Supply Chain Mapping and Visualisation of UK Rail Sector

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Abstract
The UK government in 2018 announced a rail sector deal in conjunction with the UK Rail Industry and identified four key pillars to double export performance by 2025 (HM Government, 2018) as follows.

1. Digital transformation
2. Innovate intelligent mobility
3. Create sustainability in UK rail sector
4. Improve exports and investment

The area of research in this developmental paper is creation of a UK rail supply chain map to identify strengths and weaknesses to improve exports and investments thereby meeting objectives three and four. Authors involved in this project liaise with different stakeholders from Unipart Rail, Department for International Trade, Railway Industry Association, Department for Transport, Depart for Business, Energy and Industrial Strategy. This paper consists of a brief rationale for the project undertaking followed by an initial literature review to understand the historical importance of using big data analytics and visualisation in the rail industry in UK and globally. This paper will investigate and conduct data analytics methods to create a comprehensive supply chain visualisation through Microsoft Power BI. Outcome of supply chain mapping will aid towards improving the export capability of the UK Rail sector by enabling the stakeholders to identify strengths and weaknesses of suppliers in different geographic clusters.

Keyword: Rail Supply Chain, Big Data, Visualisation, UK Rail Sector
Track: Operations, Logistics and Supply Chain
Word Count: 2303 (excluding tables and references)

Introduction and Rationale

The organisational purpose of this research entails the UK government in joint collaboration with UK rail industry to double export performance by the year 2025. The aim of doubling export performance is not limited to increasing growth and productivity but also to insulate the UK rail supply chain against demand fluctuations in the domestic sector. An export working group was put in place to work towards this goal and explore three key elements as part of the research (HM Government, 2018)

I. Creation of a UK rail supply chain map to identify strengths and weaknesses
II. Analysis of international market opportunities and barriers
III. To create an export mentoring programme

The authors for their research have undertaken the task of creating a UK rail supply chain map to enable stakeholders and beneficiaries to identify strengths and weaknesses in various geographic clusters.

The scope of UK rail for the overall research covers light rail, metro, conventional mainline, freight and high-speed rail services and includes sub-sectors of supply chain like infrastructure builders/contractors, maintenance companies, vehicles, systems, components and raw materials manufacturers.

The theoretical rationale for this project can be understood from the explanation provided by (Minelli, et al., 2013) in their book on big data analytics. Minelli, et al., 2013 states that with advancements in technological innovations, the size of data sets also increases exponentially with size varying from one sector to another. They also argue that the complexity of big data is not the sheer volume of data but the actual usability of data to generate cost-effectiveness and reliability. Simultaneous with data capture, the need for visualising data also becomes equally important.

The aim of this project is to create a capability map of the UK Rail Supply Chain in order to identify strengths and weaknesses to improve export performance as part of the Rail Sector Deal initiative between the UK government and UK Rail Industry. The authors look to achieve the following objectives as part of this undertaking:

1. Conduct an extensive literature review to understand how data analytics and visualisation improve rail supply chain performance
2. Collate and categorise supplier data from project stakeholders to create a solid database for visualisation
3. Using data modelling techniques, create inter-relationships between supplier information
4. Visualise data using Microsoft Power BI by creating an interactive dashboard and supply chain map using geocodes

The remaining part of this paper is divided into different sections that provides a brief overview of initial literature review, methodology and conclusion.

Literature Review

The key objective of this research is to conduct a capability mapping of suppliers within the UK rail sector to visualise and create an interactive dashboard to achieve a collective objective of doubling export performance by the year 2025. To begin with, it is important to understand the definition and significance of big data analytics (BDA) and visualisation in the rail industry using case study examples where data analytics and visualisation was used in the commercial domain.

According to (Minelli, et al., 2013), big data can be defined as datasets whose size is beyond the capability of conventional ordinary software to capture, store and analyse. BDA has been the most focused and sought-after areas in academics and industry due to the rapid development of advanced technologies (Ghofrani, et al., 2018). Ghofrani, et al., 2018 in their study of data analytics in rail transportation surveyed 106 articles and concluded that the main type of analysis used in railway was descriptive followed by predictive analytics and prescriptive analytics were the least used. There are 5 main characteristics big data can be attributed with: volume, variety, velocity, veracity and value (Wamba, et al., 2015). The main characteristics relevant to this research are

a. Volume, considering the magnitude of data that is required to be modelled and visualised
b. Variety, considering the function of suppliers based on which data needs to be structured and classified according to tiers
c. Velocity, which is concerned with the speed of generating, structuring, modelling and visualising data to meet client deadlines

In their book, Minelli et al. (2013) has defined data visualisation as the technique of data identification using patterns and synthesis of data in a cohesive and comprehensible format using charts, graphs and interactive dashboards. The book goes on to identify different intents, styles or methods of explanation of data to be visualised namely (Minelli, et al., 2013)

I. Describing – method of providing a description to comprehend the basic meaning
II. Reporting – method of summarising findings over a timeline
III. Observing – method of viewing data to identify significant patterns over a timeline
IV. Discovering – method of exploring and interacting with data from various sources and deduce inter-relationships between them

There has been an increasing demand for BDA and data visualisation in rail transportation because of the necessity to improve customer satisfaction by providing safe and reliable services (Ghofrani, et al., 2018). Figure below shows an example of how data analytics is used for rail safety.

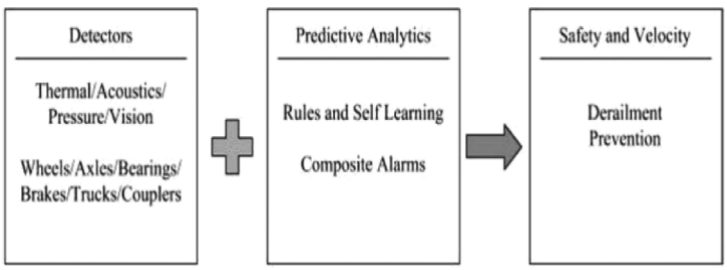

Figure 1 – Data Analytics for Safety (Land, et al., 2020)

Recently, BDA has been used to improve sustainability of rail transportation by focusing on important parameters like increased fuel efficiency, noise reduction, land use and pollution (Land, et al., 2020). Land, et al., 2020 studied these parameters across three dimensions, namely, people, planet/environment and profit in the American rail sector. In the people's dimension, BDA helped improve safety and reliability of rail travel using real-time data to improve risk analysis methods. From an environmental dimension, data analytics helped reduce particle emissions by 90% and annual emissions of nitrogen oxides by 80 tons and carbon monoxide by 12 tons per locomotive (Land, et al., 2020). In terms of profit, Land, et al., 2020 found out that as of 2017, an average of one ton of freight was transported with a fuel efficiency of 479 miles per gallon, which was double the performance capability of 1980.

Shifting the focus on to UK rail sector, a couple of examples are highlighted to show how BDA and visualisation have helped achieve major milestones for UK rail major Network Rail and their programmes.

In 2016, Network Rail associated with Deloitte to develop cloud based analytic systems to improve their network efficiency. Data analytics in this project utilised billions of data rows generated by the railway signalling system about train movement across various networks to validate timetable planning (Deloitte, 2016). The following outcomes were achieved using cloud-based data analytics (Deloitte, 2016)

- Improved train punctuality performance on approximately 7200 services (Deloitte, 2016) annually
- 1.3 million hours (Deloitte, 2016) saved in manual data processing times
- Enabled preparation of 18 months of data and analysis of over 9 million train services (Deloitte, 2016) in minutes which otherwise took days

Another example where big data and visual solutions were made use of was the Great Western Electrification Programme (GWEP) (Berryman & Cheung, 2020). Made up of approximately 200 multi-disciplinary projects, GWEP was a £3 billion pound undertaking by Network Rail to modernise and future-proof infrastructure between London and South Wales (Berryman & Cheung, 2020). This project generated a large volume of data over a period of 9 years, and it was imperative for the project management team to identify and document data on time due to multiple changes in teams and stakeholders over this course. Bentley's eB (businesswire, 2011) was used by Network Rail to create virtual structures for asset management and document control as a standardised approach to measurement because of the large number of suppliers that delivered complex work packages.

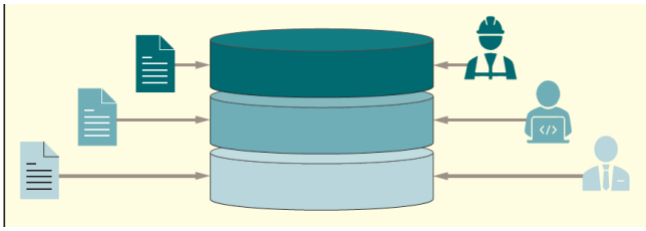

Figure 2 - Virtual Structure for Asset and Document Management (Berryman & Cheung, 2020)

The project also added around 20,000 new assets to Network Rail which generated nearly 500,000 unique documents (Berryman & Cheung, 2020), of which 30% were required to be distributed across various stakeholders and asset managers. In order to facilitate this task, Network Rail used the Logi platform and geocodes generated by Bentley eB to visualise asset

information on a map where a user could select any asset, zoom in and see progress and all associated documents related to that asset. An illustration of this model is shown in Figure 3.

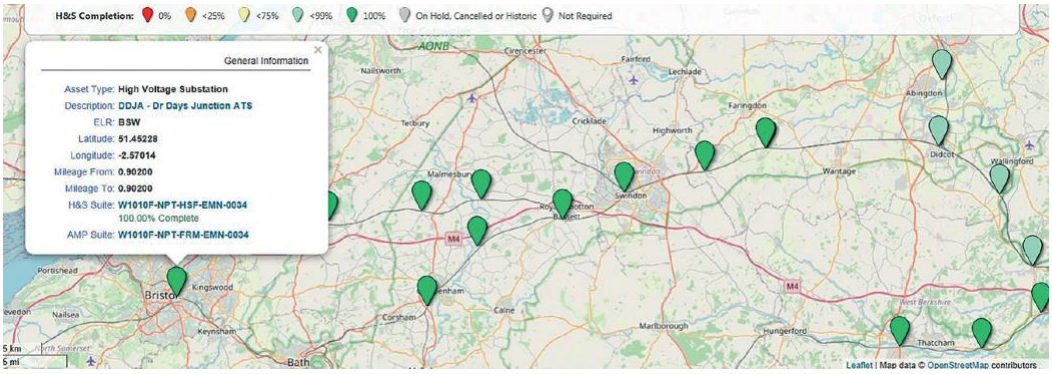

Figure 3 - Asset Data using geocodes (Berryman & Cheung, 2020)

The following highlights can be identified from the literature review:

- Big data analytics and visualisation have been used historically in optimising rail supply chain networks both in the UK and internationally

- Literature review has mainly focused on how BDA has helped rail industry to improve in areas of sustainability, safety and project management. Therefore, in view of drafting the final paper the authors have to investigate a higher volume of literature to understand how BDA and visualisation can be used with similar levels of historical efficacy at a macroscopic level to improve export performance within the supply chain.

Methodology

This paper will provide an overview of the research on the capability mapping of the existing UK rail sector using applied qualitative research. For the purpose of presentation, this paper will be developed simultaneously using progress made in the mapping exercise and supply chain visualisation will be presented at the conference. Research will involve the area of practices like big data analytics, modelling and visualisation using software tools.

Descriptive data analysis will be used to collect data, validate, model and visualise the supply chain. Outcome of the supply chain capability mapping will directly aid the export working group to identify strengths and weaknesses in the rail supply chain and suggest recommendations to improve export performance by increasing growth and productivity and reducing fluctuation of the existing supply chain against domestic UK rail demands.

Applied qualitative research using rail suppliers data provided by the export working group will be used to create the supply chain map. The supply chain map will be visualised using Microsoft Power BI tool because of its simple user interface and excellent integration with Excel, which will enable smooth import of data, and remote enhanced accessibility of business intelligence on smartphones, tablets and laptops.

Data for supply chain mapping will be collected using supplier data provided by rail operators like Network Rail, Unipart Rail and government data sources like DIT and BEIS. Data collected will then be read across FAME company database to collect relevant company information. The nature of data collected will include key company information like business name, location (city, post code, geocodes etc.), unique supplier registration number, type of

business, level of rail activity and export data. Data will then be categorised under various headers depending on their activity/service provided and this will be done in line with capability requirements laid out by the export group. Upon completion of this task, data will be imported into Microsoft Power BI and using the star schema dimensional data modelling technique, all supplier related information will then be visualised. With regular meetings with the export working group, this process will undergo multiple iterations to meet their requirements.

Visual Data Review

To evaluate the outcome of the visualisation task, the author will adopt the framework used by (Bresciani, et al., 2008). The produced output will be evaluated against the following attributes to ensure effective interaction between the output and export subgroup.

I. Visual Impact
   The visualisation will possess characteristics that will invite exploration from the users. Features like geographic mapping and graphical representation using necessary data filters and an overall dashboard with aesthetic appeal will aid in creating a visual impact.

II. Clarity
   The output will need to be repeatedly evaluated for its cognition to users at all levels. Visualisation will be self-explanatory, understandable and easy to navigate. This can be ensured by designing rigid data inter-relationships during the data modelling stage.

III. Modifiability
   The visualisation being an initial stage delivery will need to undergo further modifications to tailor to the requirements by the export subgroup. Therefore, the final output and files linked need to be presented in a manner that is easily modifiable by the end users.

Conclusion

This development paper details aim and objectives of creating a supply chain capability map and visualisation of the UK Rail Sector. This project is undertaken in the view of achieving the following outcomes:

1. Increase export performance of UK Rail Industry by 2025
2. Promote investments into UK rail
3. Improve growth and productivity by insulating UK rail supply chain against demand fluctuations in the domestic sector
4. Identify strengths and weaknesses in difference geographic competence clusters

The adopted research will have limitations of time constraints from the author leading to gaps in conducting larger research. Additionally, accuracy of supplier data categorisation may not be 100% as data providers have higher knowledge levels of individual supplier activities. Therefore, validation of data may be required in multiple iterations upon completion of project.

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