EXCESSIVE SEA PORT TARIFFS, PORT EFFICIENCY AND UKRAINIAN TRADE

by

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Abstract

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Sea-port tariffs are extremely high in Ukraine compared to other Black Sea ports and, generally speaking, elsewhere in the world. This research analyzes the effect of the excessive Ukrainian sea-port tariff rates on port efficiency and Ukrainian sea-borne trade using a two-stage approach. First of all, it estimates port efficiency scores by the using stochastic frontier approach. In the second stage, a fixed effect panel data model is used to estimate the effect of port tariffs on sea-borne trade and port efficiency. Furthermore, this research creates a rating of Ukrainian sea ports using their efficiency scores. The research is based on the panel of performance indicator of all 18 Ukrainian ports for 2006-2018. Empirical results demonstrate a significant negative effect of port tariffs on ports' efficiency when a 1% increase in tariffs will reduce efficiency by 1.1%. Port tariffs also have a negative effect on the sea-borne trade, especially on the exports of dry bulk and general cargo with -1.04 elasticities on average. The estimated efficiency scores clearly have positive effects on Ukrainian cargo handlings. All these results imply that Ukrainian policy makers should review sea-port tariff rates and redirect future money flows on the improvement of sea ports' technical characteristics.

TABLE OF CONTENTS

LIST OF FIGURES

Number *Page*

LIST OF TABLES

Number *Page*

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GLOSSARY

DEA – Data Envelope Analysis

IFC – International Finance Corporation. It is a sister organization of the World Bank and the largest global development institution focused on the private sector in developing countries. It was established in 1956 among 184 counties.

IMF – International Monetary Fund. It is an organization of 189 counties, created in 1945 and works for worldwide cooperation, financial stability and economic growth

KSE - Kyiv School of Economics

LPI – Logistics Performance Index. It means index created by the World Bank that makes comparison of performance of trade logistics among 160 countries

OECD – Organization for Economic Co-operation and Development. It was established in 1961 among 36 countries for improvement of economic growth and international trade

OLS – Ordinary Least Squares. It is the method to find unknown coefficients within a linear regression model through minimization of sum of squared errors of the estimate

OPEX – Operating expenditure. Such expenses are tracked in income statement and are necessary and unavoidable in business.

REER – Real effective exchange rate. According to IMF, it is a measure of country's currency in relation to weighted average of basket of foreign currencies divided by the price deflator.

UNSTAD – The United Nations Conference on Trade and Development. It is intergovernmental organization established in 1964 that manage global cooperation, maximize international trade and development

USPA – Ukrainian Sea Port Administration. It is a Ukrainian organization established in 2013 that is a part of the Ministry of Infrastructure. Its main functions are to manage the work of all Ukrainian Ports, develop them and increase their competitiveness

WEF – World Economic Forum. It is an international organization created in 1971 as an independent institution for public-private cooperation

Chapter 1

INTRODUCTION

Port tariffs are extremely high in Ukraine compared to other Black Sea ports (4 times larger) and, generally speaking, elsewhere in the world. They are twice or even three time as much as world tariffs, which lead to higher pressure on consumers through the high final prices and on producers through the reduced producer prices and revenues (IFC, 2016).

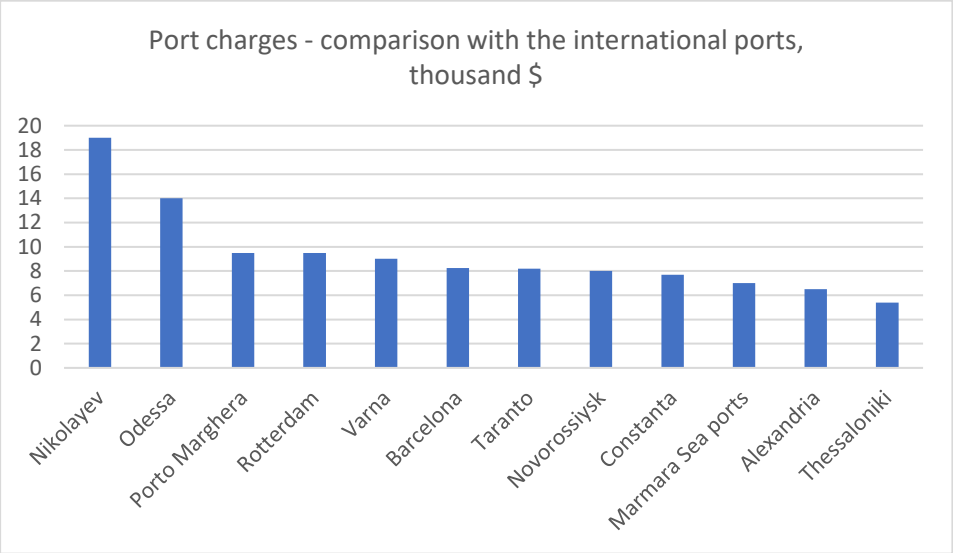

Figure 1. Comparison of Ukrainian port tariff rates with international tariffs, in thousands of USD[1]

In Ukraine there are 7 port tariff rates, which are established and regulated by the Ukrainian government, namely by USPA (Ukrainian Sea Port Administration) and by the Ministry of Infrastructure - administrative, channel, ship, lighthouse, sanitary, mooring and anchor tariffs. They exist to pay for the

[1] Source: *World Bank (2015)*

use of port infrastructure. Payments from lighthouse tariffs are directed to the public company "State Hydrography" (ukr. Держгідрографія)[2], from administrative tariffs to the budget, and from the six others to the USPA. Over 70% of Ukrainian Sea Port Administration total profits are generated in the state budget as dividends or taxes "for the further development and maintenance of the sea's water infrastructure." However, these functions are not adequately performed in our country as there is no sufficient control over spending and regulation of the targeted use of funds received.

High fees also affect competitiveness of Ukrainian ports, exporters and producers through increased transportation costs and effect incomes of both consumers and producers. High export costs mean low revenues and profits for producers and exporters. High logistics costs also mean high consumer prices.

In 2008, the government of Ukraine increased the port tariffs by 58%.[3] Initially, the government pursued a goal of getting tariffs paid in Euros and since that was not possible as the common practice is charging the tariffs in USD, the government made a trick when all port tariff rates were multiplied by the USD/EUR exchange rate which was equal to 1,58 in 2008. In 2018, the Government, nevertheless, under the pressure of the business community and international donors, decreased port tariff rates by 20%. Nevertheless, there is a substantial scope of further reduction.[4]

So, the situation which took place in 2008 as the sum of increased port tariff rates and "The Great Recession" had a huge influence on Ukrainian cargo flow. At the same time, high tariff rates provoked a high increase of inefficiency of Ukrainian ports.

[2] http://hydro.gov.ua/
[3] https://zakon.rada.gov.ua/laws/show/z0930-13
[4] https://voxukraine.org/en/how-reducing-sea-port-tariffs-in-ukraine-can-contribute-to-economic-growth/

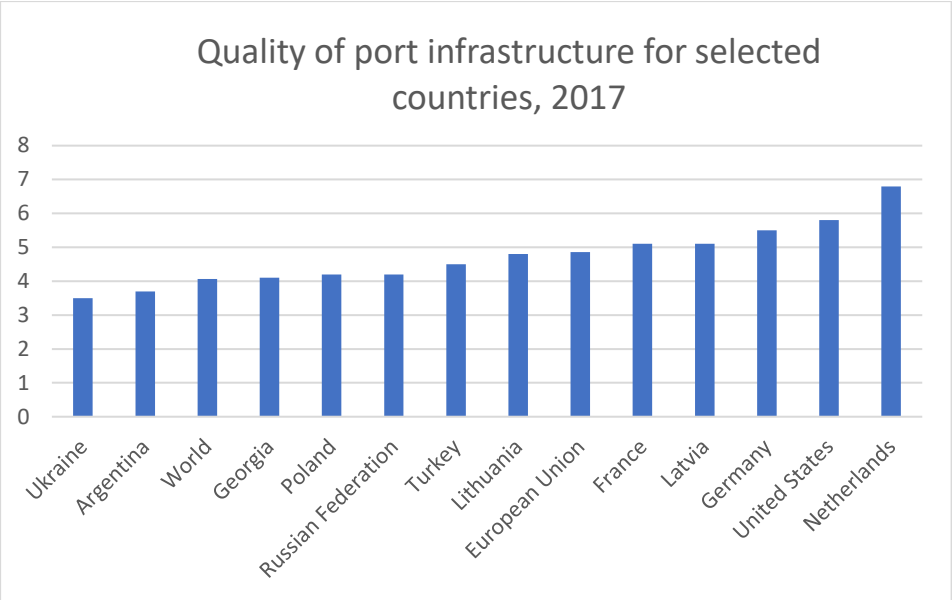

Figure 2. Comparison of quality in Ukrainian with international ports, 2007[5]

Measured by the World Economic Forum survey, Ukrainian ports are now below average by the quality of their infrastructure.[6] According to the World Bank 2018 Logistics Performance Index (LPI), Ukraine is 66th among 160 countries, down from 61st place in 2014. Diversity of port quality within Ukraine makes research of Ukrainian port efficiency highly demanded. An opportunity to see all pros and cons in the ports is good for further governmental regulation of the industry. To change the current situation of Ukrainian trade for the better there are two possible ways: through decreased port tariff rates (it will supposedly lead to higher port traffic and cargo flows) and/or through improvement in port efficiency. Research on this topic can help Ukrainian policy makers to understand better the determinants of maritime trade behavior for subsequent more profound redistribution of money and innovations implementation for increasing the efficiency level of sea infrastructure.

[5] Source: *World Economic Forum*

[6] https://mtu.gov.ua/files/foto_to_news/Ukraine_Logistics_Strategy_WB_Kyiv_17_11_2017_GI_LO.pdf

The main findings of this master's thesis are the negative and significant effects of the port tariff rates on the efficiency and both significantly positive effect of efficiency and negative effect of tariff rates on the total export and transit (which compose 81% of total port cargo handling), especially of dry bulk and general cargo. The majority of total cargo in 2018 was handled by Mykolaiv, Odessa, Yuznyi and Chornomorsk ports. And these ports according to our efficiency estimation showed the highest results. Nevertheless, we found that all Ukrainian ports suffer from inefficiency and can be more productive.

In this thesis we deal with the unique Ukrainian port-level dataset for 2006-2018. The data were collected from various annual statistical records and processed by the author. It contains the information from ports' financial statements and operational data on cargo turnover, macroeconomical indicators, world price indexes, etc. To the best knowledge of available current empirical studies, tariff data was not used yet for maritime economic impact studies as it is hard to collect it due to many variations of tariff rate types (Wang, Chang and Cui, 2016). Our dataset is in some sense unique including tariff data of the Ukrainian ports.

The structure of this master's thesis is the following: Chapter 2 describes the main port studies on relation between efficiency and port tariff rates and their effect on the maritime trade; Chapter 3 provides the methodology of the research; Chapter 4 contains data sources and main limitations related with data; the main empirical results can be found in Chapter 5; Chapter 6 summarizes all findings of the paper, contains ideas for policy implications and further research.

Chapter 2

LITERATURE OVERVIEW

Progress in logistics and strategic management increases the demand for an in depth research and analysis of port economics. All port studies in the past 20 years paid their attention mostly to such fields that are interrelated with each other: ports in transport and supply chain, port governance, planning and development, regulation, competition, etc. (Pallis et al, 2011).

Maritime trade liberalization is a trend of the last 30 years and has high impact on economic growth. Open countries with low trade barriers perform higher income growth in comparison with more closed countries (Bernard, Jensen and Schott, 2006). With a decrease of trade costs, more efficient firms expand their opportunities and increase their level of trade and, consequently, their income. It also boosts industrial productivity (Melitz, 2003; Bernard et al, 2003). Productive firms within the country that were non-exporters before will increase their production and expand the trade boundaries outside the country. There are always not only winners but also losers. In this case, losers are non-effective and non-productive firms that will suffer from trade liberalization due to the drop in their competitiveness.

The world annual income will increase by 3% due to the "full liberalization" of trade between countries. It is equal to $151 billion (Francois, 2005). Every 1% decrease in the costs of port services is expected to increase global GDP by 7 billion USD that is equal to 0.02% of annual result (research of developing countries in 1997) (UNSTAD, 2001).

Analysis of empirical studies shows the two possible effects of increasing port tariff barriers: price and efficiency. The first one increases the price of trade in goods and services and consequently drops the level of trade and has a negative effect on domestic production. Efficiency effect means ineffective allocation of resources within the country which can lead to a drop of foreign direct

investments due to higher costs and risks of conducting business. These two effects are negative for the economy as they generate deadweight losses (Melitz, 2003; Engman, 2005; Sachish, 1996).

2.1. Relationship between trade and trade/transaction costs

Transport costs are a widely researched question as they are barriers to trade and influence profits of businesses. The drop in trade costs leads to an increase in industrial productivity as it provokes higher income for mostly productive firms. It also expands the domestic sales market due to increased opportunities for importing resources and producing and exporting value added products which lead to higher GDP (Melitz, 2003). On the other hand, some studies conclude that higher openness will decrease domestic sales as more firms will move from selling within the country to exporting their goods and services (Bernard, 2003; Melitz, 2003). Nevertheless, there is no incentive to deviate for such domestic producers, until no foreign producer has lower costs of production or firm becomes the most efficient one on the market.

Deep analysis and improvement of trade border procedures, which include port charges, will have a highly significant effect on new trade and investment opportunities among the countries (Engman, 2005). Lack of transparency and information on customs laws, complicated documentation requirements, inefficient port infrastructure, and high port charges produce high losses in the form of trade costs.

The main problem in measuring an impact of trade costs on cargo flow is the lack of full information about the components of the trade costs. So, a new method of estimating such an impact was implemented by dividing it into several categories: natural transport costs, "behind the border" costs (includinginefficiencies in infrastructure within the country), "explicit beyond the border" costs (control of tariffs and exchange rates) and "implicit beyond

the border" costs (inefficiencies in infrastructure outside the country) (Kalirajan, 2007).

The following factors influence change in cargo flow: change in demand, change in size and income per capita of trading countries, change in tariff rates and exchange rates and through domestic reforms in the trade policy and infrastructure, regulations and restrictions. Empirical research in Pakistan shows that the increase in export was due to the decrease of custom payments and inefficiencies of the infrastructure outside the country (Khan, 2011). An increase in trade costs by 10% will lead to a decrease in the volumes of trade by 20% (Limao and Venables, 2001). Nowadays, there is a lack of literature on this topic and no optimal analysis of full trade costs impact on cargo flow as trade costs consist of many points such as freight rates, tariff rates, import/export taxes, etc. and there is lack of statistical information for conducting such an analysis.

Port tariffs are the prices of services which are provided in the ports like vessel service, cargo service, transportation, warehousing, security, banking, and insurance service, etc. Nowadays there are few research paper studies of an economic reaction of increased port tariffs on the cargo flow within physical export/import and transit through the country. For the most part, they study the determinants of demand on maritime trade taking into account different parts of trade costs and analyzing their impact on the maritime cargo handling using mainly demand models for it (Barros, 2016; Coto-Millan et al, 2013; Coto-Millan et al, 2004).

To make an analysis of results of certain changes in economic activity, the researchers use mainly economic impact analysis (EIA). Currently, there are three methods of estimation: I/O (industrial organizational), computable general equilibrium (CGE) and gravity model (Bichou, 2006; Fannin, 2008; Chang, 2014; Pagano, 2016; Tiwari and Itoh, 2001; Dwyer, 2004). The first method is used, in general, in regional studies, but as it has a static production function, it is ineffective in making any conclusions about effects on the

economy by the changes in prices, supply/demand or some unpredictable events. The CGE model is the best tool for estimating intersectoral relationships. It shows how the economy reacts to changes in policy, technology, price or any other factors. The main disadvantage of this model is parameter uncertainty, high costs and structural complexity.

Maritime transport costs are a very significant factor in trade of agricultural products, especially in Ukraine, as they form 10-30% of value of such products. If the transfer costs will double, it will lead to a drop in agroproduction trade by 42%. As in Ukraine, agroproduction makes more than 10% of annual GDP, therefore it is huge economic losses. Increase of transport costs on any goods and services produced by two times will lead to drop in trade of them on average by 18% (Korinek and Sourdin, 2009).

2.2. Relationship between trade and port efficiency

In 75 analyzed countries, the increase in the port efficiency level within the country to the global average will increase trade flows by $107 billion. It is mostly beneficial in developing countries: Russia – by 30% of port cargo handling, Indonesia – 22% (Wilson, 2004). Custom modernization programs like improvement of port efficiencies and decrease of port charges were implemented in Angola, Bangladesh, Bolivia, Bulgaria, Ghana, Morocco, etc. From such analysis, Morocco can be a good example for Ukraine with their reforms in 1996, which provoked custom services improvement and lead to 48% increase in import during next five years.

Analysis of port efficiency and productivity as the role of port infrastructure through the time become more and more demanded. The first studies on port efficiency are new as they were published in 1990th. Technological progress nowadays is huge, thus port industry experience organizational and managerial improvement. This is a significant driver for efficiency. There are three methods to measure efficiency used in studies on the port efficiency: partial

productivity indicators (Suykens, 1983; Talley, 1994; Tongzon, 1995; Kim and Sachish, 1986), engineering approach with simulations and queueing theory (Sachish, 1996), and technological efficiency frontier analysis with estimation of efficiency indexes (Chang, 1978; Estache, 2002; Cullinan, 2002; Wang, 2005).

The performance of any firm has improvement through the increase in productivity/efficiency. Here, frontier analysis is the best tool for estimation of efficiency and making conclusions about the most appropriate policy regulations (Bauer, 1990). The port efficiency frontier is created to show the most efficient ports within the country (they are placed on the frontier) and the least ones (they are located below the frontier). Productivity of the port industry can be by technological progress (new handling equipment), or by increasing efficiency in the industry (higher worker qualifications in tasks with such equipment).

According to the empirical evidence, port privatization has also a positive impact on technical efficiency. Thus, public authorities should only regulate the market and increase private investments (Tongzon and Hang, 2005; Cullinane, 2006 – in Singapore; Cullinane and Song, 2003 – in South Korea). Some economists conclude that port size also has a positive effect on port efficiency due to higher trade activity (Tongson and Hang, 2005; Wang and Cullinane, 2006), while others show a insignificant impact of port area as there can be problem of the overcapitalization due to an increase in port activity (Notteboom, 2000; Cullinane, 2004; Liu, 1995).

Deregulation is also statistically significant and positive in relationship with efficiency level as private ports improve data gathering, increase technical characteristics attracting more private investments (Cullinane, 2002). So, there should be high investments in equipment and infrastructure to increase traffic (Gonzalez and Trujillo, 2009). Mainly, efficiency analysis is made on the ports within one country, and scientists don't compare them with the foreign ports to make the conclusions about the port infrastructure improvement in the country.

Improvement in port efficiency from the 25th to 75th percentile will lead to a reduction in shipping costs by 12% (Frink, 2002). When shipping costs double, it will lead to a 0,5% decrease in annual worldwide economic growth (Radalet and Sachs, 1998). Economists also conclude that governmental regulation is shown to increase port efficiency, but an excess of it will reverse all benefits (Clark, Dollar and Micco, 2004).

For estimation of port efficiency, such variables are often used: infrastructure quality (which has always a positive impact), port services, weight value, containerization, policy variables, traffic volume, transfer of cargo, max and min water depth at port terminals, the handling facilities, time a vessel needs to stay in a port (Slack, 1985; Tongzon, 1995; Itoh, 2002; Cullinane and Wang, 2006; Nordas, 2006; Alvarez, 2012; Wu and Goh, 2014; Ducruct, Itoh and Merk, 2014). Some part of such metrics is unavailable in Ukraine due to the lack of statistical data and inefficient regulation of port data gathering process. So, it can appear as a problem in this research paper.

Chapter 3

METHODOLOGY

In the analysis of the impact of excessive sea port tariffs and port efficiency on Ukrainian trade, we follow a two-stage approach. In the first stage we will employ a frontier analysis to estimate port efficiency scores. In the second stage we will explore how port tariffs and port efficiency affect Ukrainian sea-borne trade flows.

3.1. First stage estimation

For economic theory and optimal policymaking, efficiency is quite an important issue. Basically, when economists talk about efficiency, they have in mind both technical and allocative efficiency estimation. Here our emphasis will be on the technical efficiency as it can measure the progress of a port in producing the maximum output with a given set of inputs. Thus, the purpose of the first stage is to analyze the technical efficiency of Ukrainian ports by using parametric or non-parametric techniques.

Efficient production is basically defined by the frontier function. Efficiency frontier analysis can be parametric and non-parametric. First one means stochastic frontier tools and the most important advantage is that it differentiates noise effects from inefficiency, but it usually makes bad functional specification of inefficiency (Schmidt, 1985-86; Forsund, 1980; Bauer, 1990; Battese, 1992; Coelli, 1995-1998). Non-parametric analysis can be made with linear programming tools like DEA and alpha-score and it does not require any functional form on the data, but on the other hand, the main hypothesis cannot be statistically tested (Banker, 1989; Seiford and Throll, 1990; Lovell, 1993; Ali and Seiford, 1993; Coelli, 1998; Cooper, 2000). Therefore, there is no one optimal method of estimating the efficiency frontier.

Table 1. Comparison of efficiency measurement approaches

Method	Advantages	Disadvantages	Authors and year
Parametric - Stochastic frontier analysis - OLS - Distribution-Free Approach	Can be used for panel data Distinguish random noise from inefficiency Calculates the standard error of efficiency scores Allows to test the hypothesis of goodness of fit	Require a specific functional form Causes specification and estimation problems Have many restrictive assumptions	Bauer, 1990 Battese, 1992 Lovell, 1993 Notteboom, 2000 Cullinane et.al., 2003 Kuosmanen, 2007
Non-parametric - Data Envelope Analysis - Alpha-score - Free Disposable Hull	Easy to estimate The data can be measured not only quantitatively but also qualitatively Do not have so many restrictive assumptions as in parametric approach Do not require specific functional form for the production function	Do not have a solid statistical foundation Is sensitive to outliers Do not assume any functional form for the frontier Is non-stochastic, so based on the assumption of no noise (i.e., vi =0 for all firms i) - any deviation from the frontier is attributed to inefficiency	Cullinane et al, 2006 Tovar et al, 2007 Wang et.al., 2005 Notteboom, 2000 Coelli, 1995 Cooper, 2004 Itoh, 2002

Table 1 shows the main advantages and disadvantages of using parametric and non-parametric methods. It is made substantially on the basis of research paper by Asmare and Begashaw, 2018.

In the case of non-parametric frontier analysis, DEA as linear programming tool could be used. However, as it suffers from the curse of the dimensionality (our data has only 209 observations which includes only 18 ports within 2006-2018 years), usage of this method would show biased estimates of port efficiency scores with such low number of observations and high dimensionality of the model.

To deal with all mentioned problems we could use the alpha-score approach as a non-parametric tool. Alpha-score generalizes Free Disposable Hull (FDH) method for the efficiency estimation but in different way. FDH relaxes convexity assumption of the DEA approach, so it is the so-called an updated and nowadays partial frontier is a new update for all previous methods.

Alpha-score does not use peers as a benchmark as it uses (100-alpha)th percentile and when it is less than 100, some of the ports will be superefficient and will not be enveloped by the partial production efficiency frontier. It is the fastest method among other non-parametric methods as it doesn't involve a resampling before the estimations of the efficiency scores. It is used for avoiding potential outliers in data and it also identifies discontinuities in the resulting curve. Such points are the outliers that are classified as superefficient at the particular alpha-score (Aragon et al., 2005; Daraio and Simar, 2007).

In the case of parametric frontier analysis, after taking into account all advantages and disadvantages, the stochastic frontier approach appears to be the best approach, especially in our case we are able to use its specification to model efficiency effects stochastic frontier. It has slightly more functional assumptions but allows to assume a stochastic relationship that means the deviations from the frontier may reflect not only inefficiencies but also noise in the data. The idea behind this method is that technical efficiency may vary

among the ports, depending possibly on some special inputs. Given certain inputs, efficient ports may realize the full potential of them and obtain the maximum possible output.

In many empirical studies, the output quantity does not only depend on the inputs characteristics, but it can also be affected by the additional explanatory variables like port tariff rates in our case. As this factor can influence the trade through the ports, we include it into the analysis of efficiency in order to avoid omitted variables bias. Such a factor is included in the form of a z-variable that affects the output for given inputs, which mean that it influences the whole frontier.

Efficiency function has specific functional form especially for the panel data:

$$y_{it} = f(x_{it}, z_{it}) * TE_{it} \quad (1)$$

The base model after a log transformation will have the following form:

$$\ln y_{it} = \alpha + \sum_i \alpha_i \ln x_{it} + \alpha_z z_{it} + v_{it} - u_{it}; \text{where } u_{it} > 0 \quad (2)$$

where y is the total cargo handling though the ports which represents the output of the port; x is the vector of inputs (technical characteristics of each port); z is the vector of additional parameters that affect output for given inputs; v is a zero-mean random error; u is the technical inefficiency parameter. Here the efficiency scores and the coefficient before the z variable are of main interest.

The stochastic frontier models use both the inefficiency term u with the error term v. The last one satisfies the stochastic nature of the function and possible measurement errors of inputs and output. Main assumptions of our model are:

1. The efficiency term and stochastic error are independent

2. When the inefficiency is equal to zero it means that the port is perfectly efficient, and ports have some inefficiency when it is positive
3. $v_i \sim N(0, \sigma^2)$ - It means that the stochastic error term is normally distributed
4. $u_i \sim N^+(\mu, \sigma_u^2)$ - It means the inefficiency term has half-normal distribution when the point of truncation is 0 and means non-negative values of u
5. The parameters of the stochastic frontier model in the panel data are calculated by the fixed-effect panel estimators
6. The variance parameter lies on the interval [0, 1]

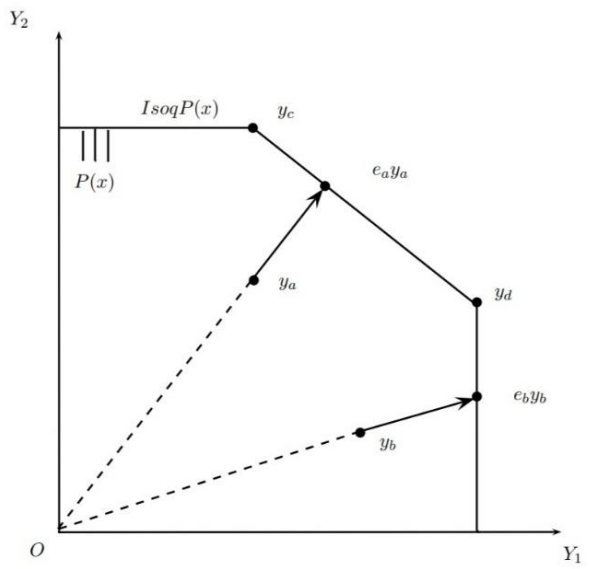

Figure 3. Representation of output-oriented efficiency measure

As we calculate technical efficiencies and they are output-oriented, Figure 3 represents the isoquant with the most efficient and ideal input combinations for producing maximum output. Input combinations, which lie on the isoquant shows the most efficient ports in the country and those below it - inefficient

ones. In the figure we can observe only two inputs – Ya and Yb, but the stochastic frontier measurement is also a good choice in the situation when we have several inputs and all of them are quite important for understanding the efficiency of the ports.

There are various variables that researchers use as input and output variables. Based on researches by Tovar et al, 2007; Tongzon et al, 2005; Cullinane et al, 2006; Notteboom, 2000; Wang et.al., 2005 Cullinane et.al., 2003, the most common output variables in studies on port efficiency using parametric and non-parametric approaches are: tons of total cargo handling, tons of containerized general cargo, tons of non-containerized general cargo, tons of liquid cargo, tons of dry bulk, throughput (1000 TEU) (output), number of passengers.

The most common input variables used for analyzing technical efficiency scores are:

1. Labor price (Sum of payroll/number of workers), Capital price (sum of all fixed assets)
2. Terminal area (ha), Quayside gantry cranes (number), Straddle carrier (number), Number of berths, Total berth length (m), Portland area (m2), Number of quay cranes, Total number of yard equipment, Port Capacity, Storage area (m2), Length of docks (m)
3. Operational and capital expenditure, total operating expenditure

In our research, total cargo handling in thousands of tons will be the output variable which consists of four parts: export, import, transit and cabotage. As for port inputs we can use such vectors as number of berths in each port, maximum depth of berths, overall length of berths coast and total area of port. These variables can rarely vary over time (as some ports like Yuznyi did dredging). After estimating the results, by using efficiency effects stochastic frontier model we can also observe the effect of tariff rates increase on the port efficiency.

3.2. Second stage estimation

Increasing port tariff rates by 58% on average in 2008 and decreasing by 20% in 2018 were the shocks determined exogenously by the Ukrainian Government and the research question in this case is to analyze the impact of such shock on the cargo flow.

As we use panel data that has both cross-sectional data of 18 Ukrainian ports and time-series dimension from 2006 to 2018 for the estimation of own-price elasticity on the transport service demand, we decided to use fixed effects model as the method for the estimation of port tariff increase to remove initially the problem of the unobserved heterogeneity. Our models finally have such specification:

$$Log(Export_{it}) = \beta_0 + \beta_1 port\ tariff\ rates + \beta_2 efficiency\ scores + \beta_3 gdp_{world} + \beta_4 \log(real\ effective\ exchange\ rate) + \beta_{it} \log(real\ prices\ indexes) + a_i + u_i \quad (3)$$

$$Log(Import_{it}) = \beta_0 + \beta_1 port\ tariff\ rates + \beta_2 efficiency\ scores + \beta_3 \log(gdp_{Ukraine}) + + \beta_4 \log(real\ effective\ exchange\ rate) + \beta_{it} \log(real\ prices\ indexes) + a_i + u_i \quad (4)$$

$$Log(Transit_{it}) = \beta_0 + \beta_1 port\ tariff\ rates + \beta_2 efficiency\ scores + \beta_3 \log(gdp_{Ukraine}) + \beta_4\ gdp_{world} + + \beta_5 \log(real\ effective\ exchange\ rate) + \beta_{it} \log(real\ prices\ indexes) + a_i + u_i \quad (5)$$

The models include only variables in log form except for dummies (for example, for regions) to equalize all variables. The logarithm of the original data can be used to estimate elasticities with a better economic interpretation. To be more precise we want to observe the effect of increased port tariff rates and efficiency on import, export and transit separately by the 3 main types of goods traded, so we would use them as dependent variables and regress on the identical independent variables. The variable a_i includes all unobserved time-invariant constant factors, which affects dependent variable y_{it}. This unobserved factor can also be correlated with the independent variables. In our case freight rates could be one of such fixed factors that are publicly unavailable as they are established by the private companies. In our model we want to measure not only the effect of increased port tariff rates, but the effect of port efficiency on the cargo flow.

The main assumptions we made:

1. Each explanatory variable change over time and there is no perfect linear relationships among the independent variables.
2. The error term has expected value equal to zero with given the explanatory variables. $E(u_{it}|X_{i1,}X_{i2}, \dots, X_{iT}) = 0$
3. There is no serial correlation of idiosyncratic errors. BUT: Serial correlation tests apply to macro panels with long time series and is not a problem in micro panels with small number of years.

From these, the fixed effects model is the best one for getting linear unbiased estimators. This method is good for the data which falls into the categories such as port industry in our case. The main advantage is that it eliminates the problem of omitted variable bias as our main assumption is that all unobserved factors are time-invariant.

We used unbalanced panel data. Some of the ports have missing years, like information about ports in Crimean Peninsula which are not observed for the last four years due to the fact of temporally occupied territories. And any

package that can calculate fixed effects model with panel data makes the adjustment for such loss.

There are various variables that researchers use for the estimation of demand of maritime trade determinants, based on the research papers by Cotto-Millan et al, 2004; Cotto-Millan et al, 2013 and Barros, 2016. The most common dependent variables in these studies are: maritime export (in thousands of tons), maritime import (in thousands of tons) and maritime transit (in thousands of tons).

The most common independent variables in these studies are: maritime freight indexes, prices of other means of transport (air transport, railway and road transport), different levels of income, relative prices of maritime trade, world income (especially for export).

In our research we will use export, import and transit separately for 3 types of goods: liquid, dry bulk and general cargo as independent variables, thus we will estimate 9 regressions. As for dependent variables, we can use such vectors as international port tariff rates, efficiency scores, country and world income, real effective exchange rate and different world price indexes of the most tradable goods through the Ukrainian ports.

Chapter 4

DATA DESCRIPTION

In this work, we used the unique firm-level dataset of 18 Ukrainian ports for 2006-2018. The data were collected and processed by the author. There is one dataset which can be divided into two for the convenience of two-stage estimation. The first one consists of efficiency indicators which include the key information about technical characteristics of the ports and the second dataset which includes the main macroeconomic indicators that influence the Ukrainian port trade such as international port tariff rates, Ukrainian GDP, real effective exchange rate, real world price indices, etc. Dependent variables are as follows: for the first stage approach it is aggregated total volumes of cargo handling in seaports, for the second stage they are separately volumes of export, import and transit in seaports in thousands of tons.

4.1. First stage estimation

For the purpose of port efficiency estimation, we use such variables as total costs of ports, number of berths, maximum depth and length of berths, maximum length, width and draught of vessels that can enter the seaport, etc.

Dependent variable in this part is the aggregated total volume of cargo handling in each Ukrainian seaport. It consists of three main types of flows – export, import and transit passing through the Ukrainian sea ports and is measured in thousands of tons.

Table 2. Descriptive statistics for the variables selected for the first stage analysis

Variable	Unit of measurement	Mean	Min	Max	St. Dev
Total Cargo	10^3 tons	7 651.7	8.4	48 582.1	9 943.2
Total Area	10^3 m^2	1 283.9	51.5	3 706.0	1 116.8
Number of berths	unit	17.2	1	54	14.3
Max depth of berths	m	9.9	3	24	4.9
Max length of berths	m	292.1	150	546	99.0
Length of vessels	m	210.9	120	329	65.1
Width of vessels	m	30.7	6	54	12.4
Draught of vessels	m	9	4	18.5	3.8
Port Capacity	10^3 tons/year	12 642.6	1 320	47 245	13 913.1
Volume of vessels	m^3	81 611.2	3 510	328 879	87 332.9
Total costs	10^3 UAH	135 091	0	575 380	145 741

Notes: 209 observations for every Ukrainian sea port over a period of 13 years

All the data have been gathered from many various sources. The technical characteristics of the ports are taken from the Ukrainian Sea Port Administration site, especially from the register of Sea Ports of Ukraine[7]. It is prepared based on the draft resolutions of the Cabinet of Ministers of Ukraine "On defining the boundaries of the territories of seaports"[8] and "On amendments in addition to some regulations of the Cabinet of Ministers of Ukraine" (concerning determination the boundaries of water areas of

[7] http://www.uspa.gov.ua/en/sea-ports-register
[8] https://zakon.rada.gov.ua/rada/show/v0270879-18?lang=en

seaports)[9]. It contains all the main information about each working port in Ukraine.

As some of the ports have missing years, like Crimean ports which are not observed for the last four years due to the fact of temporarily occupied territories, information about their technical characteristics are obtained from the sites of every Crimean port.

The information for total costs of every port is also obtained from the USPA site[10], but it contains the financial statements of every port and is available only for 2013-2016. It means that if we use it for the whole dataset, it will provide us with N/A in efficiency scores for all other years. A possible solution is to evaluate the efficiencies of ports using total costs and then without them and look at the correlation between the two results. In the case when the correlation of efficiencies is high, we can assume that total costs can be dropped from the model and do not highly influence the efficiency scores of Ukrainian ports. For the total costs we use OPEX (operational expenditures for every port) that include material costs, payroll, social payments, amortization and other operational costs.

The correlation matrix in Appendix A shows that there is a correlation between maximum depth of ports and technical characteristics of vessels entering this port. In this case we can use another parameter – vessels' volume, which we can get from our data by multiplication of length, width and draught of vessels.

4.2. Second stage estimation

It is relevant to understand the impact of the port tariff rates and efficiency scores not only on the total volume of cargo handling, but on its main components and categories. So, for the estimation of factors influencing cargo flow, firstly, we should explore the structure of the previous one. The data of

[9] https://zakon.rada.gov.ua/laws/show/ru/491-2015-%D0%BF?lang=en
[10] http://www.uspa.gov.ua/en/

these parameters were obtained from the USPA documentation and contained such parameters as export, import and transit in thousands of tones for every year and every port.

In Ukraine the total cargo through the sea ports is categorized into:

1. liquid bulk (crude and vegetable oil, petroleum products, chemical liquids)
2. dry bulk (coal, coke, various ore, cereals, sugar, fertilizers, cement, etc.)
3. general cargo in containers, semi-containers and non-containerized (automashines, agricultural technics, forestry cargo, black and colored metals, cotton, food, industrial products)

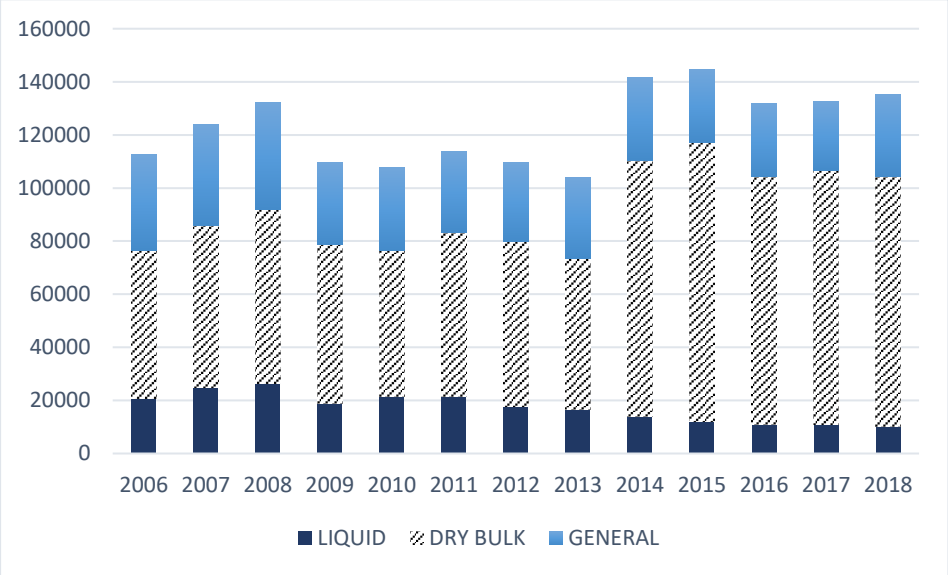

Figure 4. Total sea-borne trade structure in Ukraine in thousands of tons, 2006-2018

Liquid bulk: It includes any type of liquid and requires special equipment for loading/unloading. In Ukraine it takes third place by volume of trade and its percentage decreases with time from 18.4% of total cargo in 2006 to 7.5% in 2018.

Dry bulk: In Ukraine, it occupies the biggest part of total cargo handling through the sea ports and with time it increased one and a half times from 49.5% of total cargo in 2006 to 69.7% in 2018. Generally, it increased due to the development of agriculture in Ukraine and the fact of five-fold increase of cereals trade (from 14.5% of total dry bulk trade in 2006 to 43.9% in 2018) and almost a doubling of various ore trade (from 22.7% in 2006 to 30% in 2018).

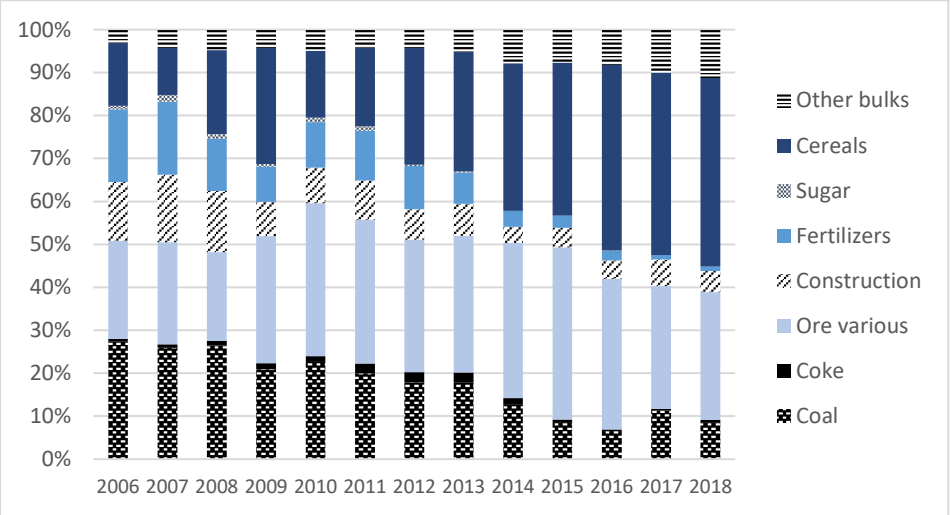

Figure 5. Total volume of sea-borne dry bulk trade in Ukraine, 2006-2018

General cargo: In Ukraine, this category takes second place by volume of trade but decreases with time from 32% of total cargo in 2006 to 22.6% in 2018. It consists mostly of black metals (52.4%) and containers (35.6%).

Main components of total cargo consist of export, import, transit and cabotage. In Figure 4.4 we can observe that main part of trade is export, which significantly increased with time from 50% of total cargo in 2006 to 73% in 2018. This happened due to the increase of export of dry bulk from 43.6% of total export in 2006 to 71.5% in 2018. The main exported goods from Ukraine through the sea are various ore (18.4% of total export) and cereals (40.2%) in 2018.

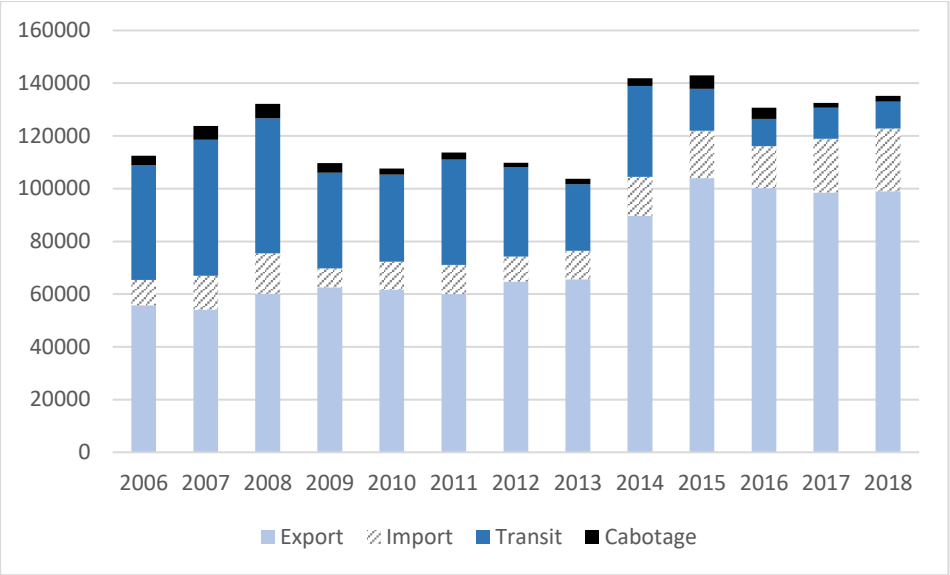

Figure 6. Sea-borne trade components in Ukraine in thousands of tons, 2006-2018

Import also increased over time from 9% of total cargo in 2006 to 18% in 2018. Coal dominates in the import structure through the sea ports of Ukraine (24.2% of imported goods). At the same time, transit hugely decreased not only as the percentage of total cargo (from 39% in 2006 to 8% in 2018), but also in units (from 43 500 thousand tons in 2006 to 10 200 thousand tons in 2018). Consequently, the structure of transit trade did not change over time and each category decreased proportionally with time. Cabotage in Ukraine is very poorly developed and occupies only 1.6% (in 2018) of total cargo through the sea ports.

Thus, we will use 9 main components and categories of total cargo as dependent variables: import, export and transit of liquid, dry bulk and general goods. Using such separation, it will be easier to understand the impact of independent variables and make more reasonable policy implications based on profound research.

Independent variables in the second stage are port tariff rates, Ukrainian GDP, GDP growth, Logistic performance index, WEF port quality, real effective

exchange rates, real world price indexes for agriculture, energy, meals and oils, fertilizers, etc. Our dataset has 209 observations of 18 ports for 13 years.

Table 3. Descriptive statistics for the variables selected for the second stage

Variable	Unit of measurement	Mean	Min	Max	St. Dev
Total export	10^3 tons	4 241.8	0	38 254.5	6 294.6
Total import	10^3 tons	789.1	0	7 445.1	1 576.3
Total transit	10^3 tons	1 736.1	0	17 371.3	3 065
Ukrainian GDP	10^9 USD	138.2	121.2	153.7	9.3
World GDP	10^9 USD	69 791	51 466	83 686	9 568
International port tariffs	USD/m^2 of vessels volume	0.25	0.09	0.392	0.07
LPI	index	2.7	2.5	2.98	0.16
WEF port quality	index	3.5	3.16	4	0.23
Real effective exchange rate	index	95.2	72.5	116.2	13.5
Meals and oils real index	index	95.9	64.2	113.7	13.4
Grains real index	index	102.4	77.9	128.2	17.3
Energy real index	index	97.3	58.6	125.6	19.9
Metals real index	index	88.6	66.9	113.3	14.3

All the variables were gathered from different sources. Information like GDP, population and real effective exchange rate were gathered from the open annual

data of the World Bank[11]. WEF port quality and LPI indexes are the main indicators of Ukrainian sea port quality and there are special statistics and evaluation each year of such indicators[12].

Price indices were obtained from the World Bank Commodity Price data[13]. As we observed previously, various ore and cereals dominate in the export structure (18.4% and 40.2% of total export correspondingly) and coal dominated in the import structure (24.2% of total import), thus we will use real indices of these goods to control for the global price changes.

WEF port quality indicator was obtained from the World Economic Forum's Executive Opinion Survey[14], conducted over 30 years in collaboration with 150 partner institutes. It means that if one of the ports is extremely underdeveloped and seven if it is well developed and efficient.

LPI was obtained from the World Bank site and it is the main identifier of a country's trade logistics performance. This indicator is measured for 160 countries annually and helps to improve special indices like infrastructure, customs clearance, logistic services, arrangements, etc.

Ukrainian and world GDP statistics were obtained from the World Bank site and are in USD and are constant. To see the effects of the 2008 and 2013 crises, we use such variable as real effective exchange rate that is weight of Ukrainian national currency related to the index of other major currencies.

One of the main variables is Port Tariff rates. It is conducted from the information given in the Ukrainian law "About Port Tariff Rates"[15]. In our work, we use the aggregate rate from 7 port tariff rates - administrative, channel, ship, lighthouse, sanitary, mooring and anchor tariffs. We estimated international tariff rates as we want to understand the impact of them on the

[11] https://data.worldbank.org/
[12] https://lpi.worldbank.org/
[13] http://www.worldbank.org/en/research/commodity-markets
[14] http://reports.weforum.org/
[15] https://zakon.rada.gov.ua/laws/show/z0930-13?lang=en

international trade indicators. As mostly all tariff rates in the ports are distributed on the two groups of vessels, we selected first group as it contains the mostly driven vessels in the ports. It consists of such categories as:

1. Cargo ships and floating structures
2. Passenger ships, including high-speed vessels for underwater wings and ferries entering cargo and passenger operations, as well as ice-breakers
3. Lighter, tugs, tugboats, pushers, barges, river self-propelled vessels, as well as those, which go in for further overload of cargoes to seagoing vessels and vice versa

Table 4. Descriptive statistics for the international port tariff rates separately, in USD per 1 m^2 of vessels volume

Variable	Mean	Min	Max	St. Dev
Ship	0.12	0.066	0.18	0.03
Mooring	0.031	0.018	0.035	0.007
Anchor	0.004	0.002	0.004	0.001
Channel	0.037	0	0.126	0.037
Lighthouse	0.04	0.022	0.045	0.009
Administrative	0.021	0.011	0.022	0.003
Sanitary	0.024	0.011	0.043	0.01

All these seven tariff rates are in USD per one squared meter of vessel, so we can sum them up and receive rates for all included services in the ports.

All independent variables that are used in the model and all the expected signs are represented below in the Table 4 with the possible explanation of such effects.

Table 5. Expected effect of independent variables

Variable	Expected effect	Explanation
International Port Tariffs	-	With increase of prices of the port service, there will be a decrease of traded goods through the ports due to the law of demand
Efficiency scores	+	The more efficient the port – the more reasonable it is to use it for trade. All materials, costs, energy, efforts are at the level to conduct business without waste.
Ukrainian GDP	+	High GDP means high development of the country, high competitiveness of traded goods and high development of international relations, in particular, trade
World GDP	+	High world GDP means higher development of all countries, and should expand the Ukrainian export as all prices and income of people will increase
REER	+	One of the control variables for crisis as financial crisis has some effects on international trade through changes in exchange rates (REER is one of the competitiveness measure). Increase in REER leads to devaluation and export goods now are more competitive and intuitively imported goods become less competitive. But: research papers on this topic show counterintuitive results concerning import affected by the currency devaluation as it comes about real rather than nominal trade
Grains real index	+	It is one of our main exported goods, thus with an increase in prices we will observe increase in total cargo
Energy real index	-	This is our main imported good, so with increase of prices on energy, both export and import would drop as this is our price on resources and inputs for producing other goods and services. Import will drop as demand on energy will decrease
Metals real index	+	It is our second exported good by the volume, so if the world prices on metals increase, our cargo flows should also increase as it is more profitable for mining

Chapter 5

EMPIRICAL RESULTS

This chapter describes the estimation results of the two-stage approach stated in Chapter 3. So, we will proceed in 2 steps: 1) showing the results of the efficiency effect stochastic frontier model and explaining the impact of port tariff rates on ports' efficiency, 2) reporting the elasticity results of port tariff rates and efficiency scores on the trade flows.

5.1. First stage estimation

At first, we used efficiency effect stochastic frontier analysis approach to estimate the efficiency scores of every port for every year and use it in the next stage for understanding their impact on the total cargo flow. Such a method allows us to look simultaneously at the scores and the port tariff rates impact on them.

The following table gives the results of the first stage estimation process. Our main coefficient of interest here is the coefficient of the variable "International Port Tariff Rates", which is the z-variable in the regression and is the additional parameter that has impact on the efficiency scores. As can be seen, the coefficient is statistically significant at 1% and has the value of -1.101. This implies that the port tariffs negatively influence the ports' efficiency. When the port tariff rates increase by 1%, the efficiency of ports will decrease by 1.1%. The negative effect of port tariff rates occurs because traders are faced with additional transportation costs. Such result meets our expectations about negative impact of increasing tariff rates policy. The results are in line with all assumptions stated in Chapter 3, using model (2) and were checked for consistency.

Table 6. Results of the efficiency effect stochastic frontier model

	Estimate
Intercept	0.47***
	(0.102)
Number of berths	0.936***
	(0.07)
Max depth	1.08***
	(0.13)
Port Capacity	0.237***
	(0.06)
Total area	0.295***
	(0.03)
Dummy for 2009-2013	-0.217***
	(0.007)
Z variable for Intercept	-0.895
	(0.081)
Z variable for International Port Tariff Rates	-1.101*
	(0.532)
Z variable for Dummy for 2014	0.46
	(0.689)
sigma^2	1.4***
	(0.183)
gamma	1.00***
	(0.00)

Notes: · if p-value < 0.05, * if p-value < 0.01, ** p < 0.001, *** p = 0. Total number of observations: 209. Number of time periods: 13. Number of cross-sections: 18. Mean efficiency: 0.385. All variables except dummies are estimated in log form. Dependent variable: total cargo handling

As we do not have all necessary data of total costs of ports during all years, we estimated efficiencies using total costs and then without them, and the correlation between such efficiencies was very high – 73.98%, which means that we can estimate an efficiency score for every 13 years without using total costs.

The following figures show the efficiency score development from 2006 to 2018.

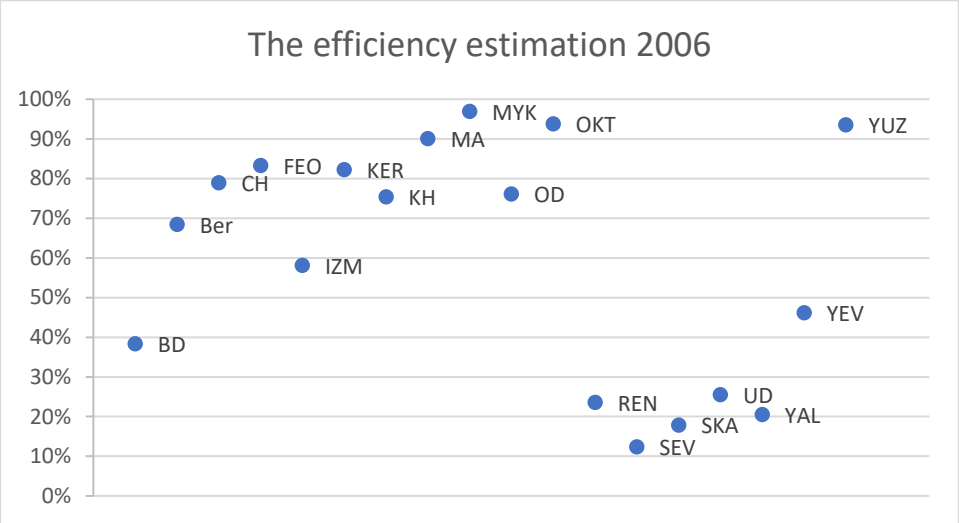

Figure 7. The efficiency scores distribution among the Ukrainian ports in 2006

Notes: all the abbreviations for the port names are in the Appendix C

The efficiency scores in 2006 for a greater amount of ports (11) are quite high – more than 50%. This fact means that ports use their inputs in a highly efficient way for producing maximum output (in our case it is total cargo handling). The most important cargo for Ukrainian ports is grain, which is generally transferred by the Nikolaev port which has the highest efficiency score. The port of Yuznyi leads in transshipment of ore. Odessa port significantly leads in the handling of containers. Thus, all efficiency scores are quite logically consistent.

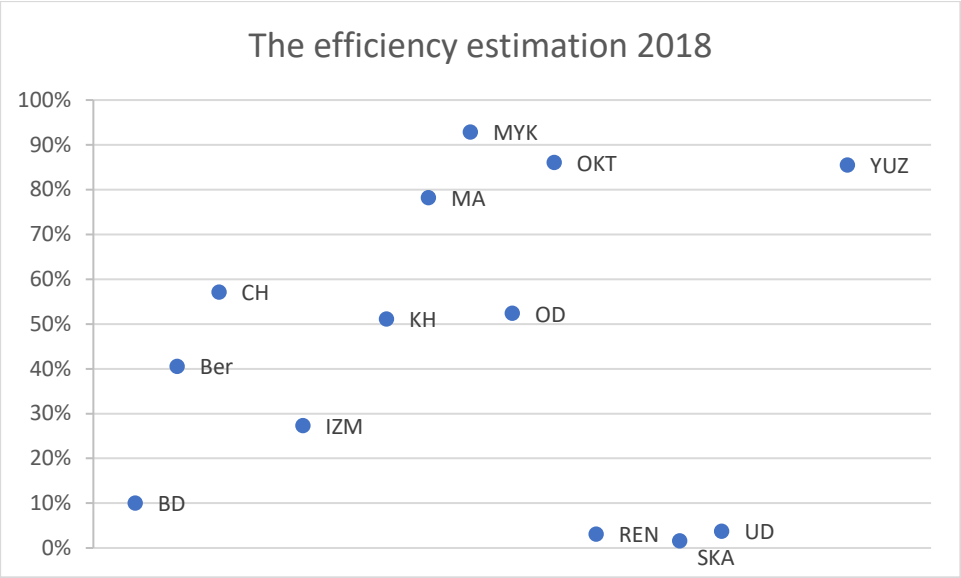

Figure 8. The efficiency scores distribution among the Ukrainian ports in 2018

Notes: all the abbreviations for the port names are in the Appendix C

The figures above show that almost every Ukrainian port lowered their efficiency score from 2006 to 2018. The results of 2018 represent 7 ports above 50% efficiency and shows that Mykolaiv, Oktyabrsk, Yuznyi, Mariupol are the most efficient ports in Ukraine. There is no port which has an efficiency score equal to 1 and it means that they all suffer from inefficiency and can be more productive. Thus, there is an opportunity to increase an output with optimal usage of resources on the basis of the increased efficiency or based on the decrease of port tariff rates.

5.2. Second stage estimation

Now by using the results obtained from stochastic frontier estimation, we can provide the effect of port tariff rates and efficiencies on the cargo flow of liquid, dry bulk and general (which consists mainly of black metals and industrial products) as these are the main traded goods by the sea in Ukraine. The results are below.

Table 7. Results of the fixed effect model

Independent variables	Total export	Total import	Total transit	Export of liquid cargo	Import of liquid cargo	Transit of liquid cargo	Export of dry bulk cargo	Import of dry bulk cargo	Transit of dry bulk cargo	Export of general cargo	Import of general cargo	Transit of general cargo
Elasticity of Port tariff rates	-1.175	-1.798	-0.482	-0.375	0.41	0.878	-1.435	0.904	0.490	-1.732	-2.52*	-0.109
	(0.956)	(1.498)	(1.552)	(1.409)	(1.578)	(0.885)	(1.298)	(1.810)	(1.985)	(1.181)	(1.454)	(1.444)
Elasticity of efficiency scores	**1.653*** **	0.678	**2.572*** **	0.017	**1.398*** **	-0.209	**3.007*** **	-0.383	**1.586*** **	**1.161** **	**1.950*** **	**1.105*** **
	(0.412)	(0.5)	(0.521)	(0.607)	(0.527)	(0.297)	(0.559)	(0.604)	(0.666)	(0.509)	(0.485)	(0.484)
Interaction terms of Railway and Port tariffs	0.345***	0.012	-0.533***	-0.167	-0.124	-0.467***	0.421**	-0.168	-0.49***	0.414***	0.188	-0.076
	(0.115)	(0.142)	(0.147)	(0.17)	(0.149)	(0.084)	(0.156)	(0.171)	(0.188)	(0.142)	(0.138)	(0.136)
Total 1% change in Port tariffs (p-value of joint significance)*	**-0.83***	-1.786	**-1.015*** **	-0.542	0.286	**0.411*** **	**-1.014***	0.736	-0.003*	**-1.318***	-2.332	-0.185
	(0.011)	(0.4487)	(0.0003)	(0.477)	0.707	(8e-08)	(0.027)	(0.613)	(0.023)	(0.014)	(0.167)	(0.82)

Notes: · if p-value < 0.05, * if p-value < 0.01, ** p < 0.001, *** p = 0. Total number of observations: 209. All variables are in log form. The whole table of results are in the Appendix. Port tariff rates are in log form. *estimated results by the author

The table contains the main variables of our regression. In the results, we can see that port tariff rates have an intuitive negative sign and in some cases are quite significant, so we can conclude that increase in port tariff rates have a negative impact on the cargo flows.

As we added interaction terms of port and railway tariff rates, we tested a hypothesis of joint significance of these factors. The results of these tests are in Table 7 on the last row in the form of F-test p-value and values of port tariff rates 1% change effect. Estimations show that port tariff rates have a significantly negative effect on the total export and transit (81% of total cargo flows), export of dry bilk and general cargo (77.2% of total export).

We are especially interested in the effect on total export as it takes the largest proportion of the whole maritime trade. The result is significant and negative and shows that if port tariff rates increase by 1%, the export cargo handling will decrease by 0.83%. Thus, we can conclude that port tariff rates have a high significant effect on the cargo handling.

At the same time, efficiency scores are highly significant and positively influence cargo flows. It means that if government invest in port infrastructure, increase maximum depth of berths, total area of the ports, port capacity, it will lead to higher maritime trade and an increase of port competitiveness. As we are interested greatly in the effect on the total export, with increase of efficiency score by 1% the export cargo handling will increase by 1.65%.

The other variables (that can be found in Appendixes) have consistent signs except for Ukrainian GDP which has a negative significant effect on the transit cargo handling and in some cases on import. This counterintuitive result can be since maritime trade takes only 25% of all trade and is one of the cheapest ways of transport. And since there are many other factors that can affect whole local import and transit trade, this can cause counterintuitive results. Maritime trade in comparison with air trade is the longest and cheapest transportation

type, that's why relatively more money is redirected to trade by airplanes, railways and roads.

All our estimations were checked for all main assumptions stated in Chapter 3. Robustness check was done by using different methodologies, by dropping some variables, using subsamples and all models showed have consistent signs, which mean that our model is robust. All the tests are in Appendixes.

Table 8. Port traffic change with decreased port tariff rates

	Efficiency of Port Tariff Rates	Interaction of railway and port rates	Port handling elasticity of **20% decrease**	Port handling elasticity of **60% decrease**
Total export	-1.175	0.345	23%	70%
Total transit	-0.482	-0.533	9%	28%
Transit of dry bulk cargo	-1.435	0.421	29%	86%
Export of general cargo	-1.732	0.414	33%	103%

Table 8 shows a possible application of estimated elasticities. We showed the two possible options: reduction of port tariff rates by 20% (as in 2018) and 60% (the level of 2008 increase). The results show high impact on port cargo handling even despite its influence through the port efficiency that also will increase the results.

Our conclusion about these results is the high impact of port tariff rates and port efficiency on the port cargo handlng which is a good reason for reorganization and improvement of current port traffic for getting significant benefits to the Ukrainian economy.

Chapter 6

CONCLUSIONS

The main aim of this paper was to provide the estimation of Ukrainian port efficiency and on the effect of sea port tariffs on the sea-borne trade in Ukraine. This study discovered the negative impact of port tariff rates on the port efficiency and cargo handling and positive influence of efficiency on the cargo flows.

The findings of this paper offer several contributions to the literature. First, we provide the extension of the previous frontier efficiency estimation models and allow for tracking the port efficiency scores and the effect of international port tariff rates on them simultaneously within one model. We found interesting and significant results working with Ukrainian port-level data within the 13-year interval. Second, we found efficiency and price elasticity effects on the Ukrainian port cargo handling and distinguish these effects between the most common traded goods.

We have applied the two-stage process approach with first stage of efficiency scores estimation and the second stage of fixed effect model for estimation of the main determinants that explain the change in maritime export, import and transit in Ukraine.

We obtained logical efficiency scores distribution when Mykolaiv, Yuznyi, Oktyabrsk, Mariupol and Chornomorsk are the most effective ports in Ukraine. The results also showed that all Ukrainian ports suffer from inefficiency and can be more productive. It can be realized in the case of improvement of technical characteristics of ports, especially increasing total area of berths, maximum depth, port capacity or optimizing total operational costs. Port tariff rates used a z variable in the first stage stochastic efficiency effects model showed negative and significant effect on the efficiency scores. Decreasing port tariff rates by 1% will lead to 1.1% increase of port efficiency.

The second stage fixed effect model showed a positive and significant effect of efficiency on the total export and transit (together they form 81% of total cargo flows) and breaking down on the goods – effect on the import of liquid and general cargo, export and transit of dry bulk and general cargo. What about international port tariff rates, they have negative and significant effect also on the total export and transit, especially of dry bulk and general cargo.

It is important to note the export predominance in the overall structure of port cargo handling, which is influenced essentially by unreasonably high port tariff rates. At the current stage, we can observe port deterioration and inability to negotiate with investors to build mutually beneficial business relations, although exactly these factors together with profound regulatory policy could lead to the significant changes at the macroeconomic level.

The methodology used in the study can be revised and supplemented in the subsequent research papers. In general, a set of factors, both external and internal, also may be revised as some factors like maritime freight rates or total costs for all years are missing. This methodology can be also replicated in other countries.

The policy implication is quite straightforward. The easiest way is to change the port tariff rates, which will entail changes in port efficiency as well as in port cargo handling. Revision of port tariff rates by regulatory authorities may lead to increase of port competitiveness and attractiveness for the foreign merchant ships. This will also lead to a search for new investments to modernize the ports, increase the number of berths, and also deepen them. The technical characteristics of Ukrainian ports can also be improved by profound money redistribution within the country, and this will also entail a significant increase in trade through the ports.

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APPENDIX A

Check for multicollinearity

Table 9. Correlation matrix for the technical characteristics of the ports

	Total area	Number of berths	Max depth	Volume of vessels	Port Capacity
Total area	1	0.471	0.419	0.748	0.822
Number of berths	0.471	1	0.351	0.629	0.581
Max depth	0.419	0.351	1	0.728	0.549
Volume of vessels	0.748	0.629	0.728	1	0.850
Port Capacity	0.822	0.581	0.549	0.850	1

Table 10. Correlation matrix of dependent and independent variables in the second stage approach

	Total export	Total transit	Total import	Efficiency	World GDP	Ukrainian GDP	International Port Tariff Rates	Real effective exchange rate	Real price index on grains	Real price index on energy	Real price index on metals
Total export	1	0.477	0.780	0.083	0.147	-0.208	0.103	-0.206	-0.134	-0.252	-0.168
Total transit	0.477	1	0.478	-0.113	-0.207	0.185	-0.055	0.232	0.091	0.111	0.194
Total import	0.780	0.478	1	-0.081	0.125	-0.113	0.001	-0.140	-0.109	-0.167	-0.079
Efficiency	0.083	-0.113	-0.081	1	-0.118	0.073	0.232	0.116	0.084	0.066	0.076
World GDP	0.147	-0.207	0.125	-0.118	1	-0.371	0.306	-0.659	0.134	-0.109	-0.550
Ukrainian GDP	-0.208	0.185	-0.113	0.073	-0.371	1	-0.133	0.881	0.610	0.859	0.781
International Port Tariff Rates	0.103	-0.055	0.001	0.232	0.306	-0.133	1	-0.121	0.324	0.078	-0.291
Real effective exchange rate	-0.206	0.232	-0.140	0.116	-0.659	0.881	-0.121	1	0.549	0.747	0.748
Real price index on grains	-0.134	0.091	-0.109	0.084	0.134	0.610	0.324	0.549	1	0.788	0.193
Real price index on energy	-0.252	0.111	-0.167	0.066	-0.109	0.859	0.078	0.747	0.788	1	0.568
Real price index on metals	-0.168	0.194	-0.079	0.076	-0.550	0.781	-0.291	0.748	0.193	0.568	1

APPENDIX B

Estimation results

Table 11. Results of second stage approach

	Total Export	Total Import	Total Transit	Export of liquid cargo	Import of liquid cargo	Transit of liquid cargo	Export of dry bulk	Import of dry bulk	Transit of dry bulk	Export of general cargo	Import of general cargo	Transit of general cargo
International Port Tariff Rates	-1.175	-1.798	-0.482	-0.375	0.410	0.878	-1.435	0.904	0.490	-1.732	-2.520*	-0.109
	(0.956)	(1.498)	(1.552)	(1.409)	(1.578)	(0.885)	(1.298)	(1.810)	(1.985)	(1.181)	(1.454)	(1.444)
Efficiency	**1.653*** **	0.678	**2.572*** **	0.017	**1.398*** **	-0.209	**3.007*** **	-0.383	**1.586** **	**1.161** **	**1.950*** **	**1.105** **
	(0.412)	(0.500)	(0.521)	(0.607)	(0.527)	(0.297)	(0.559)	(0.604)	(0.666)	(0.509)	(0.485)	(0.484)
World GDP	13.940***		9.938**	8.580*		2.28	10.420**		2.899	3.725		0.469
	(3.114)		(3.955)	(4.587)		(2.26)	(4.227)		(5.057)	(3.847)		(3.680)
Ukrainian GDP		-8.74	-14.31**		-1.47	-3.29		4.661	-5.537		-11.991**	-2.225
		(6.115)	(6.356)		(6.442)	(3.624)		(7.389)	(8.126)		(5.935)	(5.913)
Real effective exchange rate	0.318***	0.167***	0.246***	0.124***	0.043*	0.046**	0.263***	0.112***	0.159***	0.210***	0.146***	0.134***
	(0.028)	(0.023)	(0.038)	(0.042)	(0.024)	(0.022)	(0.038)	(0.028)	(0.049)	(0.035)	(0.022)	(0.036)
Real price index on grains	0.020	0.050***	0.036*	0.012	0.015	0.011	0.017	0.014	0.031	0.032*	0.030*	0.016
	(0.016)	(0.017)	(0.021)	(0.023)	(0.017)	(0.012)	(0.021)	(0.020)	(0.027)	(0.019)	(0.016)	(0.019)

TABLE 11 - Continued

	Total Export	Total Import	Total Transit	Export of liquid cargo	Import of liquid cargo	Transit of liquid cargo	Export of dry bulk	Import of dry bulk	Transit of dry bulk	Export of general cargo	Import of general cargo	Transit of general cargo
Real price index on energy	-0.18***	-0.07***	-0.11***	-0.09***	-0.04***	-0.03***	-0.15***	-0.07***	-0.08***	-0.12***	-0.03**	-0.05***
	(0.013)	(0.014)	(0.019)	(0.019)	(0.014)	(0.011)	(0.018)	(0.016)	(0.024)	(0.016)	(0.013)	(0.017)
Real price index on metals	0.020*	0.041***	0.025*	0.022	0.013	0.011	0.018	0.033**	0.021	0.019	0.025**	0.006
	(0.010)	(0.013)	(0.014)	(0.015)	(0.013)	(0.008)	(0.014)	(0.015)	(0.018)	(0.013)	(0.012)	(0.013)
Railway tariffs	0.553**	0.626**	-1.062***	-0.427	0.139	-0.642***	0.845**	0.255	-0.763*	0.951***	0.789***	-0.072
	(0.240)	(0.247)	(0.308)	(0.354)	(0.260)	(0.175)	(0.326)	(0.299)	(0.393)	(0.297)	(0.240)	(0.286)
Interaction terms of Railway and Port tariffs	0.345***	0.012	-0.533***	-0.167	-0.124	-0.467***	0.421***	-0.168	-0.49***	0.414***	0.188	-0.076
	(0.115)	(0.142)	(0.147)	(0.170)	(0.149)	(0.084)	(0.156)	(0.171)	(0.188)	(0.142)	(0.138)	(0.136)
F-test of port tariffs and interaction term (joint significance)	**0.011***	0.4487	**0.0003*****	0.477	0.707	**8e-08*****	**0.027 ***	0.613	**0.023 ***	**0.014***	0.167	0.82
R2	0.753	0.490	0.646	0.208	0.245	0.275	0.574	0.305	0.431	0.568	0.387	0.530
Adjusted R2	0.718	0.417	0.593	0.095	0.137	0.167	0.513	0.206	0.346	0.506	0.299	0.460
F-Statistics	61.6***	19.4***	33***	5.3***	6.6***	6.87***	27.23***	8.9***	13.7***	26.5***	12.8***	20.4***

Notes: · if p-value < 0.05, * if p-value < 0.01, ** p < 0.001, *** p = 0. Total number of observations: 209. Number of time periods: 13. Number of cross-sections: 18.
All variables except dummies are estimated in log form

APPENDIX C

Robustness check 1. Dropping some variables

Table 12. Results of second stage approach after dropping some variables

	Total export	Total import	Total transit
International Port	0.04	-1.050	-3.752***
Tariff Rates	(1.02)	(0.683)	(1.082)
Efficiency	1.7608**	0.603	2.843***
	(0.761)	(0.642)	(0.596)
World GDP	-0.866		6.528***
	(1.55)		(2.014)
Ukrainian GDP		-11.163***	-32.997***
		(3.625)	(5.547)
Real effective exchange rate	0.038***	0.77***	0.266***
	(0.014)	(0.019)	(0.034)
Observations	209	209	209
R2	0.117	0.12	0.517
Adjusted R2	0.018	0.021	0.459

Robustness check 2. Dropping all variables except for the main ones

Table 13. Results of second stage approach after dropping all variables except for the main ones

	Total Export	Total Import	Total Transit
International Port	-1.216	-1.472***	-2.484***
Tariff Rates	(0.792)	(0.678)	(0.789)
Efficiency	2.078***	1.036	3.735***
	(0.771)	(0.66)	(0.768)
Observations	209	209	209
R2	0.047	0.036	0.147

Robustness check 3. Different specifications of the regression

Table 14. Results of second stage approach using Pooled OLS model

	Total Export	Total Import	Total Transit
International Port	-2.119	-0.444	-0.601
Tariff Rates	(1.379)	(1.445)	(1.647)
Efficiency	2.565***	1.011	2.235***
	(0.675)	(0.679)	(0.776)
World GDP	11.389		7.96
	(7.275)		(8.39)
Ukrainian GDP		-2.477	-13.86
		(9.486)	(10.85)
Real Effective	0.282***	0.158***	0.218***
Exchange Rate	(0.064)	(0.044)	(0.081)
Real prices on grains	0.024	0.026	0.043
	(0.031)	(0.021)	(0.036)
Real prices on energy	-0.165***	-0.079***	-0.103***
	(0.031)	(0.025)	(0.039)
Real prices on metals	0.019	0.038	0.026
	(0.023)	(0.025)	(0.029)
Railway tariffs	0.932*	0.929**	-1.05
	(0.547)	(0.469)	(0.645)
Interaction of international port tariff rates and Railway tariffs	0.46*	0.192	-0.596*
	(0.26)	(0.268)	(0.306)
Constant	-376.84	50.185	88.796
	(229.983)	(237.424)	(363.415)
Observations	209	209	209
R2	0.343	0.188	0.295

APPENDIX D

List of Ukrainian port abbreviations

Table 15. List of Ukrainian port abbreviations

Abbreviation	Explanation
Ber	Berdiansk
BD	Bilgorod -Dnistrovsky
YEV	Yevpatoria
IZM	Izmail
CH	Chornomorsk
KER	Kerch
MA	Mariupol
MYK	Mykolaiv
OKT	Oktiabrsk
REN	Reniysk
SKA	Skadovsk
SEB	Sebastopol
UD	Ust Dunay
FEO	Feodosia
KH	Kherson4
YUZ	Yuzhniy
YAL	Yalta
OD	Odessa