GMDH Neural Network-Based Study and Forecast of Effects of Export Instability on Iran's Economic Growth

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Abstract: The contribution of exports to economic growth and development and their impact on different economic sectors constitute a broad and significant issue upon which a large number of economists have been concentrating their minds, and has even branched out extensively into other scientific fields. Therefore, export instability is focused up by policymakers as an influential factor in macro-economic models on the one hand, and a basic variable in risk management and efficiency models on the other. This study aims to present a model to forecast export instability. To that end, Autoregressive Distributed Lag (ARDL) and Artificial Neural Network models have been applied for the 1976-2010 period. The findings of this study are indicative of the efficacy of artificial neural networks in forecasting export instability and its declining impact on economic growth.
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1. Introduction

Studying the impact of exports on different economic sectors in Iran is a very significant issue that has even spread to other fields including sociology, politics and even technical issues. Balasa (1985) believes that effective management, optimized production technology and competition expertise – all achieved under the aegis of broadened exports and positive outer direction – accelerate economic growth.

Revenues from exports notably in oil-rich countries like Iran make large contribution to their economic conditions. These revenues account for a large part of the countries' hard currency needs on the one hand, and cover the governments' costs on the other. In such countries, planning for development basically needs such revenues. In case such revenues are not reaped by these countries, development plans would come to a halt and the forecasted economic growth rate would not be achieved. In that even, export instability would be in negative proportion to economic growth.

This proportion is likely to become positive under certain circumstances. Anytime the instability factor grows into an uncertainty condition so as to reduce consumption while increasing savings and investment, the outcome would be economic growth.

When export revenues are more than forecasted, the country would either see its economic power grow or get tapped in ambitious plans and experience economic imbalance like budget deficit, deficit in balance of payments, deficit in external trade and even investment-savings gap.

The main objective in this study is to measure the impact of export instability on economic growth. With an accurate understanding of causes of instability, it would be possible to minimize its impacts on the economy. To that effect, the effect of oil and non-oil export instability on Iran's economic growth would be examined for the 1976-2010 period by applying Autoregressive Distributed Lag (ARDL) and Artificial Neural Network (ANN) models. This study will seek to find answer to the following questions:

- Does export instability meaningfully affect economic growth in Iran?
- Are the short-term and long-term impacts of this instability the same?
- Is ANN forecast more precise than ARDL's?

One of important principles in the economic growth and development is to create a sustainable and stable economy. The studies conducted about export instability indicate that any instability in exports would damage the economic system can cause negative economic growth rate.

In this section, some studies conducted about the effects of export instability on economic growth and some others about the application of ANN in economic changes forecast.

Abraham (2004) explored the relation between export instability and economic growth in Ethiopia for

the 1966-2002 time span. In his study, he has used endogenous growth model and export instability index to examine the effects of export instability on economic growth in the short and long terms. The findings of the study are indicative of the negative impact of export instability on economic growth with short-term impacts much more significant than long0-term ones.

Marzban et al (2005) examined structural econometric models by ANN to forecast foreign exchange rate in Iran. The conclusion was that ANN functions effectively and is preferred to other models.

Hadian and Parsa (2006) studied the impact of oil price fluctuations on macroeconomic variables like gross domestic product (GDP), the general level of prices and employment for the 1961-2005 period. They found that the oil price fluctuations constitute a major factor in Iran's economy and cause 20 percent of the GDP fluctuations.

Sinha (2007) conducted a study about the impacts of export instability in the Philippines and Thailand – both Asian states – for a period beginning in the first quarter of 1960 and ending in the third quarter of 2005. He examined the statics of the model by applying Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. Since the variance of serial correlation often changes, General Autoregressive Conditional Heteroscedastic (GARCH) Modeling has been applied to study instability. The results indicate that in both Asian states, exports growth fluctuations continuously send shockwaves and the past fluctuations would largely contribute to the estimation or forecast of future fluctuations. Application of neoclassic growth equations indicated that the instability of exports leaves negative and meaningful impacts on the economic growth rate in the Asian states.

Ahrary et al (2011) conducted a study under title of "Oil Price Instability Forecast by Neural Network" and presented a model to that effect. For this purpose, they forecasted instability in the price of Brent and West Texas Intermediate (WTI) crude oil from December 5, 1990 to February 2, 2010. The data were obtained from the International Energy Agency (IEA) and US Department of Energy. They used Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) to assess the accuracy of forecast of different models. Comparing four models including one GARCH-based, two Group Method of Data Handling (GMDH)-based and one mixed GARCH-GDMH-based indicates that mixed models and RSME-based neural networks offer a more accurate forecast than GARCH modeling.

2. Theoretical Bases

2-1. Micro and Macro Impacts of Export instability on Economic Growth

In this section, the theory of minor and major impacts of export instability on economic growth is examined.

a. Macro Impacts

Based on international trade theories, developing countries benefit from primary economic expertise due to their comparative advantages and the diversity of their products. However, some economists are sharply critical of international expertism due to the dependence of economy on export products. They believe that international expertism for a product in a country would make that country dependent on export revenues, but since the prices of export products are exogenous, sharp fluctuations would give rise to instability in revenues and leave negative impacts on the economy.

Since capital and intermediate goods account for a large share of developing countries' imports financed by export revenues, instability in the export revenues would disturb imports and subsequently affect the economic growth rate (Sinha, 1999 & Feder, 1983).

Traditional theories of economic development have highlighted the negative consequences of economic macro-instability. Myrdal (1958) says price fluctuations of export products cause inflation if the prices stick to downward trend. In that even, budget deficit will react in view of economic balance, and due to ratchet effect, budget deficit and export revenues instability would be in positive proportion.

Keynes (1938) and Nurkes (1962) are of the view that economic macro-instability causes economic uncertainty, that would in turn, leave negative impacts on investment decision-makings and technological progress. In this regard, Keynes says uncertainty happens when there is no scientific basis to forecast possible fluctuations. However, the latest progress in the risk literature has made it possible to use risk calculations. These theories were later used extensively by Hirschman (1958) and Friedman (1954-57). Hirschman found that fluctuations in export revenues remarkably cut imports of manufactured products in the short term, to the benefit of domestic industries. This advantage is a positive effect of import substitution strategy on economic growth. For his part, Friedman concludes that instability in revenues would increase the savings rate. Therefore, liberalization of the primary products market would push export revenues out of state-run enterprises to the private sector. That is why Friedman's permanent income hypothesis is now a foundation of risk management.

b. Micro Impacts

The first question here is to know if price instability would also cause income instability. The answer is affirmative for exporters. Although the

factors of price instability leave different impacts on the instability of prices and the amount of goods, they would finally end in the instability of revenues of producers. Price instability happens when supply or demand is destabilized. Price instability benefits income instability. In other words, the instability of prices increases revenues.

In the event of supply instability, the most probable scenario is that price instability could stabilize the revenues of producers (Newbery and Stiglitz, 1981). Price instability benefits producer for certain fluctuations in demand.

The second question is to know how instability affects the welfare of producers. Previous studies are based on Marshall's surplus commodity concept (Aw, 1961 & Massel, 1969).

In the current economic literature, cost-benefit analysis is used. In this context, the risk expenditure is defined as the sum the producers are inclined to pay as risk premium in a bid to avoid instability. The risk expense depends on the attitude of the enterprise. For instance, if the enterprise is risk-averse, the risk expense is positively correlated with it. But high risk costs do not mean that the stabilization process is required to be implemented at both national and international levels.

2-2. Effect of Exports on Economic Growth

Based on evidence indicating exports enterprises are much more creative and productive than non-exports enterprises, economists unanimously believe that contribution to export markets would be beneficial (Blalok & Gertler, 2004: p. 397). Export enterprises, specifically in developing economies, can benefit from the technical expertise of their foreign buyers, while non-export enterprises have no such expertise at their disposal (Aw et al 2000: p.67). The relationship between export enterprises and foreign buyers often goes beyond the deal and contract. Foreign buyers demand products of better quality and lower costs. To that end, they are strongly motivated to transfer knowledge to exporters (World Bank, 1993: p. 320). Foreign buyers provide exporters gratuitously with the latest designs, information about new production methods and technical cooperation for improved production (by dispatching engineers or technicians to inspect factories and even train workers). By acquiring such knowledge and data, export enterprises can become more productive than their rivals, which are active only in domestic market (Aw et al, 2000: p. 65).

2-3. Effect of Monetary and Fiscal Policies on Economic Growth

Implementation of expansionary monetary policy shifts liquidity-money (lm) curve to the right. When the interest rate declines, investment increases, thereby causing demand to rise. Implementation of expansionary monetary policy would directly increase the total real demand and the prices would be driven up. Under such conditions, the wages would be raised, but not in harmony with the price hikes. Then, people would show more inclination for employment, and the real supply would increase.

2-4. Export instability Indices

Generally, instability could be calculated from numerous indices, some of which are as follows:

a) The first index for calculating export instability is the standard deviation of time given by the following formula:

b)

LnXt=a+bt

Whereas X_t shows exports for *t*time span.

b) The second index is the regression of coefficient of export revenues variations. See the following formula in which *x* is the export revenue:

$$LogX = a_0 + a_1 t + a_2 t^2 + v_t$$

$$Inst = c_0 v \quad :$$

c) The third index is to calculate the mean absolute difference between real and normal export revenues. In the following formula, N represents the number of years under study, X_t is the real export revenues and $\bar{X}_t$ represents the normal export revenues.

$$Inst = \frac{1}{n}.\sum_{t=1}^{n} \frac{X_t - \bar{X}_t}{\bar{X}_t}$$

n.....، 2 ، 1 t=

The normal export revenue is estimated by calculating the regression of logarithm of X_t to time and its square.

d) The fourth index is to calculate the arithmetic absolute mean of variations for a specific period of time.

$$Inst = \frac{100}{\bar{X}}.\frac{\sum_{t=1}^{n} \left| X_t - X_{t-1} - b \right|}{n-1}$$

In this equation, b is the coefficient of variation which could be calculated as follows:

$$X_t = a + bt$$

e) The fifth index is to calculate the absolute value of deviation of exports from the five-year

moving average. This index was proposed by... (1992) to analyze time series. He believes that it might be impossible to calculate the average exports value, and therefore, he suggests this formula. Kundsen and Parmez (1975) have used this index to calculate instability in their time series. In the following equation, X_t shows the value of exports and $\bar{X}_t$ the average value of exports.

$$Inst = \frac{\Sigma\left(X_t - \bar{X}_t\right)}{\left(\bar{X}_t\right)^2}$$

Given the structure of Iran's economy, this final index has been used to estimate export instability in Iran.

3. Methodology

This research focuses on examining and forecasting the impacts of export instability on economic growth by applying and ARDL and ANN models.

The data used in this model have been extracted from the annual records of Central Bank of Iran (CBI) for the 1976-2010 period. The data for 1976 to 2005 have been selected for the theory's meaningfulness test. The data for 2006 to 2010 are used for forecasting the performance of the system by ANN. The model proposed for forecasting the effects of exports on economic growth is discussed here.

Since single-layer artificial neural networks are not able to forecast properly, we have used multi-layer networks with non-linear functions for more precise forecast.

The proposed model's inputs include export instability, investment, money supply, government expenses and exports. The output in ANN model is economic growth. Based on the inputs, the system forecasts the economic growth. The ANN model has been simulated by MATLAB 2010. The network model comprises 10 hidden layers. Non-linear transfer function is applied in the input and linear transfer function in the output.

Since the formulae and methods developed for determining the number of layers and weights are not specific, trial and error methods is used to determine the number of neurons of middle layers and the output and by comparing RMSE and MAE, the answer is chosen.

$$RMSE = \frac{\sqrt{\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}}{n}$$

$$MAE = \frac{\sqrt{\sum_{i=1}^{n}(\hat{y}_i - y_i)}}{n}$$

The main model used in this research is as follows:

$$Y=\beta 0 +\beta_i\chi+\beta_2 I+\beta_3 M+\beta_4 G+\beta_5 V_l$$

Y represents GDP, X exports, I investment, M the total money, G the government's expenses and V_l the instability of exports.

A logarithmic relationship has been used to equalize the weight of data and remove problems stemming from the non-homogeneity variances and multicollinearity of variables. Microfit 4 is used for estimation in ARDL modeling.

4. *Experimental Results*

a) *ARDL Results*

Table 1 – Impact of Export Instability on Economic Growth

Variable	Coefficient	Standard deviation	Statistic *t* (probability)
Y (-1)	0.172	0.073	2.355(0.027)
I	0.172	0.022	7.767(0.000)
G	0.235	0.066	3.561(0.002)
G (-1)	0.226	0.091	2.488(0.020)
G (-2)	-0.123	0.053	-2.327(0.028)
M	-0.049	0.084	-0.589(0.561)
M (-1)	-0.075	0.127	-0.592(0.559)
M (-2)	0.208	0.079	2.654(0.014)
X	0.107	0.018	6.033(0.000)
V_l	-0.011	0.005	-2.386(0.025)
C	2.807	0.385	7.446(0.000)
R-Squared	0.997	R-Bar-Squared	0.996
F (10, 25)	874.784 (0.000)		

ARDL modeling analysis is based on interpretation of dynamic and long-term equations and correction of errors. Schwarz Criterion is used to determine the optimal amount. The results of dynamic equations are indicative of long-term correlation in the model. Among the features of the model are its accuracy, lack of autocorrelation and normal distribution in remainders.

As this table shows, F does not reject the meaningfulness of all coefficients. The results indicate that the export instability variable meaningfully and negatively affects economic growth.

The investment, government expenses and its first lag positively and meaningfully affect the economic growth, but the second lag's effect is not meaningful. The effect of money supply and its first lag is not meaningful either, but the second lag leaves positive and meaningful effect on the economic growth. So do exports.

Table 2 – ARDL-Based Long-Term Correlation Estimate

Variable	Coefficient	Standard Deviation	Statistic t (probability)
I	0.208	0.026	7.873(0.000)
G	0.408	0.039	10.260(0.000)
M	0.101	0.003	30.680(0.000)
X	0.129	0.019	6.580(0.000)
V_1	-0.013	0.005	-2.405(0.024)
C	3.464	0.378	9.156(0.000)

Long-term estimation indicates that investment leaves positive and meaningful effects on the economic growth. In other words, investment and economic growth complement each other and as long as investment increases, Iran's economic growth keeps rising. The same conclusion could be deducted regarding the effect of government's expenses, money supply and export revenues. However, export instability leaves negative and meaningful impact on the economy. For one percent increase in the export instability, the economic growth would fall by 1.3 percent.

Table 3 – ECM Estimate

Variable	Coefficient	Standard Deviation	Statistic t (probability)
dI	0.172	0.022	7.76 (0.000)
dG	0.235	0.066	3.56 (0.001)
dM	0.049	0.083	-0.58 (0.58)
dX	0.107	0.017	6.03 (0.000)
dV_1	-0.01	0.004	-2.38 (0.020)
C	-0.828	0.072	-11.34 (0.000)
ECM	-0.828	0.075	-11.139 (0.000)

If economic growth is impinged upon by a shock, approximately 83 percent of the deviation from the long-term correlation would be corrected in each short-term time span. Moreover, the meaningfulness of error correction coefficient indicates the dependent variable is endogenous.

Other variables indicate that in the short run, the instability of exports equals -0.01., meaning that 10 percent increase in the export instability would result in one percent fall in the economic growth in the short term. Therefore, the short-term and long-term effects of export instability on the economic growth are in the same direction. Investment, government's expenses and exports all leave positive and meaningful effects on the economic growth in the short term, but money supply's effect is not meaningful.

b) ANN Findings

In this section, the efficacy of multi-layer artificial neural network is tested versus ARDL in terms of forecasting economic growth. The network's precision is measured by RMSE and MAE. Fig. 1 distinguishes real growth rate and forecast growth rate in a neural network.

As this figure illustrates, the productively of the education plan implemented here is nearly 99 percent, showing the high efficiency of the system to forecast the economic growth rate.

Fig. 2 shows the efficacy of the network based on MSE, which is calculated as below:

$$MSE = \frac{\sqrt{\sum_{i=1}^{m} (\hat{y}_i - y_i)^2}}{n}$$

As the figure indicates, the network's learning registers high MSE in the initial periods. The more the periods, the less the errors. In the 38th lag, MSE reaches $^{6-}10\times {}^{6}$ 87/9.

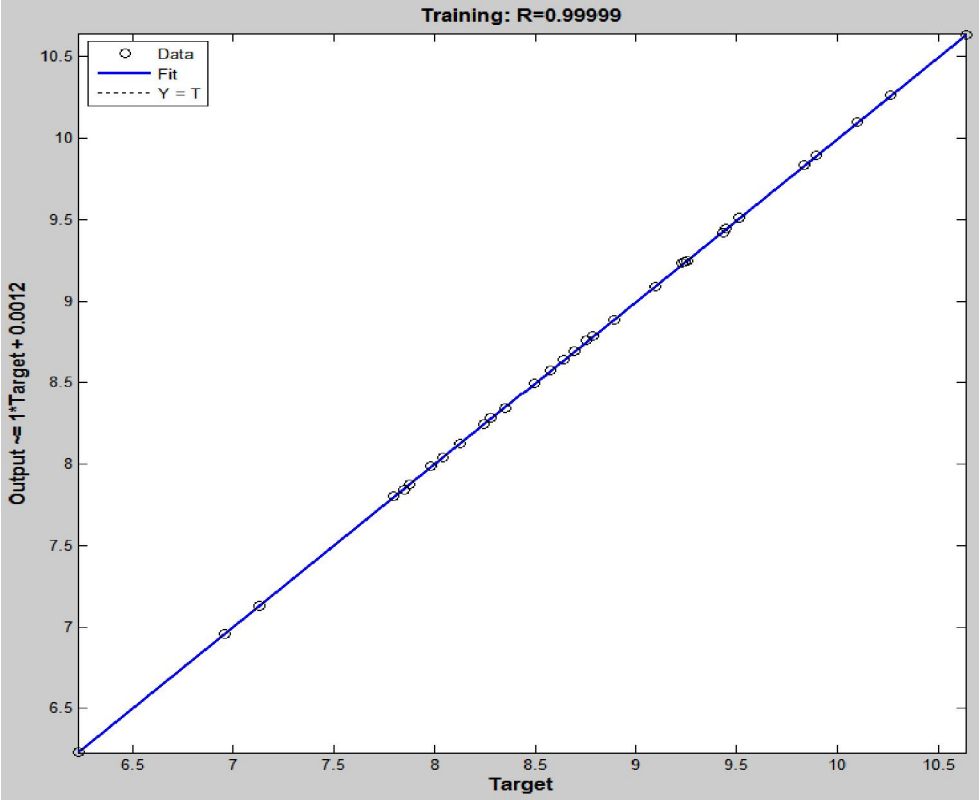

Fig.1 – Real and Forecasted Economic Growth Rate in a Neural Network

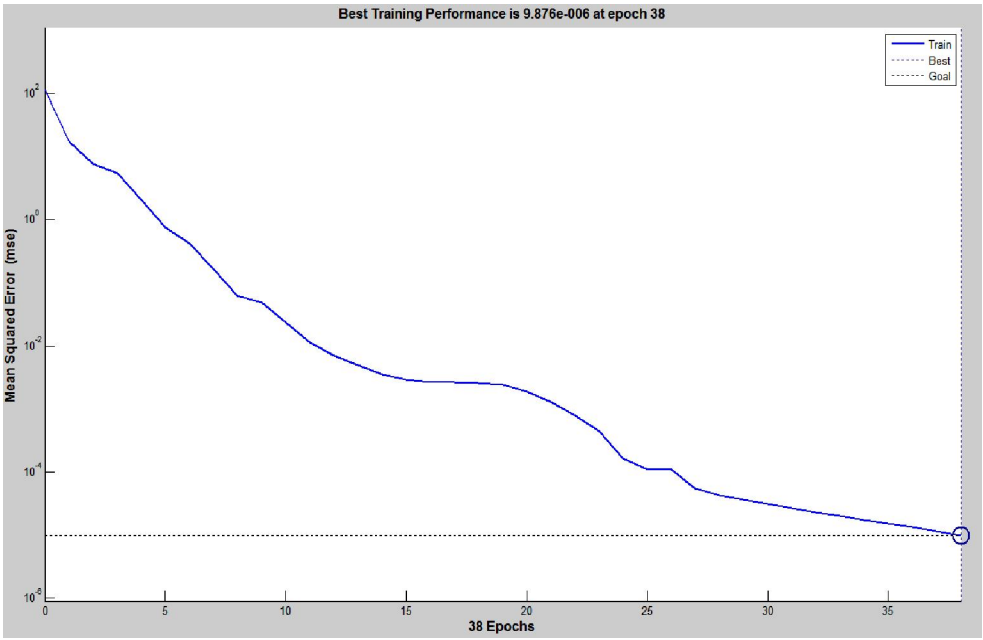

Fig. 2 – Efficacy of Neural Network

Fig. 3 illustrates the μ for the lu algorithm's efficacy and accreditation of multi-layer artificial neural network.

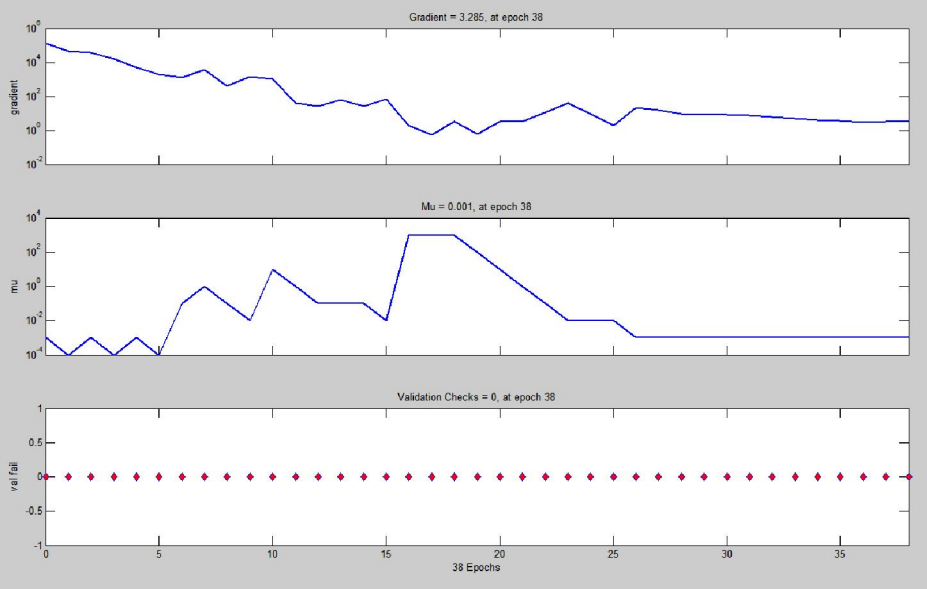

Fig. 3 – Multi-Layer ANN Accreditation

The results indicate that in the 38th lag, gradient equals 3.285 and μ equals 0.001 while the network's accreditation is zero. Everything is proof of the efficacy and effectiveness of multi-layer ANNs for economic growth rate forecast.

Table 3 – ARDL- and ANN-Based Economic Growth Forecasts Comparison

Forecast Rates		Real Rates	Year
ANN	ARDL		
13.0471	13.0201	13.0560	2006
13.1186	13.1037	13.1205	2007
13.1532	13.1208	13.1871	2008
13.2313	13.1928	13.2520	2009
13.3019	13.2687	13.3169	2010

ANN forecasts are closer to real rates than ARDL's.

Table 4 – Assessment of Different Methods

MAPE	MAE	MSE	RMSE	Forecast
0.00134	0.0174	0.00041	0.02016	Neutral Network
0.00287	0.0436	0.02269	0.15063	ARDL

5. Conclusion and Suggestions

The findings of this research, conducted based on ARDL method for the 1976-2010 period, indicate that export instability leaves negative impact on economic growth. But this effect is much more significant in the long term than in the short term. The study also showed that GMDH-based economic growth forecast is much more effective than ARDL-based modeling.

Given the research findings and the structure of Iran's economy, the following suggestions are made:

1. In the light of the negative impact of export instability on the economic growth, it is necessary to remove all causing factors. One of these factors is inappropriate atmosphere for investment and commercial transactions in Iran. But it could change for better if the World Bank's indices like supporting investors, facilitation of permission and stabilizing of foreign exchange rate are improved. Moreover, more political and economic stability as well as further domestic investment and inflation control would stabilize commercial transactions.

2. Since most obstacles and problems created for exports stem from complicated rules and regulations, it would be better to remove legal hurdles to trade, streamline bureaucracy and benefit from the experience of other countries.

3. Given the positive effects of trade liberalization and opting for free market economy, taking advantage of the experience of other countries to make domestic industries more competitive would be a great step towards stabilization of commercial transactions and exports.

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