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EXAMINATION AND COMPARISON OF THE ECONOMIC EFFECTS OF INTERNATIONAL RISK SPILLOVERS ON THE IRAN'S MONEY MARKET USING DCGE MODEL

Pardis Alsadat SEYEDMASHHADI[1]

Sayyed Abdolmajid JALAEE[2]

Mehdi NEJATI[3]

Mohsen ZAYANDERODI[4]

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Abstract

Opening doors of the economy and moving toward the globalization process increase business transactions, capital mobility and at the same time economies of scale and technology transfer. Naturally, risk spillovers are occurred along with business transactions and capital mobility. Risk spillovers can be effective in various sectors of the economy that the most important sector is the money market. Thus, the main question in this study is that do risk spillovers of the oil market affect Iran's money market? Given the structure of Iran's economy, one of the most important channels of transferring international risk to the country's economy is oil price changes. According to the exploration of economic effects of financial crises on oil price as well as the previous process of its changes, the seven percent decrease of oil price has been explored as the major scenario, and the effect on macroeconomic variables especially the money market is shown. Considering the effect

[1] Ph.D. Student of Economics, Kerman Branch, Islamic Azad University, Kerman, Iran. E-mail: pardis_seyedmashhadi@yahoo.com

[2] Professor of Economics, Shahid Bahonar University, Kerman, Iran. Corresponding Author. Department of Economics, Faculty of Management and Economics, Shahid Bahonar University, Pajoohesh Sq., Kerman, 76169-14111, Iran. Phone: +98 913-142-0026. Fax: +98 (34) 3322-2037. e-mail: jalaee@uk.ac.ir; jalaee44@gmail.com

[3] Assistant professor of Economics, Shahid Bahonar University, Kerman, Iran. E-mail: mehdi.nejati@gmail.com

[4] Assistant professor of Economics, Kerman Branch, Islamic Azad University, Kerman, Iran. E-mail: m_roody2000@yahoo.com

of international risk spillovers on macroeconomic variables via structural equations, dynamic computable general equilibrium models (DCGE) are employed. The results revealed that the international risk index influences macro variables that most of them are inflation, investment, welfare and demand for money.

Keywords: international risk spillovers, DCGE, money market, oil price

1. Introduction

Exploring spillovers in all developed and developing countries has special importance because economic growth and development are faced with a slow process without paying attention to technology spillovers. Thus, indigenous growth models should be used in the exploration of technology spillovers since research, development and human capital are regarded as indigenous factors in the establishment of technology and its spillovers in these models. In this regard, exploring risk and its spillovers will be especially important because the risk is one of the most important features for decision making in the investment field, financial markets and different types of economic activities. Investment in economic and social growth and development is so important that it is regarded as one of the strong leverages to achieve development. Given that proper investments can be highly effective on creating new job opportunities and help development of a country and considering the importance of foreign investment and the fact that attracting foreign investment is usually one of the most important indexes of economic growth, especially in developed countries that are influenced by several factors such as risk index, it is important to explore risk and risk spillovers in different countries. The aim of this study is to explore risk spillovers arising from the oil market in Iran and its effect on the money market; as the money market is more flexible than other markets. Therefore, the importance of the research topic is to evaluate appropriate conditions of Iran's money market through the open doors of the economy which is influenced by risk spillovers and propose a suitable strategy. Thus, the main question in this study is that do risk spillovers of the oil market influence Iran's money market?

To respond to this question, this study is organized as follows. In the next section the research literature is presented. The third section, address theoretical principles. In the fourth section, the research model is estimated, and conclusions will be proposed in the fifth section.

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2. Research Literature

Chengyu & Shuai (2016) simulated China's innovation-based economy under the new normal. They believe that the computable general equilibrium (CGE) model has outstanding advantages on predicting the external shock influences on the economic system, but previous studies on the forecast for China's future economy mostly considered a high growth rate which is hard to comply with the New Normal scene. By constructing China's macroeconomic dynamic CGE (DCGE) model and anticipating the economic impact of the New Normal, they found that the New Normal has a certain extent inhibition on China's macro-economy and innovation. However, after adding the research and development (R&D) subsidy policy, the negative impacts of the New Normal on macro-economy can be eliminated to realize the optimization of economic structure.

Lin & Li (2015) investigated both price and volatility spillover effects across natural gas and oil markets in a comprehensive VECM-GARCH framework. The results showed that the European and Japanese gas prices are integrated with Brent oil prices, but US gas price is decoupled from oil due to natural gas market liberalization and shale gas expansion. In all cases, the results support the presence of price spillover from crude oil markets to natural gas markets, but a reverse relationship does not exist.

Du & He (2015) investigated the spillovers of extreme risks between crude oil and stock markets using daily data of the S&P 500 stock index and West Texas Intermediate (WTI) crude oil futures returns. Based on the method of Granger causality in risk, Value at Risk (VaR) is employed to measure market risk, and a class of kernel-based tests is used to detect negative and positive risk spillover effects. Empirical results reveal that there are significant risk spillovers between the two markets. Extreme movements, past or current, in one market, may have significant predictive power for those in the other market. Before the recent financial crisis, there are positive risk spillovers from the stock market to the crude oil market and negative spillovers from crude oil market to stock market.

Liu (2014) investigated extreme downside risk spillover from the United States and Japan to Asia-Pacific stock markets. The results had shown that the majority of Asia Pacific markets become more sensitive to Japan's extreme downside risk when the Japanese market switches into high volatility periods, whereas the U.S. spillover effect is intensified only on Taiwan during high volatility periods in the U.S. Mainland China is the least sensitive to extreme downside risk in the U.S. and Japan, Australia is the most sensitive to the U.S., and Singapore is the most sensitive to Japan.

Arouri and et al. (2012) made use of a recently developed VAR–GARCH approach which allows for transmissions in volatilities between oil and stock markets in Europe. Also, they analyzed the optimal weights and hedge ratios for oil–stock portfolio holdings based on their results. On the whole, the findings show significant volatility spillovers between oil price and sector stock returns.

Arouri and et al. (2011) investigated the return links and volatility transmission between oil and stock markets in the Gulf Cooperation Council (GCC) countries over the period 2005–2010. They employed a recent generalized VAR-GARCH approach which allows for transmissions in return and volatility. On the whole, the results point to the existence of substantial return and volatility spillovers between world oil prices and GCC stock markets. Also, the rise in oil price volatility caused by shocks and policy changes affects oil supply, and demand-side would directly increase the volatility of GCC stock markets.

Bozovik et al. (2009) analyzed how the exchange-rate risk of foreign-currency loans spills over into default risk. They showed that in an economy where foreign-currency loans are a dominant source of financing economic activity, depreciation of the local currency establishes a negative feedback mechanism that leads to higher default probabilities, reduced credit supply, and reduced growth. This finding has some important implications that may be of special interest for regulators and market participants in emerging economies.

Schmidbauer & Rosch (2008) investigated volatility spillovers between crude oil prices and US dollar to Euro exchange rates. They applied a novel bivariate asymmetric quadratic GARCH model and found even though crude oil prices and US dollar exchange rates are somehow linked, the correlation of price changes is almost zero. This is because the link between them is in terms of volatility spillovers rather than in terms of co-movements of returns.

Jensen and Tarr (2003) studied business policies, exchange rate increase and energy policies in Iran in a computable general equilibrium model and concluded that the combined reforms had had great advantages in three cases. Also, these advantages have increased consumers' revenue up to 50% that, 7% of it is obtained due to commercial reforms, 7% due to exchange rate reform and 36% due to the reform of energy carriers' price. Thus, exchange rate changes can have strong and important spillover effects.

3. Theoretical Principles and Model Specification

We assume that the global bank equalizes expected risk-adjusted rates of return so that risk-adjusted rates for all regions are equal to some global average.

$$R\qquad(r)/R\qquad(r) = R \tag{1}$$

In accordance with the GTAP notation convention, these capitalized variables represent levels, while lower-case variables represent percentage rates of change from initial levels.

RORE(r) is a non-risk-adjusted expected rate of return, i.e., it is the expected rate of return in the absence of any default by the borrower.

RISK(r) represents the ratio of equilibrium returns in region r to the global average rate of return. For relatively high-risk countries, this ratio will be above 1, and for relatively safe countries below 1. It is important to note that this variable represents a ratio rather than a certain number of basis points – it is better called a 'risk ratio' than a 'risk premium.'

RORG does not represent a risk-free return but a weighted average of returns around the world. This formulation differs from the more familiar representation of the required rate of return in a country is equal to the risk-free return plus some risk margin.

If we rewrite this as

$$R\qquad(r) = R\qquad * R\qquad(r) \tag{2}$$

Then by total differentiation and division through by RORE(r), we can obtain

$$r \quad (r) = r \quad + r \quad (r) \tag{3}$$

Where these variables are percentage changes in their levels equivalents. This is the analog of equation (11) in the standard GTAP model in the case where RORDELTA=1:

$$r \quad e(r) = r \quad + c \quad (r) \tag{4}$$

This equation states that the percentage change in the rate of return on investment in region r is equal to the percentage change in the global rate of return plus a disequilibrium factor which is generally exogenous and set at zero in a general equilibrium closure. Normally, the cgdslack variable is only non-zero when we allow disequilibrium to exist in the market for capital goods. The main proposition of this paper is that cgdslack can be interpreted to represent a risk premium as defined above, although it was not originally designed for this purpose. In a general equilibrium closure, cgdslack is unused for any other purpose (being exogenous and unshocked), and therefore we do not disturb any other components of the model by using it in this way.

In the general equilibrium model that can be calculated for the implementation and application of each scenario, a change is required in the standard model closure. In other words, the combination of the endogenous and exogenous variables of the model must be changed. Also, the number of functions must be equal to the number of unknowns so that the system can be solved. Therefore, the classification of variables in the closing of each model depends on the economic problem, in a way that is in line with the purpose and policy. The first new function that is considered in the table and shows the effect of internal equilibrium on product changes is the function of the initial factors.

$$q \quad (i,r) = qo \quad (i) + q \quad (r) + q \quad (i,r) \tag{5}$$

In function (5), $q \quad (i,r)$ is the change percentage in the amount of product related to the initial commodity i in the region r and are determined by three primary factors that are normally exogenous in the standard GTAP. Adding this new function and primary shifter makes it

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easier to isolate the internal and external balance. These three primary factors in the regions r and qoall are the change percentage in the amount of the product related to the primary factor in the region r.

The second new function introduces another closure variable, which is the total actual per capita consumption (uc) as the sum of government and private sector spending. It should be noted that for the separation of curves FE and BP, the variable uc is used. Adding a function to define this variable expresses its endogenously in the GTAP standard closure.

$$A \quad (r) \cdot u \ (r) =$$
$$P \quad (r) \cdot u \ (r) + G \quad (r) \cdot u \ (r) \tag{6}$$

In function (6), uc(r), is the per capita consumption utility of the government and private sector in the region r. This endogenous variable is divided into up(r) and ug(r), which are the per capita consumption of the private sector and the government, respectively.

The two remaining variables that are effective in the closure are dpsave and pfactor(r). dpsave represents the growth rate of a part of the income that affects the savings distribution based on the savings function in the region r. Also, the change in dpsave affects the balance of investment-savings.

$$P \quad (r) + q \quad ve(r) - y(r)$$
$$= u \quad (r) + d \quad (r) \tag{7}$$

In function (7), psave is the change percentage in the savings price in the region r, qsave (r) is the change percentage in regional demand for net savings, y(r) is the change percentage in the regional household income in the region r, uelas is the elasticity of the cost relative to the changes in desirability. dpsave (r) is the savings distribution parameter.

The intended shock is applied by the variable pfactor which is the weighted average of the relative price of the production factors. This variable, which is an appropriate index to show the real exchange rate, is considered by the equations (8), (9) and (10) in the standard closure.

$$VENDWWLD \cdot pfactor(r) = \sum_{i \in END-COM} (VOM\,(i,r) \cdot\ pm(i,r)) \tag{8}$$

Function (8) calculates the percentage of changes in the primary price index in each region. In this function, pfactor(r) is the primary market price index in the region r (average weight of the variety of production factors receivables), VENDWWLD(r) is the global value of the primary factors, VOM (i, r) is the value of the product i in the market price in the region r, pm(i, r) is the market price of the commodity i in the region r.

Equation (9) specifies the actual return rate of the primary factor i in the region r.

$$p \qquad (i,r) = p \quad (i,s) - p \qquad (s) \tag{9}$$

In function (9), pfactorreal (i, r) is the difference between the rate of return of the primary factor i from the growth rate CPI (Consumer Price Index), pm(i, s) is the market price of factor i in the region s, pprive(s) is the price index for the private sector's consumption expenditure.

The function (10) calculates the percentage of change in the global price index of the primary factors.

$$VI \qquad .p = \sum_{r \in R} (VI \qquad (r).p \qquad (r)) \tag{10}$$

In function (10), pfactwld is the percentage of change in the global price index of the primary factors.

$$VI = \sum_{r \in E \quad -C} (VI \qquad (r)) \tag{11}$$

In function (11), VENDWREG(r), the value of the primary factors for the market price in each region, is obtained endogenously through the function (12).

$$VI \qquad = \sum_{i \in E \quad -C} V \quad (i,r) \tag{12}$$

In the standard closure of the global trade analysis project model, qoreg and dpsave are exogenous; while pfactor and uc(r) are defined endogenously. On the other hand, the curve FE and BP are analyzed through the relationship between consumption and real exchange rate. Hence, the exogeneity of consumption and the real exchange rate in the model are essential. To apply these modifications, you also need to change the model closure; so that the transition parameters are endogenous. So, using the replacement functions, consider uc exogenous and dpsave endogenous; so that these functions enable the model to change the total savings. It also makes pfactor exogenous and qoreg endogenous, so that makes it possible to change at the level of the primary factors.

GARCH model is not only the square function of its past residuals but is their lagged conditional variance function. For this reason, this model can consider the error term variance better. There are several subsets for GARCH model. In this study, one of these specifications referred to as Multivariate GARCH is considered.

This model explores the relationship between the volatility of two series of variables. For instance, via this method in this study, it is possible to explore whether or not oil market volatilities are effective on volatilities of foreign exchange market and whether or not volatilities and shock are transferred from one market to another market.

4. Model Estimation

Multivariate GARCH model is as below:

$$o_t^2 = w + \alpha_i \varepsilon_{t-i}^2 + \beta_i o_{t-i}^2 \rightarrow G \qquad (1,1) \qquad (13)$$

$\varepsilon_t \approx N(0, H_t)$

Conditional variance is a function of its lagged values, and those of its residual error and H is the covariance matrix that is a function of covariance and cross-multiplication lags of its residuals. This value has zero mean and is distributed normally. Matrix H is equal to:

$$H = \acute{A}_C A_C + \acute{\beta}_j H_{t-j} B_j + \acute{A}_i \varepsilon_{t-i} \varepsilon'_{t-i} A_i \qquad (14)$$

This is a positive definite matrix. There are three approaches to the above covariance matrix.

1- Fixed relation that is:

$$h_{1,t} = \rho \sqrt{h_{1,t} \cdot h_{2,t}} \qquad (15)$$

In this method, the path of volatility spillovers between the two series is not determined.

2- VECM method that is:

$$H_t = \begin{bmatrix} h_{1,t} \\ h_{1,t} \\ h_{2,t} \end{bmatrix} = \begin{bmatrix} \alpha_{1,C} \\ \alpha_{1,C} \\ \alpha_{2,C} \end{bmatrix} + \begin{bmatrix} \alpha_{1,1} & \alpha_{1,1} & \alpha_{1,1} \\ \alpha_{2,1} & \alpha_{2,1} & \alpha_{2,1} \\ \alpha_{3,1} & \alpha_{3,1} & \alpha_{3,1} \end{bmatrix} \begin{bmatrix} \varepsilon^2_{1,t-1} \\ \varepsilon^2_{1,t-1}\varepsilon^2_{2,t-1} \\ \varepsilon^2_{2,t-1} \end{bmatrix} + \begin{bmatrix} \beta_{1,1} & \beta_{1,1} & \beta_{1,1} \\ \beta_{2,1} & \beta_{2,1} & \beta_{2,1} \\ \beta_{3,1} & \beta_{3,1} & \beta_{3,1} \end{bmatrix} \begin{bmatrix} h_{1,t-1} \\ h_{1,t-1} \\ h_{2,t-1} \end{bmatrix} \quad (16$$

Table 1 shows the effect of oil price spillover on the real exchange rate. This relationship is positive and significant. Thus, the occurrence of volatility and risk in oil price can transfer the volatility and risk to the real exchange rate.

Table 1. Results of GARCH estimations for the effect of oil price spillover on the real exchange rate

BVGARCH		
	Coefficient	**Prob.**
Alpha(4)	0.23	0.001
Alpha(3)	0.62	0.004
Alpha(2)	0.77	0.0041
Alpha(1)	0.79	0.005
Beta(4)	0.66	0.00
Beta(3)	-0.461	0.00
Beta(2)	-0.031	0.00
Beta(1)	0.91	0.001
Omega(3)	-0.012	0.51
Omega(2)	0.009	0.0005
Omega(1)	0.031	0.11

Source: researcher's calculations

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Now, the long-term relationship between these series can be explored, and it is possible to explore whether or not there is a long-term relationship between them. Given Table 2, the real exchange rate is not the reason for the change in oil price; rather, oil price is the reason for the change in real exchange rate.

Table 2. Results of VECM model estimation for oil price

VECM		
	coefficient	Prob.
Y1(-1)	0.21	0.19
Y1(-2)	0.001	0.03
Y2(-1)	-0.2	0.31
Y2(-2)	-0.16	0.42
Y3(-1)+2.79*y4(-1)-0.34	-0.09	0.02
DUM	-0.08	0.1

Source: researcher's calculations

The existing recursive dynamic CGE model includes GTAP-Dyn model (Ianchovichina and McDougall, 2001), the World Bank's LINKAGE model (van der Mansbrugghe, 2005) and MIRAGE (Bchir et al., 2002).

GTAP-Dyn is a recursive dynamic CGE model that expands the standard GTAP model (Hertle, 1997) to include international capital mobility, capital accumulation, and adaptive expectations hypothesis. GTAP-Dyn is different from most recursive dynamic models that are proposed in continuous time due to GEMPACK differential equations approach. It differentiates between asset status and ownership, and between physical asset and claims over the physical asset. The second one is shown in the model as equity.

The World Bank's LINKAGE model is a recursive dynamic CGE model. There are several differences between the two models. One difference is that LINKAGE model considers the increasing production efficiency via increasing fixed costs. The second one is that the structure of production function has been explained more extensively than PEP-w-t-fin and it is different in the production of agricultural products than other products. Finally, household saving in LINKAGE is determined through the static linear expenditure system while in PEP-w-t-fin, there is the linear function of disposable income. Given the dynamism of the two models, the most important difference is accumulation behavior and capital allocation in LINKAGE. There is only capital supply and demand with the deficient mobility of old and new capital. (The eroding sectors supply their old capital that is added to the new capital supply, but they do not supply all their capital surplus in one section.) In LINKAGE, there is a putty/semi-putty specification technology while PEP-w-t-fin model has a semi-putty specification.

Likewise, MIRAGE is a recursive dynamic model. There are differences between the two models. First, there is a foreign direct investment in MIRAGE, but there is no foreign direct investment in this PEP-w-t-fin version. Second, MIRAGE intends more to evaluate business policy and uses the current mutual tariffs in MAcMap-HS6 database instead of the accumulated tariff rates in GTAP. Third, MIRAGE considers incomplete competition and production quality difference along with economic geography models. Given dynamic models, MIRAGE allocates investment among the countries and industries based on one type of gravity model while PEP-w-t-fin uses Jung-Thorbecke's investment demand function (2001). Main elements of this model contain activities, products, and factors of production, household, government, financial and non-financial institutions, and the external world. Activities include agriculture, industry and mine, oil and gas, construction and other services.

In this section, the effect of international risk spillovers is explored from the channel of oil price.

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Table 3. Effect of international risk spillovers from the channel of global oil price (output of the dynamic computable general equilibrium model)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
inflation	0.832	2.384	1.186	0.688	0.531	0.268	0.672	0.346	0.579	0.436	0.224	-0.051	-0.202
GDP	13.349	3.502	3.601	4.4	5.006	5.242	5.44	5.647	5.906	5.895	5.74	5.511	5.261
investment	17.6	15.427	10.374	8.311	8.1	6.754	6.891	5.744	6.348	6.031	5.099	3.86	2.656
exports	28.559	-6.995	-4.533	-1.447	0.311	1.995	2.405	4.129	4.622	5.044	5.428	5.749	5.915
imports	8.719	14.051	10.752	9.719	9.577	8.938	10.382	9.219	9.738	9.252	8.514	7.517	6.702
welfare	-0.923	1.548	1.666	1.88	6.14	6.411	7.299	7.094	7.3	7.127	6.95	6.685	6.383
wealth	7.312	8.397	7.324	6.998	7.178	7.134	7.799	7.609	7.957	7.934	7.834	7.668	7.553

Source: Research findings

As it is shown in Table 3, one of the variables that are influenced by this shock is inflation that can change other variables too. According to the results, reduction of oil price creates price shock at first. Then, it will have volatilities towards increase and decrease and finally is decreased.

One of the important reasons is the reduction of oil revenues and supplying them through other methods such as relying on banking resources. But its decreasing process across time is related to the modification of the structure of government's funding across time. Risk spillover in this study has a continuous flow. Generally, if this conception is considered in macroeconomic policies, Firstly, there are international risk flows in the world, and secondly, they can influence Iran's economy, specially, on the prices and macroeconomic variables. Another important point in the international risk spillover from the channel of oil price is the preventive effect of the oil shock on investment. It means that international risks, especially oil flow decrease investment. As the results show, if the international risk spillover is durable, it can disturb the investment structure and capital formation. This situation indicates the intensive dependency of one of the important economic variables on oil and its changes.

The results disclosed that GDP has at first a descending order and then, it is increased with a very insignificant rate. It seems that if international shocks have a continuous process, GDP changes will have stable relative and suitable sustainability. From this perspective, it can be claimed that the continuous process of international risk spillovers can in long-term help GDP stability. Another macroeconomic index that is influenced by international risk spillovers is a money market. But given the sticky structure of demand for money in Iran that is influenced by individual behaviors and habits, oil price shock has at first an increasing effect on demand for money, but totally it is led to stability gradually. This issue can also be justified via oil shock decrease in investment. Therefore, it can be concluded that international risk spillovers will have not any effect on the demand for money through oil price because of their zero effect on interest rate and insignificant effect on revenue.

5. Conclusion

Considering the global financial crisis as well as exploring the effect of some international policies (like international sanctions and policies of OPEC member countries and non-OPEC countries), it was determined that if the oil price is moderately decreased to 7%, it shows the international risk flow in Iran's economy. Hence, the 7% shock of oil price was inserted into a dynamic computable general equilibrium model and in the framework of structural equations. Preventive effect of the oil shock on investment is important in the international risk spillover from the channel of oil price, that is, international risks especially its oil flow decrease investment. As the results show, if the international risk spillover is continued, it can disturb the investment structure and capital formation. This issue indicates the intensive dependency of one of the important economic variables on oil and its changes. Despite the welfare level and its indexes have special complexities in the effectiveness, this study showed that they could be influenced by one variable known as oil price in a general equilibrium model. Oil price shock decreased welfare level in the first step, but its positive effect began gradually and reached sustainability conditions. Indeed, continuity of risk spillovers is led to self-confidence in optimal use of possibilities and improved welfare in the long term. Given the main research question, the results of model estimation showed that the money market flow is influenced by international risk spillovers. Considering that demand for money in Iran has a sticky structure and is influenced by individual behaviors and habits, the oil price shock has at first an increasing effect on demand for money, but gradually it is led to totally slow stability. This is also justifiable via the decrease of the oil shock in investment. Therefore, it can be concluded that international risk spillovers will have not so much

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effect on demand for money through oil price because of zero effect on interest rate and the insignificant effect on revenue. Likewise, the results of this study revealed that if oil risk spillovers are continuous, they help planners adopt applied decisions to confront it in spite of the fact that international spillovers of the oil market have helped some of these indexes. It is noteworthy that international spillovers of oil are not controllable so much.

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