**
			–2.61***	–3.98*	–2.61***
Log invid	intercept	0.56	-3.46		-3.46
			-2.59		-2.59
			-2.61	–5.86*	-2.61
Log open	intercept	-2.40	-3.46		-3.46
			-2.59		-2.59
			-2.61	–3.33**	-2.61
Log m2	intercept	1.07	-3.46		-3.46
			-2.59		-2.59
			-2.61	–2.84**	-2.61
Log rer	intercept	-2.18	-3.46		-3.46
			-2.59		-2.59
			-2.61	–4.05*	-2.61
Log cpi	intercept	-0.26	-3.46		-3.46
			-2.59		-2.59
			-2.61	–3.39**	-2.61

, ** and * indicate critical numbers in the level 1%, 5% and 10%, respectively*

Table source: calculated author

Table 2: The stationary of inflation uncertainty of industrial products prices by Dicky Fuller test

Variable		Status	Values	Results
IU	level	intercept	Observed value	-2.33
			Critical value	-3.64
				-2.95
				-2.61

Table source: calculated author

RESULTS

The first step in the analysis of time series variables is to study the stationary of variables. Therefore, the stationary of all variables was done by Augmented Dicky Fuller Test for which the results are given in Table 1.

The null hypothesis in Dicky Fuller Test assumes that the variable is stationary, yet the alternative hypothesis is vice versa. If the value of statistics is greater than the critical Mackinnon, the null hypothesis, the variable that is stationary is accepted. If the value of statistics is smaller than the critical Mackinnon, the null hypothesis is rejected and the variable is introduced non-stationary. It should be noted that because of Dicky Fuller Stationary Test is a tailed test for stationary or non-stationary comparison of variables, the absolute value is not used. As Table 1 shows, all the industrial products price index variables in Dicky Fuller Stationary Test are stationary with the first order difference. The estimation results for inflation uncertainty variable from industrial products price index are in equation 16:

$$\sigma^2 = 0.0017 + 0.981\varepsilon_{t-1}^2 \qquad (16)$$

The above equation is GARCH (1, 0). The estimated equation provides both the necessary and sufficient condition for GARCH model based on theoretical principles and foundations, because the necessary condition for weak stationary GARCH model is that the sum of GARCH coefficients needs to be less than one. This is 0.98 in the evaluated equation and is less than one. In other words, the necessary condition for the incoming shocks is not stable in disturbance, that is, the sum of GARCH coefficients is less than one. The sufficient condition for the GARCH model is that the intercept be positive and the conditional variance of the disturbance coefficient be positive and significant. The estimated equation, thus, provides the conditions. After estimating the inflation uncertainty variable, the stationary of the variable is tested by Dicky Fuller Test. The results are shown in Table 2 and indicate that the variable is stationary at the level:

By examining the variables, it was found that variables are stationary at first difference. In order to explain the model, the maximum lag should be considered at first. Then with the use of LR, Akaike, Schwartz, Schwarz Bayesian and Hanan-Quinn criteria, the suitable

Table 3: Optimal lag for VAR model

Lags	Schwarz Bayesian criteria
(1,1)	-11.55
(1,2)	-11.03
(1,3)*	-14.91

Table source: calculated author

lag will be choosen. According to Ivanova and Kelly (2005), for models with the sample size of less than 120, the most appropriate measure is Schwartz Bayesian [18]. The results are shown in Table 3 determining the optimal lag. According to Schwartz Bayesian criteria, the lag that has the smallest figures may be determined as the optimal lag.

As can be seen in Table 3, the optimal lag is determined at (1, 3). After determining, the optimal lag is evaluated by using Johansen cointegration test. Johansen cointegration test has two matrices which represent Trace and Maximum Eigenvalue Matrix. The null hypothesis says that there is no cointegration of vectors; it means that there is not any long run relationship between the variables and the alternative hypothesis says that there is cointegration of vectors. The level which the null hypothesis can be rejected at indicates the numbers of vectors that are co-integrated. Test results are presented below:

As can be seen in the results of Trace and maximum Eigen value test, the null hypothesis of Trace is accepted at the first 6 levels, which means that there is no cointegration vector. The null hypothesis of Trace is rejected at level 7 with 0.05 probabilities, but the null hypothesis in the maximum Eigenvalue is rejected at level 4, which indicates that there is long run equilibrium and cointegration vectors. In the VAR model to interpret the results, it should be noted that the estimated VAR method basically, in the estimation of equations, coefficients and the percent of explanation of pattern parameters has not the importance of single equation methods. Therefore, the impulse response functions and variance decomposition analysis are used for analyzing [19]. The results of long run relationship between the variables and normalize vector in proportion with the first endogenous variable are as follows in Table 6:

As can be seen in Table 6, the degree of openness index (Log OPEN) and consumer price index (Log CPI) have a significant negative correlation with the industrial products' price index variable as well as added-value of industrial sector (Log INVID), real exchange rates (Log RER). The volume liquidity (Log M2) and inflation uncertainty (IU) are positive and have a significant relationship with the industrial products' price index..

Table 4: Trace results of Johansen cointegration test

Null hypothesis	the alternative hypothesis	Observed value	Critical value at 95%	Probability at 95%
r=0	r≥1	348.620	125.61	0.0000
r≤1	r≥2	220.405	95.75	0.0000
r≤2	r≥3	120.779	69.81	0.0000
r≤3	r≥4	72.959	47.85	0.0001
r≤4	r≥5	36.771	29.79	0.0067
r≤5	r≥6	16.551	15.49	0.0345
r≤6	r≥7	4.297	3.84	0.0381

Table source: calculated author

Table 5: Maximum eigenvalue results of Johansen cointegration test

Null hypothesis	The alternative hypothesis	Observed value	Critical value at 95%	Probability at 95%
r=0	1=r	128.21	46.23	0.0000
r≤1	2=r	99.62	40.07	0.0000
r≤2	3=r	47.81	33.87	0.0006
r≤3	4=r	36.18	27.58	0.0031
*r≤4	5=r	20.21	21.13	0.0668

Table source: calculated author

Table 6: Results of using VAR test for industrial price index

Variable	Coefficient	Standard error
Log invid	2.608	0.571
Log open	-3.073	0.222
Log rer	0.005	0.0429
Log m2	0.100	0.1149
Log cpi	-0.0315	0.502
IU	4.559	0.1725

Table source: calculated author

Table 7: Impulse response functions result

Period	Log ind	Log invid	Log open	Log rer	Log m2	Log cpi	IU
1	0.1679	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.1767	-0.0235	-0.0116	-0.0153	-0.0023	-0.0103	-0.0077
3	0.1999	-0.0373	-0.0482	-0.0116	-0.0273	-0.0277	0.0149
4	0.2012	-0.0161	-0.0421	0.0046	-0.0254	-0.0336	0.0044
5	0.1878	0.0084	-0.0329	-0.0169	-0.0063	-0.0454	0.0011
6	0.1772	0.0150	-0.0132	-0.0317	0.0086	-0.0420	0.0087
7	0.1693	0.0124	-0.0032	-0.0427	0.0064	-0.0309	0.0216
8	0.1626	0.0179	-0.0035	-0.0463	0.0019	-0.0217	0.0302
9	0.1471	0.0277	-0.0025	-0.0463	0.0049	-0.0155	0.0372
10	0.1247	0.0302	0.0035	-0.0404	0.0122	-0.0067	-0.0445

Table source: calculated author

Impulse Response Functions: This index shows a variable response to the shock or impulse that is caused by the variable or other variables over the course of time. In other words, it shows how a shock acts, causes a reduction and an increase in a variable and disappears when a shock or impulse enters over time. To calculate, the shocks are inserted according to the size of a standard deviation of a variable and then the reaction is observed over the time which will be done in 10 periods in future.

The evaluation of impulse response functions of industrial product price index was done for the next 10 period, which will analyze the behaviors and reactions to the incoming shocks by the relevant variables in three periods of short term, midterm and long term. The results are as follows:

- Industrial product price response function to industrial product price index: the incoming shock from industrial product price in the first period causes the industrial product price to increase by 0.16 units. This in turn causes the industrial product price to increase by 0.17 units in the next period. This trend attains its peak at the fourth period and industrial product price rises by 0.20. After that, the trend falls and in the tenth period it causes industrial product prices to go up by 0.12 units. In general, industrial product price responses to industrial product price shocks in a short period of time and middle of the period will be positive. Also this response will be positive in a long term but with decrement. In other words, the shock from industrial price index will cause the industrial price index to increase.
- Industrial product price index response function to industrial added-value: The incoming shock from industrial sector's added-value to industrial product price in a short time period is ineffective at first, but in the mid-term period, it is negative and in a long term period is positive and causes the industrial product to increase.
- Industrial product price index response function to the degree of trade openness index: the industrial product price response to the incoming shocks in a short period of time has no reaction at first but it decreases afterwards. However, in the mid-term period it gradually becomes positive and continues its trend in a long term period of time. That is, applying this trade policy has no effect on industry sector at first, but in the middle of the period it causes the industrial price to drop. Also, the implementation of this policy in a long period of time will cause the industrial price to develop.
- Industrial product price index response function to real exchange rate: the industrial product price to the incoming shock from real exchange rate in a short time is negative and after that, temporary in the mid-term period is positive and in a long term period is negative again. This fluctuation is caused by the real exchange rate.
- Industrial product price index response function to the volume of money liquidity: the incoming shock from money liquidity to industrial product price is ineffective at first and has its negative effect by the middle of the period. But in a long period of time, the industrial price response is positive and this shows that money liquidity grows and that money supply in a long term period causes the industrial prices to grow.
- Industrial product price index response function to consumer product price index: the industrial product price response to the incoming shock from consumer product price in a short period of time is negative and has a decreasing trend. In the middle of the period, this trend is an ascending one and continues for a long period of term. In a long term, consumer price index shocks still have negative effects on industrial product prices and make it decrease.

Table 8: Variance decomposition of industrial products price

Period	Log ind	Log invid	Log open	Log rer	Log m2	Log cpi	IU
1	72.44	7.49	0.02	5.29	2.05	11.65	1.02
2	69.03	7.06	3.69	4.82	4.49	9.98	0.91
3	62.54	6.60	2.72	14.52	3.47	8.24	1.89
4	59.70	7.69	2.67	16.68	3.07	7.12	3.02
5	55.16	8.26	2.54	18.85	2.90	6.53	5.73
6	52.67	8.04	2.49	18.74	2.85	6.81	8.35
7	51.14	7.79	2.46	18.31	2.75	7.13	10.38
8	50.72	7.71	2.71	17.73	2.67	7.28	11.15
9	51.42	7.55	2.93	17.31	2.56	7.14	11.05
10	52.81	7.27	2.88	17.12	2.46	6.88	10.55

Table source: calculated author

- Industrial product price index response function to inflation uncertainty: industrial product price response to inflation uncertainty shocks has no reaction in a short time period but it has positive effects on industrial product prices in the middle of the term and a long term period of time. In other words, inflation uncertainty causes the industrial product price to increase in the mid and long term periods of time.

Variance Decompositions Analysis: In this section the results of analysis variance decomposition forecast for a period of 10 year can be interpreted. The function also as impulse response function is used in short term dynamic analysis. In this method, fluctuations of different variables can be divided into variables of the pattern and the relative importance of a variable can be seen in the behavior of other variables [20]. Thus, the contribution of each variable can be measured based on the changes in other variables over the time. The results are shown in Table 8.

Also, with the help of variance decomposition, the contribution of each variable on changes of other variables was evaluated. Results show that in a short period of time, most contributions of fluctuations for industrial products' price index is about 70% followed by consumer price index with 11%. In the middle of the period, this amount reaches 55% for industrial products price and 18% for the real exchange rate. Also, in a long period of time, about 50% of fluctuations can be represented by industrial products price index, 17% by the real exchange rate and about 10% by inflation uncertainty.

DISCUSSION

In this paper, the Impact of Inflation Uncertainty on the Prices of Industrial Products in Iran has been reviewed over the period 1974 to 2007. For this purpose, the GACRCH and VAR models have been used.

The results reveal that the effect of economic decisions is reflected effectively in the industrial sector. The monetary policy is one of the most important macroeconomic tools and awareness of how it influences planning. National and regional development is also an important step. Therefore, planning and determining the appropriate economic policies and implementing these policies can play important roles in price stability in this sector.

One of the effective factors in industrial products' price is inflation which is caused by money supply growth. Thus, essential efforts should be made to eliminate inflation and move toward price stability, using contractionary monetary policy.

Due to the negative relationship between the degree of openness and industrial products' price, if Iran's trade policy moves to join the WTO for a wider economy, the contribution of subsidies paid by the government will reduce. As noted in the results, this will in turn increase the industrial products' prices in the middle and long periods of time. According to the study, we can make several important observations as follows:

- Dicky Fuller Stationary test was used to determine the stationary of variables. The results show that all the variables are not stationary at level and were stationary at first difference.
- After reviewing the stationary of variables, the inflation uncertainty variable was estimated by using the GARCH model. The variable is estimated at GARCH (1, 0) with respect to the necessary and sufficient conditions using GARCH process and Box-Jenkins method. After estimating the inflation uncertainty variable, the stationary of the variable was investigated and it was stationary at level.
- The model was estimated by the VAR method. It is worth mentioning that the VAR model and its results are not interpreted. But the pattern is used to investigate the cointegration and dynamics in

the pattern. The results show that there is a long term relationship between the variables. In industry, the value added of industry sector, the real exchange rate, the liquidity volume and inflation uncertainty have positive and significant relationship with industrial product price index. The consumer price index and the degree of openness have negative and significant relationship with the industrial product price index.

- The results show that the inflation uncertainty variable along with other variables has a significant impact on industrial products' price, especially in a long term. Thus, in studies which analyze the behavior of industrial products' prices and affecting factors, the inflation uncertainty variable should be considered along with other variables. In this way, the null hypothesis based on the effects of inflation uncertainty on industrial products' price will be accepted.

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