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# The Relationship between the Social Investment and Volume of Freight Carried by Water Transport in Vietnam

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**ABSTRACT**
This article explored the relationship between social investment and volume of freight carried by water transport in Vietnam during the period 2002 Q4 to 2022 Q2. Using a VAR approach we capture their relationship. The findings suggest an overall, substantial investment has the potential to promote Volume of freight in Vietnam. We recommend more investments towards water transport infrastructure to ensure a significant increase in trade, and to enhance Vietnam's trade competitiveness.

**KEYWORDS:** Social investment; volume of freight; water transport; VAR model

## 1. INTRODUCTION AND BACKGROUND

Vietnam's economy had many positive changes after the economic reform in 1986, continued to grow after joining the World Trade Organization WTO in 2007. This result is a clear signal shows the effectiveness of the economic transformation and policies that Vietnam has been implementing, especially in the current globalized environment. From 2002 to 2020 GDP per capita increased 3.6 times reaching nearly 3,700 USD (Worldbank, 2022).

The development of the economy would not be possible without adequate development of transport. Freight transport is an essential and integral part of the national development planning process because it promotes the full exploitation of factors of production. According to the United Nations Conference on Trade and Development (UNCTAD), maritime remains the backbone of global trade and manufacturing supply chains. (UNCTAD, 2020) reports that more than a quarter of world trade volume is conducted through seaway. Furthermore, ocean freight handles 80% of trade by volume at about 70% of its value (UNCTAD 2020). According to the UNCTAD 2019 report, this trade has linked the global economy and plays an important role in promoting trade and social development. This is also true for the growth of Vietnam, a country that is not least dependent on an extensive transport system, including the water transport system.

Maritime shipping not only faces rapid growth in demand and pressure from shipping services, but also technical challenges including outdated infrastructure leading to congestion and delays. Furthermore, this includes a lack of investment to upgrade and maintain port infrastructure. (W. Matekenya, 2022). According to data from the Asian Development Bank, infrastructure investment in both the public and private sector of Vietnam is reaching about 5.7% of GDP in recent years, the highest in Southeast Asia and ranked second in Asia after China (Minh, n.d.). Investment capital for development is increasing but still does not meet the demand, posing a big task is to increase the mobilization and use of investment capital effectively.

### *1.1 Overview of water transport in Vietnam*

Water transport includes maritime and inland waterway transport. Both perform freight as well as passenger transport. (Coyle, Novack, & Gibson, 2016). Volume of freight carried is the volume of cargoes transported by transportation establishments and others operating in transportation business activities regardless of travel distance. Volume of freight carried is calculated by the actual weight of goods carried (including packing). It is only measured after the completion of transportation to the destination as mentioned in the contracts and finishing delivery procedure. Volume of freight traffic is volume of freight traffic through a length of transportation distance, that is calculated by multiplying volume of freight carried with the actual transported distance.

Figure 1 represents the freight transport volume and activities of the different modes of transport in Viet Nam from 1995 to 2020. Based on statistics obtained from the General Statistics Office of Viet Nam, Vietnam's freight transport market is largely dominated by two modes: Water and road transport. Together, these modes account for 97% of the tons transported annually.

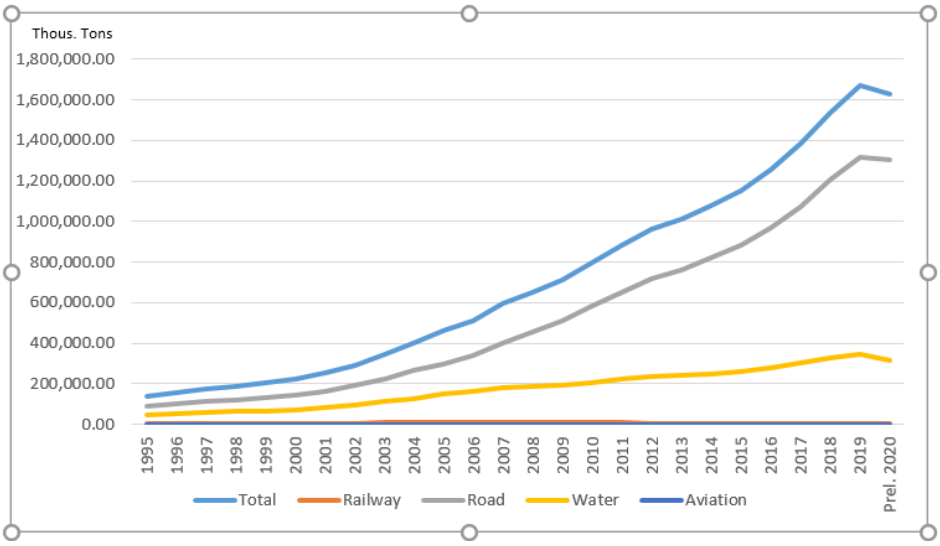


**Figure 1.** Volume of freight carried by types of transport
**Source:** GSO

However, the market share of water transport decreased from 32% in 1995 to 20% in 2020 in which the market share of inland waterways decreased significantly from 26.8% to 15%, while the market share of road transport increased from 64.8% to 80.3% over the past several years. Inland waterways transport has been losing tonnage share is from a combination of factors. While inland water transport is low cost and has a larger capacity and flexible service, the speed of transport is very slow, making it unsuitable for transactions where time is an important factor. In addition, inland water transport is sometimes unreliable as it can only be used when the water level is sufficient, or economic (and population) growth in areas outside the geographic coverage of the waterway transport network, plummeting truck transport rates in an environment of deregulated competition and low barriers to entry, and a significant expansion of the road network (Blancas & El-Hifnawi, 2014). Despite having lost share to the road sector over a number of years, the water transport sector remains essential to the functioning of the Vietnam trade.

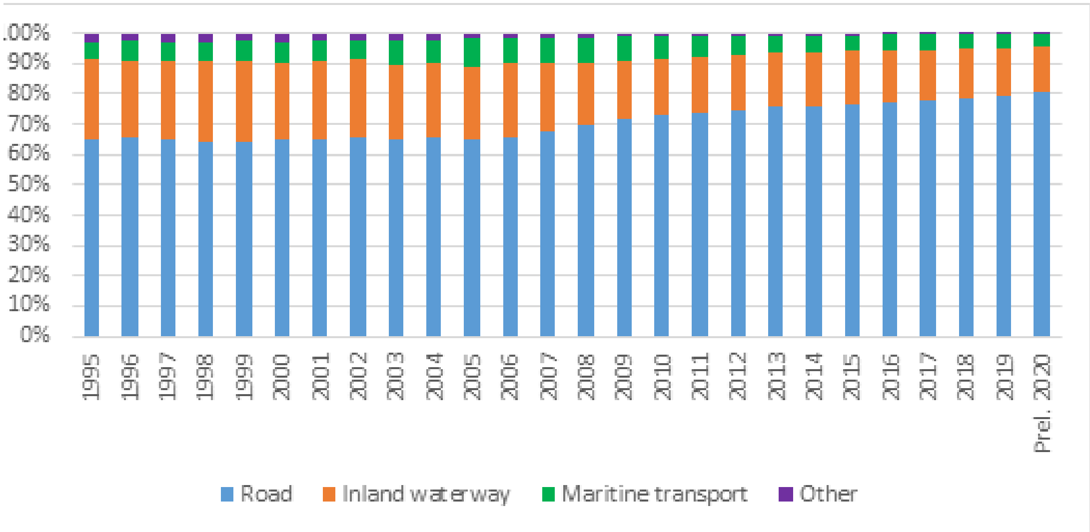


**Figure 2.** Modal shares (based on tons)
**Source:** GSO

Although maritime shipping carries a tonnage share that at 5% is lower than IWT, Official statistics from the GSO show that, between 1995 and 2020, maritime shipping tonnage grew at a rate of 8.5 —faster than IWT tonnage rate of 5.5% but still slower than road tonnage.

Table 1 shows the 2008 modal shares of freight transportation by commodity. The inland water transport in Viet Nam is mainly used for transport of large bulk commodities mainly construction materials, cement, coal and agricultural products. Coastal shipping had an advantage for long-distance trips for products such as cement, coal, and manufacturing goods.

**Table 1.** Modal shares of freight transportation by commodity

| *Commodity* | *IWT* | *Coastal* | *Road* | *Rail* | *Total* | *% IWT* | *% Coastal* |
|---|---|---|---|---|---|---|---|
| Rice | 36,109 | 4,261 | 78,969 | 204 | 119,543 | 30 | 4 |
| Sugar cane/sugar | 4,847 | 88 | 3,682 | 0 | 8,617 | 56 | 1 |
| Wood | 11,683 | 914 | 11,499 | 523 | 24,619 | 47 | 4 |
| Steel | 1,015 | 764 | 41,965 | 2,156 | 45,900 | 2 | 2 |
| Construction materials | 370,787 | 1,914 | 129,219 | 8,213 | 510,133 | 73 | 0 |
| Cement | 64,387 | 13,021 | 38,965 | 3,810 | 120,183 | 54 | 11 |
| Fertilizer | 28,678 | 1,168 | 8,813 | 2,939 | 41,598 | 69 | 3 |
| Coal | 92,549 | 10,092 | 12,106 | 2,377 | 117,124 | 79 | 9 |
| Petroleum | 5,018 | 8,234 | 33,374 | 404 | 47,030 | 11 | 18 |
| Industrial crops | 2,415 | 0 | 5,628 | 0 | 8,043 | 30 | 0 |
| Manufacturing goods | 3,916 | 13,524 | 171,895 | 4,895 | 194,481 | 2 | 7 |
| Fishery products | 12,203 | 0 | 7,186 | 0 | 19,389 | 63 | 0 |
| Animal meat and others | 9,373 | 4,118 | 61,578 | 0 | 75,069 | 12 | 5 |
| Total (tons/day) | 642,980 | 58,098 | 604,879 | 25,521 | 1,331,729 | n.a. | n.a. |

**Source:** (Blancas & El-Hifnawi, 2014)

### *1.2 Overview of total social investment In vietnam*

Social investment is the entire amount of capital spending (expenditure) to increase or maintain capacity and resources for production, including: investment to generate fixed assets, investment to increase current assets, spending on purchasing rare and precious assets, reserves gold in the form of goods, storage of commodities in the resident and other investment to improve people's knowledge, enhance social welfare, improve the ecological environment, support people's welfare, etc. The nature of total investment for social development includes investment from the public sector, private sector, and foreign direct investment.

Figure 3 and Figure 4 show the investment by types of ownership in Vietnam from 1995 to 2022. Over the last 25 years, Vietnam investment has increased significantly. This increase shows a positive signal in mobilizing and using social investment for socio-economic development. This is also an important driving force contributing to economic growth. In the period 1995 - 2017, the largest share of total investment came from the public sector, but in the period after 2018 the proportion came from the private sector.

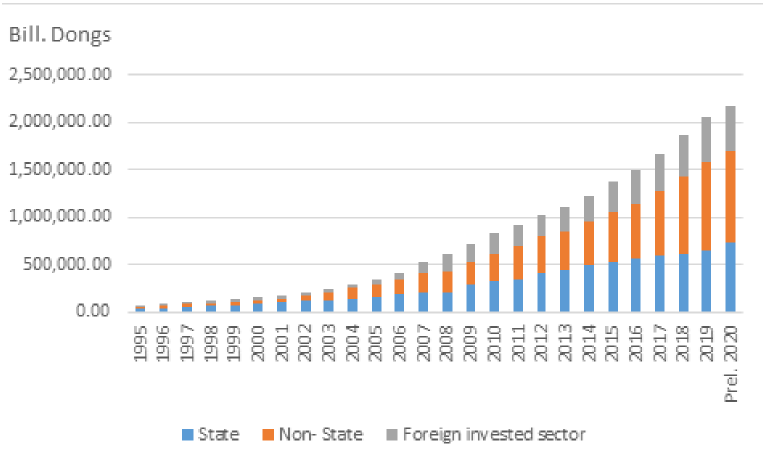


**Figure 3.** Investment by types of ownership in Vietnam from 1995-2020
**Source:** GSO

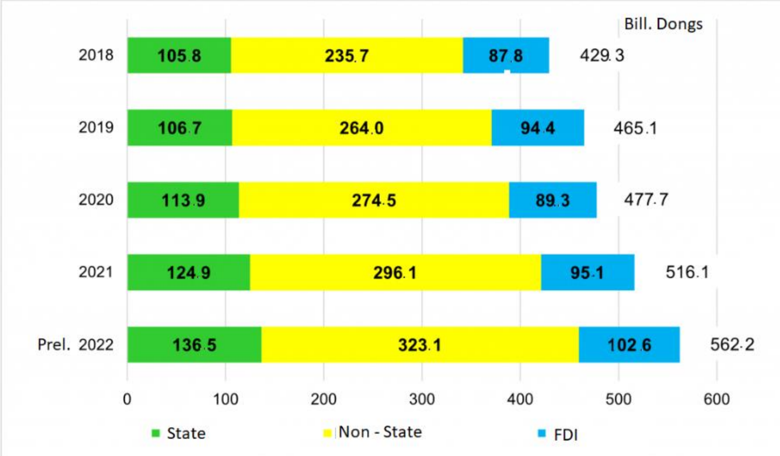


**Figure 4.** Investment by types of ownership in Vietnam from 2018-2022
**Source:** GSO

In 10 years from 1996 to 2005, transport sector has renovated, upgraded and renewed more than 16,000 km of roads; 1,400 km of railway; more than 130,000 md of road bridges; 11,000 m long railway bridge, upgrading and building a new 5,400 m long harbor; dredging 4.8 million m3 of canals. (MT, 2014)

Regarding the island way, two southern waterways have been upgraded (Hochiminh City - Ca Mau, Hochiminh City - Kien Luong); and step by step upgrade other major river routes. Regarding maritime, the Transport Industry in the past period has completed the first phase of upgrading major national seaports such as Cai Lan Port, Hai Phong Port, Cua Lo Port, Vung Ang Port, Tien Sa Port, and so on. Quy Nhon Port, Nha Trang Port, Saigon Port, Can Tho Port and complete the upgrading of a number of local ports necessary to meet the throughput of goods (MT, 2014)

With more than 3,200 km of coastline, Viet Nam currently has 37 seaports, with 166 docks and 350 wharfs, with a total length of about 45,000 m of wharves and capacity of about 350-370 million-tons per year. Port groups have been established and are capable of receiving vessels with the load of up to 100,000 tons in containers. The construction of international gateway ports in key economic zones and wharves in other areas is ongoing. (CleanAirAsia, ICCT, & CCAC, 2017)

## 2. LITERATURE REVIEW

(Munim & Schramm, 2018) conducted an empirical investigation for 91 developed and developing countries. Structural equation modeling (SEM) was used to provide empirical evidence on the significant economic impacts of port infrastructure quality and logistics performance. The results show that it is important for developing countries to continuously improve the quality of port infrastructure resulting in higher seaborne trade. However, this impact weakens as developing countries become richer.

(T.R.Lakshmanan, 2011) highlight the benefits of transport infrastructure from the observed role of railroads and waterways in economic growth and identify the mechanisms which connect transport and economic growth. Investment is an exogenous factor that plays an important role in the quality of port infrastructure by improving it. Thus, better infrastructure will improve the logistics efficiency of the country's trade and will expand the market by providing opportunities for both local and international market.

(AlbertoPortugal-Perez, 2012) estimate the impact of aggregate indicators of “soft” and “hard” infrastructure on the export performance of more than 100 countries over the period 2004–07. The research shows that investments in infrastructure create a better business environment and transport efciency, which improve export growth.

(Song & Geenhuizenc, 2014) estimate the output elasticity of port infrastructure in China applying panel data analysis for the period of 1999–2010. The results indicate clear positive effects of port infrastructure investment in all regions, however, the strength varies considerably among the regions.

(Sakyi & Immurana, 2021) show empirical evidence on the effect of seaport efficiency on the trade balance in a sample of 27 African countries for the period 2010-2017 by using Generalised Method of Moments (GMM) estimation technique. From a policy-oriented perspective, improving the efficiency of seaports in Africa is the goal of policy reforms.

In the Vietnam context to date, there is not much research indicating the impact of investment on volume of freight. This study attempts to contribute towards exploring the the relationship between the investment capital and volume of freight carried by water transport in vietnam and also contributing to the body of literature on the subject.

## 3. METHODOLOGY AND RESULT

### *3.1 Methodology*

To carry out the topic, qualitative research is conducted on theoretical documents and previous researches in order to build the research model, and then apply quantitative research on research model. To evaluate the relationship between investment and the volume of goods transported by waterway in Vietnam, three variables are used in the analytical model: the total social investment capital *(tiv)*, Volume of freight carried in tons *(vfc)* and volume of freight traffic in ton.km *(vft)*. Due to data limitations, the research utilized quarterly data about the country of Vietnam in the period 2002-2022 from the Vietnam General Statistics Office.

After collecting data, the study uses EViews to perform analysis such as descriptive statistics and regression. To evaluate the relationship between investment and the volume of goods transported by waterway in Vietnam, this study uses the VAR model. The research model is estimated by the least squares method considering the correlation and stationarity when using time series data. The process is carried out as follows: first the stationarity test, next choose the optimal lag which is the lag at which the variables modeled over the lagged variable and other variables with the same lag give the best results. The determination of the optimal lag is based on the selection index . Then cointegration test, model fit test, Granger causality test, then push response function analysis and finally variance decomposition analysis (Agung, 2009).

### *3.2 The results*

The Unit root test confirm that the data of these variables are non-stationary and therefore to process these time series, the first difference for analysis is taken.

**Table 2.** Unit root test

| Variable | ADF test | t - statistics | | |
|---|---|---|---|---|
| | | 1% | 5% | 10% |
| DTIV | -3.2 (0.0259) | -3.523 | -2.902 | -2.588 |
| DVFC | -4.3 (0.0009) | -3.527 | -2.903 | -2.589 |
| DVFT | -5.0 (0.0001) | -3.525 | -2.903 | -2.589 |

**Source:** Authors’ own calculation

According to the results of literature review, it shows that time series economic variables usually have a certain lag when considering the impact between variables. The results of the analysis are shown in Table 3. According to the test criteria, determined by the AIC and HQ criteria, we can determine the optimal delay length, the optimal delay of the model for DTIV and DVFC is 4 and for DTIV and DVFT is 2.

**Table 3.** VAR Lag Order Selection Criteria for DTIV and DVFC

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -1057.147 | NA | 1.84e+11 | 31.61632 | 31.68213* | 31.64236 |
| 1 | -1051.189 | 11.38153 | 1.74e+11 | 31.55788 | 31.75532 | 31.63601 |
| 2 | -1042.486 | 16.10671 | 1.51e+11 | 31.41750 | 31.74656 | 31.54771 |
| 3 | -1041.636 | 1.523715 | 1.66e+11 | 31.51151 | 31.97219 | 31.69380 |
| 4 | -1029.562 | 20.90278* | 1.31e+11* | 31.27052* | 31.86283 | 31.50490* |
| 5 | -1027.902 | 2.775764 | 1.41e+11 | 31.34036 | 32.06428 | 31.62682 |
| 6 | -1026.120 | 2.872643 | 1.51e+11 | 31.40656 | 32.26211 | 31.74511 |
| 7 | -1024.406 | 2.659997 | 1.63e+11 | 31.47481 | 32.46199 | 31.86544 |
| 8 | -1019.777 | 6.908555 | 1.61e+11 | 31.45604 | 32.57484 | 31.89875 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

**Source:** Authors’ own calculation

To ensure the conclusions from the estimated model, the authors test the violation of the assumptions of the regression estimate. The stability test shows that all the roots is inside the unit circle, which indicates that the VAR model is stable, as shown in Figure 5. Therefore, this model is a good VAR model.

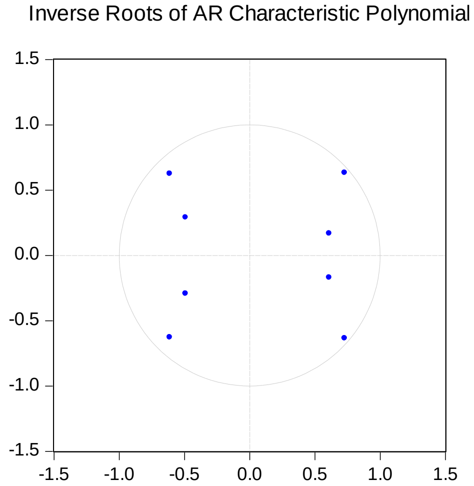


**Figure 5.** Test of stability

**Source:** Authors' own calculation

The results of residual autocorrelation test shown in Table 4 based on statistics show that with different lag steps, the p-values of the statistic are all greater than 5%, that is, the hypothesis Ho- No autocorrelation is accepted and the model is considered to satisfy the condition that there is no autocorrelation of residuals.

**Table 4.** VAR Residual Serial Correlation LM Tests

| Lag | LRE* stat | df | Prob. | Rao F-stat | df | Prob. |
|---|---|---|---|---|---|---|
| 1 | 3.819502 | 4 | 0.4310 | 0.962211 | (4, 118.0) | 0.4310 |
| 2 | 1.246013 | 4 | 0.8705 | 0.310508 | (4, 118.0) | 0.8705 |
| 3 | 0.305963 | 4 | 0.9894 | 0.075946 | (4, 118.0) | 0.9894 |
| 4 | 5.158834 | 4 | 0.2714 | 1.306996 | (4, 118.0) | 0.2714 |
| 5 | 0.515129 | 4 | 0.9720 | 0.127977 | (4, 118.0) | 0.9720 |

**Source:** Authors' own calculation

Thus, the VAR model to assess the relationship between social investment and volume of freight in Vietnam is appropriate and stable, the conclusions from the estimation results are reliable. Next, Granger causality is conducted with the results shown in Table 5 below.

**Table 5.** Check Granger causes–effects

| H0 | chi-sq | p- value | Conclusion |
|---|---|---|---|
| DTIV does not Granger Cause DVFC | 10.06301 | 0.0394 | Volume freight carried in tons depends on the social investment |
| DVFC does not Granger Cause DTIV | 2.776825 | 0.5958 | Social investment does not depend on the Volume freight carried in tons |
| DTIV does not Granger Cause DVFT | 2.545596 | 0.2800 | Volume freight traffic in tons.km does not depends on the social investment |
| DVFT does not Granger Cause DTIV | 1.290353 | 0.5246 | Social investment does not depend on the Volume freight traffic in tons.km |

**Source:** Authors' own calculation

Figure 6 and Table 6 displays the results of impulse Response and variance decomposition of DVFC for 20 periods/.

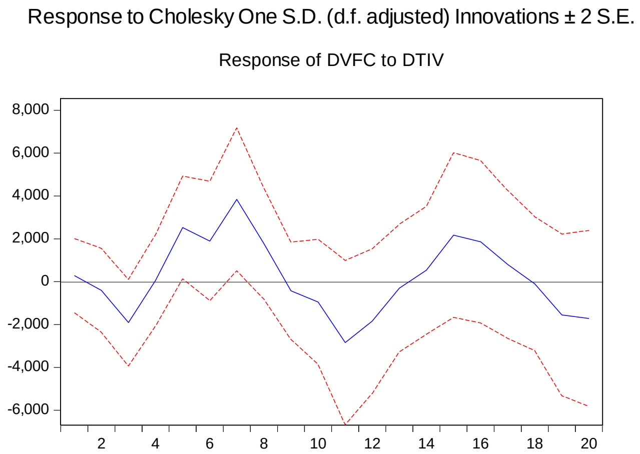


**Figure 6.** Impulse Response
**Source:** Authors' own calculation

**Table 6.** The results of variance decomposition of DVFC

| Period | S.E. | DTIV | DVFC |
|---|---|---|---|
| 1 | 7304.898 | 0.148446 | 99.85155 |
| 2 | 7636.201 | 0.418015 | 99.58199 |
| 3 | 7949.576 | 6.150303 | 93.84970 |
| 4 | 7950.442 | 6.154576 | 93.84542 |
| 5 | 9455.362 | 11.51006 | 88.48994 |
| 6 | 9983.280 | 13.92493 | 86.07507 |
| 7 | 10793.27 | 24.58900 | 75.41100 |
| 8 | 10946.37 | 26.54365 | 73.45635 |
| 9 | 11389.17 | 24.65945 | 75.34055 |
| 10 | 11727.32 | 23.90845 | 76.09155 |
| 11 | 12219.92 | 27.44351 | 72.55649 |
| 12 | 12392.07 | 28.90255 | 71.09745 |
| 13 | 12542.20 | 28.27235 | 71.72765 |
| 14 | 12758.99 | 27.49632 | 72.50368 |
| 15 | 13108.81 | 28.79508 | 71.20492 |
| 16 | 13302.00 | 29.91885 | 70.08115 |
| 17 | 13359.98 | 30.02451 | 69.97549 |
| 18 | 13478.61 | 29.50354 | 70.49646 |
| 19 | 13715.13 | 29.77867 | 70.22133 |
| 20 | 13903.79 | 30.49849 | 69.50151 |

**Source:** Authors' own calculation

Based on the results of the push reaction analysis and the decomposition of variance, the variation in volume is correlated with investment and its past values. However, it is until the third quarter that investment has a clearly impact on volume and tends to increase over time. After 11 periods - 3 years, the impact of investment on volume does not change much. Thus, besides promoting investment for social, the government also needs other policies to increase the volume of freight.

## 4. CONCLUSION

The purpose of the research was to examine the relationship between social investment and volume of freight carried by water transport in Vietnam, the VAR technique was employed and shown that social investment has a positive impact on volume of freight, thus indicating the importance of investment in this sector.

Based on the results, it is recommend that Vietnam continued investment for enhancing the capacity and commercial development of the country. To be able to take advantage of the opportunities and benefits of the existing water transport system and increase the volume of freight, continuous improvement and maintenance of the water infrastructure is required. This has the potential to boost the country's economic development and trade turnover.

## 5. LIMITATION AND FUTURE RESEARCH

The main limitation of this study is data availability. The available data for investment only covers quarterly data for the period 2002 to 2022. To explore other analysis, future research would also look at the impact of investment on economic growth or the impact of investment and other policies of government on trade of Vietnam.

## 6. ACKNOWLEDGEMENT

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## REFERENCES

1. Agung, I. G. (2009). T*ime series data analysis using Eviews.* John Wiley & Sons (Asia) Pte Ltd.
2. AlbertoPortugal-Perez, J. S. (2012). Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure. *World Development*, 1295-1307.
3. Blancas, L. C., & El-Hifnawi, M. B. (2014). *Facilitating Trade through Competitive, Low-Carbon Transport: The Case for Vietnam's Inland and Coastal Waterways. Directions in Development.* Washington DC: World Bank.
4. CleanAirAsia, ICCT, & CCAC. (2017). *Vietnam freight assessment guidance for developing a national green freight program.* CCAC.
5. Coyle, J. J., Novack, R. A., & Gibson, B. J. (2016). *Transportation: A Global Supply Chain Perspective.* Cengage Learning.
6. GSO, G. S. (2019, 06). *Explanation of terminology, content and methodology of some statistical indicators on investment*. Retrieved from General Statistics Office: https://www.gso.gov.vn/en/metadata/2019/03/investment-and-construction-2/
7. GSO, G. S. (2022). *Statistics Information.* Retrieved from General Statistics Office of Vietnam: https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/
8. JICA, J. I. (2009). *The Comprehensive Study on the Sustainable Development of Transport System in Vietnam (VITRANSS-2).* Hanoi: JICA.
9. Minh, N. (n.d.). *Bloomberg: Vietnam leads in infrastructure investment*. Retrieved from Department of agriculture and rural development Hiep Duc district: http://hiepduc.quangnam.gov.vn/Default.aspx?tabid=351&Group=46&NID=400&bloomberg-viet-nam-dan-dau-ve-dau-tu-co-so-ha-tang
10. MT, M. o. (2014, 05 19). *70 years of development history of Vietnam's transportation industry*. Retrieved from Portal of the Ministry of Transport (Cổng thông tin điện tử Bộ GTVT Việt Nam): https://mt.gov.vn/vn/tin-tuc/34827/lich-su-70-nam-phat-trien-cua-nganh-gtvt-viet-nam.aspx
11. Munim, Z. H., & Schramm, H.-J. (2018). The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. *Journal of Shipping and Trade*.
12. Ozcicek. O, O. D. (1996). *Lag Length Selection in Vector Autoregressive Models:Symmetric and Asymmetric Lags.* Louisiana State University.
13. Pasaran, H. S. (1997). Generalized impulse response analysis in linear multivariate models. *Economic letters*, 17-29.
14. Sakyi, D., & Immurana, M. (2021). Seaport efficiency and the trade balance in Africa. *Maritime Transport Research*.
15. Song, L., & Geenhuizenc, M. v. (2014). Port infrastructure investment and regional economic growth in China: Panel evidence in port regions and provinces. *Transport Policy*, 173-183.
16. T.R.Lakshmanan. (2011). The broader economic consequences of transport infrastructure investments. *Journal of Transport Geography*, 1-12.
17. UNCTAD. (2020). *Review of maritime transport 2019.* New York: United Nations.
18. W. Matekenya, R. N. (2022). The impact of maritime transport financing on total trade in South Africa. *Journal of Shipping and Trade*.
19. *Worldbank*. (2022, 04 14). Retrieved from Overview of Vietnam: https://www.worldbank.org/vi/country/vietnam/overview

## APPENDIX

### Appendix 1. Unit root test

***Null Hypothesis: DTIV has a unit root***
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=16)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.169713 | 0.0259 |
| Test critical values: | 1% level | -3.522887 | |
| | 5% level | -2.901779 | |
| | 10% level | -2.588280 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DTIV)
Method: Least Squares
Date: 07/14/22 Time: 21:08
Sample (adjusted): 2004Q2 2022Q2
Included observations: 73 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DTIV(-1) | -0.411070 | 0.129687 | -3.169713 | 0.0023 |
| D(DTIV(-1)) | -0.419604 | 0.108883 | -3.853723 | 0.0003 |
| C | 16.22358 | 6.960576 | 2.330781 | 0.0227 |

| | | | |
|---|---|---|---|
| R-squared | 0.465981 | Mean dependent var | 0.789667 |
| Adjusted R-squared | 0.450723 | S.D. dependent var | 58.04235 |
| S.E. of regression | 43.01704 | Akaike info criterion | 10.40130 |
| Sum squared resid | 129532.6 | Schwarz criterion | 10.49543 |
| Log likelihood | -376.6473 | Hannan-Quinn criter. | 10.43881 |
| F-statistic | 30.54076 | Durbin-Watson stat | 1.956609 |
| Prob(F-statistic) | 0.000000 | | |

***Null Hypothesis: DVFC has a unit root***
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=16)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -4.329541 | 0.0009 |
| Test critical values: | 1% level | -3.527045 | |
| | 5% level | -2.903566 | |
| | 10% level | -2.589227 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DVFC)
Method: Least Squares
Date: 07/14/22 Time: 21:09
Sample (adjusted): 2005Q1 2022Q2
Included observations: 70 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DVFC(-1) | -1.059916 | 0.244810 | -4.329541 | 0.0001 |
| D(DVFC(-1)) | 0.393561 | 0.193212 | 2.036936 | 0.0458 |
| D(DVFC(-2)) | 0.381265 | 0.180328 | 2.114285 | 0.0384 |
| D(DVFC(-3)) | 0.324086 | 0.165928 | 1.953172 | 0.0552 |
| D(DVFC(-4)) | -0.187671 | 0.147445 | -1.272817 | 0.2077 |
| C | 5396.955 | 1521.885 | 3.546230 | 0.0007 |

| | | | |
|---|---|---|---|
| R-squared | 0.485444 | Mean dependent var | 148.6261 |
| Adjusted R-squared | 0.445244 | S.D. dependent var | 10263.85 |
| S.E. of regression | 7644.716 | Akaike info criterion | 20.80323 |

| | | | |
|---|---|---|---|
| Sum squared resid | 3.74E+09 | Schwarz criterion | 20.99596 |
| Log likelihood | -722.1132 | Hannan-Quinn criter. | 20.87979 |
| F-statistic | 12.07580 | Durbin-Watson stat | 2.011788 |
| Prob(F-statistic) | 0.000000 | | |

***Null Hypothesis: DVFT has a unit root***
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=16)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.024161 | 0.0001 |
| Test critical values: | 1% level | -3.525618 | |
| | 5% level | -2.902953 | |
| | 10% level | -2.588902 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DVFT)
Method: Least Squares
Date: 07/14/22 Time: 21:09
Sample (adjusted): 2004Q4 2022Q2
Included observations: 71 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DVFT(-1) | -0.768957 | 0.153052 | -5.024161 | 0.0000 |
| D(DVFT(-1)) | 0.055477 | 0.153149 | 0.362240 | 0.7183 |
| D(DVFT(-2)) | 0.337691 | 0.144698 | 2.333773 | 0.0227 |
| D(DVFT(-3)) | 0.497404 | 0.114209 | 4.355217 | 0.0000 |
| C | 2492.403 | 891.0268 | 2.797226 | 0.0067 |

| | | | |
|---|---|---|---|
| R-squared | 0.504830 | Mean dependent var | 231.1974 |
| Adjusted R-squared | 0.474819 | S.D. dependent var | 9059.953 |
| S.E. of regression | 6565.689 | Akaike info criterion | 20.48492 |
| Sum squared resid | 2.85E+09 | Schwarz criterion | 20.64427 |
| Log likelihood | -722.2147 | Hannan-Quinn criter. | 20.54829 |
| F-statistic | 16.82187 | Durbin-Watson stat | 1.784009 |
| Prob(F-statistic) | 0.000000 | | |

**Appendix 2. VAR Lag Order Selection Criteria**

VAR Lag Order Selection Criteria
Endogenous variables: DTIV DVFC
Exogenous variables: C
Date: 07/14/22 Time: 21:10
Sample: 2002Q4 2022Q2
Included observations: 67

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -1057.147 | NA | 1.84e+11 | 31.61632 | 31.68213* | 31.64236 |
| 1 | -1051.189 | 11.38153 | 1.74e+11 | 31.55788 | 31.75532 | 31.63601 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | -1042.486 | 16.10671 | 1.51e+11 | 31.41750 | 31.74656 | 31.54771 |
| 3 | -1041.636 | 1.523715 | 1.66e+11 | 31.51151 | 31.97219 | 31.69380 |
| 4 | -1029.562 | 20.90278* | 1.31e+11* | 31.27052* | 31.86283 | 31.50490* |
| 5 | -1027.902 | 2.775764 | 1.41e+11 | 31.34036 | 32.06428 | 31.62682 |
| 6 | -1026.120 | 2.872643 | 1.51e+11 | 31.40656 | 32.26211 | 31.74511 |
| 7 | -1024.406 | 2.659997 | 1.63e+11 | 31.47481 | 32.46199 | 31.86544 |
| 8 | -1019.777 | 6.908555 | 1.61e+11 | 31.45604 | 32.57484 | 31.89875 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: DTIV DVFT
Exogenous variables: C
Date: 07/14/22 Time: 21:12
Sample: 2002Q4 2022Q2
Included observations: 67

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -1051.100 | NA | 1.54e+11 | 31.43581 | 31.50162 | 31.46185 |
| 1 | -1044.168 | 13.24213 | 1.41e+11 | 31.34831 | 31.54574 | 31.42643 |
| 2 | -1033.978 | 18.85893 | 1.17e+11 | 31.16353 | 31.49259* | 31.29374* |
| 3 | -1033.865 | 0.203880 | 1.32e+11 | 31.27954 | 31.74022 | 31.46183 |
| 4 | -1022.695 | 19.33808* | 1.07e+11* | 31.06553* | 31.65783 | 31.29990 |
| 5 | -1021.803 | 1.491231 | 1.17e+11 | 31.15830 | 31.88223 | 31.44476 |
| 6 | -1020.564 | 1.997136 | 1.28e+11 | 31.24072 | 32.09627 | 31.57926 |
| 7 | -1018.309 | 3.499899 | 1.36e+11 | 31.29282 | 32.27999 | 31.68344 |
| 8 | -1015.090 | 4.805283 | 1.40e+11 | 31.31611 | 32.43491 | 31.75883 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

**Appendix 3. Test of stability**

Roots of Characteristic Polynomial
Endogenous variables: DTIV DVFC
Exogenous variables: C
Lag specification: 1 4
Date: 07/14/22 Time: 21:14

| Root | Modulus |
|---|---|
| 0.727516 - 0.633225i | 0.964496 |
| 0.727516 + 0.633225i | 0.964496 |
| -0.613355 - 0.626524i | 0.876776 |
| -0.613355 + 0.626524i | 0.876776 |
| 0.609262 - 0.168143i | 0.632038 |
| 0.609262 + 0.168143i | 0.632038 |

| | |
|---|---|
| -0.491931 - 0.291993i | 0.572063 |
| -0.491931 + 0.291993i | 0.572063 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

Roots of Characteristic Polynomial
Endogenous variables: DTIV DVFT
Exogenous variables: C
Lag specification: 1 2
Date: 07/14/22 Time: 21:13

| Root | Modulus |
|---|---|
| 0.731188 | 0.731188 |
| 0.613407 | 0.613407 |
| -0.458809 - 0.104392i | 0.470536 |
| -0.458809 + 0.104392i | 0.470536 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

**Appendix 4. Residual Serial Correlation LM Tests**

VAR Residual Serial Correlation LM Tests
Date: 07/15/22 Time: 15:49
Sample: 2002Q4 2022Q2
Included observations: 71

Null hypothesis: No serial correlation at lag h

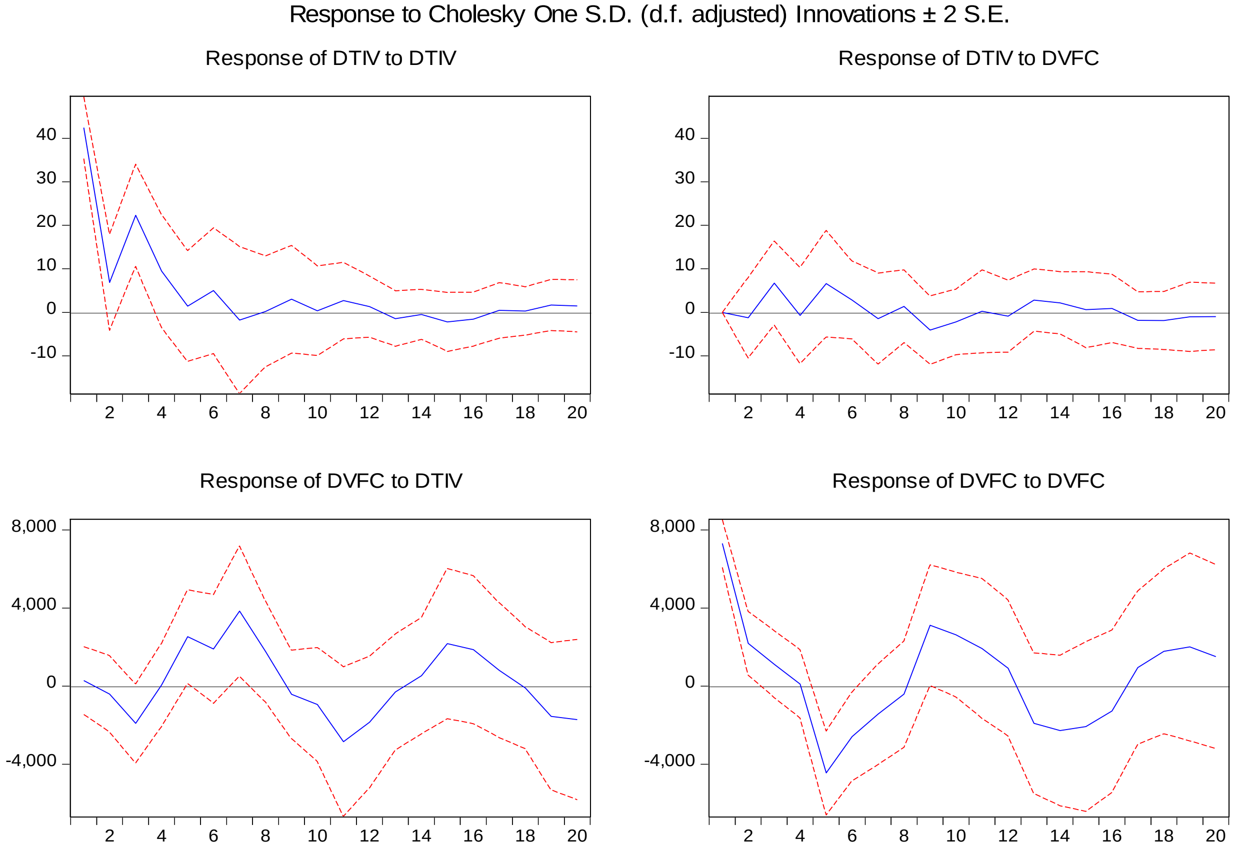
| Lag | LRE* stat | df | Prob. | Rao F-stat | df | Prob. |
|---|---|---|---|---|---|---|
| 1 | 3.819502 | 4 | 0.4310 | 0.962211 | (4, 118.0) | 0.4310 |
| 2 | 1.246013 | 4 | 0.8705 | 0.310508 | (4, 118.0) | 0.8705 |
| 3 | 0.305963 | 4 | 0.9894 | 0.075946 | (4, 118.0) | 0.9894 |
| 4 | 5.158834 | 4 | 0.2714 | 1.306996 | (4, 118.0) | 0.2714 |
| 5 | 0.515129 | 4 | 0.9720 | 0.127977 | (4, 118.0) | 0.9720 |

Null hypothesis: No serial correlation at lags 1 to h

| Lag | LRE* stat | df | Prob. | Rao F-stat | df | Prob. |
|---|---|---|---|---|---|---|
| 1 | 3.819502 | 4 | 0.4310 | 0.962211 | (4, 118.0) | 0.4310 |
| 2 | 4.156796 | 8 | 0.8427 | 0.515377 | (8, 114.0) | 0.8428 |
| 3 | 5.072297 | 12 | 0.9555 | 0.413363 | (12, 110.0) | 0.9556 |
| 4 | 11.47974 | 16 | 0.7790 | 0.708413 | (16, 106.0) | 0.7800 |
| 5 | 13.76622 | 20 | 0.8421 | 0.673397 | (20, 102.0) | 0.8436 |

*Edgeworth expansion corrected likelihood ratio statistic.

**Appendix 5. IMPULSE RESPONSE**




**Appendix 6. Variance Decomposition**