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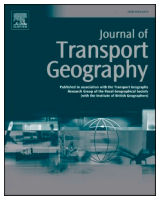

Regional resilience for rail freight transport

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ABSTRACT

This paper applies the concept of resilience to the rail freight industry, taking a regional perspective and considering the disturbances that have affected demand over a six year period from 2015 to 2021. This contrasts with many existing studies relating to rail freight which look at managerial factors or only consider short term disruptions. To overcome issues with data availability, four sample weeks were surveyed using online data sources, supplemented by secondary sources. Using the Cardiff Capital Region in Great Britain as an example, we show how the rail freight industry is particularly affected by disturbances in other sectors, due to the connecting role it plays, but also that some new growth paths have emerged. The number of trains operated decreased by 30% over the six year period, with significant declines in coal and automotive traffic following the closure of sources for freight. By contrast, intermodal has seen growth, due to wider economic conditions as well as policy disturbances. The study builds on existing rail freight research, the resilience perspective effectively highlighting that external disturbances affect demand over the long term. Such insights are valuable for regional transport policy makers, who often lack awareness of freight and logistics, as well as practitioners in engaging with regional bodies.

1. Introduction

Freight transport plays a critical role in the economy today, and the ability of the sector to respond to disturbances ensures the supply chains it supports function effectively. Although a small component of the whole sector, rail freight makes a valuable contribution, particularly in the movement of bulk products but also increasingly for manufactured goods through intermodal transport. In Great Britain (GB), the sector lifted 68.5 million tonnes in 2020, accounting for 4.8% of all goods lifted (ORR, 2022). The sector also contributes to the wider economy, and brought £2.45bn of benefits to the GB economy in 2018/19, three times operator revenues (RDG, 2021). Given the mix of products moved by rail, the sector is both influenced by wider industrial changes and competition with other modes. Over time, this has brought about significant changes in volumes moved, and the ability of the sector to respond reflects its resilience.

The concept of resilience in academic literature has a range of meanings. However, in the context of freight transport generally, the focus is often on short term, operational disruptions (Ta et al., 2009) although there are some studies that look at the longer-term development of market segments at a national level (e.g. Woodburn, 2012). However, as Hall and Hesse (2012) comment, there is an interaction between freight flows and the regions they move through, leading to local actions having an impact on these.

This paper draws from the regional resilience literature in economic geography when examining the rail freight sector. Martin (2012) identifies three different approaches to assessing resilience within this literature: (i) an engineering perspective, where following a disturbance, the system returns to its previous state; (ii) an ecological perspective, recognising that a system may have multiple equilibrium points and a disturbance leads to a change from one to another; and (iii) an evolutionary perspective, where systems adapt to withstand disruptions. This last perspective reflects the approach taken in this paper and therefore we use the definition of Martin (2012, p10): "*the capacity of a regional economy to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time*".

Therefore, this paper aims to examine the resilience of the rail freight sector at a regional level. Assessing resilience to longer term changes, and focused on a specific region is valuable for regional policy makers given their investment in transport network capacity, desire to reduce carbon emissions from transport, and financial support for the sector (e.g. through grants). The sector also supports the operations of other manufacturing and service businesses too. Academically, studies of the

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rail freight sector in transport geography are less common than for other modes (Rodrigue, 2006), despite the important role it plays. As context, we examine the Cardiff Capital Region (CCR), through which 10% of all rail freight lifted in GB passes (Network Rail, 2019). The CCR comprises 10 local authority areas within South East Wales and, with City Deal funding (UK Government, 2016), there is a focus on improving economic performance. Supporting this, the CCR has responsibility for coordinating investment in the transport network, in partnership with the Welsh Government (Cardiff Capital Region, 2021).

The paper proceeds by reviewing literature on factors affecting the demand for rail freight and giving an overview of resilience. We then outline the method adopted, before providing more details on the CCR setting for the work. Rail freight data and its analysis follows, leading to a discussion on the understanding gained on resilience in this sector, and the implications for policy makers and practitioners. The timeframe for this analysis is between 2015 and 2021, with additional data from 2019 and 2020. Finally, conclusions are drawn and future research outlined.

2. Literature review

The literature review begins by considering the factors that affect demand for rail freight, highlighting a particular focus on managerial decision making. This leads to a definition of resilience, and the application of this concept in understanding regions, sectors and freight transport.

2.1. Factors affecting demand for rail freight

When considering factors that influence the demand for rail freight, a common starting point is the modal choice literature from logistics management. This extensive body of work stretching back to the early 1970s (Hall and Wagner, 1996) has examined the factors considered by decision makers within organisations when choosing the mode of transport for their products. For example, Lirn and Wong (2013) provides a summary of 13 distinct studies in this area, listing 33 different factors which are then categorized as cost, cargo-related and carrier-related. A feature of these factors is that they are related to the movements at a firm level, and general ignore wider market influences on demand for freight transport.

In looking at the rail freight sector more widely, reports that holistically consider the sector within a specific country are common. For example, Network Rail (2013) provides a long term view for GB. These reports may focus on specific flows and/or sectors, but often aggregate data making it difficult to determine regional trends. Academic studies often look to disaggregate this data, looking at particular market segments of rail freight. There has been particular interest in the non-bulk/intermodal sectors, including studies that cover GB (Woodburn, 2012), USA (Spychalski and Thomchick, 2009) and Australia (Ghaderi et al., 2015). While the focus is often at a national level, there are some studies that consider specific flows, typically inland from seaports (Bergqvist and Woxenius, 2011; Woodburn, 2017).

Many of these studies extend the existing modal choice literature by reflecting on factors within the logistics network. For example, Woodburn (2006) highlights the services provided by rail freight operators and government support as influencing the decision to use intermodal transport by shippers, while wagon availability and gauge clearance are examples of operator constraints. Spychalski and Thomchick (2009) provide a broader framework, with globalization, trade flows and ICT developments identified as factors beyond the firm. Empirical examples of these factors include economic recession (Bergqvist and Woxenius, 2011), government policy (Woodburn, 2003), driver shortages in road haulage and severe service disruption (Woodburn, 2006).

What these studies often lack is a regional geographical focus despite the opportunities regional approaches offer in generating rail freight traffic (Gray et al., 2015) and evidence of regional policy development to support this (Haywood, 2003; Dablanc, 2009).

2.2. The concept of resilience

Resilience as a concept has emerged across a range of different scientific disciplines over recent years, as a way of considering the ability of a system to cope with disturbances. As noted earlier, three main perspectives have emerged in the context of economic geography (Martin, 2012) and this paper adopts an evolutionary view. As such, resilience of an economic system is multidimensional, encompassing resistance to and recovery from a disturbance, as well as re-orientation by adapting the economic structure and renewal by taking on new growth paths (Bristow and Healy, 2014; Boschma, 2015). These new growth paths are often shaped by pre-existing resources and capabilities in the region (Boschma, 2015). Disturbances can be caused by the market, competition and/or the wider socio-economic environment within which the system operates (Bristow and Healy, 2018; Soroka et al., 2020). Pendall et al. (2010) characterises disturbances as either a single “acute shock” or a “slow burn” that happens over a longer period. As Martin (2018) discusses, ‘slow burn’ issues can be related to disturbances and the ability of a system to adapt to these will affect the resilience. Fig. 1 shows how different bodies of resilience literature in transport and economic geography interact, and the focal position of the research in this paper.

There has been a significant growth in the focus on regional economic resilience. While much of the early work was on the resilience of the whole region, it is recognised that regions are a collection of individuals, organisations, industries, networks and institutions (Boschma, 2015). These different actors are constantly interacting, as well as demonstrating interdependencies, and therefore it becomes essential to relate resilience to these various actors (Bristow and Healy, 2014; Billington et al., 2017). This is particularly pertinent in the freight transport and logistics sector, which connects different industries together (Closs and Bolumole, 2015), yet is an aspect often overlooked in the regional resilience literature (Coe, 2014). In Fig. 1, freight transport and logistics is specifically identified to recognise that all regions will have interactions with this sector.

Focusing on the sectoral dimension, Fromhold-Eisebeth (2015) proposes a concept of sectoral resilience which takes a holistic view of an industry reflecting the supply chain(s) within which they operate. A key feature of their model, reflected in Fig. 1, is the intersection between sectoral and regional resilience. Sectors will typically operate across a range of regions, and therefore a disturbance in one of these may have consequences elsewhere. Equally, the interaction of the sector with other actors in a region will affect the level of resilience for that sector in a specific region (McLeod and Curtis, 2020). As an example, Vanthillo et al. (2018) highlight the co-evolution of chemical and freight transport industries in Antwerp as a chemical sector cluster emerged in the 1970s.

Mention should also be made of freight transport resilience. The concept is defined by Ta et al. (2009) as “the ability for the system to absorb the consequences of disruptions to reduce the impacts of disruptions and maintain freight mobility”. Here, the focus is very much on a return to the original state over a short or medium time frame, rather than looking at alternative growth paths over a longer term as in regional resilience literature. Three distinct components, infrastructure, infrastructure manager and users, are identified, with the resilience of each being important. For example, following an earthquake in 2016, the New Zealand wine sector faced significant logistical issues and, in resolving these, each of the components played a role in recovering to the original state (Cradock-Henry and Fountain, 2019). Focusing specifically on rail freight resilience, few studies exist. Chen and Miller-Hooks (2012) use operational research techniques to develop a measure to evaluate the resilience of an intermodal freight network, while Woodburn (2019) examines the rail freight sector response to a major, unforeseen rail line closure in Scotland. The latter study shows how rail freight services adapted in the aftermath of this ‘acute shock’, as well as considering any impact up to two years later.

The review of resilience has highlighted the lack of sectoral studies considering the freight transport sector (Coe, 2014), while

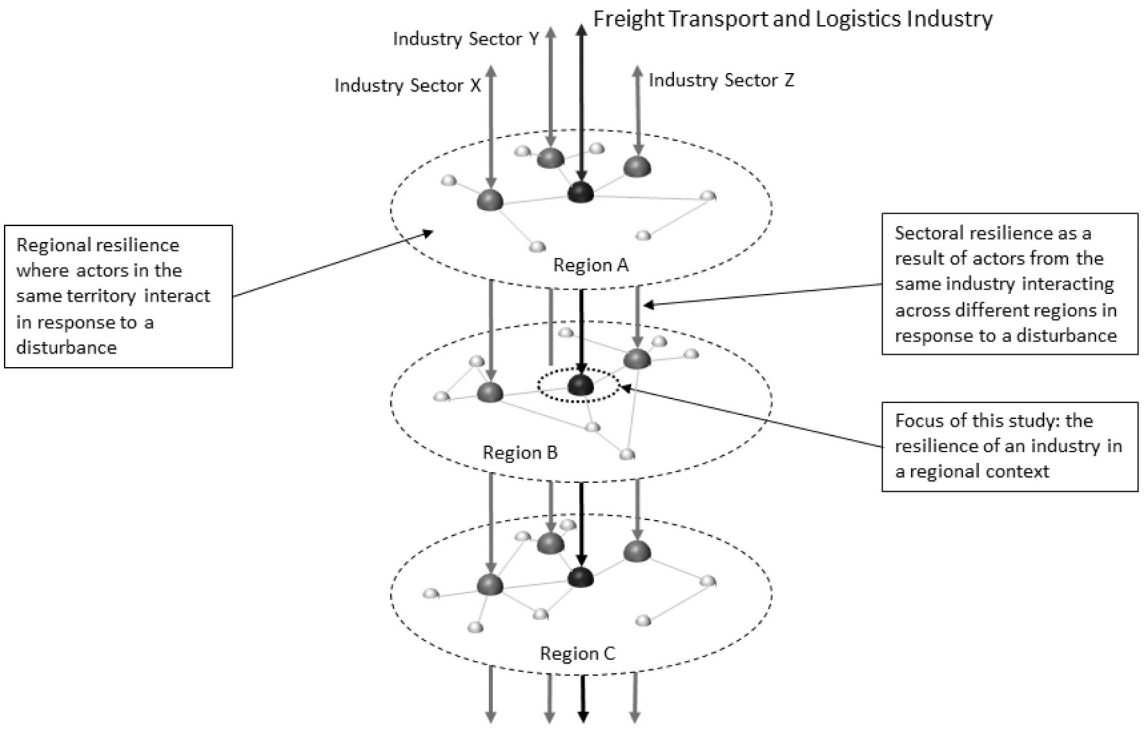

Fig. 1. The interaction between regional and sectoral resilience (adapted from Fromhold-Eisebeth, 2015).

demonstrating that sectoral resilience can vary between regions (Fromhold-Eisebeth, 2015). Analysing the regional-sectoral resilience of freight transport not only benefits those working in the sector, but also policy makers. To improve regional development, there is a need for policy makers to build on existing logistics competencies to support longer term economic goals (Closs and Bolumole, 2015; Heitz et al., 2020). Yet, there is also evidence that such policy makers often lack knowledge of freight transport (Ballantyne et al., 2013; McLeod and Curtis, 2020).

3. Method

Pendall et al. (2010) emphasise the importance of defining space and time when considering regional resilience. For this study, the 'space' is the CCR. This area sees significant rail freight volumes, covering both traditional bulk freight such as steel and non-bulk/intermodal products. The CCR is also developing a strong economic development role, including regional transport policy making. In terms of 'time', a six year time frame is considered, allowing time for 'slow burn' issues to have an impact while also capturing the effects of 'acute shocks' including the COVID-19 pandemic.

To understand the level of rail freight activity, we draw the approach taken by other studies of rail freight in GB (Woodburn, 2019). Because of the lack of archival published data, we collected open access real time information on freight train operations from https://www.realtimetrains.co.uk/ and http://charlwoodhouse.co.uk/rail/liverail. The former was used to collect data during 2015 and 2021 while the latter allows access to the same data for three years and was used for the 2019 and 2020 data collection. A cross-check on 2021 data was undertaken to ensure consistency between the two sources. Both of these sources use data from Network Rail, the infrastructure operator.

The data collection aimed to capture all freight trains operating within the CCR during these survey weeks. Therefore, census points were set at the main entry/exit locations for the rail network as well as two key locations (Newport and Cardiff) to capture any intra-region trains. Data for all freight trains passing each location was captured, with duplicate entries removed from the data set, for example, a transiting train would pass four of the census points.

Data collection took place for a randomly selected one week period during July 2015 and the equivalent weeks in July 2019, 2020 and 2021. In choosing to do the data collection in July only, it is acknowledged that the increased demand for coal in the winter would be missed. However, the period chosen also avoid disruption due to public holidays and, in 2015, also avoided any engineering works disrupting services. The final choice of starting on Monday 13th July was made randomly from a selection of dates at that time.

In choosing the length of the census period, it was important to balance the volume of data against the time required for the manual data collection process. One week ensures daily variations are captured, while monthly cycles are less prevalent. There is also consistency with other studies of GB rail freight activity in studying services over a week, albeit with a slightly different sampling approach (Woodburn, 2017). However, it is recognised that this approach may miss flows that do not run weekly. Therefore, data for the preceding and subsequent weeks for Newport station was captured to identify any additional flows. Only one such movement was observed, and this is noted in the results later. It should also be noted that occasional services may not be captured by the source websites, for example, if organised at very short notice or if a data outage occurred.

Each train was then checked to identify whether it was a commercial freight train (i.e. conveying wagons either loaded or empty), engineering train for maintaining the infrastructure, or locomotive positioning movement. The latter two categories were removed from the data set. While recording the number of trains gives a measure of activity, the movement of freight is more often more meaningfully evaluated in terms of the weight moved. As Woodburn (2015) notes, there are issues around commercial sensitivity given the competitive rail freight market and actual train loads cannot be obtained. Therefore, the planned trailing load for each train was recorded, based on the value recorded on source data websites. This information is normally used for timetabling purposes as, by reflecting the weight of the train (wagons and freight combined), it will influence the time taken to travel between locations on the rail network. It represents a maximum value for each train rather than the actual load moved for a particular service. Therefore, the

planned trailing load data will represent an overestimate of rail freight tonnages.

The main advantage of the planned trailing load data is that it does give an insight into key traffic flows in the absence of officially recorded data. Another advantage is that, by comparing inbound and outbound tonnages, it is possible to identify if flows are in both directions or just one – for locations such as Newport Docks which both receives and dispatches loaded trains at different times of the week, this distinction assists the analysis. A disadvantage is that the data is a maximum and also includes the weight of the wagons. Therefore, it can be difficult to determine both the maximum and actual weight of products being moved. Services on a specific flow tend to have the same weight every day regardless of actual load – for example, services between Wentloog and Felixstowe have the same planned trailing load but, as video evidence shows (https://youtu.be/ag472ZaFD-M), use of the available capacity varies by service. Further, although a service may stop enroute to add/detach wagons (many Tata Steel services from Port Talbot will also call at Llanwern), the planned trailing load remains the same throughout the journey.

Finally, we recorded the commodities on each train, using information from the source data websites, and secondary reports, such as news and magazine articles, and whether a train was loaded or empty, based upon the secondary sources plus planned trailing loads.

To provide some triangulation of the recorded data, online sources such as photo databases and videos were consulted. Services operating to, from or through the CCR during the sampled weeks were identified and cross-checked against the data as a way of confirming that services operated. The photos and videos also allowed confirmation of whether services ran loaded or empty, and the type of products conveyed. Between 5% (2015) and 21% (2019) of services could be identified in this way. Online photo and video searches were also used to check if any unrecorded services were operated, but none were found. A further check was to compare the number of arriving and departing services from each terminal to see if these were matched and, if not, whether such differences would be expected. For example, a flow with one loaded train per day could be expected to have an empty movement in opposite direction while flows with multiple frequencies per day (such as between the Tata Steel sites at Llanwern and Port Talbot) may have different numbers of services operating in each direction.

Reference was also made to a range of secondary data sources. These included government (UK and Welsh Government) documents such as policy statements, public meeting records and statistical releases, as well as articles from news media and trade publications. This breadth of more qualitative data contextualised the analysis of freight trains and enabled various disruptions to logistics operations through the CCR to be identified. The research team considered each of these and, through comparison with the collected data, looked to confirm if there was an impact on rail operations particularly in terms of any changes in the number of services and the terminals served within CCR. Each disruption was also categorized against criteria identified through the literature review, namely the source of the disruption (based on Soroka et al., 2020), whether the disruption type was an 'acute shock' or 'slow burn' (Pendall et al., 2010) and finally which component(s) of freight transport resilience were evident (based on Ta et al., 2009). From this assessment, a judgement could be made as to the resilience of the rail freight industry in the CCR.

4. Study context: Cardiff capital region

Fig. 2 shows the railway infrastructure in the CCR. The main route that crosses the region is the east-west South Wales Main Line. At the eastern end, the route splits in two, one route through Chepstow allowing trains to access the Midlands and north of England while the other goes through the Severn Tunnel towards Bristol and London, giving access to the south of England. To the west, the line continues to Swansea and West Wales. At Newport, the line through Abergavenny joins the main line, providing access to North West England and North Wales. Finally, there is a network of routes around Cardiff that owe their development to the extensive coal sector across South Wales in the early 20th Century but now predominantly serving commuters.

The rail infrastructure is predominantly under the control of Network Rail, a body of the UK Government, with freight terminals run by the private sector. Passenger rail operations are the responsibility of the Welsh Government while freight trains are run by private operators.

Regular data sets for rail freight are only collected at a GB level and Fig. 3 shows the number of freight trains, goods lifted and freight moved in GB between 2011/12 and 2020/21. However, limited figures for Wales are available as given in Table 1. For goods lifted, activity in Wales equates to about 10–15% of GB figures while for freight moved, it is 5–6%, with little change over the past 10 years. As a comparison, Wales accounts for around 4% of both goods lifted and freight moved by road in GB (DfT, 2021). Although these figures cover Wales as a whole, the majority of freight uses the rail network within the CCR. Predominant cargoes moved within Wales were steel, petrochemicals and coal

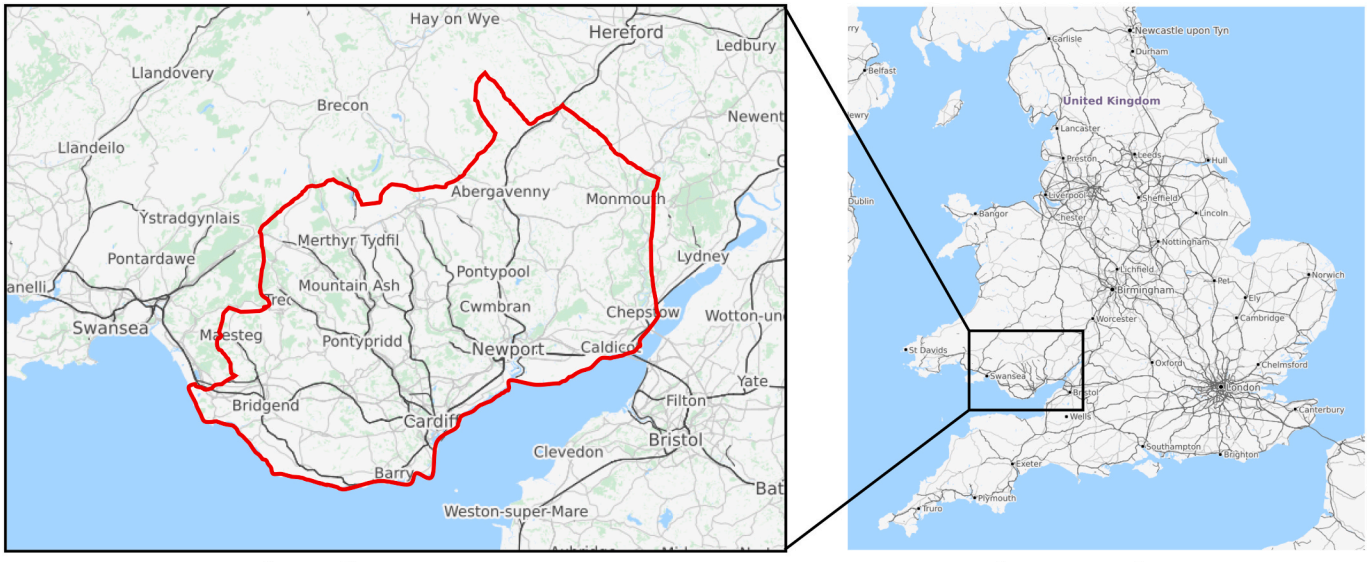

Fig. 2. Location of Cardiff Capital City Region and its rail network: adaptation of base map from openstreetmap.org (© OpenStreetMap contributors).

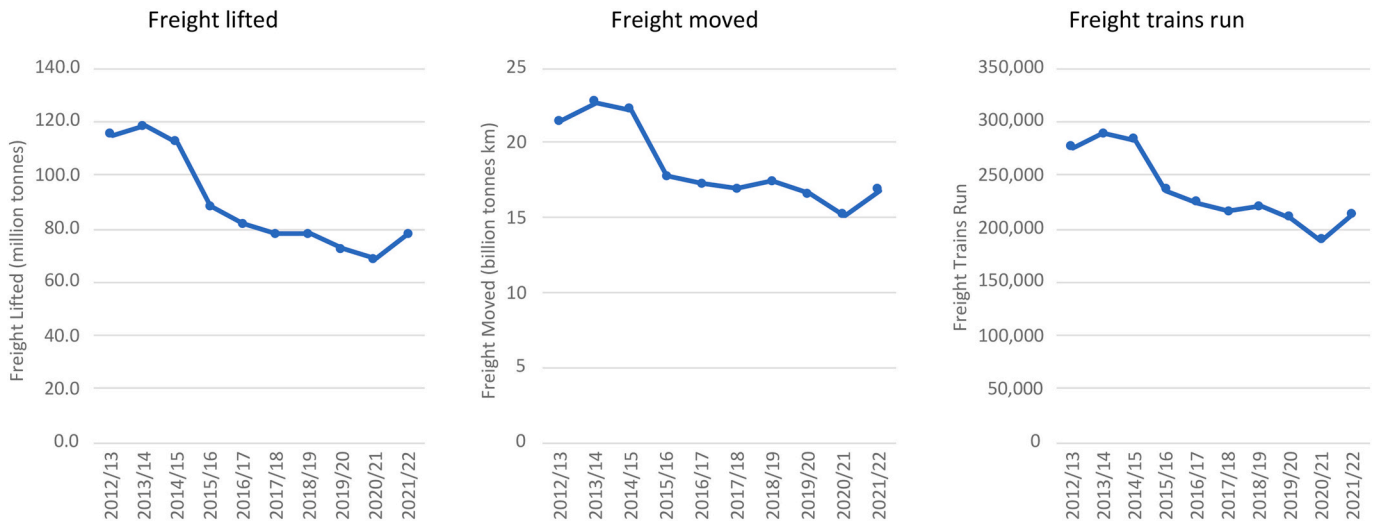

Fig. 3. Measures of GB rail freight activity, 2011/12 to 2020/21 (ORR, 2022).

Table 1
Rail freight activity in Wales.

Measure	Units	Year	Amount	% of GB rail freight [a]	Source
Goods lifted	Thousand net tonnes	2010/11	10,459	11.6%	Welsh Government, 2013
		2018/19	8100–18,200[b]	10.7-24.1%	MDS Transmodal, 2020
Freight moved	Million net tonne km	2012	1063	5.0%	Network Rail, 2016
		2019/20	1095	6.6%	Network Rail, 2020
		2020/21	881	5.8%	Transport for Wales, 2022

[a] Total GB rail freight statistics from ORR (2022).
[b] Estimated from mapped data.

(Network Rail, 2016).

5. Rail freight in CCR

Table 2 shows the total number of trains and the planned trailing weight recorded in the four sample weeks. There has been a decline in rail freight over the period, with a 30% drop in the number of trains and 26% reduction in gross tonnage. This suggests that, while the total number of trains has reduced, their planned trailing weight has increased slightly. As noted earlier, this represents a planned value and not the actual amount conveyed. To illustrate the geography of rail freight, Fig. 4 shows the location of the main customer terminals in CCR and the number of loaded trains to/from them. Note that freight marshalling yards are excluded from the map but are included in all other data tables. Table 3 shows where the freight trains in the CCR operate to in GB.

Table 4 shows a breakdown of the rail freight data by commodity. The steel sector was the biggest contributor to these traffic flows, with Tata Steel operating from several locations across South Wales, both within and outside the CCR, and Llanwern is the largest generator of rail freight traffic in the region, receiving semi-finished steel for further processing and despatch, by road and rail, to customers. Celsa Steel has a plant in Cardiff, mostly receiving scrap for processing although finished goods were also dispatched. Relating these flows to the geography of GB, most operate in a corridor through the West Midlands to either Yorkshire and the Humber or North East England.

In 2015, coal was the second largest generator of rail freight despite the decline of the sector since the 1980s, both originating from two coal mines and servicing the coal-fired power station in Aberthaw. By 2021, coal services had reduced by 79%, with Cwmbargoed coal mine generating the only traffic in the CCR. These flows have generally remained local, with most volume being used either in CCR or Wales more widely.

Other important commodities in CCR include intermodal, petrochemicals and aggregates. The intermodal terminal at Wentloog is the main container handling facility for South Wales and handled regular trains of imported containers from the Port of Southampton as well as a domestic intermodal flow on behalf of a grocery retailer. Growth to 2021 has come from new flows between Wentloog and the ports of Felixstowe and Tilbury, both located in the East of England region. Petrochemicals largely transit the CCR en-route from the large refinery complexes in Milford Haven to distribution points in southern England.

For aggregates, most trains are operated on a hub-and-spoke type operation, with the hub being a freight yard in the CCR. This gives the

Table 2
Weekly CCR freight train activity.

		Origin in CCR	Destination in CCR	Within CCR	Transit	Total
Number of trains	July 2015	84	87	68	125	364
	July 2019	85	92	23	113	313
	July 2020	75	76	25	83	259
	July 2021	72	74	19	88	253
	% Change 2015–2021	*−14%*	*−15%*	*−72%*	*−30%*	*−30%*
Planned Trailing Load (000 t)	July 2015	86.7	146.7	82.4	188.5	503.2
	July 2019	106.8	148.8	32.8	170.9	459.1
	July 2020	100.6	122.9	33.4	134.3	391.1
	July 2021	84.2	132.6	21.2	137.3	374.1
	% Change 2015–2021	*−3%*	*−10%*	*−74%*	*−27%*	*−26%*

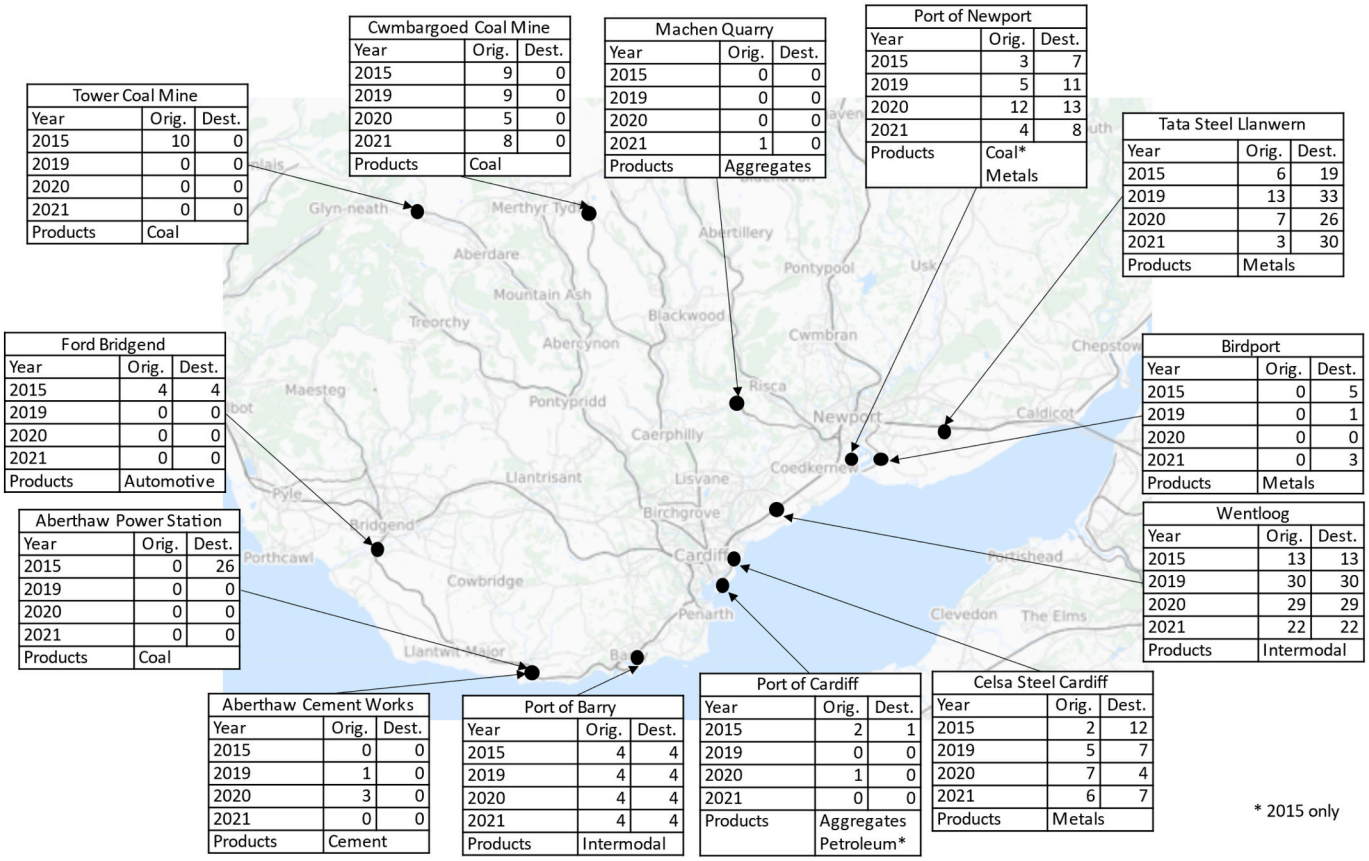

Fig. 4. Terminals for rail freight in the CCR.

rail freight customer flexibility on the source, either Wales or West Midlands, and destination of flows, depending upon their requirements for stone. High demand for aggregates has seen Machen quarry restart rail movements in 2021. Aggregate flows from the North West are limestone used in crude steel production. One flow not captured every year is that between Cardiff Docks and Avonmouth. This runs approximately twice per month and was only present in the census week in 2015 and 2020.

Of the remaining commodities, automotive traffic no longer uses rail due to the closure of Ford Bridgend and therefore, because of changes by the rail freight operator, there has been a consequential impact on the number of mixed commodity trains.

6. Disturbances affecting CCR rail freight

We now reflect upon some disturbances that have happened during the period studied. These are summarised in Table 5, and categorized based on the literature reviewed. The source of disturbance is based upon work by Soroka et al. (2020) while the type of disturbance reflects the classification by Pendall et al. (2010). Finally, the freight transport resilience component is taken from Ta et al. (2009). Recognising that the impact from disturbances may take time to manifest themselves, Table 5 also considers future implications for the rail freight sector in CCR.

The biggest disturbances have affected the coal sector, both in terms of supply and demand. On the supply side, Tower Coal Mine closed in 2018 when its operating licence ended. The Welsh Government took over responsibility for issuing licences for coal mining in 2018, and has subsequently stated that no new mines will be authorised (Welsh Government, 2021a). Therefore, these flows will diminish further in the early 2020s when coal mining ceases altogether. On the demand side, in 2013 the UK Government introduced the Carbon Price Support tax to reflect the environmental impact from burning fossil fuels (Hirst, 2018). This increased significantly in April 2015 and impacted the viability of using coal for electricity generation. Consequently, Aberthaw power station closed in December 2019 (Clowes, 2019). Although triggered by a single disturbance, the time taken for these policy changes to be implemented are more reflective of a 'slow burn'. The impact from these disturbances is particularly concentrated in CCR and Wales, given the lack of significant coal traffic to other areas of GB, with 79% of the coal related services no longer running.

Steel traffic has also declined, although the decline is reflective of the drop in steel production in Wales between 2015 and 2021 where output volumes have dropped around 10%, due to Brexit and COVID-19 (StatsWales, 2022; Munday and Turner, 2020). Gross trailing loads for steel trains in CCR have reduced by a similar amount. Throughout the period, there has been both uncertainty (Ruddick, 2016) and optimism (Farrell, 2017), and this remains so today. Munday and Turner (2020) outline several future scenarios for the steel sector in South Wales, all of which would have implications for rail freight. For example, a conversion in production technology towards recycled steel could increase freight volumes of both raw materials and finished products. By contrast, retaining existing technology only is predicted to reduce output, with a consequential impact on rail freight both to Llanwern and more widely. Steel flows through CCR have a wide geographical spread in GB, and therefore disturbances may be felt in different regions. Equally, changes elsewhere may have consequences for activity in CCR.

Another significant disturbance was the closure by Ford of their Bridgend engine factory (BBC News, 2020). In 2015, this supported four trains per week to a similar factory in London, before shipping engines to car assembly locations. Because of the volumes moved, this traffic was combined with other flows on its journey (this mixed service being referenced in Woodburn, 2015). By reconfiguring rail freight operations, some of this other traffic has been retained, reducing the consequential impacts from the factory closure. For example, intermodal traffic to the

Table 3
GB origins/destinations of CCR rail freight traffic.

	No. of trains								Planned Trailing Load (000 t)								Main Product(s)
	July 2015		July 2019		July 2020		July 2021		July 2015		July 2019		July 2020		July 2021		
	Origin	Dest.	Origin	Dest.	Origin	Dest.	Origin	Dest.	Origin	Dest.	Origin	Dest.	Origin	Dest.	Origin	Dest.	
East Midlands	20	16	15	16	11	14	13	14	22.4	25.8	15.6	27.0	10.6	24.2	13.8	22.6	Intermodal, Steel
East of England	3	8	12	12	15	13	6	7	2.0	12.6	14.7	15.9	19.5	17.4	8.0	10.3	Intermodal
London	6	4	2	6	5	6	0	2	4.1	7.4	1.2	12.0	3.0	12.2	0	4.0	Aggregates
North East	7	9	10	10	8	6	6	7	11.6	13.6	16.8	17.6	12.4	10.8	10.0	12.0	Steel
North West	7	5	3	3	3	5	3	3	7.0	5.5	1.8	4.5	3.6	8.5	3.6	4.5	Aggregates
Scotland	0	3	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	–
South East	17	18	12	13	11	10	11	11	22.7	29.5	14.2	22.1	13.6	16.6	12.7	19.9	Intermodal, Petrochemicals
South West	19	19	22	16	11	10	10	10	19.3	26.9	16.2	32.6	7.2	22.4	7.5	24.2	Petrochemicals
Wales (excluding CCR)	103	98	103	95	80	76	91	83	206.4	104.2	206.7	101.2	168.1	89.8	183.5	85.8	Coal, Steel, Petrochemicals
West Midlands	22	20	15	16	8	8	13	14	25.1	33.9	15.4	26.4	7.6	15.6	10.6	27.6	Aggregates, Steel
Yorkshire and Humber	8	9	11	11	7	10	9	9	13.5	11.5	17.0	18.3	11.6	17.4	19.6	10.6	Steel

Port of Barry is now conveyed in an extension of a Wentloog train, rather than being combined with the Ford traffic. Since the closure, no automotive traffic now uses the CCR rail network.

The above are particularly driven by the sectors that rail freight supports. There are also some disturbances from the wider socio-economic environment that have impacted upon rail freight volumes in the CCR. The first of these is the removal of tolls from the M4 motorway bridge where it crosses the River Severn. In 2015, the toll for a truck was £19.60. However, the tolls were removed in January 2018 with concerns at the time about the transfer of freight from rail to road as a result (van Leijen, 2017). However, there does not appear to have been a significant impact and, in fact, the service between Bristol and Felixstowe transferred to Wentloog (Giles, 2019). One reason for this was that, because removing the tolls lowered the cost of road transport from CCR to Bristol, consolidating operations in one place became viable. This has contributed to the 38% growth of intermodal services within CCR, and with up to two trains per day to Felixstowe during July 2020.

Another 'slow burn' disturbance relating to the ability of rail to retain freight has been congestion on the M4 motorway around Newport. Congestion here has been a long term issue, and plans existed for a relief road to be built to improve traffic flow (Henry, 2014). However, the proposed M4 Relief Road around Newport was scrapped (BBC News, 2019), replaced by a proposal by both the Welsh Government and the CCR to significantly improve to public transport in the area (South East Wales Transport Commission, 2020). Although the impact during the studied period is negligible, there are potential disturbances in the future as infrastructure capacity is constrained and some of the proposals will conflict with existing rail freight operations (Walton, 2021). The wide spread of destinations across GB that trains operate to may constrain the ability of operators to respond to constraints in CCR, as services will travel through locations in other regions where infrastructure is also constrained. There is also potential misalignment with wider Welsh Government priorities, with a recent transport strategy looking to increase the movement of passengers by more sustainable modes such as rail (Welsh Government, 2021b).

Finally, the timing of the study is such that the impact of COVID-19 pandemic can be considered. Looking at Table 2, there was a 17% reduction in services between 2019 and 2020 for the census week, with a further reduction to 2021. As a comparison, the annual figures at a UK level between 2019/20 and 2020/21 (Fig. 3) reduced by 10% but have since recovered. This suggests COVID related changes are taking longer to recover from in CCR compared to other parts of GB. Of the main rail freight commodities, Munday and Turner (2020) identify a drop in steel production due to the pandemic and this is also likely to have impacted remaining coal traffic too. In July 2020, there was a reduction in petroleum trains operated, likely due to reduced motor vehicle use at this time, and this traffic has returned to previous levels in 2021. Intermodal services grew significantly during 2020, offsetting some of these losses, but have the declined in 2021. This may be related to the economy, but also may reflect capacity constraints elsewhere (such as on the access route to Felixstowe) plus shortages of truck drivers, leading to operators prioritising train paths for other services.

7. Discussion and implications

In evaluating the resilience of the rail freight sector in the CCR, we refer back to the four aspects that reflect the multidimensional nature of this concept (Martin, 2012). The first is resistance, where it is clear that the rail freight industry is often unable to avoid significant impacts from disruptions. There has been a significant drop in output largely due to the decline of the coal sector, although changes in steel production volumes have also affected traffic. Resistance in the CCR case relates to market changes, and these are often 'slow burn' in nature. The reason for this is that demand for moving freight is a derived demand and so, when an industrial sector stops or reduces its activity, there is a consequential impact on transport movements. The rail freight sector is particularly

Table 4
Weekly CCR rail freight activity by commodity.

	Number of trains					Planned trailing load (000 t)				
	July 2015	July 2019	July 2020	July 2021	Change 2015–2021	July 2015	July 2019	July 2020	July 2021	Change 2015–2021
Aggregates	22	35	34	16	*−33%*	28.1	43.5	42.1	19.8	*−32%*
Automotive	14	0	0	0	*−100%*	10.0	0	0	0	*−100%*
Coal	76	25	13	16	*−79%*	94.0	35.2	17.6	21.6	*−77%*
Intermodal	32	60	58	44	*+38%*	43.5	73.7	73.5	54.3	*+25%*
Steel	170	154	127	144	*−15%*	251.8	248.1	218.4	229.2	*−9%*
Mixed	20	9	5	2	*−90%*	31.4	14.3	7.0	2.8	*−91%*
Petroleum	20	22	16	22	*+10%*	32.4	38.2	27.8	37.4	*+15%*
Other	10	8	6	9	*+13%*	11.9	6.2	4.8	9.0	*−3%*

Table 5
Summary of disturbances affecting rail freight in the CCR.

Disturbance	Source of disturbance			Type of disturbance		Freight transport resilience component			Impact 2015 to 2021	Future impact
	Market	Competition	Wider Environment	Acute Shock	Slow Burn	Infrastructure	Infrastructure Manager	Users		
End of coal mining licences	X				X			X	Negative (10 services/week) due to the closure of Tower Coal Mine.	The Welsh Government will issue no new mining licences, so all coal mines will close by the end of 2022.
Carbon tax on coal power generation	X		X		X			X	Severely negative (60 services/week), as the increased tax affected the viability of coal fired power sources.	May impact on steel production, although any change will likely be linked to wider developments in the steel sector.
Uncertainty in the steel sector	X				X			X	Negative (34 services/week), with continued uncertainty due to steel market pressures reducing production output in Wales.	Various potential future scenarios which could lead to both positive and negative outcomes for rail freight.
Closure of Ford Bridgend	X			X				X	Negative (8 services/week), although some service changes to retain other traffic that shared the train.	Site remains rail connected although a new user has yet to be found.
Removal of Severn Bridge Tolls		X	X	X			X		Positive (6 services/week), with a service between CCR and Felixstowe starting while no discernible changes to other rail freight flows.	Unlikely to lead to further developments due to time since the disturbance occurred.
M4 congestion around Newport		X	X		X	X	X		None, despite the current situation affecting the competitive position of road transport.	Depends upon the allocation of infrastructure capacity to passenger trains, and any consequences for the competitiveness of rail freight.
COVID-19 pandemic			X	X				X	Negative (around 50 services/week) with reduced production in the steel sector and lower demand for petroleum particular factors.	Any impact will likely be linked to the long term impact of the pandemic on the global economy, and any shifts in production that occur as a result.

affected by this as many wagons are specific to particular commodities whereas, for example, a goods vehicle trailer may be used by a variety of commodities. There is no evidence currently of recovery within the markets where significant disturbances have occurred. Looking forwards, movements of coal are likely to reduce further and there is no indication of automotive traffic restarting. There is clearly a strong reliance now on the steel sector with over 50% of trains being linked to this sector. However, this is an industry where prospects in the long run appear to remain mixed.

The other two aspects of resilience are reorientation and renewal, and there is evidence of these occurring. In terms of reorientation, there have been new intermodal movements between Wentloog and

Felixstowe, and changes to operating practices to ensure the continued movement by rail of containers to the Port of Barry as well as enabling new flows from Machen quarry. While other changes in aggregate movements have affected overall demand, there is growth in intermodal and these trains now account for 17% of movements in CCR, and GB wide forecasts suggest further growth is possible (Network Rail, 2013). Therefore, some evidence of renewal is present, even though overall rail freight activity levels in CCR are significantly reduced from 2015.

By focusing on the important regional-sectoral interactions that affect resilience, this study has particularly identified the significance of the market and wider socio-economic environment in affecting rail freight traffic. As identified earlier, much of the extant literature relating to rail freight focuses more on managerial decision making and makes less mention of these wider sources of disturbance. Previous studies of rail freight in GB (such as Woodburn, 2012 and Network Rail, 2013) have tended to focus on nationwide markets, such as intermodal. For a region such as CCR, traditional bulk commodities are more significant and lead to different challenges for rail freight managers and policy makers.

Another important aspect highlighted by Fromhold-Eisebeth (2015) is that the response of actors within a sector and region can have consequences for other regions. The CCR data shows this through the range of locations to which rail freight services operate. For example, steel trains in CCR also operate to other areas associated with the steel sector, such North East England. Changes to the structure of the production networks in these areas affect not only the rail freight services to these specific regions but other regions through which the services pass. Therefore, the resilience consequences of production changes can be more widely felt in freight transport than when just considering manufacturing sectors.

More generally, the study highlights the dynamics that exist between sectoral and regional resilience. Fromhold-Eisebeth (2015) particularly highlights how, with global production networks, a disturbance that affects a sector can have an influence across all the regions that the sector operates in. This study illustrates how disturbances in one sector can have consequences for other sectors that are connected, both directly and indirectly. For example, the changes in the coal sector have significantly impacted the number of freight trains operated and volumes moved. In the automotive sector, the closure of the Ford Bridgend plant not only impacted rail freight operators but also other firms that shared those resources. This reflects the strong connecting role of freight transport and logistics, with interdependence between the sector and major industries (Closs and Bolumole, 2015). Finally, there are region specific disturbances that can have more localised consequences only. For example, the removal of the Severn Bridge tolls increased rail freight activity in CCR, but at the expense of the neighbouring Bristol/South West region.

Turning to implications for policy makers, there is a need to understand rail freight in more detail to avoid tensions when considering the use of constrained rail infrastructure. This is demonstrated in the CCR through the proposals by the South East Wales Transport Commission (2020) to increase passenger services, taking capacity on lines currently allocated to freight. Such a lack of consideration for freight is not uncommon in regional transport policy making (Ballantyne et al., 2013). The consequences of such decisions can be felt across all regions within which services affected operate. Policy makers also need to consider how to improve the availability of rail freight data to make informed decisions. In the context of GB, this study reinforces the concerns raised previously about this issue by Woodburn (2015). However, this is not a unique situation with Dablanc (2009) identifying similar issues in France.

For managers working in the rail freight sector, the increasing devolution of transport governance to regional authorities means that there is a need to engage effectively with these sub-national bodies, therefore ensuring that the importance of the sector is fully understood. Thinking about resilience and the external factors that affect this will also help to ensure that appropriate investment decisions are made. Purchasing a new wagon fleet can be expensive and with risk if it is for a traffic flow where there may be continuing market uncertainty. Therefore, operators may look at extending the life of existing assets. For example, DB Cargo have converted covered steel coil wagons into open wagons, reflecting changing market requirements while not purchasing new rolling stock (Global Railway Review, 2021). These wagons transit the CCR.

Any changes to services will also have implications for timetabling. If there is a substantial reduction in services, then it may be that the train paths used will need to be relinquished for other operators, including passenger services. This may constrain operators for future opportunities, and reflects the dependency that influences resilience. In the context of this study, the South East Wales Transport Commission (2020) identified a significant number of unused freight paths and suggested these be used for enhanced passenger services. By contrast, operating new services may be challenging, particularly if they are over a long distance and travel through bottlenecks on the rail network. This may see compromises in timetabling, resulting in less than ideal journey times. Managing timetables and train path availability requires cooperation between rail freight operators and the infrastructure owner.

8. Conclusions

This paper has looked to advance thinking on rail freight transport, by focusing on the resilience of the sector. In doing so, the work also emphasises the value in looking regionally rather than just nationally. This reflects the different mix of industrial sectors in regions, as well as the increasingly devolved nature of policy making. We focus on the CCR in South Wales, where there is significant rail freight activity and a strong reliance on traditional bulk cargos. In this environment, we identify that the resilience of the rail freight sector is heavily dependent on a small number of key sectors and so, because of disturbances to these industrial sectors, the rail freight sector has been unable to resist change or demonstrate recovery. However, there is evidence of re-orientation and renewal along new growth paths, particularly in intermodal freight. While focusing on the CCR, over 90% of services have an origin or destination outside the region. Therefore, the CCR provides a vivid illustration of the interactions and dependencies between sectors and regions, in part because of the connection that logistics provides between industrial sectors.

The paper contributes to the literature by focusing on resilience within a specific geographical region. Existing research predominantly focuses on managerial factors behind the choice to use rail freight, with limited mention of the wider factors that affect this decision making. Further, the emphasis is often at a national level and intermodal freight, while in practice there are often significant regional differences that exist, reflecting the structure of production networks. The work highlights the continued importance of traditional cargos to the rail freight sector, and how the rail freight sector often has to respond to significant disturbances that are beyond their control. Further, research relating specifically to freight transport resilience tends to focus on what Pendall et al. (2010) term “acute shocks” while this study has shown that “slow burn” disturbances can actually have a significant long term impact.

This work provides an initial evaluation of rail freight resilience in a regional context, and there are opportunities to take this concept further forward. With a reliance on predominantly archival and secondary data, undertaking primary data collection such as through interviews would offer richer insights. In doing so, there would be a need to engage with a wide range of agents within the focal region, including sectors that use rail freight and policy makers. Collecting broader, more detailed data sets on rail freight activity would also be valuable, recognising existing challenges that result in more ad-hoc data collection.

We finish with a short reflection on the approach taken in this paper, and provide some thoughts for those wishing to undertake a similar study. Creating the data set manually required tacit knowledge about

what data sources are available and how to interpret them. While we felt confident in the approach taken, new potential data sources and issues with the collected data emerged as the research progressed. Engaging with those familiar with the data sources at an earlier stage may have helped. The initial work in 2015 was intended to get insights into activity at that time, and was not the starting point for a longitudinal study. It was only later, as we noted changes in rail freight activity and how that related to the wider economy, that the need for more regular data collection arose. With hindsight, more regular data collection would have been useful. Finally, we would encourage those creating data sets from online sources to be mindful of the time and resources it can take. Throughout the process, we retained a manual approach but other researchers may consider using data scraping tools to scale up data collection. While appropriate, we would caution that there are technical, legal and ethical considerations in using data scraping, as summarised by Luscombe et al. (2022).

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CRediT authorship contribution statement

Andrew Potter: Conceptualization, Methodology, Investigation, Writing – original draft. **Anthony Soroka:** Conceptualization, Writing – review & editing. **Mohamed Naim:** Conceptualization, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

None.

Data availability

Information on the data underpinning the results presented here, including how to access them, can be found in the Cardiff University data catalogue at https://dx.doi.org/10.17035/d.2022.0217445300.

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