Innovative Data Visualization Tools: Facilitating Logistics Management in Times of Crisis

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Abstract

This paper attempts to address the macroeconomic consequences of various crises impacting the economy, supply & demand balance, and supply chains. The authors, as a part of a joint logistic company-academia effort, enhanced the analytical potential in the field of data evaluation by providing a tool that monitors key indicators for road freight transportation across Europe. The tool, based on a vast dataset, calculates values for given places and time windows to visualize them on maps. Using it, we highlight the changes in the transport market, emerging in times of pandemic and afterward.

Keywords: Data Visualization, Crisis Management, Interactive Maps, Logistics.

1. Introduction

Transport plays a key role in a globalized economy. Supply chains enable logistics firms to cope with competitive environments, resulting in attractive prices to service recipients. Through their complexity, processes related to transportation are highly vulnerable to any external influence. As crises and their consequences are exceptionally difficult to predict, logistics management comes with economic risks that final customers are also exposed to. The COVID-19 was such a worldwide disruption. Focusing on the consequences of the pandemic for the transportation industry, not only a decrease in the volume of freight, but also a change in the average time of some activities done by people is reported [1]. Whereas Loske sees a spike in transported goods correlated with an increase in COVID-19 infections [2], a decline in demand for public passenger transport amounts to 80% [3]. Yet, the demand for water transport falls only by ~10%. Transport profitability grows at the peaks of pandemics [4]. Montoya-Torres et al. highlight a need to probe technology adoption/diffusion, knowledge creation, collaboration, and promoting awareness along supply chain stakeholders [5]. Post COVID-19, we began to seek solutions for improving crisis management for the future to come. A tool was created taking advantage of data collected throughout the years of the company's operation. It can visualize the trends observable in the geographic area of the company's presence. This paper discusses some of the phenomena revealed when working with it, in search of an answer to the questions: (1) to what extent are some processes in the transportation industry predictable? (2) does an insight into visualized data enhance company management in times of crisis?

2. Data Gathering Tool

The foundation of the created tool is the data: hundreds of thousands of transport offers evaluated by the staff of the authors' company. Information about loading places, dates, and prices are taken into account in further analysis. Its results are finally presented to the user on a graphical interface in the form of a colorful map. The map of Europe is divided into ten thousand points, according to the geographical coordinates net. For each of those points, in each time unit, several factors are counted for all transport offers appearing in that particular time and place, to be presented on a graphical map. Table 1 introduces the list of counted factors as well as the meaning of colors on the evaluated maps. The technological core of the tool is the real-time server, processing all the appearing offers in seconds, written in node.js technology. The data are then transferred to the computation scripts, working cyclically on the server, written in PHP language. The results are stored in an SQL database and presented on a Google map.

Table 1. Meaning of counted factors and colors visible on the maps.

Factor	Description	Unit	Red	Yellow	Green	Cyan	Blue
capacity	proportion between the number of offers from and offers to a particular place	Proportion	~4	~3	~2	~1	~0,2
earn	difference between the price offered by the client and the transport cost of the carrier	EUR	> 400	300	150	~0	< -100
rate from	average rate offered by clients for every kilometer of freight from a given place	EUR / km	> 1,6	~1,4	~1,2	~1	< 0,8
rate to	average rate offered by clients for every kilometer of freight to a given place	EUR / km	> 1,6	~1,4	~1,2	~1	< 0,8
wind direction	direction of a vector aggregating the directions of freights from a given location	Azimuth	~360	~270	~180	~90	~0
wind speed	length of a vector aggregating the directions of freights from a given location	km	> 700	~500	~300	~100	0
wind length	average length of transport offers to start in a given place	km	> 1200	~900	~600	~300	0

3. Findings

3.1. Discovered Patterns

Capacity. The map visualizing one of the scenarios revealed is shown in Fig. 1 (left). The values are translated into a scale of colors. The red color indicates a large surplus of loads from a given place against the number of vehicles available. In contrast, blue highlights locations where there are plenty of vehicles ready to take care of a specific load, but there are simply not enough items to be transported to take advantage of this capacity.

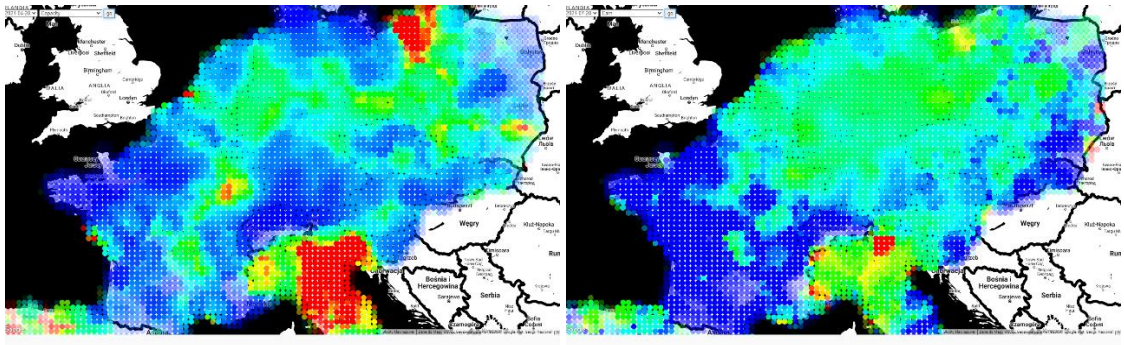

Fig. 1. Left: Capacity [map from April 2021]; right: Earn [map from July 2021].

Earn. The map with the most common situation is shown in Fig. 1 (right). Values are translated into a scale of colors. Red means the highest profit, and blue represents the lowest. It can be seen that some colors correspond to countries' borders.

Rate From. A typical map is shown in Fig. 2 (left). It is no surprise that the distribution of rates corresponds to the profits in Fig. 1 (right).

Freights To Rate. Exemplified in Fig. 2 (right). It is a stable trend to offer high profits for transports to places, from where it is difficult to find a profitable next freight or where

road tolls are higher, increasing freight costs. And low rates are incessantly offered for freights to places, from where a profitable next one can be easily found (northern Italy) or to places where carrier companies host their depots where they have to go back (Poland).

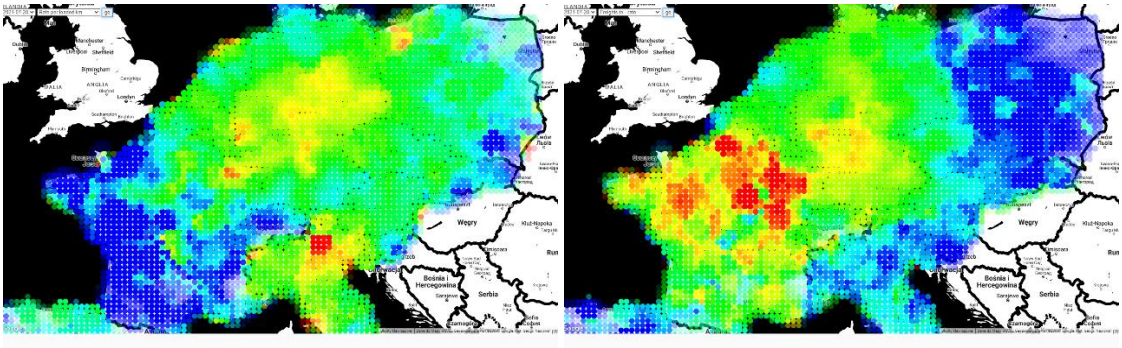

Fig. 2. Left: Rate From [map from July 2021]; right: Rate To [map from July 2021].

Wind Direction. The colors in Fig. 3 (left) represent the average directions of freights from all the places. The colors are distributed around some common centers***:*** the area of Frankfurt (Main) and Paris. The gradient of colors suggests that the dominant directions of freights in Europe are concentric**,** leading mainly to the places mentioned above.
Wind Speed. A typical map is shown in Fig. 3 (middle). The red color represents the longest average vector, which means long loads in similar directions. In contrast, the blue color means the average is short, which reflects freights in many different directions starting from a particular point. The map confirms that some centers in European road freight transport exist, where the goods are transported to from all over the continent, and from where other freights originate in all directions.

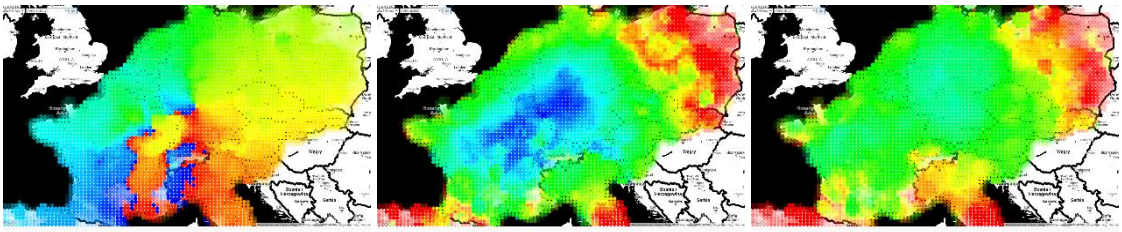

Fig. 3. Left: Wind Direction [July 2021]; middle: Wind Speed [July 2021]; right: Wind length [June 2021].

Wind Length. A typical map is shown in Fig. 3 (right). The rule here is remarkably similar to the previously discussed map, with the difference that the direction is not taken into account here. Red represents the longest average freight, and blue – the shortest. The map is another example of the phenomenon of central and peripheral regions that can be distinguished in Europe.

3.2. Extraordinary Changes

We observed some phenomena that are likely to be related to the current extraordinary situation. First of all, a strong anomaly in the number of offers from Poland against offers to Poland resulted in a deficiency of vehicles to transport the loads (red spots in Fig. 4). On top of that, an increase in rates by the end of 2021 is noticeable. Growing rates towards year-end are normal, but their spike has never been as significant as in the year 2021, presumably as a result of a huge increase in fuel prices (the effect is visible in Fig. 5). Another unusual increase in rates took place in the Spring of 2022, caused by the growth in fuel prices caused by the war in Ukraine. Gradual decentralization of the transport market is also being observed. It is a slow deconstruction of what we see in Fig. 3. Permanent centers in Germany and France still exist, but more such places appear on a limited scale. It is a relatively new phenomenon that needs further scrutinization. On the maps showing “wind speed” and “wind direction” (Fig. 6) new areas emerge from where freights in one direction do not prevail anymore, e.g. Austria – mixing of colors on the

left map and blue color on the middle map.

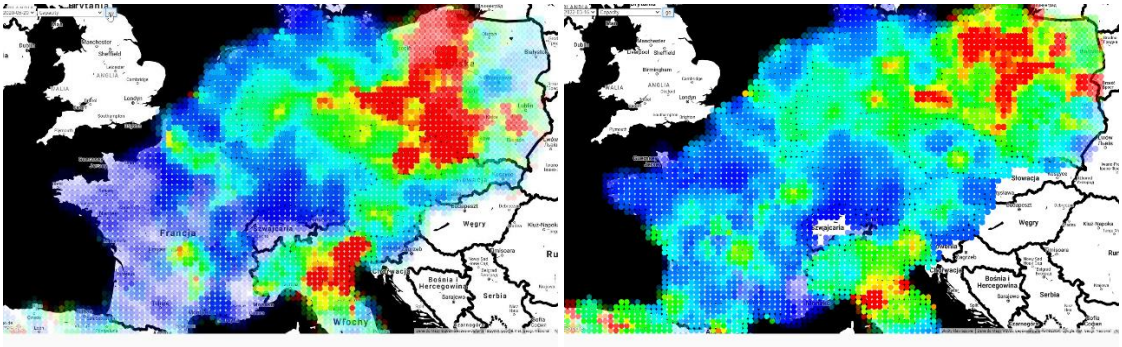

Fig. 4. Disproportion of loads from and to Poland. [left map: May 2020; right map: March 2022].

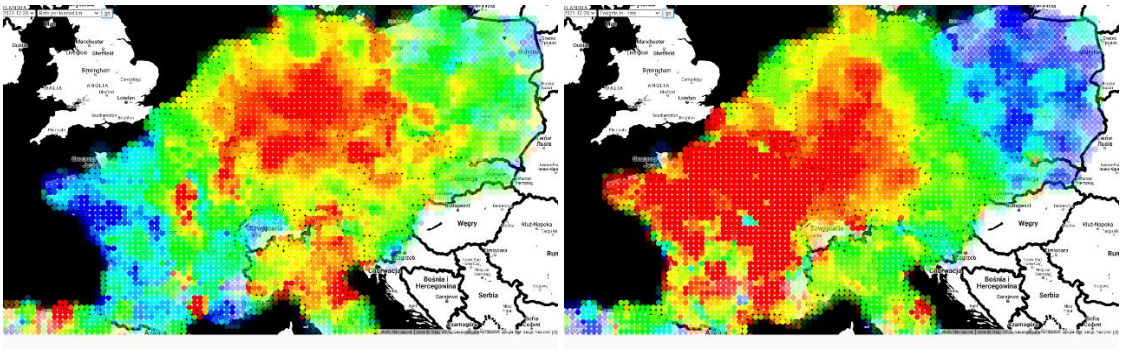

Fig. 5. Increase in rates in December 2021 [left map: average rates per km from a given place; right map: average rates per km to a given place].

Moreover, an increasing length of freights from the Benelux coast is observed. The spiking importance of ports in times of war might be considered probable cause. Fig. 6 (right) shows it as red and yellow in the Netherlands and Belgium (compared to Fig. 3).

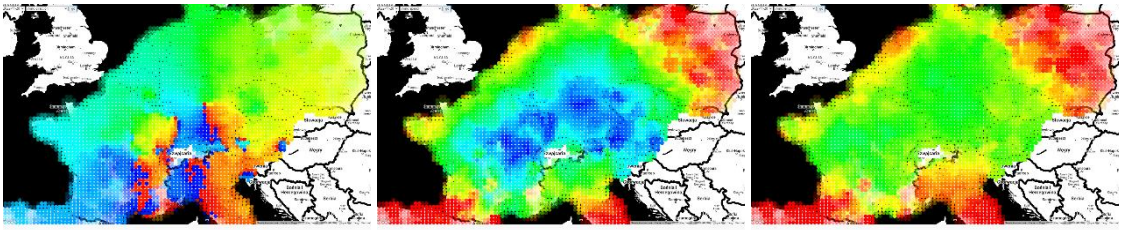

Fig. 6. Decentralization. Left map: the dominant direction of freights; middle map: "wind speed" – the sum of directions' vectors; right map: a likely spike in Benelux ports' importance [maps from November 2022].

References

1. Arellana, J., Márquez, L., Cantillo, V.: COVID-19 Outbreak in Colombia: An Analysis of Its Impacts on Transport Systems. J. Adv. Transp., article 8867316 (2020).
2. Loske, D.: The Impact of COVID-19 on Transport Volume and Freight Capacity Dynamics: An Empirical Analysis in German Food Retail Logistics. Transp. Res. Interdiscip. 6, article 100165 (2020).
3. Munawar, H.S., Khan, S.I., Qadir, Z., Kouzani, A.Z., Mahmud, M.A.P.: Insight into the Impact of COVID-19 on Australian Transportation Sector: An Economic and Community-based Perspective. Sustainability 13 (3), article 1276 (2021).
4. Shan-Ju, H., Wenwu, X., Wenmin, W., Chien-Chiang, L.: The Impact of COVID-19 on Freight Transport: Evidence from China. MethodsX 8, article 101200 (2020).
5. Montoya-Torres, J.R., Muñoz-Villamizar, A., Mejia-Argueta, C.: Mapping Research in Logistics and Supply Chain Management during COVID-19 Pandemic. Int. J. Logist. 26 (4), 421-441 (2023).