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ANALYSIS OF THE TREND IN THE NUMBER OF CONTAINERS IN CANADA AND ON GLOBAL LEVEL

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ABSTRACT

This paper analyses the trend in the development of container transshipment volumes in TEU units. It elaborates forecast models for Canada and the world as a whole in order to make the establishment of the throughput of container terminals possible in the future. The trend analysis method is thereby applied to assess the development of the variable of container transshipment volumes in TEU units. By using the relative indicators of coefficient of determination and coefficient of variation, the precision of the model is examined. It has been established that there is a growth trend of container transshipment volumes in Canada and on global level, which implies that there is a need to increase the efficiency of container transshipment or, respectively, to increase transshipment capacities. The global trend model helped establish an expected average growth of container transshipment volumes in ports by 24.55 mil TEU in each subsequent year, whereas for Canada, we established an expected average growth of 0.22 mil TEU in each subsequent year. The respective models are representative models, in which the global coefficient of determination R^2 is 98.37% and the coefficient for Canada is 91.61%, on the basis of which a high level of interpretation for the trend of development in container transshipment volumes can be determined for each of the models.

Keywords: trend analysis, Canada, global, TEU

1. INTRODUCTION

The global container traffic is growing. The global trends in container traffic, in TEU units (twenty-foot equivalent unit), also occur in Canada, which is evident from the data obtained from the UNCTAD (United Nations, UN Trade & Development database) (<https://unctadstat.unctad.org/>), for which reason the need for the modelling of container transshipment volumes by means of representative and reliable assessors has been established, thus making a precise projection of container transshipments in ports possible. Canada is a member of the G7 (Group of Seven) and G20 (Group of Twenty) groups and is classified as one of the most developed countries in the world. Canada carries out part of its import and export of container goods via the container ports of Vancouver, Halifax, Montreal, Prince Rupert and Saint John. There are a very small number of papers which analyse container traffic in Canada. Research related to container traffic mostly refers to the throughput and efficiency of ports, especially in the Asia region (Liu, Park, 2011; Zheng, Park, 2016; Kutin *et al.*, 2017; Li *et al.*, 2024; Hsu *et al.*, 2024). Research concerning the region of Canada also mostly refers to the throughput and efficiency of the container ports of Saint John, Halifax, Montreal and Vancouver (McCalla, 1994, Turner *et al.*, 2004, Ircha, 2008; Ke *et al.*, 2012; Nikolau, Dimitriou, 2021). Models with a time variable are often used for long-term forecasts of container traffic in the ports of individual countries. Sachram, Munim (2021) used the Autoregressive Integrated Moving Average (ARIMA), AutoRegressive Integrated Moving Average with exogenous inputs (ARIMAX) and Vector Autoregression (VAR) models for forecasts of container traffic on the routes between the ports of the Far East and Northern Europe. The stochastic frontier analysis was used for establishing the efficiency and productivity of the container ports in Brazil (Lopez-Bermudez *et al.*, 2019), whereas the stochastic production frontier method was used to establish the efficiency of container ports in the regions of the Caribbean and Latin American countries, (Perez *et al.*, 2016). The time forecasting methods ARIMA, Seasonal Autoregressive Integrated Moving Average (SARIMA), Holt-Winters seasonal method (HWES) and the Prophet model were used for forecasting container traffic in the ports of Japan and South Korea (Munim *et al.*, 2023), while the ARIMA and Time Series Regression with ARIMA Noise, Missing Observations, and Outliers (TRAMO-SEATS) models (Huang *et al.*, 2015), as well as the ARIMAX model (Huang *et al.*, 2014) were used on the data for China. The stochastic production frontier model was used to demonstrate the efficiency of container ports in Africa (Trujillo *et al.*, 2013). The forecasts of container port traffic in Mexico and the USA were carried out by using the VAR and the SARIMA models (Morales-Ramirez *et al.*, 2025). The regression model was used for forecasting container traffic in Taiwanese ports (Chou *et al.*, 2008.), while (Peng, Chu, 2009.) used the method of time series decomposition (multiplicative method), the trigonometric regression model, the regression model with dummy variables, the grey model, the hybrid grey model and the SARIMA forecast model. The dynamic model based on the Markov chain model of the annual growth rate, the time trend model, the time trend model with periodical terms, and the grey system model were used for forecasts of container traffic in Northern Adriatic ports of Italy, Slovenia and Croatia (Twrđy, Batista, 2016).

On the basis of the established research problem based on relevant literature, the research question is posed whether the use of trends is an adequate tool for analysing the development of container transshipment volumes in ports through time, as well as whether it is reliable for forecasting the volumes of container transshipments in future periods. In order to establish the necessary throughput of container terminals in the future, one must be able to predict the trend of development in container transshipment volumes on national level. Therefore, this paper aims to analyse the trend of development in container transshipment volumes in Canada, in TEU units, as well as to elaborate a forecast model. It will also examine the trend of development in container transshipment volumes on global level and elaborate a forecast model. On the basis of the data obtained by means of the trend analysis method, it estimates the development of the variable of container transshipment volumes in TEU units. The statistical significance of the trend model is established on the basis of results of the Analysis of variance (ANOVA) test, which examines the hypothesis that the trend models can be used for estimating container transshipment volumes on national and global levels, whereas, by using the relative indicators of coefficient of determination and coefficient of variation, we examine the precision of the model. Chapter one offers a literature overview, sets the objective, poses the research question and presents the structure of the paper. The methodology used in this paper is described in chapter two, while in chapter three, the developments in container transshipment volumes in Canada and on global level are presented. Chapter four offers a demonstration of the trend of development in container transshipment volumes through time and a comparison of the obtained results with regard to previous research. Chapter five, the final chapter, offers a summary of the research results.

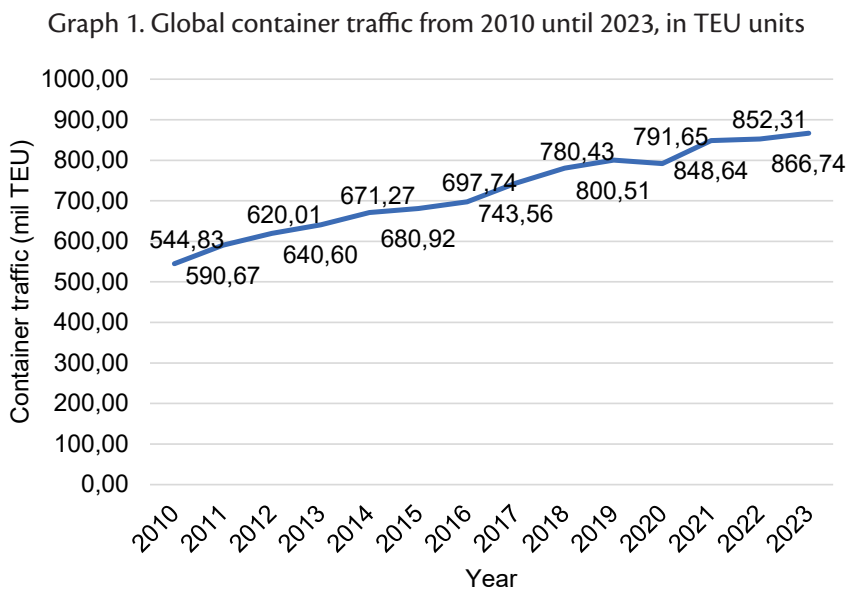
2. METHODOLOGY OF RESEARCH

In order to obtain insight in the throughput of container ports, we searched the ScienceDirect database published by Elsevier from Amsterdam, the Netherlands, and analysed scientific papers related to the throughput of containers in Canada and on global level. The data used in the analysis performed in this paper was issued by the UNCTAD (United Nations, UN Trade & Development database) (<https://unctadstat.unctad.org/>). For examining and displaying the results, the methods of analysis, synthesis and inferential statistics (correlation and trend models) were used. By means of the Pearson correlation coefficient, the link between container transshipment volumes in Canada and on global level was examined. By means of the linear trend model used in the analysis of container traffic, the volume of container traffic was analysed. Both models were validated by means of the ANOVA test, the coefficient of determination and the coefficient of variation. Statistical data processing was carried out by means of the Statistica 13 program of the manufacturer Tibco, California, United States of America (USA).

3. EMPIRICAL DATA AND ANALYSIS

In the research, an analysis of the development in the number of containers on global level and in Canada was carried out. Container traffic is presented in TEU units, whereby 1 TEU

represents one 20-foot container (<https://databank.worldbank.org/>). The global volume of container transshipments measured in TEU units has increased, in the period from 2010 to 2023, by the average annual rate of 3.64%. In the observed period, beginning from 2010, the volume had the tendency of increase, which was interrupted by the onset of the coronavirus disease (COVID-19) in 2020. Despite the pandemic, container traffic continued to increase in 2021. Graph 1 displays the global volume of container transshipments from 2010 until 2023.



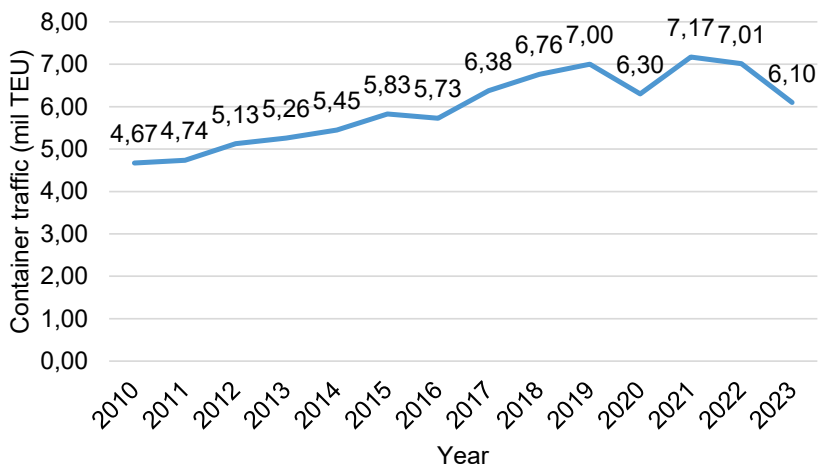
Source: UNCTAD, 2024.

Container traffic in Canada in the observed period had the tendency of growth, with the exceptions of 2016, 2020 and 2022. In 2016, the increase was interrupted due to the investment cycle in the ports of Vancouver and Montreal, where investments in the expansion and modernisation of container terminals were carried out, as well as due to the improvement of ecological efficiency of the terminals in 2016, lack of qualified personnel in the ports (<https://www.portvancouver.com/>; <https://tc.canada.ca/>), economic recession (<https://www.bankofcanada.ca/>), major wildfires (<https://www.budget.canada.ca/>), decline in investment spending primarily in the oil sector (<https://www.canadianenergycentre.ca/>) and the export and import of Canada (<https://tc.canada.ca/>), decreased value of the Canadian dollar in comparison to the years before, low prices of natural resources and reduced economic growth rate compared with Canada's key export markets (USA, European Union (EU), Japan, China, Mexico) (<https://www.budget.canada.ca/>). In 2020, the increase in the throughput of containers in ports was interrupted by the onset of the COVID-19 pandemic, whereas the throughput also decreased in 2022, in the TEU unit four largest Canadian container ports in 2022 as compared to 2021. On the West coast, the demand for the return of empty containers to Asia has significantly decreased by the end of 2022, while the export volumes of loaded containers have not returned to their pre-pandemic levels. These trends, combined with the

influence of the large floods that occurred in British Columbia by the beginning of 2022, have brought about a reduction in the throughput of containers by 3.7% in the Vancouver port and by 1.2% in the Prince Rupert port. On the East coast, the Montréal port records a slight decrease in container throughput (-0.3%). Contrary to this, container volumes increased by 0.9% in the Halifax port, which resulted in the decrease of the total throughput of containers in Canadian ports by 2.1% (<https://tc.canada.ca/>). Container traffic in Canada decreased by 13.53% in 2023 in comparison with 2022. Some of the causes for the decrease in the number of containers were slow economic growth, inflation, restrictive monetary politics, full warehouses and excessive stocks created during 2022, the slowdown of economic growth on global level after the pandemic and competition with other North American ports (<https://www.port-montreal.com/en/>). The supply chains between the East and West coast of Canada in 2023 were affected by a long major worker strike, which occurred in the ports on the West coast (<https://www.ajot.com/>), devastating wildfires in the provinces of Nova Scotia, Québec, Ontario, Northwestern Territories, Alberta and British Columbia (<https://tc.canada.ca/>), as well as external factors, such as the low water level in the Panama canal caused by long-term drought, disruptions in the Red Sea and the redirection of maritime navigation routes (<https://www.portvancouver.com/>).

The average annual growth rate of containers in Canada in the observed period is 2.07%. Graph 2 displays the development of container numbers in Canada from 2010 until 2023.

Graph 2. Container traffic in Canada from 2010 until 2023, in TEU units



Source: UNCATD, 2024.

It is evident from the analysis of the development in the number of containers that Canada keeps up with global trends. The increase in the volume of container transshipments that is taking place on global level is also occurring in Canada. It is also evident that the events occurring on the global level, such as the COVID-19 pandemic, also affect business activities on national level, in this case Canada and its container traffic.

4. RESULTS AND DISCUSSION

In this paper, two trend models have been elaborated (for the world as a whole and for Canada). The statistical significance for both models has been examined by means of the ANOVA test. The influence of the time variable on the developments in container transshipment volumes has been examined by means of the linear trend model. In this paper, by means of the Pearson correlation, we have tested the connection between container transshipment volumes in Canada and in the world as a whole.

4.1 Global trend of developments in container transshipment volumes

Based on the analysis of container transshipment volumes in the world, a linear trend model was composed, the regression coefficients of which and their accompanying parameters are displayed in Table 1.

Table 1. Global linear trend model

	B*	Standard error	B	Standard error	t(12)	P
Constant member			564.01	6.98	80.84	<0.001
Trend	0.99	0.04	24.55	0.91	26.91	<0.001

Source: Authors

Therefore, the estimated model is as follows:

$$TEU_t(\text{global}) = 564.01 + 24.55 \cdot \text{time}_t \quad (1)$$

i.e. the linear regression equation has the following form:

$$TEU_t(\text{global}) = 564.01 + 24.55 \cdot X_t \quad (2)$$

According to the estimated model, a statistically significant positive trend in container transshipment volumes can be observed in global ports, so that every subsequent year, an average increase in the volume of container transshipments by 24.55 mil TEU can be expected. The representative nature of the model is presented by means of the determination coefficient R^2 which is 98.37% for the estimated model, i.e. the estimated model interprets 98.37% of the sum of the square deviation of the container transshipment volumes from the arithmetic mean. The model is representative and has the property of a precise estimation of container transshipment volumes. The respective estimation model is reliable (R^2 is higher than 80%) (Rozga, 2017). The statistical significance of the trend model for the world as a whole is tested by means of the ANOVA test, as displayed in Table 2.

Table 2. ANOVA test for the global level

Indicator	Value
Correlation coefficient r	0.99
R ²	98.37%
Corrected R ²	98.23%
F (1.12)	724.06
p	<0.001
Standard error of the estimate	13.76

Source: Authors

On the basis of the empirical F-value 724.06 it was established that the model as a whole is statistically significant (empirical p-value <0.001).

4.2 Trend of the developments in container numbers in Canada

First, the link between the volumes of container transshipments in Canada and container transshipment volumes on global level has been tested. The connection between transshipment volumes in Canada and on global level has been examined by means of the Pearson correlation coefficient and displayed in Table 3.

Table 3. The Pearson correlation between container transshipment volumes in Canada and container transshipment volumes on global level

		Container traffic in Canada from 2010 until 2023 (mil TEU)
Global container traffic from 2010 until 2023 (mil TEU)	r	0.98
	p	<0.001

Source: Authors

The existence of a positive and strong statistically significant connection ($p < 0.001$) between container transshipment volumes in Canada and the volumes on global level is evident. The change in container transshipment volumes in Canada in the observed fourteen-year period has been analysed by applying the linear trend model, the regression coefficients of which, along with their parameters, are displayed in Table 4.

Table 4. Linear trend model for Canada

	B*	Standard error	B	Standard error	t(12)	p
Constant member			4.66	0.14	33.44	<0.001
Trend	0.96	0.09	0.22	0.02	10.96	<0.001

Source: Authors

The estimated model is as follows:

$$\text{TEUt (Canada)} = 4.66 + 0.22 \cdot \text{time}_t \tag{3}$$

i.e. the linear regression equation has the following form:

$$\text{TEUt (Canada)} = 4.66 + 0.22 \cdot X_t \tag{4}$$

According to the estimated model for Canada, a statistically significant positive trend in container transshipment volumes can be observed in Canadian ports, so that every subsequent year, an average increase in the volume of transshipments by 0.22 mil TEU can be expected. The representative nature of the model is presented by means of the determination coefficient R^2 which is 91.61% for the estimated model, which means that the estimated model interprets 91.61% of the sum of the square deviation of the transshipment volumes from the arithmetic mean. It has been established that the model is representative and that it also has the property of a precise estimate of the container number. The ANOVA test displayed in Table 5 tests the statistical significance of the model as a whole, and it has been established that the estimated model is statistically significant ($F=120.08$; $p<0.001$). It is a reliable estimation model, as R^2 is higher than 80%.

Table 5. ANOVA test for Canada

Indicator	Value
Correlation coefficient r	0.96
R^2	91.61%
Corrected R^2	90.85%
F (1.12)	120.08
p	<0.001
Standard estimation error	0.27

Source: Authors

On the basis of the empirical F-value 120.08 we established that the model as a whole is statistically significant (empirical p-value <0.001).

4.3 Discussion

The research established the presence of a positive trend in container transshipment volumes in Canada and on global level. The obtained results are in accordance with (Twrdy, Batista, 2016) who established, on the sample of the five maritime ports of Rijeka, Koper, Trieste, Venice and Ravenna, a positive trend in container transshipment volumes. Also, according to (Peng, Chu, 2009), by using the time series decomposition through application of the multiplicative method over the trend component, cycle component, season component and irregular component, it has been proven that the developments in container transshipment volumes can be modelled through time with a high degree of reliability, and the presence of

a statistically significant increase in container transshipment volumes through time has also been established. The obtained result is also in accordance with (Chou *et al.* 2008), indicating that, by using the time component, container transshipment volumes through time can be forecast, while a positive trend of container transshipment volumes was also established on the sample of Taiwan. (Huang *et al.*, 2014) established that by use of the time component, container transshipment volumes through time can be forecast, which is in accordance with this research. The research (Morales-Ramírez *et al.* 2025) also established the possibility of modelling container transshipment volumes by using the time component. The development of container transshipment volumes has also been affected by geopolitical events, such as economic recession, decline in investment spendings in the oil sector, decline in export and import as well as the COVID-19 pandemic.

5. CONCLUSION

After the conducted analysis, a trend of growth in container traffic has been established on global level, also including Canada. Global events can also affect container traffic, which was also evident, in the observed period, in 2020 during the COVID-19 pandemic, after which there was a swift recovery and increase in traffic as early as in the following year. The influence of the time variable of the trend on container transshipment volumes on global level and in Canada has been established. In this research, conducted on the basis of data stemming from the period between 2010 and 2023, also including the years of the COVID-19 pandemic, we established the representative nature of both estimated trend models by use of the determination coefficient R^2 , which amount to 98.37% for the estimated model on global level, whereas in relation to the trend model for Canada it is 91.61%. On the basis of an overview of the research conducted to-date and the available literature, it can be concluded that the research is most frequently aimed at the throughput and efficiency of maritime ports, while the container traffic of individual countries has not been researched to a sufficient extent, wherefore future research can be focused in this direction. In addition, future research can be focused on finding additional variables, apart from the time variable, which can also be used for forecasting container traffic on global level and in Canada. Also, if monthly or weekly data for Canada will be available over time, we will be able to compose a more precise model, which will then be able to predict container traffic in shorter time intervals than is the case with the present models. In the future development of the model, machine learning models can also be applied.

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SAŽETAK

U ovom radu analizira se trend kretanja opsega prekrcaja kontejnera u TEU jedinicama. Izrađeni su prognostički modeli za Kanadu i svijet kako bi se mogla utvrditi buduća propusnost kontejnerskih terminala. Korištena je metoda trend analize za procjenu kretanja varijable opsega prekrcaja kontejnera u TEU jedinicama. Upotrebom relativnog pokazatelja koeficijenta determinacije i koeficijenta varijacije ispitana je preciznost modela. Utvrđen je trend rasta opsega prekrcaja kontejnera u Kandi i svijetu što implicira na potrebu povećanja efikasnosti kod prekrcaja kontejnera odnosno porasta prekrcajnih kapaciteta. Trend modelom za svijet utvrđen je očekivan porast opsega prekrcaja kontejnera u lukama u prosjeku za 24,55 mil TEU u svakoj narednoj godini, dok je za Kanadu utvrđen očekivan porast opsega pretovara u prosjeku za 0,22 mil TEU u svakoj narednoj godini. Riječ je o reprezentativnim modelima s koeficijentom determinacije R^2 za svijet 98,37 %, odnosno 91,61 % za Kanadu temeljem čega se može utvrditi visoka protumačenost trenda kretanja opsega prekrcaja kontejnera za svaki od modela.

Ključne riječi: trend analiza, Kanada, svijet, TEU