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Abstract

Examining energy as a strategic commodity in the world and analysis of the effect of changes in its price on key economic factors has been always considered as significant. The importance of this issue is twofold in Iran: first, policies in this country, as one of the great possessors of energy resources in the world, affects not only the price of domestic and foreign oil products but also other economic variables. On the other hand, for different reasons such as oil price volatilities and income from oil export, economic planners and policy makers in Iran have been mainly focused on the promotion of non-oil exports especially during the last few decades. Therefore, methanol as one of the most commonly used petrochemical products has a high potential for production and export of non-oil products in Iran. For this reason, in the present study there was an attempt to examine the relationship between the prices of Iran's crude oil, natural gas, and methanol using IGARCH model and based on the weekly time series data related to the research variables. The results of the study showed that the shocks caused by the price of crude oil and natural gas to the price of methanol were lasting and meaningful and were revealed in the long term.

Keywords: Methanol Price, Natural Gas Price, Crude Oil Price, IGARCH Model.

JEL Classification: Q43‹C13‹C32.

1. Introduction

Energy is internationally considered as a strategic commodity. Governments, organizations, and manufacturers' activities are widely dependent on energy and its market. In fact, governments' and international organizations' policies with respect to energy and financial markets have direct and indirect effects on the price of this commodity. There are evidences to show that any change in the price of energy influences the price of other commodities and household consumption (Komijani et al., 2013). Therefore, in order for sustained economic development, producing and utilizing energy should be coordinated and planned in line with other dimensions such as technology, human resources, raw materials, financial resources, etc. (Barbiroli, 2002).

Crude oil as one of the main sources of energy is also the main source of income for members of OPEC. This is most noticeable in Iran because income obtained from oil and gas comprises about 60 percent of the Iranian government's revenues and 90 percent of its export earnings (Farzanegan, 2011). Therefore, volatilities in oil price has an important role in creating economic fluctuations in oil-producing countries including Iran (MehrAra and Niki Oskuyi, 2006). The reason might be the high sensitivity of oil price to political, economic and cultural issues worldwide and consequently its volatility on the one hand, and the high influence of the volatile prices on macroeconomic variables (Kang et al., 2011). This is the reason why the Iranian economy is always exposed to receiving blows from foreign currency income and the danger of sudden changes in oil revenues. The continuous and lasting effect of this process on Iran's economy especially during the recent years calls for a pressing need to make correct decisions in macroeconomic policies. Therefore, the dependence of Iran's economy on revenues from selling fossil resources and the instability caused by their price volatility has made Iran prioritize non-oil exports (Mehrara and Mohaghegh, 2012). A remarkable portion of Iran's non-oil exports include petrochemical products; methanol is one of the important petrochemical products. Furthermore, the relative advantage of producing and exporting petrochemical products, i.e., in its potential for creating jobs and increasing current earnings, can mitigate the negative effects of oil shocks (Mehrara and Oskui, 2007).

After Oil, natural gas as the Main feedstock of petrochemical products, is the second energy resource in the world. Today it has a particular advantage over other energy carriers especially in terms of environmental factors. Changes in demand for energy during the last few decades from fossil fuels to fuels with low carbon such as petrochemical products confirm this fact (Masih et al., 2010a). Accordingly, during the recent years, the need for energy has changed from wood to coal and from coal to oil and currently to natural gas (methane with 65 percent carbon). In line with this process, the share of natural gas as a fuel is increasing. In fact, natural gas produces 24 percent lower pollution compared to crude oil and 42 percent lower than coal. This indicates that we can consume more energy and produce a lower level of pollution compared to crude oil and coal (Komijani et al., 2013). Natural gas is not only a huge and almost clean energy resource but also a cheap one. Furthermore, the international attempt to decrease greenhouse gases and CO2 clearly shows the advantage of natural gas over other fuels. There is evidence to show that an increase in consuming this commodity in 1990s among European countries (30 percent in Germany, 50 percent in Italy, and 100 percent in England) led to a decrease in production of CO2. In addition, due to its relation with other economic institutions (especially in petrochemical industries or final products) and sections, natural gas has a considerable role in the process of making economic decisions and meeting developmental goals of the countries (Schroder et al. (2011), Olivier et al. (2012)).

The importance of natural gas is not just due to its value as a fuel or its cleanness. Gas is, in fact, the most important raw material for different industries especially the petrochemical industry. One of the most important features of the petrochemical industry which is based on gas materials, is its very high added value in the sense that with chemical and physical changes in oil and gas hydrocarbons, the value of their products can be increased about 10 to 15 percent (Lissek and Muller, 2012). Another feature of this industry is its high variety and its potential for providing raw materials for thousands of manufactories and factories in its downstream industries which plays an influential role in the economy of a country in terms of creating jobs and increasing current earnings and reducing dependence.

Methanol is one of the three important products of petrochemical industries in the world and it has many derivatives such as MTBE, DME, Acetic acid, Resins, polyamides, Formaldehyde, solvents, adhesives, anti-ices, toxins and pesticides (Masih et al., 2010b). Therefore, this industry as one of the best alternatives for increasing exports plays a very significant role in improving and promoting economy, localizing technology and developing side industries. Considering the important role of this industry, improving the level of productions and promoting exports of this commodity can help to increase currency earnings, improve economic growth, and decrease rate of unemployment.

The present study will attempt to address whether crude oil price has a meaningful and positive effect on return volatilities of Iran's methanol price, whether the price of natural gas has a meaningful and positive effect on return volatilities of Iran's methanol price, and if 'yes', whether price elasticity of methanol is higher for crude oil or natural gas. For this purpose, weekly time series data related to methanol price, Iran's crude oil and natural gas price from the first week of 2005:1 to the third week 2013:5. The relationship between the mentioned variables will be modeled using GARCH models. As an outline, in this study after examining the previous studies in this regard, the theoretical bases of the research will be discussed and the results will be analyzed and interpreted and finally related conclusions and suggestions will be made.

2. Natural Gas, Crude Oil Price and Methanol Price

Though all kinds of energy are essential inputs for production processes; crude oil and natural gas play a distinguishable role. Oil price whether as an important manufacturing input -for energy importers- or a valuable source of income –for energy exporters- has significant effects on the macroeconomic situation in almost all countries. In particular, oil price not only affects major economic indicators i.e. GDP, unemployment and exchange rate but also has direct and indirect impacts on its rare alternatives like gas (Ji, 2011). Various dependant downstream industries, increasing demand for energy (caused by both rapid population and economic growth rate) as well as technological limits has made oil a strategic substance which hardly can be substituted. As Bachmeier and Grifen (2006) argue, the only substance that may replace oil in the modern economies is natural gas because it not only is more productive but environmentally speaking is less polluting than oil. However, in addition to its applications as a fossil fuel, several petrochemical -including methanol- are derived from natural gas. And more interestingly, the majority of the economic value is related to the role natural gas plays in petrochemicals industry (Liu et al., 2011).

In comparison with other industrial petrochemical products, the very simple chemical structure and its application in producing a great number of goods have made methanol an important product. Though natural gas is the main source for producing methanol, it can be produced from other substances such as wood, crude oil, coal and carbon dioxide. Therefore, considering the global concerns about carbon dioxide emissions, developing CO2-based methanol production technologies is a potential solution for improving environmental quality (Methanex, 2011).

The volume of methanol production doubled in less than 25 years, has increased from 15.9 million tons in 1983 to more than 32 million tons in 2006 (Vora et al., 2009). This demand enlargement proves the rising inclination toward and demand for methanol in the world market. So, determining the factors which affect methanol price has a significant importance. According to Nexant (2009), these factors can be classified to three categories:

- Technological Changes
- Market Condition
- Natural Gas Price (as the main source of methanol)

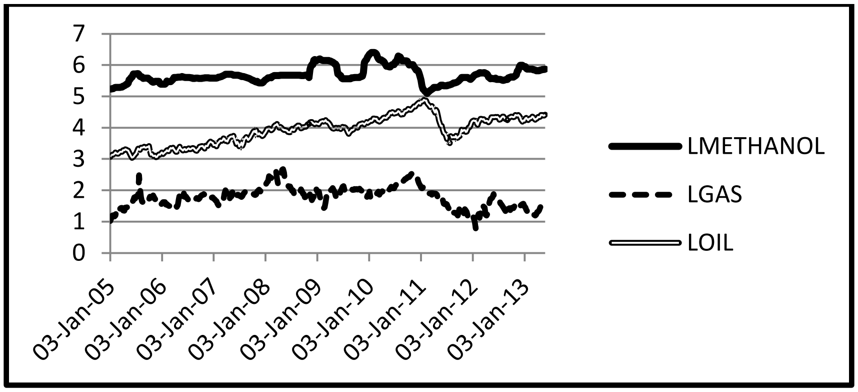
This paper investigates the relationship between oil price and methanol. So, considering the Nexant (2009) classification, oil through two channels may affect methanol price; market condition and natural gas price.

The first mechanism is elaborately studied in the literature. In fact, numerous researchers have studied the effects of oil price changes on economic activity and discussed the mechanisms through which these effects transmit to other macroeconomic indicators (e.g. Hamilton, 1983, 1996; Pindyck and Rotemberg, 1983; Bernanke et al., 1997; Bernanke, 2004; Devlin and Lewin, 2004; Cologni and Manera, 2007). In addition to these papers which are focused on industrialized oil importing economies, some have studied developing -or recently developed- oil importing countries (e.g. Ziramba, 2010 in South Africa, Bashiri and Manso, 2012 in Portugal, Ghosh, 2011 in India and Ou and et al., 2012 in China) as well as oil exporting countries (e.g. Dibooğlu and Aleisa, 2004 in Saudi Arabia; Mehrara and Oskui, 2007 in four oil exporters; Lescaroux and Migno, 2008 in OPEC members; and Mehrara and Mohaghegh, 2012 in oil exporting countries). All these studies have confirmed that oil price change is an important source of macroeconomic fluctuations both in national and global level. In brief, as He et al. (2010) assert, oil price movements systematically change economic indicators in the world market in both short- and long-run (He et al., 2010). So, evidently oil price affects both supply and demand sides of the methanol world market.

On the other hand, since gas-driven petrochemicals like ethanol and methanol are substitutes for oil-driven fuels such as petroleum and gasoline, there is a mutual relationship between oil price and gas-driven petrochemicals – including methanol. Joets and Mignon (2006) show that oil and gas act as substitutes in the market. Masih et al. (2010a) have investigated the interconnection between oil price and ethylene price in the US and confirmed the existence of such a substitution relationship. Masih et al. (2010b) also, highlight the role of oil price as the major instigator of methanol price movements in Europe, US and Far East. Moreover, some researchers suggest that oil price affect gas price which as a main source for producing methanol affects its price. Stephen et al. (2008) claim that oil price variations are the major source of gas price movements. Highlighting this relationship, Rosthal (2010) confirms that in the US there is a long-run relationship between oil and gas prices. So, we can conclude that oil price -via affecting natural gas price or by determining the price of its substitutes- has a significant impact on methanol price. Though this conclusion seems robust, our literature review showed that no study has investigated this relationship empirically; what we do in this paper.

The results of these studies also confirmed substitutionary of natural gas and oil and therefore, dependability of their price to each other. Figure 1 also confirms the existence of a relationship between oil and gas price and the price of methanol.

Figure 1: The Study Variables Graph



Source: The Finding of the Study

As shown in the figure above and based on the results of experimental studies and considering the confirmed effect of changes in natural gas price on the price of methanol and also the confirmed meaningful and long-term relationship between prices of natural gas and crude oil, the fact that volatilities in the price of natural gas and crude oil can lead to volatilities in the price of methanol calls for more detailed and systematic investigation.

4. Methodology

Overall, the fact that prices in financial markets (including oil, gas, and petrochemical products) are highly dynamic and volatile is like a general pattern and framework; these types of markets are modeled and forecasted using GARCH model in the literature on econometrics. This model eliminates the problem of volatility clustering and fat-tailed (non-normality) in the time series and takes account of the factors that highly affect the price of properties including sudden shocks, structural changes, responding to domestic demand, world economic conditions, and political events paying special attention to them in modeling (Vu, 2011).

Autoregressive conditional heteroscedasticity (ARCH), first introduced by Engel (1982) and later on generalized by Borlerslev (1986) are among the models that are used for explaining volatilities of a time series. Subsequently, different models of conditional heteroscedasticity were introduced which can be divided into two categories: linear (GARCH and IGARCH) and nonlinear models (EGARCH, TGARCH, PGARCH, FIGARCH, etc.).

Based on Engel's model, Borlerslev (1986) introduced the generalized form of ARCH model, i.e., GARCH. The distinguishing factor between these two models is the existence of variance lags in the conditional variance equation. Indeed, GARCH model has a structure similar to an ARMA model. The general form of this model is as follows:

(1)
$$M_t = \mu_t + \varepsilon_t$$
$$\varepsilon_t = z_t \sqrt{h_t} \ , \quad z_t \sim N(0,1)$$

(2)
$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$$
$$h_t = \sigma_t^2$$

Equation (1) is a mean equation and includes two parts: μ_t which is an appropriate structure for explaining the mean equation and ε_t which represents residuals of the model which have the conditional heteroscedasticity and is composed of two parts including 'normal' (z_t) and conditional standard deviation ($\sqrt{h_t}$) which has been included in equation (2). In fact, h_t is the conditional variance equation which is estimated along with mean equation to eliminate the problem of ε_t heteroscedasticity. In this equation, ω is the mean of σ_t^2, ε_{t-1}^2 coefficient represents the effects of ARCH and h_{t-1} is indicative of the effects of GARCH (Kang et al., 2009). One of the most important features of this model is the temporary shocks to the time series under investigation.

The results of studies by Engel and Borlerslev (1986) show that in some cases the above GARCH equation has a unit root in the sense that for example in GARCH(1,1) the $\alpha_1 + \beta_1$ value is very close to one. In this case, the GARCH model is cointegrated in which case it is known as IGARCH (Arouri et al., 2010). In these models, is there is a shock to the time series under investigation, its effects will be lasting and will be revealed in the long term.

5. Empirical Results

In this research Weekly data from the first week of 2005:1 to the third week 2013:5 related to the price of crude oil, natural gas and methanol were used. These data were obtained from the website for U.S. Energy Information Administration (EIA), International Energy Agency (IEA) and Fannavaran Petrochemical Company. It should also be mentioned that the abbreviations for the applied variables in thus study include LOIL representing logarithm of heavy crude oil price, LGAS which represents logarithm of the natural gas price and LMETHANOL which indicates logarithm of the methanol price.

Before going through the different stages of the modeling, in order to avoid creation of a false regression, stationary of the variables of the study should be first considered in the models based on the time series data otherwise the results will not be reliable. Therefore, stationary test was first carried out based on Augment Dickey- Fuller and Philips-Pron tests (see Table 1 for the results).

Table 1: The Study Variables Stationary Tests

Test	Critical Value	Accounting Value	Result
		LMETHANOL	
ADF[1]	-1.94	-0.26	Non-Stationary
PP[2]	-1.94	-0.64	Non-Stationary
		LOIL	
ADF	-1.94	-1.37	Non-Stationary
PP	-1.94	-1.23	Non-Stationary
		LGAS	
ADF	-1.94	-1.02	Non-Stationary
PP	-1.94	-1.06	Non-Stationary

Source: The Finding of the Study

As shown in Table 1, all the research the level of variables are non-stationary based on the ADF and PP tests. Indeed, all these variables are cointegrated with first order (i.e., I(1)) and in order for a correct modeling of the relationship between these models differencing is required because otherwise the results of forecasts will not be reliable. Therefore, considering the performance of different models of the time series is influenced depending on the different data, before doing anything the descriptive statistics related to differencing the dependent variable, as shown in Table 2, will be examined.

Table 2: Summary Statistics of dLMETHANOL

Stat.	Return Of Gold Prices Series	Stat.	Return Of Gold Prices Series
Mean	0.0014	Kurtosis	25.0406
Max	0.3342	Jarque- Bra	8986.18(0.000)
Min	-0.2586	Box- Ljung Q(10)	179.02(0.000)
S.D	0.0389	ADF	-7.714(0.000)
Skewness	1.2850	PP	-15.400(0.000)

Source: The Finding of the Study

Based on Table 2, mean of the return series of methanol price (differencing of methanol price) in the period under investigation was 0.0014 with the standard deviation of 0.04. Comparing these two it can be found that this time series has been highly volatile during the period under investigation. This implies that

[1] Augmented Dicky-fuller Test
[2] Phillips-Perron Test

there is a possibility of heteroscedasticity of the return series variance. The test of normal distribution of the time series under investigation indicated non-normality of this series and skewness statistics are indicative of leaning to right side of the mean. Based on the Liang-Box statistics (with 10 lags) the null hypothesis about 'lack of serial autocorrelation between series can be rejected. Finally, analysis of the statistics related to the stationary test (ADF and Phillips-Pron) indicate stationary of the related variable. Thus, for eliminating the problem of continuous autocorrelation, ARIMA models can be used. The results of forecasts made by different models have been provided in Table 3.

Table 3: The Estimated ARIMA Models

Model	AIC	SBC	ARCH-TEST
ARIMA(1,0.04,1)	-3.838	-3.792	F(1,434) = 8.88 (0.000)
ARIMA(1,0.04,2)	-3.671	-3.652	F(1,433) = 7.34 (0.000)
ARIMA(2,0.04,1)	-3.666	-3.626	F(1,433) = 7.68 (0.000)
ARIMA(2,0.04,2)	-3.564	-3.523	F(1,432) = 7.54 (0.000)

Source: The Finding of the Study

As shown in Table 3, based on the Akaik (AIC) and Schwarz (SBC) criteria, ARIMA(1,1) model yielded the best forecast among all the ARIMA models. It is worth mentioning that the heteroscedasticity test was examined using the ARCH test and the results, as shown in the above table, were indicative of the existence of the mentioned feature in the residuals of all the models. For this reason, in order to eliminate this problem from White's consistent estimators (Robust) were used for estimation. So in order to eliminate the problem of heteroscedasticity, models of the GARCH family will be used. the results of forecasts made by different models is as follows.

Table 4: The Estimated GARCH Models

Models	ARIMA(1,1)	
	AIC	SBC
GARCH	-8.375	-8.322
EGARCH	-8.430	-8.353
GJR-GARCH	-8.538	-8.506
APGARCH	-8.528	-8.504
IGARCH	-8.579	-8.515

Source: The Finding of the Study

Comparing the values of the information criteria related to different types of GARCH models it can be easily found that ARIMA(1,1,1)- IGARCH model has the lowest value for Akaike and Schwarz information criteria and, thus, gives the best explanation for the behavioral pattern of the existing volatilities in the return series of methanol price. The coefficients of the variables of this model have been presented in Table 5 along with the statistics related to significance of these coefficients. The statistics related to examining the existence of heteroscedasticity in the residuals in this model (statistics related to Liang-Box and McLeod Li and ARCH tests) have been also provided below the table related to forecast made by this model.

Table 5: The Estimated ARIMA(1,1)- IGARCH Model

Variable	Coefficient	Standard Error	t-Stat.	Prob
Mean Equation				
C	0.13	0.04	3.19	0.002
dLGAS	0.21	0.02	10.97	0.000
dLOIL	0.64	0.03	17.19	0.000
AR(1)	0.79	0.05	13.52	0.000
MA(1)	-0.51	0.08	-6.02	0.000
Dum	0.76	0.02	3.49	0.002
Variance Equation				
ARCH	0.67	0.023	29.11	0.000
GARCH	0.32	0.012	26.63	0.000
R^2= 0.78				
Log likelihood	1747.28	Box- Ljung Q(10)		11.15 (0.193)
Akaike	-8.57912	McLeod-Li Q2(10)		2.426 (0.965)
Schwarz	-8.51567	ARCH(10)=F(10,2503)		0.083 (0.775)

Source: The Finding of the Study

Based on the above table, some points can be mentioned. First, the introduced virtual variable in the mean equation of the above model (*Dum*) indicates the unconventional shocks to the time series under investigation as a consequence of the financial crisis worldwide in 2008. The unconventional shocks were selected based on their greatness in the sense that they were four times higher than the standard deviation of the return series. In addition, all the coefficients of this model were significant at 0.95 level. The results of Liang-Box also show no sign of serial autocorrelation in the residuals of this model. The existence of heteroscedasticity in the residuals is refuted based on the McLeod Li and ARCH tests.

6. Conclusion

In this study, we examined the short-term relationship of changes in oil and natural gas prices and the price of methanol from the first week of 2005:1 to the third week of 2013:5 using the weekly data and IGARCH model. Analysis of the results of the stationary test of the research variables (ADF and PP test) showed that variables of the crude oil price logarithm, natural gas price logarithm, and methanol price logarithm are non-stationary and integrated with first order and were, therefore, used for modeling differencing of the research variables.

In the next step, diagnostic tests such as Liang-Box were carried out to determine an appropriate model which is consistent with the structure of the data related to the return of methanol price. The results of these tests confirmed the existence of autocorrelation and the likely existence of heteroscedasticity. Then, different ARFIMA models were used to eliminate the problem of heteroscedasticity. The results showed that among all ARFIMA models, ARFIMA (1,1,1) had the best performance based on the Akaike and Schwarz information criteria. What is worth mentioning is that in examining residuals of all the models, the existence of heteroscedasticity was confirmed in all ARFIMA models. Therefore, to eliminate this problem (heteroscedasticity) which causes inefficient and skewed forecasts, different models of the GARCH family were used including GARCH, EGARCH, GJR-GARCH, APGARCH, and IGARCH and their performance was compared in terms of forecasting error based on the mentioned information criteria. The best GARCH model for modeling return behavior of methanol price was found to be IGARCH.

The results of forecasts made by the best model. i.e., ARIMA(1,1,1)- IGARCH imply that based on the information criteria forecasting accuracy of this model is much higher than ARIMA(1,1,1). Indeed, all the estimated coefficients in this study were meaningful at 0.95 level.

Furthermore, analyzing the coefficients of the research variables in the best model it can be found that price elasticity of methanol is approximately 0.64 compared to crude oil price while its price elasticity was about 0.21 when compared to natural gas price. This implies that an increase in crude oil price has more effects on methanol price compared to when there is a rise in the price of natural gas. The reason can be sought in the price setting structure of these two products, i.e., crude oil and natural gas; the previous is determined in the competitive markets all over the world and has higher volatilities in response to economic and political issues and international changes; the second, on the other hand, is presented by the Iranian government and as subsides to petrochemical companies and undoubtedly it is less affected by economic events and consequently can be less effects on other related variables.

An overall analysis of the results of this study indicates that there are two reasons for the positive relationship between crude oil and methanol prices; first, an increase in crude oil price leads to an increase in demand for alternative commodities such as natural gas (as the most important Main feedstock of methanol production) which naturally leads to an increase in methanol price; second, in an oil-dependent economy an increase in oil price leads to a higher inflation (Arman & Aghajari, 2009) and consequently an increase in the costs of production. In this way, the production costs go higher resulting in an increase in the price of all products including methanol.

The results of this study further suggest that based on IGARCH model the shocks to the price of methanol are lasting and are revealed as a highly significant relationship and effect on methanol price in the long term. Based on the results, although petrochemical products can replace oil products, due to lack of appropriate infrastructures for using these products (as a production factor) and the fact that making the required technological changes is not cost-effective, they will replace oil products with an increase in oil price (which is possible in the long term). Furthermore, as the price of natural gas which is used as Main feedstock of petrochemical products is reduced as the result of subsides in Iran, the claim about the susceptibility of methanol price to changes in crude oil price through the channel of natural gas seems illogical. Therefore, considering the explanations about the channels of influence of changes in oil price on the methanol price in the theoretical background changes in crude oil price through the channels of market and changes in the price of production factors will influence methanol price and considering the time consuming nature of this influencing process, it can be found that the findings of this study in terms of the lasting nature of the effects of shocks from the research variables (crude oil and natural gas) on methanol price and the existence of a strongly significant relationship between these variables in the long term are totally consistent with the reality.

As petrochemical products form the major part of Iran's non-oil exports and because methanol is one of the most important petrochemical products in Iran, an increase in the price of crude oil leads to an increase in methanol price and consequently a decrease in Iran's non-oil exports based on the findings; therefore, under such conditions due to volatilities in the price of crude oil and consequently instability of Iran's oil revenues, the stability of foreign exchange earnings from methanol as one of non-oil export items will be threatened. This situation will mitigate and reduce the consequences and risks of macroeconomic decisions in Iran.

It should be noted that in the time period under investigation in this study, the price of natural gas used for methanol production was subsidized; therefore, by enacting the law of targeting subsidies and removing subsides for energy carriers, changes in oil price can be expected to influence the price of methanol through the channel of natural gas. Therefore, as a suggestion the results of this study can be reanalyzed after enacting the law of targeting subsides.

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