THE MELTING OF ARCTIC ICE: THE CASE OF NORWEGIAN INTERNATIONAL TRADE

By

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ABSTRACT

The Arctic ice sheet continues to melt because of climate change, presenting opportunities for new trade routes through the Arctic, the Northern Sea Route (NSR) being a prime example. Norway, like other Northern European countries is set to significantly benefit from this, in terms of increases in international trade. This thesis investigates this, utilising OLS regression to analyse the impact of the ice extent of the Arctic ice sheet, total gross registered tonnage transiting the NSR, number of ships transiting the NSR, and the navigability of the NSR, on the total trade in goods, of Norway. The study finds that there is a positive correlation between reductions in Arctic ice extent and total Norwegian trade. However due to insignificant results for the NSR measurements, it is not possible to conclude whether this is due to the ability to use the NSR for shipping, or whether reductions in ice extent simply increase other factors influencing Norwegian international trade.

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LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
GT	Gross Tonnage
GRT	Gross Registered Tonnage
NSR	Northern Sea Route
OLS	Ordinary Least Squares
VIF	Variance Inflation Factor

1. Introduction

Over the last decades the world has seen a rapid globalisation, with new and better communication and transportation technologies being the facilitators. This has caused the world citizens, countries, and regions to become increasingly interconnected, and geographical distance has become less of a hindrance to human interaction. International trade of goods is one example of this. With increasing economic activity between countries international trade of goods has become increasingly important for economic welfare and the everyday lives of people (Potrafke 2015). Furthermore, international trade of goods has become a measure of globalisation (Eurostat n.d.) as it is an indicator of economic globalisation. Therefore, research on international trade and the factors influencing whom trade with whom, what is traded, how they trade, etc. is essential to modern society. [1]

Simultaneously, global warming has been increasing due to the emission of greenhouse gases from human activities. This has become a threat to nature and humans, as it will have lasting negative effects on the environment. Global warming could have an impact on international trade, changing the circumstances of trade itself. One of the ways it could do this is through the melting of the Arctic ice cap. As the ice coverage in the Arctic lowers year by year due to climate change (Walsh 2013), maritime trade routes in the Arctic stay open for longer periods of time, providing an alternative to existing routes (Farré et al. 2014; Schach and Madlener 2018). These routes through the Arctic are shorter in comparison to the conventional routes in use, thus they are more attractive to businesses which aim to decrease transport times and transport cost of goods.

[1] When using the terms "trade" or "international trade" in this paper, I am referring to international trade in goods.

The topic of this thesis is an important and current one, as climate change continues to take place and Arctic ice continues to melt (Walsh 2013). Investigating the impact the melting of Arctic ice has had on trade until now, with there being a potential for the complete disappearance of the Arctic ice cap, would give an indication of what will happen in the future as well. Thus, this thesis could help give insight into the effect that the melting ice could have on transportation and international trade, and the possibilities it creates.

In this thesis I will therefore explore the impact of melting ice in the Arctic on international trade. More specifically, the thesis will investigate how the melting of Arctic ice has affected Norwegian international trade. Norway, as an Arctic state, is a good country of examination due to having a trade surplus and due to the extensive coastline, which has made maritime trade important. Therefore, my thesis aims at answering the question: *Has the melting of Arctic ice had an impact on Norwegian international trade?* I expect that melting Arctic ice has caused an increase in Norwegian trade. This is because the possibility of more shipping through the Arctic allows for Norway to better take advantage of its position on, for example routes between Europe and Asia, which is trade that likely benefits from melting of Arctic ice (Liu et al. 2019).

To investigate this question, I employed OLS regression analysis, investigating how 4 different measures have impacted Norwegian international trade. Using OLS regression analysis, it is possible to investigate the potential linear relationship between Arctic ice, three other variables based on traffic data on the Northern Sea Route, and Norwegian international trade, giving an indication of whether there could be a causal relationship between the two. To increase the robustness of the models, I included several control variables, to ensure that potential confounding factors on trade and Arctic ice are accounted for and performed robustness checks and altered the regression models accordingly.

The results indicate a significant negative correlation between Arctic ice extent and Norwegian international trade, meaning increases in ice extent are associated with increases in trade. This also means that reductions in Arctic ice may be associated with increases in trade for Norway. However, the results for the models using the three Northern Sea Route traffic variables the findings are not statistically significant. Thus, the results suggest there could be a causal link between Arctic ice and international trade, although further research is needed to confirm this, and this link is not necessarily due to the increasing navigability of the Arctic for maritime transport, but likely due to a variety of economic factors influencing trade, that are again influenced by Arctic ice extent.

The thesis starts off with a literature review, discussing previous research on the topic and how the thesis aims to complement this, specifically as most research has been focused on future effects of Arctic ice melting on trade, and not on if and how it already affected trade like this thesis aims to do. The thesis then goes on to cover the data and methodology used in the paper, before discussing the results of the OLS regression models. Subsequently, robustness checks are performed to account for potential issues with the models, before altering and discussing the results of the models accounting for robustness issues. Finally, the thesis discusses the findings and how they fit in with the literature, before concluding.

2. Literature Review

International trade is an important part of modern-day economics. As such, a lot is written on the topic, and that also includes regarding the possibilities of using the Arctic for maritime trade. The Arctic presents an alternative to existing trade routes, particularly between the Pacific and Atlantic oceans, for which trade usually must travel through the Suez Canal. Thus, unsurprisingly, an important factor for whether the Arctic is a viable alternative for maritime trade is its viability in comparison to the Suez Canal. A variety of papers have been written on the topic. The grounding of a cargo vessel in the Suez canal in 2021, and concerns about the Suez Canal's reliability, has made the Arctic an increasingly attractive alternative for international maritime transportation, especially as polar ice caps continue to melt (Pawelski 2022; Bayırhan and Gazioglu 2021). There are several cost saving advantages, such as shorter shipping times and fuel efficiency, associated with the Arctic, and the already existing routes in the Arctic were possibly profitable already back in 2011 (Schøyen and Bråthen 2011). Alternative routes to the Suez Canal, in the Arctic, are significantly shorter for trade between Asia and Europe. For example, the Northern Sea Route (NSR) is around 40% shorter in distance (Zeng et al. 2020, pp. 34). However, some of the research also indicates that Arctic routes are not commercially viable options due to the development of railway as part of the Belt and Road initiative (Zeng et al. 2020). The belt and road initiative provides a solid alternative to the Suez Canal, however as Bayırhan and Gazioglu point out, the Arctic is included in the maritime initiatives of the Belt and Road initiative (Bayırhan and Gazioglu 2021), and the Arctic might still be a viable alternative despite increasing rail capacity.

Particularly trade between East Asia and Europe could benefit significantly from the melting of Arctic ice. The previously mentioned Northern Sea Route (NSR) is widely considered an especially attractive Arctic maritime shipping route. The route moves through the Arctic along the Siberian coastline of Russia, and it is already in use by commercial shipping, although at a relatively small scale (NORD University n.d.). One of the main reasons for the viability of the NSR, as with Arctic shipping routes in general, is the decreased travel times for ships between the East Asian countries, some of the largest economies in the world, and Europe. The melting ice caps in the Arctic are predicted to have a significant positive impact on East-Asian trade with Europe due to time and cost efficiency, and Norway is an example of a country that is expected to see significantly increased trade with the East Asian Countries of China, Japan and South Korea (Bekkers, Francois, and Rojas-Romagosa 2018). China specifically would likely see large trade gains due to the NSR's increasing navigability for maritime trade, as it allows for increased potential of exports and imports to Northern and Western European countries (Liu et al. 2019). In Europe, Norway is expected to be among the largest European benefactors in terms of import and export potential with China, due to the melting of Arctic ice, expecting a 12% increase in the former, and 17.83% in the later (Liu et al. 2019). It is thus likely that, particularly trade between East Asia and Europe would benefit significantly from the melting of Arctic ice, and the opening of the NSR, and that Norway is expected to see a significant increase in trade.

The main concern with the NSR is its seasonality, as the navigability varies drastically with seasons (Zeng et al. 2020; Pawelski 2022; Y. Zhang, Meng, and Zhang 2016). This reduces predictability for companies in navigating the passage, and also increases costs as they need to have ships constructed specifically for traversing through ice (Y. Zhang, Meng, and Zhang 2016). Political factors could also be a concern, as the route moves along the coast of Russia. There was a drastic fall in transit along the NSR in 2014, which could be linked to the Russian annexation of Crimea (Pettersen 2014). There are also other important factors that reduce the routes viability, such as tariffs, jurisdictional disputes, lacking infrastructure, etc. (Xu and Yin 2021; Farré et al. 2014).

Nonetheless, the melting of the Arctic ice sheet is already taking place and traffic is already increasing. According to the National Snow & Ice Data Center, the sea ice extent in the Arctic, in April, has on average been decreasing by about 2.5% per decade (National Snow & Ice Data Center 2023). As a consequence, the Arctic is as already mentioned increasingly open to navigation (Farré et al. 2014; Schach and Madlener 2018), thus the increases in trade for Norway might already be taking place. Shipping activities in the Arctic point towards the same, with shipping having increased by 25% over 6 years from 2013-2019 (Arctic Council n.d.) and the NSR specifically has seen a 58% increase in traffic from 2016-2019 (Gunnarsson 2021). However, much of the existing research (e.g. Bekkers, Francois, and Rojas-Romagosa 2018; Liu et al. 2019; Zeng et al. 2020) points towards future viability and implications of this. Little is written on if and how the melting Arctic ice has affected trade. There is literature analysing the shipping traffic along the NSR (Gunnarsson 2021; Humpert 2014), however there is a gap in the literature in regards to analysing the impact of this traffic in the Arctic, and of the melting Arctic ice sheet, on international trade.

Thus, my aim with this thesis is to try to address this gap: I will focus on Norway, a country that is predicted to see increased trade due to the melting Arctic ice, as mentioned earlier (Bekkers, Francois, and Rojas-Romagosa 2018; Liu et al. 2019), investigating if and how reductions in the Arctic ice sheet has affected Norwegian international trade in the past, whilst supplementing this by analysing the effect that traffic along the NSR has had on Norway. This focus is due to Norway being an Arctic state with a heavy focus on trade, with trade making up 71% of the Norwegian GDP (World Bank n.d.). The paper will not address other Arctic routes like the Northwest passage in the American Arctic, due to its distance from Norway compared to the NSR, having less developed infrastructure, and because it is not used for commercial shipping (Pawelski 2022; Z. Zhang, Huisingh, and Song 2019). Neither will the transpolar route be measured, as it is not usable for maritime trade due to the ice cover being present all year around (Pawelski 2022).

3. Methodology and Data

This paper will focus on the context of Norway, as the literature suggests that it could be a prime benefactor of the potential trade increases caused by melting Arctic sea ice. However, while the existing literature focuses on the future potential of trade routes like the NSR, little has been written on how the melting of Arctic ice has affected international trade. Thus, I focus my research on if and how melting if Arctic ice has affected Norwegian International trade, so far. In order to do this, this paper will employ multiple regression analysis (OLS) to investigate whether there is a linear relationship between Norwegian international trade and the melting of Arctic ice and consequent opening of Arctic routes to navigation.

The dependent variable will be the total international trade of Norway. Statistics Norway, the state statistics institution of Norway, has detailed data on Norwegian trade, disseminated in several different ways. For this thesis, as I am interested in the total trade of Norway, in regards to products and not services. I use the total trade in goods (exports + imports) using the export and import numbers from Statistics Norway's "External trade in goods" data which is given in millions of NOK (Statistisk Sentralbyrå n.d., b). The data is monthly, from January 1988 to April 2023, to match the data on ice-extent.

Data on measurements of Arctic ice, will be one independent variable of interest. When measuring ice, there is a difference between using sea ice extent. Sea ice area is commonly defined as the size of an area covered by ice, whilst sea ice extent is a region with at least 15% ice cover. (Scott 2022). In general ice extent has its advantages such as there being higher confidence in ice extent measurements and there is also more consensus on extent than area among experts (Scott 2022). Thus, this paper will use ice extent as a measure of changes in the Arctic ice sheet. The data was acquired from the Norwegian Meteorological Institute's website for ice related data and information, more specifically the monthly values given from the "OSI

SAF Sea Ice Index v2.1", which are monthly means for sea-ice extent in the Arctic given in million km², from January 1988 to April 2023 (OSI SAF sea-ice team 2020). The data from 1979-1988 is excluded for continuity, as some monthly values are missing.

For control variables, there are several different variables included, to make sure other effects on trade are accounted for in the model. GDP is one of them, seeing as it is considered to have a strong effect on trade exemplified by the commonly used gravity model for international trade (Chaney 2018). Like data on total trade, data for GDP was acquired from Statistics Norway, although data on GDP was not available on the monthly level for my time period, thus, I decided to use quarterly data (Statistisk Sentralbyrå n.d., c). and temporally disaggregating it withing the months of the quarters, by assigning the quarterly value to the months in the quarter. The GDP measure might have some inaccuracies due to the temporal disaggregation, thus I also use industrial production as an additional control variable that measures the performance of the Norwegian economy. Like data on total trade, data for industrial production was acquired from Statistics Norway, using their index of industrial production, unadjusted for seasons, with 2005 being the base period (2005=100) and the data being from January 1990 and onwards (Statistisk Sentralbyrå n.d., a). By including industrial production in the model, I am able to control for changes in the Norwegian industrial sector, which would heavily influence trade, as industrial production measures the productivity of industries in the economy, such as that of manufacturing and mining (Statistisk Sentralbyrå n.d., a).

Other important variables affecting trade were also included, such as tariffs, measured in weighted means of all products (World Bank, n.d.) and the real narrow effective exchange rate for the Norwegian kroner (NOK) (Bank of International Settlements 2023). For the tariff rates, only yearly values were available, thus the data was temporally disaggregated to the monthly level, by assigning the yearly mean tariff rate to all the months of the respective years. This disaggregation should not be an issue for accuracy, as tariffs do not normally change on the monthly level, bur rather over several years. Importantly, the tariff data only covers 1995-2020, thus including it will reduce the number of observations. The real narrow effective exchange rate measures the exchange rate by weighting the average exchange rates of a currency to other currencies, adjusted by the differences in consumer prices, and in this case the Bank of International Settlements uses a basket of 27 different currencies for their narrow rate (Bank of International Settlements 2017). Trade is affected by the volatility of exchange rates (Auboin and Ruta 2013) and there is a relationship between real exchange rates and the volume of trade (Kang and Dagli 2018), thus in order to control for this effect I include the real exchange rate in the model.

Additionally, as the independent and control variables are not seasonally adjusted, I also created a monthly factor variable, composed of month dummies, to control for seasonal changes in the economy. April servers as the reference month to which the other month dummies compare themselves to.

A problem with the ice extent variable is that it could also impact other areas of the Norwegian economy and thus not only capturing the effect of Arctic shipping on trade. Therefore I created 3 additional variables of interest, all based on transit data for the Northern Sea Route, based on the records of the Northern Sea Route Information Office (NORD University n.d.): The first is GRT, which has values representing the sum of the monthly gross registered tonnage (also referred to as GT-Gross Tonnage), the internal volume of a ship, transiting the Northern Sea Route in a given month. The ship values were assigned to the month they spent the most time in as they traversed the route, although for 2019 due to no entry and exit dates and times for the route being available, the ships were assigned based on which month they primarily travelled in, calculated from the port departure time and destination arrival time. Some years of the data also did not have GRT numbers for the ships, thus the values for these ships were found cross referencing ship tracking websites (MarineTraffic n.d.; VesselFinder n.d.; ShipSpotting.com n.d.). By using the GRT I can see how changes in the volume of trade flowing through the NSR affect Norwegian international trade. The second variable created is simply the number of ships transiting the route, assigned to months in the same manner as GRT, which also allows us to see the impact of increased traffic along the Northern Sea Route. Lastly, I created a dummy variable called navigability, which =1 if there were any ships transiting the Northern Sea Route during the month, and =0 if not. Using this variable, I can see the effect of the navigability of the NSR on trade. An issue with these three variables is that the data they are based on is only reported for 2011-2021, and 2011 had to be excluded as no travel times were not available. Thus, these variables only cover 2012-2021. While having few observations, comparing the effect of these three variables with that of ice extent allows for a more thorough analysis of the effect of melting Arctic ice and the opening of the Arctic to maritime traffic, on Norwegian international trade.

Table 1 has summary statistics for the variables and Table 10 shows the pairwise correlations between the non-dummy independent variables (both tables in the appendix). It shows that there are strong pairwise negative correlations between ice extent and GRT, ships and navigability. This means increases in Arctic ice extent are associated with reductions in ship activity along the NSR. By having separate regressions using GRT, ships and navigability as replacement variables for ice extent, I can therefore assess the more specific effects of how increases in ship traffic along the NSR have affected Norwegian international trade.

3.1. Model

I have four different models, each with a different independent focus variable, being ice extent, GRT, ships and navigability. As the data is time-series, and I am using OLS to investigate, the monthly dummy variables are used to account for potential seasonal effects. The disaggregated quarterly GDP data and monthly industrial production also helps account for seasonal changes in the economy, although its main purpose along with the other control variables (tariff rate and real narrow effective exchange rate) is to reduce endogeneity, reducing omission bias and to improves the accuracy of the model. Furthermore, for interpretability, the dependent variable (total trade) is logged. Thus, in order to investigate the relationship between melting Arctic ice and shipping along the Northern Sea Route with Norwegian international trade, the following OLS regression is used:

$$\log(trade) = \beta_0 + \beta_1 x + \beta_2 industrialproduction + \beta_3 GDPquarterly + \beta_4 tariffrate + \beta_5 exchangerate + \beta_6 january + \beta_7 february + \cdots + \beta_{17} december + \varepsilon$$

x here represents the four different independent focus variables. This equation estimates how a unit change in x is correlated with a 100*β_1% change in trade, ceteris paribus. With these variables, the model is based on monthly observations from January 1995 for ice extent, and for the three other variables from January 2012, to December 2020.

4. Results

Looking at table 2 (appendix), when regressing using ice extent as the focus variable, I find that a unit increase in ice extent, meaning an additional million km² of ice extent, is associated with an approximately 2% reduction in total trade for Norway, ceteris paribus. Furthermore, while the t-value tells us it is not significant at the 5% level, it is relatively close as the effect is significant at the 7% level. The r-squared for the model is very high at a 0.967 meaning the model is very explanatory, which is likely due to the inclusion of several important economic variables (e.g., GDP and industrial production). However, while most of the variables have expected results, like a positive correlation between GDP and trade and negative between tariff rate and trade, and are statistically significant even at the 1% level, the month dummies have widely varying t-statistics, with some being statistically significant while others are not. Thus, the effect of the monthly values must be taken with a grain of salt, as they might be multicollinear with the other independent variables. For example, ice extent is likely strongly correlated with the seasons due to differences in temperature, thus months might be correlated with ice extent.

For the other three independent focus variables (GRT, ships and navigability) regressions, the results are different (appendix tables 3,4 and 5 respectively). Here GRT and ships have positive coefficients (4.31e-08 and .0011915), which is as expected, with increased tonnage and number of ships traversing the NSR having a positive correlation with Norwegian international trade. However, navigability has a negative coefficient, with the NSR being navigable being associated with an approximately 3% reduction in trade. Nonetheless, it is also evident that these three variables are not statistically significant, having very small t-statistics. This is also the case when one investigates the other independent variables in the regression, seeing as majority of the monthly dummies as well as tariff rate are not statistically significant in the three regressions. Notably, while tariff rate had a negative coefficient when regressing with ice extent, the three other regressions have positive coefficients. This seems counterintuitive as a tariff is a trade barrier, thus should not promote trade.

This difference in results can be due to several reasons. Sample size is a likely reason, as the number of observations when using ice extent is significantly larger when regressing compared with the three Northern Sea Route variables (312 compared to 108). This is due to the limitations of the data, as the Northern Sea route variables only cover 10 years, and furthermore the last year is cut off due to 2021 not having tariff data. Similarly, the tariff rate observations end in 2020, thus there are few observations along with low variability in tariffs over time, both due to the nature of tariffs themselves, but especially because they are temporally disaggregated from yearly to monthly. There is also the possibility that there is collinearity present and/or that the data has heteroskedastic errors. Thus, I need to do robustness checks.

5. Robustness

To assess for multicollinearity, of the models, I perform variance inflation factor (VIF) tests. VIF investigates how much the independent variables are exaggerated due to multicollinearity, with a VIF value of 5 or 10 being considered cut-offs, while 1 is no multicollinearity. Tables 6 7, 8 and 10 in the appendix show the VIF values for the different regression models. For the models using GRT, ships, and navigability as independent variables for increased Arctic trade, the mean VIF is relatively low (2.473, 2.592 and 3.334 respectively) (tables 7, 8 and 9). The VIF value for navigability however (6.896) points towards the variable being multicollinear with other independent variables in the regression, the monthly variables likely culprits with July, September, October, and November all having some of the other high VIF values (table 9). Thus, navigability might be more sensitive to seasonality, and this high VIF value might also be reason behind the unexpected negative coefficient for navigability.

However, while these three regressions have mean VIF values that are acceptable, the ice extent regression model has a mean VIF value of 14.202 (table 6). This means that multicollinearity plays a significant role in the regression model, thus I cannot be sure about the regression results. Investigating more in detail reveals that ice extent and the monthly dummy variables are the main culprits, as these all have high VIF values. This is likely because ice extent varies significantly with seasons, lowering in the summer months due to higher temperatures and increasing in the winter as temperatures drop. Therefore, removing the monthly dummies from the ice extent regression model seems like the appropriate step, as the multicollinearity it causes is simply too much to have confidence in the regression output.

GDP measures the overall economy, so it would be expected that it is likely correlated with other economic variables, such as exchange rate of the Norwegian currency, and especially with industrial productivity. However, while having above 5 VIF values alongside industrial production in the ice extent regression (table 6), it does not have a problematic VIF value in the three other regressions. Table 10 in the appendix, showing pairwise correlations, does show that there is some correlation between the two variables, however it is not a big correlation, only moderate, thus it should not present a problem for the interpretation.

Another important assumption for OLS is that there is heteroskedasticity. To test whether this is true, I used the Breusch–Pagan/Cook–Weisberg test for heteroskedasticity, analysing the variance in the error terms of the models, in relation to the independent variables. These tests all give p-values that do not allow us to reject the null-hypothesis that there is constant variance in the error terms (p-value for ice extent=0.1126; p-value for GRT=0.9468; p-value for ships=0.9282; p-value for navigability=0.8577), thus the results point towards the models being homoscedastic.

5.1. Final Models

Having assessed the robustness of the models, I decided to alter them accordingly. While the results of the Breusch–Pagan/Cook–Weisberg tests suggested heteroskedasticity is not present, it is not a perfect measure. Thus, I ran the regressions with robust standard errors. By using robust regression, the standard errors are changed to account for the presence of heteroskedasticity, providing us with more reliable data.

Additionally, I changed the ice extent model by removing the seasonal dummies. The multicollinearity with ice extent was too high, and reduced the reliability of the model, and since ice extent is the independent variable of interest, I removed the month dummies and not the other way around. For the three other regressions, I removed the tariff variable. While an important factor in analysing trade, the inclusion of the variable further restricts an already small sample size (from 120 to 108 with tariff rate included) potentially reducing the accuracy of the model through outliers having more effect, potentially reducing significance, and also making the sample less representative. Additionally, as the variable has a positive coefficient in these regressions (tables 3, 4 and 5), which is expected to be negative, there might be some omitted variable bias associated with tariffs. Furthermore, as tariffs are included in the ice extent model, I can compare the models and take account for tariff's impact in the ice extent model.

Thus, I am left with these final models, which are robust OLS regressions, with measures taken to reduce multicollinearity and heteroskedasticity:

$$\log(trade) = \beta_0 + \beta_1 iceextent + \beta_2 industrialproduction + \beta_3 GDPquarterly + \beta_4 tariffrate + \beta_5 exchangerate + \varepsilon$$

And for the other three independent focus variables (GRT, ships and navigability) with X as a place holder:

$$\log(trade) = \beta_0 + \beta_1 X + \beta_2 industrialproduction + \beta_3 GDPquarterly + \beta_4 realexchangerate + \beta_5 january + \beta_6 february + \cdots + \beta_{16} december + \varepsilon$$

Tables 11 in the appendix shows the results for the new ice extent model. Most notably, when compared to the earlier model (table 2) I can see that the coefficient has reduced drastically from -.0203168 to -.0049378. An additional million km² of ice extent, is associated with an approximately 0.5% reduction in total trade for Norway. The reduction in the coefficient is likely because of the decision to omit the monthly dummies, as the inclusion of these caused multicollinearity issues and, as the VIF test pointed towards (table 6), exaggerated the effect of melting ice extent. Thus, while this model does not control for seasonal variation in trade, it is likely more accurate as multicollinearity is reduced, which the new VIF values also point towards, with the mean and respective VIF values for all independent variables being well below 5 (table 15). Furthermore, the corresponding p-value for ice extent is also lower, and the results are statistically significant even at the 1% level, and the probability value for the f-test also ascertains that the overall model is statistically significant at the 1% level. The r-squared has reduced slightly from 0.967 (table 2) to 0.958 (table 11), so the model explains a bit less of the variation in trade, which is expected when removing variables, but the new model still explains a significant portion of the variation in trade (95,8%).

As for the other new models, the p-values have decreased slightly for the GRT and ships regressions, from 0.472 (table 3) to 0.35 (table 12) for GRT and from 0.457 (table 4) to 0.336 (table 13.) for shipping. The p-value for navigation in its new model however has drastically increased from 0.225 (table 5) to 0.918 (table 14), which might mean that for the navigability regression, tariffs was an important explanatory variable. Nonetheless, all three northern sea route variables, in their respective regressions, are not statistically significant, thus I cannot say that they have a significant relationship with Norwegian international trade.

The three models using GRT, ships and navigability of the northern sea route as focus independent variables all point towards there being no statistically significant relationship between increased GRT moving through the NSR, more ships transiting the NSR and the NSR being navigable, and Norwegian international trade. However, having adjusted for potential heteroskedasticity and the presence of quite severe multicollinearity between months and ice extent, the new ice extent model does point towards more Arctic ice having a negative relationship with Norwegian international trade. Or, to rephrase it, a reduction in Arctic ice extent is associated with increased Norwegian international trade, ceteris paribus. Nonetheless, it is important to note that with months excluded from the model, the ice extent coefficient could be accounting for seasonal variation in trade as well. Furthermore, as the data is time-series, and I have used OLS to assess the effects of the variables, which could cause issues such as autocorrelation or seasonality, which as I now have excluded the monthly dummies is not controlled for. Furthermore, it could also cause there to be non-linear trends between the dependent and independent variables, which OLS does not account for. Thus, the results need to be scrutinized accordingly.[2]

[2] I did not use methods that account for time-series deviation or non-linearity due to not having the necessary capabilities to do so. I have taken introductory and intermediate econometrics, but these courses did not introduce us to methods using time-series data, nor methods accounting for non-linearity, and while we were briefly introduced to panel data as a concept, we did not learn how to work with it. Thus, while I acknowledge the potential issue of non-linearity, I can unfortunately not address it.

6. Discussion

The results of the OLS regressions show that there might be some link between the ice extent in the Arctic and the amount of total trade for Norway, as increases in ice extent is associated with a lower amount of trade (table 11 in the appendix). Inversely, this means reductions in ice extent are associated with higher amounts of total international trade. However, it does not necessarily mean that reductions in Arctic ice are associated with increases in international trade due to the possibility of using the Arctic for maritime shipping. For example, our model does not account for changes in parts of the Norwegian economy that are affected by ice extent, like fishing. Fishing, is not included in the measurements of industrial production (Statistisk Sentralbyrå n.d., a) and it is an important part of the Norwegian international trade, with non-filled fish being the third biggest export (Observatory of Economic Complexity n.d.). The reduction in ice sheets could for example be correlated with the seasonal changes in fisheries (Hermansen and Dreyer 2010). This is not to mention other industries, like petroleum extraction in the Arctic (Keil 2014). Additionally, as other climate effects are not controlled for in the model, ice extent itself might capture the effect of other global warming related factors, on trade. Therefore, the changes in ice extent can't be said to exclusively affect Norwegian international trade through the opening of trade routes, nor can we say that there is solid proof that the reduction in the Arctic ice sheet has increased trade for Norway. Nonetheless, having considered the weaknesses of the model, the results do point towards there potentially being an association between reductions in the extent of the Arctic ice sheet and increased Norwegian trade.

The results from the three other linear regression models, based on transit data for the NSR (GRT, ships and navigability) support the theory that there could be other factors than the possibility of using the Arctic for international trade, that makes reductions in Arctic ice have a positive correlation with international trade for Norway. As these three models used measurements of actual shipping in the Arctic, along the NSR, and its effect on Norwegian trade, they should not be exposed to the same problems as ice extent, as they simply measure the effect of shipping, on the NSR, on Norwegian international trade. Thus, comparing the results of these regression to ice extent can give a more wholistic picture of how both ice extent and ship traffic on the NSR, which is highly correlated with ice extent, affects trade for Norway. The three coefficients in the three models (GRT=table 12; ships=table 13; navigability=table 14, all in appendix) are all positive, meaning an increase in any of the three variables (for navigability, if navigable) Norwegian trade is expected to increase, ceteris paribus. However, none of these variables are statistically significant, which might be because there are not enough observations to accurately assess the effect. But this non-significant effect on trade could also potentially be because of variation in traffic on the NSR having such a small effect on Norwegian trade that it is not significant.

Taking this into consideration, in addition to ice extent likely having the effect it has on trade due to also being correlated with other factors influencing trade, the results point towards there being no significant impact of increased shipping in the Arctic, on Norwegian international trade, specifically regarding the NSR.

When comparing these results to the previous literature on the topic, they are consistent with the pervious literature. Authors like Pawelski and Zeng et. al. point out how the NSR currently is not a viable alternative to other shipping routes, due to a variety of factors like high insurance costs, increased fuel usage due to friction with ice, cost of using ice breakers for assistance with navigation, and alternative routes through Suez, and rail, being more attractive (Pawelski 2022; Zeng et al. 2020; Xu and Yin 2021; Farré et al. 2014). Furthermore, the research arguing for its commercial viability focus on the future possibilities of the route (Pawelski 2022; Bekkers, Francois, and Rojas-Romagosa 2018; Liu et al. 2019), thus the lack of significance for NSR traffic's effect on Norwegian trade could be due to the routes simply not being open enough yet, so the results do not exclude that the Arctic could hold future potential for maritime shipping.

There are also several other factors that could have affected the results. As previously mentioned, the NSR saw a drastic fall in traffic in 2014 (Pettersen 2014), which could be linked to the Russian annexation of Crimea disincentivising companies from utilizing the passage. Thus, the usage of the NSR could potentially have seen reduced growth due to the conflict. Similarly, with the current Russo-Ukrainian war and extensive economic sanctions on Russia, the NSR might again see slower growth, or reductions, in traffic. The COVID-19 pandemic is another event that must be taken into account, as the pandemic drastically reduced trade in goods (OECD 2022). Thus, we cannot exclude that these events could have affected the results, with there for example being a larger growth in traffic if these events had not taken place, which could have contributed to more statistically significant results. Especially the NSR variable models could have been sensitive to these events, as the sample size is quite small (120 in the final models; see tables 12-14 in appendix).

However, the results of the ice extent regression (table 11 in the appendix) do point towards lower extents of the Arctic ice sheet having a positive effect on Norwegian international trade. In fact, it points towards there being quite the substantial correlation, as a million km^2 reduction in Arctic ice extent is associated with a 0.5% increase in international trade. Considering the ice sheet has reduced significantly over the past decades (OSI SAF sea-ice team 2020) and is set to shrink even more in the future (Walsh 2013), one could expect a potential increase in trade as well.

While the results of this research do not definitely point towards there being any causal relationship between the melting of Arctic ice (reductions in ice extent) and the international trade of Norway, it does suggest there could be some relationship between the two. Thus, more research on the topic is needed, to clarify the relationship. Additionally, it might be smart for the Norwegian government and businesses operating in the Arctic to look further into how climate change and the melting of the Arctic ice sheet could impact their businesses.

7. Conclusion

This thesis attempted to investigate whether there is a relationship between the melting of Arctic ice and international trade, focusing on Norway, and whether it has had an impact on Norwegian international trade. The literature on the topic points towards the Arctic being a potential alternative option to existing trade routes, like the Suez Canal, and the potential for increased trade for countries in Asia and Europe especially, with Norway being a prime example (Liu et al. 2019). Especially one specific route is emphasised: the Northern Sea Route. However, most of the previous literature is focused on the future possibilities of Arctic trade. Thus, I aimed at investigating whether there has already been any effect on trade, as melting has already been taking place (Walsh 2013), focusing on Norway.

In order to assess this relationship, I employed OLS linear regression analysis, creating 4 different regression models, each with a different independent variable of interest, being Arctic ice extent, amount of GRT transiting the NSR, number of ships transiting the NSR, and the navigability of the NSR. These models also controlled for several other economic factors, to get a more accurate model in assessing the relationship between the 4 different variables and the total trade in goods, of Norway. The robustness of the models was assessed and adjusted accordingly, taking account for things like multicollinearity and heteroskedasticity.

The results point towards reductions in Arctic ice having a positive, significant, correlation with Norwegian international trade, however, it is not possible to say whether this relationship is causal, due to other factors potentially influencing it, like Arctic ice also affecting other economic activities. Furthermore, the results for the models based on the three variables measuring NSR transit traffic were not significant. Thus, based on the results of this study, it is not possible to conclude that there is any definite causal nor correlative link between Norwegian international trade and NSR traffic. However, the results for the model using ice extent are significant, meaning there is a potential causal effect, where reductions in Arctic ice have increased Norwegian international trade.

Nonetheless, this study alone does not provide necessary evidence to guarantee a causal relationship between Norwegian international trade and the melting of the Arctic ice sheet. Thus, more research should be done on the area, using more sophisticated econometric models, like instrumental variable regression, time-series regression, and panel-data models. Furthermore, research on other national context could also help prove potential relationships between trade and the melting of Arctic ice and the possibility of Arctic shipping.

APPENDIX

Table 1

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
totaltrade	424	91886086	59012700	18232016	4.054e+08
iceextent	424	11.433	3.138	4.14	16.13
grt	120	81907.75	157440.92	0	868428
ship	120	3.567	6.082	0	28
navi	120	.483	.502	0	1
industrialproduction	399	90.815	10.456	54.3	114.6
gdp	423	543865.47	302638.15	163053	1537974
tariff	312	3.149	.837	2.33	6.45
exchange	424	115.572	7.293	93.37	132.75
: base april	.	.	.	.	.
april	424	.085	.279	0	1
august	424	.083	.276	0	1
december	424	.083	.276	0	1
february	424	.085	.279	0	1
january	424	.085	.279	0	1
july	424	.083	.276	0	1
june	424	.083	.276	0	1
march	424	.085	.279	0	1
may	424	.083	.276	0	1
november	424	.083	.276	0	1
october	424	.083	.276	0	1
september	424	.083	.276	0	1

Table 2

Linear regression with ice extent

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
iceextent	-.0203168	.011	-1.85	.065	-.042	.001	*
industrialproduct	.012	.001	12.35	0	.01	.014	***
gdpquarterly	2.14e-06	0	46.65	0	0	0	***
tariffrate	-.017	.006	-2.82	.005	-.028	-.005	***
exchange	.007	.001	11.72	0	.006	.008	***
: base april	0	.	.	.	.	.	
august	-.146	.086	-1.70	.09	-.314	.023	*
december	-.117	.029	-4.04	0	-.174	-.06	***
february	-.042	.021	-1.99	.048	-.085	0	**
january	-.109	.022	-4.91	0	-.153	-.065	***
july	-.034	.06	-0.58	.564	-.152	.083	
june	-.012	.037	-0.31	.754	-.085	.062	
march	-.004	.023	-0.19	.85	-.049	.041	
may	-.023	.025	-0.92	.357	-.072	.026	
november	-.164	.05	-3.30	.001	-.261	-.066	***
october	-.198	.076	-2.62	.009	-.347	-.049	***
september	-.104	.095	-1.09	.276	-.29	.083	
Constant	15.442	.221	69.99	0	15.007	15.876	***

Mean dependent var	18.288	SD dependent var	0.394
R-squared	0.967	Number of obs	312
F-test	542.343	Prob > F	0.000
Akaike crit. (AIC)	-728.222	Bayesian crit. (BIC)	-664.591

*** *p<.01*, ** *p<.05*, * *p<.1*

Table 3

Linear regression with GRT

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
grt	4.31e-08	0	0.72	.472	0	0	
industrialproduct	.005	.002	2.88	.005	.002	.009	***
gdpquarterly	1.69e-06	0	12.35	0	0	0	***
tariffrate	.01	.021	0.46	.644	-.032	.051	
exchange	.004	.001	4.73	0	.002	.005	***
: base april	0	.	.	.	.	.	
august	.022	.026	0.87	.384	-.029	.073	
december	-.052	.026	-2.00	.049	-.104	0	**
february	-.031	.024	-1.30	.196	-.078	.016	
january	-.022	.028	-0.80	.426	-.077	.033	
july	.03	.025	1.21	.23	-.02	.08	
june	.031	.024	1.29	.199	-.017	.079	
march	.025	.026	0.97	.337	-.027	.078	
may	.013	.023	0.56	.578	-.033	.06	
november	-.008	.028	-0.29	.769	-.064	.047	
october	-.019	.032	-0.60	.552	-.082	.044	
september	.053	.028	1.89	.061	-.003	.108	*
Constant	16.361	.266	61.44	0	15.832	16.89	***

Mean dependent var	18.652	SD dependent var	0.097
R-squared	0.778	Number of obs	108
F-test	19.885	Prob > F	0.000
Akaike crit. (AIC)	-326.992	Bayesian crit. (BIC)	-281.396

**** p<.01, ** p<.05, * p<.1*

Table 4

Linear regression with ships

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
ships	.0011915	.002	0.75	.457	-.002	.004	
industrialproduct	.005	.002	2.86	.005	.002	.009	***
gdpquarterly	1.69e-06	0	12.36	0	0	0	***
tariffrate	.009	.021	0.44	.663	-.032	.051	
exchange	.004	.001	4.75	0	.002	.005	***
: base april	0	.	.	.	.	.	
august	.019	.028	0.70	.486	-.035	.074	
december	-.052	.026	-1.99	.05	-.104	0	**
february	-.031	.024	-1.30	.197	-.078	.016	
january	-.021	.028	-0.78	.44	-.076	.033	
july	.029	.025	1.13	.263	-.022	.079	
june	.031	.024	1.28	.203	-.017	.079	
march	.026	.026	0.99	.325	-.026	.078	
may	.013	.023	0.55	.58	-.034	.06	
november	-.008	.028	-0.28	.777	-.063	.047	
october	-.02	.032	-0.61	.541	-.083	.044	
september	.047	.032	1.49	.14	-.016	.11	
Constant	16.369	.266	61.58	0	15.841	16.897	***

Mean dependent var	18.652	SD dependent var	0.097
R-squared	0.778	Number of obs	108
F-test	19.895	Prob > F	0.000
Akaike crit. (AIC)	-327.035	Bayesian crit. (BIC)	-281.439

*** *p<.01, *** *p<.05, ** *p<.1*

Table 5

Linear regression with navigability

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
navigability	-.0305014	.025	-1.22	.225	-.08	.019	
industrialproduct	.005	.002	2.68	.009	.001	.008	***
gdpquarterly	1.69e-06	0	12.45	0	0	0	***
tariffrate	.012	.021	0.57	.568	-.029	.053	
exchange	.004	.001	4.81	0	.002	.005	***
: base april	0	.	.	.	.	.	
august	.06	.034	1.77	.08	-.007	.128	*
december	-.04	.028	-1.46	.148	-.095	.015	
february	-.031	.024	-1.29	.199	-.077	.016	
january	-.019	.027	-0.69	.495	-.073	.036	
july	.062	.035	1.78	.078	-.007	.13	*
june	.04	.025	1.58	.117	-.01	.09	
march	.028	.026	1.08	.285	-.024	.08	
may	.013	.023	0.54	.589	-.034	.059	
november	.029	.037	0.76	.447	-.046	.103	
october	.024	.038	0.64	.522	-.051	.099	
september	.091	.035	2.61	.011	.022	.16	**
Constant	16.383	.265	61.92	0	15.858	16.909	***

Mean dependent var	18.652	SD dependent var	0.097
R-squared	0.780	Number of obs	108
F-test	20.157	Prob > F	0.000
Akaike crit. (AIC)	-328.134	Bayesian crit. (BIC)	-282.538

**** p<.01, ** p<.05, * p<.1*

Table 6

Variance inflation factor for ice extent regression

	VIF	1/VIF
iceextent	70.127	.014
industrialproduction	5.597	.179
gdpquarterly	5.612	.178
tariffrate	1.409	.71
exchange	1.031	.97
August	32.397	.031
December	3.705	.27
February	2.028	.493
January	2.182	.458
July	15.723	.064
June	6.184	.162
March	2.328	.429
May	2.764	.362
November	10.889	.092
October	25.316	.04
September	39.938	.025
Mean VIF	14.202	.

Table 7

Variance inflation factor for GRT regression

	VIF	1/VIF
grt	2.308	.433
industrialproduction	3.883	.258
gdpquarterly	3.097	.323
tariffrate	2.558	.391
exchange	1.95	.513
August	2.214	.452
December	2.29	.437
February	1.888	.53
January	2.553	.392
July	2.119	.472
June	1.962	.51
March	2.316	.432
May	1.843	.542
November	2.621	.382
October	3.373	.297
September	2.602	.384
Mean VIF	2.473	.

Table 8

Variance inflation factor for ships regression

	VIF	1/VIF
ships	3.17	.315
industrialproduction	3.804	.263
gdpquarterly	3.095	.323
tariffrate	2.562	.39
exchange	1.945	.514
August	2.543	.393
December	2.287	.437
February	1.888	.53
January	2.542	.393
July	2.173	.46
June	1.959	.51
March	2.308	.433
May	1.843	.543
November	2.589	.386
October	3.407	.294
September	3.358	.298
Mean VIF	2.592	.

Table 9

Variance inflation factor for navigability regression

	VIF	1/VIF
navigability	6.896	.145
industrialproduction	3.807	.263
gdpquarterly	3.092	.323
tariffrate	2.575	.388
exchange	1.942	.515
August	3.95	.253
December	2.569	.389
February	1.888	.53
January	2.543	.393
July	4.072	.246
June	2.16	.463
March	2.309	.433
May	1.843	.543
November	4.749	.211
October	4.846	.206
September	4.101	.244
Mean VIF	3.334	.

Table 10

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) iceextent	1.000							
(2) grt	-0.651	1.000						
(3) ships	-0.755	0.950	1.000					
(4) navigability	-0.841	0.540	0.609	1.000				
(5) industrialprod~n	0.169	-0.023	-0.097	-0.167	1.000			
(6) gdpquarterly	-0.150	0.344	0.206	0.128	-0.216	1.000		
(7) exchange	0.048	-0.050	-0.025	-0.023	0.029	-0.396	1.000	
(8) tariffrate	0.019	-0.017	0.022	0.044	-0.080	-0.214	-0.067	1.000

Table 11

Linear regression

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
iceextent	-.0049378	.001	-3.41	.001	-.008	-.002	***
industrialproduct	.007	.001	9.20	0	.005	.008	***
gdpquarterly	1.96e-06	3.47e-08	56.52	0	1.89e-06	2.03e-06	***
exchange	.007	.001	10.02	0	.006	.008	***
tariffrate	-.033	.005	-6.40	0	-.043	-.023	***
Constant	15.879	.126	125.89	0	15.631	16.127	***

Mean dependent var	18.288	SD dependent var	0.394
R-squared	0.958	Number of obs	312
F-test	1779.769	Prob > F	0.000
Akaike crit. (AIC)	-671.130	Bayesian crit. (BIC)	-648.672

*** *p<.01*, ** *p<.05*, * *p<.1*

Table 12

Linear regression

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
grt	4.99e-08	5.32e-08	0.94	.35	-5.56e-08	1.55e-07	
industrialproduct	.007	.002	4.55	0	.004	.01	***
gdpquarterly	1.73e-06	9.89e-08	17.49	0	1.53e-06	1.93e-06	***
exchange	.004	.001	5.79	0	.003	.006	***
: April	0	.	.	.	.	.	
August	.033	.028	1.19	.237	-.022	.089	
December	-.041	.027	-1.52	.131	-.093	.012	
February	-.033	.023	-1.43	.155	-.078	.013	
January	-.039	.026	-1.50	.136	-.09	.012	
July	.043	.026	1.63	.106	-.009	.096	
June	.049	.028	1.76	.081	-.006	.105	*
March	.025	.026	0.95	.346	-.027	.076	
May	.022	.029	0.78	.435	-.034	.079	
November	-.021	.032	-0.67	.501	-.084	.042	
October	-.039	.03	-1.28	.203	-.099	.021	
September	.073	.028	2.57	.012	.017	.129	**
Constant	16.168	.223	72.63	0	15.727	16.609	***

Mean dependent var	18.693	SD dependent var	0.172
R-squared	0.919	Number of obs	120
F-test	36.502	Prob > F	0.000
Akaike crit. (AIC)	-351.662	Bayesian crit. (BIC)	-307.063

*** *p<.01*, ** *p<.05*, * *p<.1*

Table 13

Linear regression

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
ships	.001	.001	0.97	.336	-.001	.004	
industrialproduct	.007	.002	4.51	0	.004	.01	***
gdpquarterly	1.74e-06	9.13e-08	19.05	0	1.56e-06	1.92e-06	***
exchange	.004	.001	6.04	0	.003	.006	***
: April	0	.	.	.	.	.	
August	.03	.029	1.05	.296	-.027	.088	
December	-.041	.027	-1.54	.126	-.095	.012	
February	-.033	.023	-1.44	.153	-.078	.012	
January	-.039	.026	-1.50	.135	-.091	.012	
July	.042	.027	1.58	.118	-.011	.095	
June	.049	.028	1.76	.081	-.006	.105	*
March	.025	.026	0.94	.348	-.027	.076	
May	.022	.029	0.78	.434	-.034	.079	
November	-.022	.032	-0.67	.504	-.086	.043	
October	-.04	.031	-1.30	.197	-.102	.021	
September	.068	.031	2.20	.03	.007	.13	**
Constant	16.156	.215	75.04	0	15.729	16.583	***

Mean dependent var	18.693	SD dependent var	0.172
R-squared	0.919	Number of obs	120
F-test	37.048	Prob > F	0.000
Akaike crit. (AIC)	-351.477	Bayesian crit. (BIC)	-306.877

**** p<.01, ** p<.05, * p<.1*

Table 14

Linear regression

log_trade	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
navigability	.003	.027	0.10	.918	-.051	.056	
industrialproduct	.007	.002	4.44	0	.004	.01	***
gdpquarterly	1.76e-06	8.47e-08	20.78	0	1.59e-06	1.93e-06	***
exchange	.004	.001	6.44	0	.003	.006	***
: April	0	.	.	.	.	.	
August	.041	.037	1.11	.271	-.033	.116	
December	-.044	.026	-1.70	.091	-.096	.007	*
February	-.033	.023	-1.45	.149	-.079	.012	
January	-.04	.026	-1.54	.127	-.092	.012	
July	.045	.038	1.19	.235	-.03	.12	
June	.049	.03	1.60	.113	-.012	.109	
March	.024	.026	0.90	.371	-.028	.075	
May	.023	.029	0.79	.431	-.034	.079	
November	-.021	.042	-0.50	.615	-.106	.063	
October	-.031	.04	-0.77	.442	-.109	.048	
September	.085	.039	2.20	.03	.008	.162	**
Constant	16.115	.213	75.78	0	15.693	16.537	***

Mean dependent var	18.693	SD dependent var	0.172
R-squared	0.918	Number of obs	120
F-test	39.622	Prob > F	0.000
Akaike crit. (AIC)	-350.514	Bayesian crit. (BIC)	-305.915

**** p<.01, ** p<.05, * p<.1*

Table 15

Variance inflation factor, 2nd ice extent regression

	VIF	1/VIF
industrialproduction	2.319	.431
gdpquarterly	2.315	.432
tariffrate	1.192	.839
iceextent	1.089	.919
exchange	1.026	.974
Mean VIF	1.588	.

Table 16

Variance inflation factor, 2nd GRT regression

	VIF	1/VIF
grt	2.627	.381
industrialproduction	2.955	.338
gdpquarterly	1.933	.517
exchange	1.393	.718
August	2.22	.45
December	2.071	.483
February	1.848	.541
January	2.313	.432
July	2.094	.478
June	1.925	.519
March	2.156	.464
May	1.845	.542
November	2.157	.464
October	2.572	.389
September	2.717	.368
Mean VIF	2.188	.

Table 17

Variance inflation factor, 2nd ships regression

	VIF	1/VIF
ships	3.499	.286
industrialproduction	2.961	.338
gdpquarterly	1.723	.581
exchange	1.373	.728
August	2.586	.387
December	2.061	.485
February	1.847	.541
January	2.314	.432
July	2.154	.464
June	1.925	.519
March	2.156	.464
May	1.845	.542
November	2.168	.461
October	2.792	.358
September	3.509	.285
Mean VIF	2.327	.

Table 18

Variance inflation factor, 2nd navigability regression

	VIF	1/VIF
navigability	6.42	.156
industrialproduction	2.937	.341
gdpquarterly	1.516	.66
exchange	1.346	.743
August	3.817	.262
December	2.332	.429
February	1.846	.542
January	2.307	.433
July	3.988	.251
June	2.24	.446
March	2.152	.465
May	1.845	.542
November	3.997	.25
October	4.047	.247
September	3.951	.253
Mean VIF	2.983	.

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