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Investigating the impact of bank branch closures on access to financial services in the early stages of the COVID-19 pandemic

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ABSTRACT

There is a longstanding policy interest in understanding the impacts of changes in access to public and private services in rural areas. To date much of the empirical analysis concerning changing patterns of accessibility has been predicated on assumptions regarding the mode of transport used to access such facilities. The availability of new and open sources of data, and the increasing sophistication of spatial analytical tools, has enabled alternative transportation modes to be included when investigating the impact of service changes. In this study a nationwide analysis of changes in public transport provision and bank closures has enabled the identification of those parts of Wales that were disproportionally impacted by the loss of financial services during the early years of the COVID-19 pandemic. Drawing on local scenarios which show the combined impact of such changes, the findings demonstrate how temporal variations in accessibility can be used to examine potential patterns of exclusion that arise from the loss of key services. We conclude by suggesting that any assessment of changes in accessibility needs a holistic approach that considers changes in the transport infrastructure alongside other facets of service provision to understand the full impact of such closures on rural communities.

1. Introduction

1.1. Measures of access to rural services

Farrington and Farrington (2005; p. 2) define accessibility as "the ability of people to reach and engage in opportunities and activities" and early empirical approaches often relied on relatively easily calculated metrics to examine spatial variations in those 'opportunities' available, such as those based on nearest distance/proximity approaches derived from Euclidean ('as the crow flies') distance or basic catchment analyses. Subsequently, research studies that have used Geographical Information Systems (GIS) approaches to monitor changes in the availability of services have demonstrated how such access measures could be incorporated within indicators of social disadvantage using spatial analytical approaches to record variations in provision based on physical distances between potential users and service locations (Higgs and White, 2000).

Empirical evidence included in the annual *State of the Countryside* reports published by the then Commission for Rural Communities (CRC) in England in the early 2000s (e.g. CRC, 2008) included measures based on GIS-derived straight-line distances to services considered as 'essential' to rural living to derive measures of potential accessibility based on the 'reachability' of services within some normatively defined distance. Gradually travel times were incorporated into potential access measures but tended to assume access via private transport which, given the generally high levels of car ownership in rural areas, often underestimated the problems faced by those lacking alternative transport options. The importance of this body of literature was eventually at least partially recognised by the inclusion of accessibility 'domains' within the multiple deprivation indices developed by respective governments in the UK, which tended to reinforce the types of problems of access to a range of 'key' facilities faced by those living in rural (and some urban) communities (Page et al., 2019).

Several studies have drawn attention to inadequate levels of public transport services which has encouraged a dependency on cars to access facilities and contributed to difficulties in accessing different service types by vulnerable groups living in some rural areas (see for example, Kamruzzaman and Hine, 2012; Carroll et al., 2021; Higgs and White, 1997; Moseley, 1979). Nutley (1999) drew on case studies in rural Northern Ireland and Wales for example to demonstrate the need for small area measures that include the frequency and timings of public transport availability in relation to work, shopping and leisure opportunities to map areas lacking access to services. Such research

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highlighted differences in levels of accessibility between those rural households with and without access to a private car based on the proximity to bus routes and the timing of public transport in relation to the location and characteristics of services.

Recent research findings have drawn attention to the need to extend this research beyond just a rural focus and encompass the types of transport problems facing some urban communities; so for example, Mavoa et al. (2012; p. 15) draw on a study of access to service destinations in Auckland, New Zealand to show how transit frequency measures can help to "gain a more complete and realistic picture of public transit access and to explore the potential for mode substitution and accessibility for non-car households". Others have highlighted the importance of examining the implications of the loss of public transport opportunities for vulnerable groups such as the elderly who are potentially more dependent on (mainly) bus services and for those with limited transport alternatives (Shergold et al., 2012). Such findings have shone a spotlight on those unable to access facilities within their opening times, as well as on those living in areas badly served by public transport or alternatives such as community transport (Moles and Radcliffe, 2011; Nutley, 1998). These patterns have been exacerbated during the COVID-19 pandemic as transport services were either partially or completely withdrawn or routes temporally or permanently downgraded by public transport operators in some areas in response to changes in passenger demand (Angell and Potoglou, 2022).

While there has been a longstanding interest in investigating wider aspects of spatial accessibility, the lack of suitable data sets often restricted attempts to include elements of public transport availability to localised case studies (Lovett et al., 2002; Martin et al., 2002, 2008). Martin et al. (2008) for example drew attention to the need to incorporate public transport data in accessibility modelling approaches and illustrated the technical challenges involved in integrating such datasets with private transport measures to understand patterns of access to a major hospital in Devon, SW England. Mavoa et al. (2012) used a Public Transport and Walking Access Index (PTWAI) developed at land parcel level to measure potential access to seventeen different types of destinations (including banks and ATMs) via public transit and walking that includes all aspects of the travel journey and uses actual route data to calculate access for a variety of travel times. This was supplemented by a measure of service level/frequency calculated as the 'average number of distinct public transit journeys through each transit stop'. However, both measures had acknowledged limitations such as the need to consider alternatives including the number of routes per stop or household level calculations of accessibility derived for specific times of day.

1.2. Study aims and objectives

More recently, the increasing availability of digital versions of timetable schedules has led to studies concerned with examining socio-spatial variations in access to public transport. Sun and Thakuriah (2021) for example, draw upon such resources to explore detailed patterns of public transport availability in England including changes in service frequency and spatial proximity to stops and transit stations to help identify areas of 'transport poverty'. Others have demonstrated how aspects of public transport provision can be combined with facility locations, for example sites offering NHS dental care, to examine patterns of accessibility in relation to the socio-economic characteristics of potential patients (Jo et al., 2021). However, whilst there is an expanding body of literature that has attempted to incorporate public transport timetables into accessibility calculations using GIS tools, few studies to date have explored the need to understand the impacts of service reconfiguration alongside changes in access to these types of public transport opportunities.

The present study highlights the need to combine alternative means of accessing services to gain a fuller picture of the implications of the ongoing loss of key services. By drawing on a national study of retail bank branch closures and combining this with changes in public transport availability over a time-period spanning the early phases of the COVID-19 pandemic, the aim is to focus on spatial inequalities in access to financial services emanating from a combination of branch closures and contemporaneous reductions in transport provision. This involves an examination of how open-source public transport schedule data can be used to better understand the implications of service changes for those likely to be reliant on alternative modes of transport to access the types of financial services provided through bank branches.

The specific objectives of this paper are to investigate nation-wide changes in access to banks using a database of branch locations and bus timetables for two cross sections (2019 through 2021) that span the lockdowns implemented in Wales during the COVID-19 pandemic. Even before the pandemic both services (i.e., banks and bus routes) were seen to be "at particular risk" in a survey published by Rural England, with potential impacts on access to a wide range of facilities (Wilson, 2017). An important contribution of the present paper concerns the need to draw attention to case studies that illustrate instances where a combination of bank closures and changing levels of public transport opportunities impact upon overall patterns of geographical accessibility. By analysing changing patterns in public transport availability over this relatively short time frame, albeit at a time of a public health crisis not experienced for over a century, we illustrate how these data sources can be used to assess the impact of service closures on rural geographical accessibility. This is illustrated with reference to the potential impacts of a recent wave of bank branch closures across Wales.

2. Importance of measuring access to banking services

Studies in a wide range of international contexts have highlighted the implications of the closure of services in rural areas that extend beyond the immediate impacts on access to facilities to consider the emotional and symbolic attachment of communities impacted by the loss of a variety of facilities (Amcoff, 2012; Cabras and Reggiani, 2010; Christiaanse and Haartsen, 2017; Svendsen, 2013). Geographical Information Systems have been used in a wide range of studies to examine impacts on rural communities by adopting a variety of spatial analytical approaches (Neumeier and Kokorsch, 2021). Of immediate relevance to this paper, several studies have used geographical approaches to investigate the implications of previous rounds of bank and building society closures on patterns of financial exclusion in the UK particularly within poorer and rural communities (French et al., 2008, 2013; Leyshon et al., 2008). The aim here is to build on these findings to examine potential impacts of bank service closures in Wales using multi-modal GIS approaches that benefit from recent developments in open data sources and network analysis tools.

Several policy documents have drawn attention to those factors that have impacted on the health of town centres and made recommendations on the actions needed to aid their potential regeneration in the light of the impacts of the pandemic in Wales (Audit Wales, 2021; Federation of Small Businesses, 2022; Foundational Economy Research, 2021). A consistent feature in most town centres was the presence of retail bank branches which have traditionally been seen as 'anchor institutions' on local high streets, aiding the sustainability of local businesses and boosting tourism opportunities. The impact of the closure of bank branches on local businesses reliant on face-to-face contact has been to the fore in these reports. Whilst the loss of bank branches has been a feature of such communities since the 1950s (House of Commons Library, 2018), the rate of loss in recent years is unprecedented (*Which, 2022*). Concerns that vulnerable groups were in danger of being financially excluded by these closures led to the *Access to Cash Review (2019)* which drew attention to those people most likely to be dependent on bank branch services including those more reliant on cash or those without digital means of accessing financial services. A subsequent report has further investigated the importance of such factors in the light of the impact of the COVID-19 pandemic on the reduction in cash

withdrawals and the increase in the share of digital payments (Hall et al., 2022).

The time span of changes in the branch network contained in this study covers the initial lockdowns imposed during COVID in 2020, which saw reductions in the hours of provision of banking services, the permanent closures of some branches, and changes to bus routes and frequencies of service. While the broader impacts of COVID-19 on the future use of cash in the economy, and the wider implications for banking services, is a cause for speculation (Tischer et al., 2020), the focus here is on changes to access during the early stages of the pandemic. A general decline in public transport has been a feature of some rural communities for several decades due to the shrinking commercial viability of bus services. Such pressures are likely to have been accelerated during COVID-19 as people sought alternatives to the use of public transport leading to a decline in passenger demand. This is acknowledged in the present study through the impacts of both route reductions and reduced frequencies of service on existing routes as part of a wider analysis of potential accessibility to the remaining network of bank branches.

In the lead up to this period several market towns, which play a significant service provision role in rural Wales (Woods, 2011), lost their last remaining fixed banking service in an extensive round of closures (National Assembly for Wales Economy, Infrastructure and Skills Committee, 2019). The trends described by Woods in the early 2000s have continued such that many of the market towns of rural Wales have lost bank branches in recent decades. In Wales as a whole, between 2012 and 2020 the number of bank and building society branches fell by almost 29% from 695 to 495 (Audit Wales, 2021). In the period between March 2018 and 2019 alone there was a reduction of 10% in the number of free to use ATMs in Wales (National Assembly for Wales Economy, Infrastructure and Skills Committee, 2019). At the UK level, analysis of change since the first national COVID-19 lockdown in March 2020, revealed a total of 801 branch closures in the period to July 2021, with a projected loss of a further 103 by the end of 2021 (Which, 2021). Subsequently, Lloyds Banking Group, NatWest, HSBC and Barclays have all announced further closure programmes in the UK in late 2021 and early 2022. This continues a trend of around 50 closures a month since 2015. At the same time, there are plans for some major banks to share banking hubs or implement alternatives such as the installation of ATMs through new voluntary agreements conducted as part of independent assessments following branch closures to address the needs of those still reliant on cash.

The direct knock-on effect to businesses in market towns and the loss of financial services to vulnerable customers is well documented, and concerns surrounding access to cash have led to committee enquiries in each of the parliamentary institutions in Great Britain (House of Commons Scottish Affairs Committee, 2018; National Assembly for Wales Economy, Infrastructure and Skills Committee, 2019; The Scottish Parliament Economy, Jobs and Fair Work Committee, 2018). Diminishing banking services have also focused attention on various aspects of financial exclusion in international contexts, where similar driving forces leading to reductions in face-to-face banking services are in play (see for example Alamá and Tortosa-Ausina, 2012; Argent and Rolley, 2000; Dunham and Foster, 2015; Hegerty, 2016, 2020; Kashian et al., 2018; Martin-Oliver, 2019; Morrison and O'Brien, 2001). The reasons for branch closures as forwarded by banks are well rehearsed – a decline in footfall as more customers turn to digital services is cited as the principal cause as to why many communities have lost branches. Furthermore, by signposting the potential for alternative means of access through the post office, digital banking, or in some instances via mobile vehicles moving between communities, banks purport to address concerns regarding access to financial services following branch closures. Some for example are promoting customer outreach programmes to increase awareness of support available in accessing services or are offering community 'pop-up' events to promote the use of digital services especially for cash-dependent communities.

There have been relatively few attempts to model the implications of the loss of bank branches at detailed spatial scales. Langford et al. (2021) used accessibility models to examine access to bank branches for a cross-sectional analysis of spatial variations. The study by Sonea and Westerholt (2021) used GIS approaches to examine variations in banking services offered through the post office network in Wales, with reference to the degree of adherence to geographical access criteria applied to the location of post offices. Although typically these provide only a subset of the services offered at bank branches, their study drew attention to problems facing residents in rural areas who are experiencing the closure of local branches and who may not wish to access services digitally or are unable to do so because of factors such as poor broadband and mobile coverage. Others have used GIS approaches to consider the availability of financial services in urban areas, showing that inequalities in access to cash are not confined to rural areas; Tischer et al. (2019) for example investigated changes in financial infrastructure in Bristol, UK to detect parts of the city experiencing the greatest loss in ATM provision or their replacement by fee-charging ATMs as well as the socio-economic impacts of changes in other types of financial service provision.

Given their symbolic importance within communities, bank closures remain an emotive issue especially given the controversial way their impacts are communicated to customers often without any perceived involvement of the public in the decision-making process. The signposting of alternative branch locations often overlooks the transport barriers that may be experienced by those reliant on public transport. By showing how accessibility is influenced by both facility closures and public transport availability, our aim is to examine how these factors influence overall patterns of accessibility. Such analysis points the way to how improved information could be relayed in impact assessments that fully acknowledge the consequences of service decline for such vulnerable groups.

3. Measuring access to services

3.1. Introduction to floating catchment area (FCA) accessibility approaches

There is a growing literature concerned with examining variations in the availability of services (the relationship between supply and demand) and accessibility (the physical separation of population demand and service supply locations). Various approaches have been adopted to estimate geographical accessibility and an extensive literature exists on their respective advantages and limitations (see for example Guers et al., 2015; Handy and Niemeier, 1997; Kwan, 1998; Neutens, 2015; Talen and Anselin, 1998). The focus here is on place-based measures rather than with those involving the analysis of individual space-time budgets and activity space because these have a longer history of application in policy-focused studies of geographical variations and, at least until recently with the advent of social media and GPS tracking, have tended to be less resource intensive.

Initially, place-based accessibility studies adopted simple approaches that involved the calculation of a *proximity* or a *density (supply-demand)* type measure to record variations in facility availability. Proximity measures usually involve estimating the distance to the nearest (or *nth* nearest) facility from designated demand points, based either on straight-line or on network distance/travel time. In contrast, density or 'container' metrics record the number of facilities in an administrative area or census tract, typically standardised by its population (or a relevant sub-group such as those of certain age categories) to yield a provider-to-population ratio. More recently, gravity-based approaches have been adopted to overcome some of the problems associated with both proximity and density-based techniques (Luo and Wang 2003).

Floating catchment area (FCA) techniques are a particular form of gravity model increasingly being adopted to measure potential access based on three components: supply-side information on provision, the

distribution of population demand, and the impacts of the intervening distance or travel impedance between supply and demand locations. Details of the algorithm, of various adaptations and enhancements made to its original formulation, and examples of its application to a wide range of services are well covered in published literature (see for example, Luo and Qi 2009; Langford et al., 2019; McGrail and Humphreys, 2014), so only a summary is presented here. The core concept of FCA is the 'floating catchment', which is essentially an isochrone or isodistance polygon constructed around each demand and supply site. Regardless of whether time or distance is used, the floating catchment defines a polygon centred on the point of interest and representing the area reachable from this point within a stated threshold time/distance. Floating catchments are computable using a topological road network and the spatial analysis capabilities of a GIS.

The primary focus of early FCA applications was in health geography, but the scope of their applications has since widened to consider access to a broad range of facilities such as green space, food stores, libraries, and sporting facilities (see for example, Bauer et al., 2019; Cutumisu and Spence, 2012; Dai and Wang, 2011; Dony et al., 2015; Fransen et al., 2015; Guo et al., 2017; Hu et al., 2020; Martori et al., 2020). In the present study, both the proximity of banks and their potential availability (accounting for local supply and local demand) are incorporated into an accessibility measure that reports an intuitive supply-demand ratio expressing service capacity relative to anticipated demand (e.g., number of banks per 1000 persons), much like the density metrics described earlier.

The Enhanced Two-Step Floating Catchment Area algorithm (E2SFCA; see Luo and Qi, 2009) weights the contribution of each supply point according to its network distance from a respective demand centre to better account for its proximity. Floating catchments are uniquely defined for each demand centre but nevertheless often overlap, implying that supply points (banks) can fall inside multiple demand catchments. Such supply points are shared between competing demand centres, so a second calculation (hence its 'two-step' nomenclature) determines the relative share of supply capacity allocated to each competing demand centre, again weighted by its network distance. The outcome of these calculations is a supply/demand ratio based on the natural activity space of residents at each demand centre, with distance-weighted service capacities found within this zone normalised by the expected demand placed upon them. Two important advancements to E2SFCA methodology are used in this study to examine access to banks over the allotted time-period; namely temporal and multi-modal adaptations, as described below.

3.2. Temporal and multi-modal approaches

3.2.1. Changes in FCA scores over time

The present study extends the application of FCA approaches to consider both temporal and multi-modal approaches and shows how these adaptations can be applied to analyse spatial inequalities in access to bank branches. Few studies to date have used FCA techniques to examine temporal change in accessibility; Luo et al. (2004) for example consider changes in access to primary healthcare in the state of Illinois between 1990 and 2000 using US census data and compare differences in FCA access scores calculated for the two dates. Their analysis highlights how access improved overall during the time-period considered, but also demonstrated how declines in access were experienced in rural areas and some pockets of urban areas with higher deprivation levels. Their research also identified detailed spatial patterns in changes in accessibility in relation to the socio-economic geography of the state by creating a merged coverage to take account of temporal variations in census boundary changes over the study time-period.

Williams and Wang (2014) used temporal variations in FCA-derived maps to examine access to public high schools in Baton Rouge at three timestamps (1990, 2000, and 2010). Percentage change in access scores were compared between dates to examine potential disparities by urban/rural context, social disadvantage, race/ethnicity, and student performance, and to examine changes in the strengths of relationships over the entire time-period. Accessibility was shown to be an important contextual influence, and from a methodological standpoint the approach shows how temporal change in access can be used to examine the impacts of the reconfiguration of schools in relation to shifting demand. In contrast to the present study, the researchers used Euclidean distance to define catchment areas, citing a lack of historical data on road network configurations over the time-period as the reason for this choice. An important advancement in our research relates to the incorporation of network travel into the FCA calculations that span the period of bank closures being examined.

Regarding temporal approaches to examine changes in accessibility specifically during the COVID-19 pandemic, Jabbari et al. (2021) compared FCA scores between the spring and summer of 2019 and 2020 to gauge the impact of changes in school meal access points in relation to socio-economic circumstances and race/ethnicity in St Louis, Missouri. Their study illustrated the potential for such tools to examine the efficacy of policies specifically geared to addressing impacts of school closure programs for meal provision and drew attention to some of the geographic barriers facing families during COVID-19. The present research extends their approach by including alternative transport systems (public and private) in a multimodal approach to examine temporal variations in access to banking services over the early stages of COVID lockdowns in Wales.

3.2.2. Multi-modal FCA approaches

Over recent years several attempts have been made to improve existing accessibility models by incorporating more realistic representations of the movement of people in relation to prevailing transport opportunities and service operating hours. Building upon earlier studies, where there was a common assumption of access via private car only within fixed size catchments, researchers have attempted to incorporate multiple transport modes and variable sized catchment areas into FCA modelling. The study by Mao and Nekorchuk (2013) was one of the earliest attempts to incorporate both car and bus transport. Threshold travel times (i.e., catchment sizes) were varied according to the transport mode used to access services; in the absence of detailed utilisation data for each facility however decisions are needed on the theoretical threshold time/distance beyond which a particular mode of transport is unsuitable to access that facility. Their method ideally needs data on the detailed mode of transport allocated at each population demand point; Mao and Nekorchuk (2013) used vehicle ownership at census block level to derive a dichotomous split between households travelling with and without cars (the latter being assumed to travel to hospital by bus); whilst those who might choose to walk were not considered at all. Their methodology was also limited by the fact that the modelling of public transport took no account of its fixed routes but instead simply applied a reduced set of travel speeds to the same road network as that used for car-based analysis.

Langford et al. (2016), in a study of multimodal access to primary healthcare in South Wales, demonstrated how competition between groups using alternative travel modes (car and bus) could offer a potentially more sophisticated method of incorporating public transport into a multimodal adaptation of E2SFCA. Their approach uses separate constraints (catchment sizes) for each mode of transport, separate transport networks for each travel mode, and incorporates travel times estimates based on bus timetables. Their findings drew attention to the need to compare access scores for each travel mode and the additional information that can be used to gauge those census tracts that have contrasting accessibility scores to those generated through a single travel mode (car only) model. Such an approach can benefit from the analysis of open-source datasets that are increasingly being made available as outlined in the next section.

4. Data and methods

4.1. Bank branches

A dataset of bank branches was assembled from a combination of sources including Ordnance Survey Point X Landmark data (Ordnance Survey, 2022). Data were collated for the period 2019 to 2021 and cross corroborated with bank closure data collected by the UK consumer group *Which?* (Robins 2019; Patchett 2021). Any changes identified over the time-period were further verified by cross checking with bank impact statements and closure information on company websites that provide background information on local branch closures.[1] Alternative sources were considered, including paid services such as the Google Platform API (Google Platform API, 2021) which reports various information on bank branches such as their location, opening hours, and whether they have been recently permanently closed. However, we found that not all banks that closed during the time-period had their status updated on the Google Platform API. The locations of all branches that closed between 2019 and 2021 are displayed in Fig. 1.

4.2. Demand population and its use of alternative transport modes

Demand population was modelled using the total number of residents at each Output Area centroid obtained from a recent (2020) mid-year estimate. To derive the numbers likely to be travelling by public and private transport at each demand centre, a modal split was calculated using an approach developed by Langford et al. (2016). In the absence of detailed data on the travel choices of bank customers this was based on household car ownership as recorded in the 2011 UK Census. Populations allocated to each transport mode at each OA were calculated as follows:

$$Pop_{public} = (\mathrm{P} \times Car_0) + (0.25 \times \mathrm{P} \times Car_{1+})$$

$$Pop_{Private} = \mathrm{P} - Pop_{public}$$

where Pop_{Public} and $Pop_{Private}$ are the counts likely to travel via public and private transport respectively. Car_0 is the percentage of households with no car, while Car_{1+} is the percentage reported as having one or more cars. The calculation assumes all residents in households without a car travel to banks via public transport. Households often contain multiple individuals but only one car; we assume 25% of such household's population total also use public transport based on the principle that one car will at times be unavailable due to other household activities such as travelling to work or shopping. Whilst these assumptions are subjective and contestable, they can be easily substituted for alternative estimates if any suitable evidence to guide such decisions was to become available.

4.3. Multi-temporal transport modelling

Results are based upon two sets of public transport data. The first was downloaded in August 2019 and thus preceded the onset of the COVID-19 pandemic. The second was acquired from online sources in August 2021 and coincided with public transport services as they transitioned out of the main phases of lockdown rules in the UK. Both datasets were obtained from TravelineData (Traveline 2021), with each providing details of all bus routes, bus stops, and all scheduled services of operation across Wales at their respective timestamps. These data are supplied in TransXChange format. This was reformatted into General Transit Feed Specification (GTFS) format using the R package UK2GTFS (Morgan, 2021) so that it could be used in the network routing and trip planning software described in the next section.

4.4. Multi-modal routing

Multi-modal route calculations were derived using various open-source tools and open-access data sets, drawing on the techniques and computational framework developed and described by Price et al. (2021). All data are stored in, and spatial queries executed from, a PostgreSQL/PostGIS spatial database (PostgreSQL, 2021). Data processing is directed through PHP scripts running on an HTTP server, with network routing computed using the OpenTripPlanner software (OpenTripPlanner 2022). To calculate E2SFCA accessibility scores network distances and times between specific supply and demand points must be computed to calculate the population base able to access and likely to use specific banking services. Such information is held in an origin-to-destination (OD) matrix, essentially a PostgreSQL table which is initialised using the capabilities of its PostGIS spatial extension (PostGIS, 2021). Initially a table is constructed to identify all possible supply-demand pairings falling within 16 km (10 mile) distance of each other. This eliminates from consideration all other parings that exceed this distance, and so limits the computational task to only those cases that have potential to be of interest. PHP scripts then present each supply-demand pair stored in the OD matrix to a routing engine which returns the network distance/time between them based on the chosen mode of transport.

We used an open-source routing engine, OpenTripPlanner (OTP), which is queried through its RESTful API. In practice, this means URLs are constructed to call the OTP server and pass to it the details of journey start and end points, chosen mode of transport, and a maximum allowable walking distance. OTP makes use of a topological graph built using OpenStreetMap (OSM) data (OpenStreetMap, 2022). OTP takes the OSM road network and combines it with public transport information (routes, service times, and bus stops) presented to it in GTFS-format. Once fully configured, OTP can be used to return details of any specified journey, either private (car) or public (any combination of bus, train, and walking). Multimodal journey times/distances are thus computed by OTP for all entries found in the previously stored OD matrix. Finally, the E2SFCA calculations are performed using PHP scripts that draw all necessary information from the database via appropriate SQL queries.

A linear decay weighting function was applied to all computed travel distances regardless of transport mode and we set a maximum walking distance of 400 m for any public transport routes. This value has been shown in many previous studies to be a reasonable estimate of the maximum distance passengers are prepared to walk to reach a public transport stop but again it can be varied if there is empirical evidence of the actual distances' individuals walk to access transport services. Two catchment sizes were adopted while modelling the respective accessibility of public and private cohorts: Public transport used a 30-min catchment, and private transport a 15-min catchment. This difference is intended to reflect the expectations and travel tolerances of each subgroup. Put simply, those reliant on public transport expect their journeys to take longer and are thus believed to be more tolerant of longer travelling times. The precise choice of 30-min and 15-min thresholds are once again an arbitrary decision but are easily adjusted if relevant empirical evidence can be obtained to inform on actual travel behaviours.

5. Results

5.1. Changes in public transport

Clear differences were seen to exist between the transport services datasets recorded at the two timestamps, and these are believed to heavily influence patterns of accessibility to services such as banking, retail, and medical facilities. In the 2019 dataset, a total of 1051 public transport services were operating across Wales centred mainly on bus

[1] Websites consulted regarding bank closures: (Barclays 2022; Lloyds Bank 2022; Natwest, 2021; Royal Bank of Scotland 2022; Santander and Closures, 2022; TSB 2022).

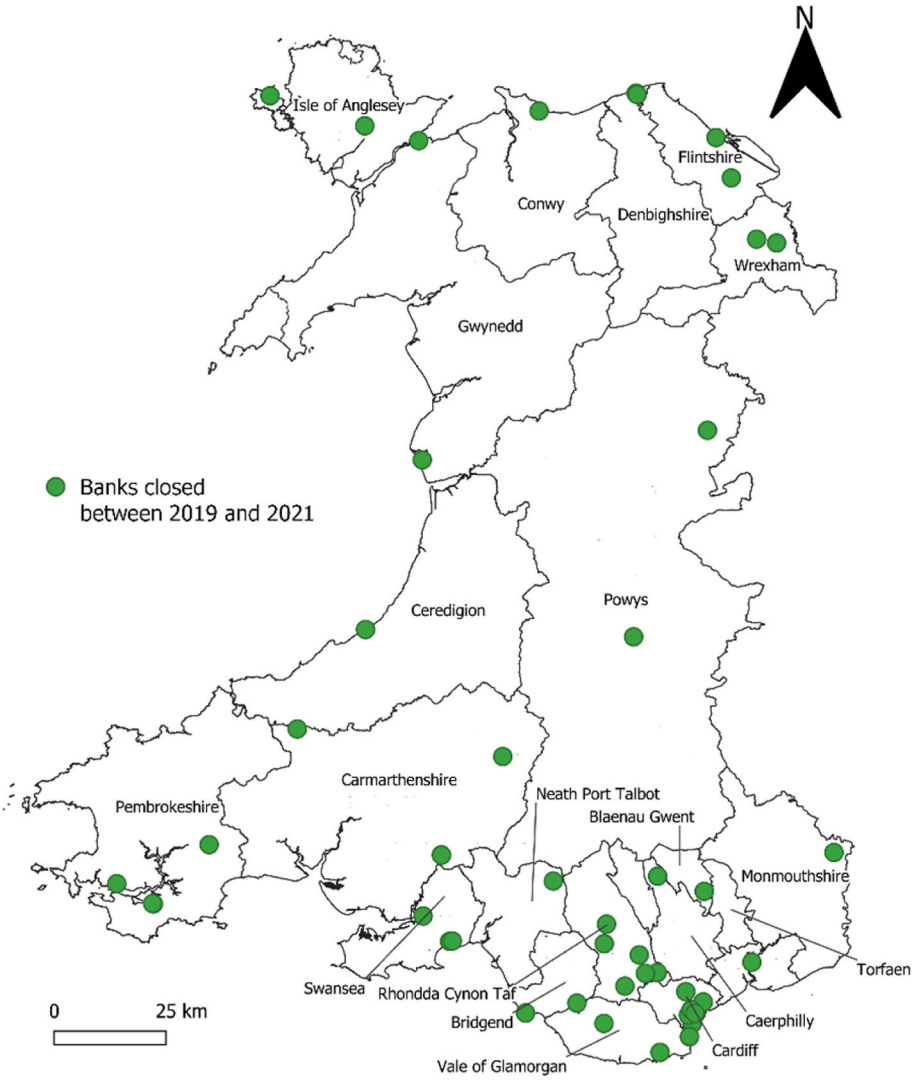

Fig. 1. Bank branches that closed during the study period.

and coach transport. This number had fallen to 900 services by August 2021. Furthermore, in addition to the decline in total number of services, the frequency of buses serving routes also reduced significantly, with fewer buses arriving at designated stops throughout the day. Fig. 2 illustrates such changes; panel (a) indicates bus routes lost or added, and those that remained constant over the time-period; panel (b) maps the change in total number of buses arriving at all bus stops, as aggregated over Lower Super Output Areas. The majority show a decline and particularly large reductions are evident in central Cardiff and extending north into Rhondda Cynon Taf, around Swansea and the Gower peninsular, and in the north between Llandudno and Rhyl extending south towards Denbigh.

5.2. Changes in access scores for public and private transport, 2019 through 2021

To illustrate the principle involved in temporal accessibility calculations, a single time slot, 11 a.m. Tuesday morning, was identified to consider whether access to a bank was possible at each OA given the location of branches prior to, and following, closures and given the changes in public transport services reported over the study time-period. Multimodal E2SFCA scores were calculated for each OA for 2019 and 2021 and then aggregated up to LSOA using a population-weighted average. The results are presented in Fig. 3 (public transport) and Fig. 4 (private transport). A careful visual comparison of Fig. 3 (a) and (b) shows that whilst some areas lost their access to a bank over this time, the majority of LSOAs continue to maintain access albeit at lower levels. When displayed on fixed scale maps such changes are often difficult to see clearly, particularly in population centres where LSOAs are small, but the majority of LSOAs that lost all access to branches are in rural areas, in rural towns and in rural villages.

Fig. 4 shows equivalent scores for private transport users and surprisingly, perhaps, appears to show more LSOAs that have lost all access to a bank. This situation arises because car travel inherently allows demand centres to reach more distance branches, and the closure of such branches then significantly impact upon this cohort's accessibility scores. Meanwhile, the cohort travelling by bus were often already excluded from reaching these sites due to the limitations of public transport even before any COVID-19 induced reductions in services are considered. Branch closures inevitably impact on local access to financial services with rural branch closures affecting both car and bus travellers in their immediate vicinity; they may also have a larger regional impact on car users simply because only they are able to reach them from afar. Returning to Fig. 3, although many instances of declining accessibility correlate closely to closing branches, this is not always so and examples exist, as discussed later, where declining transport services are clearly the main driver of change.

To better illustrate differences in accessibility between 2019 and

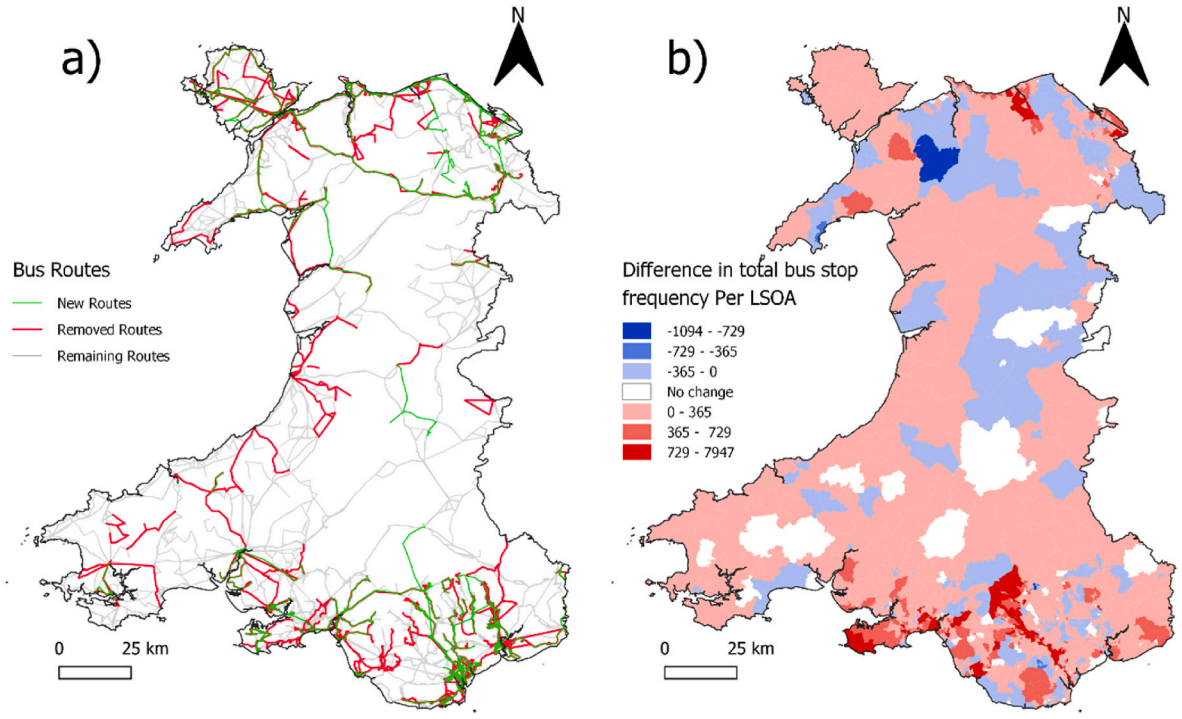

Fig. 2. a) Changes in bus routes; b) Changes in bus frequencies per LSOA.

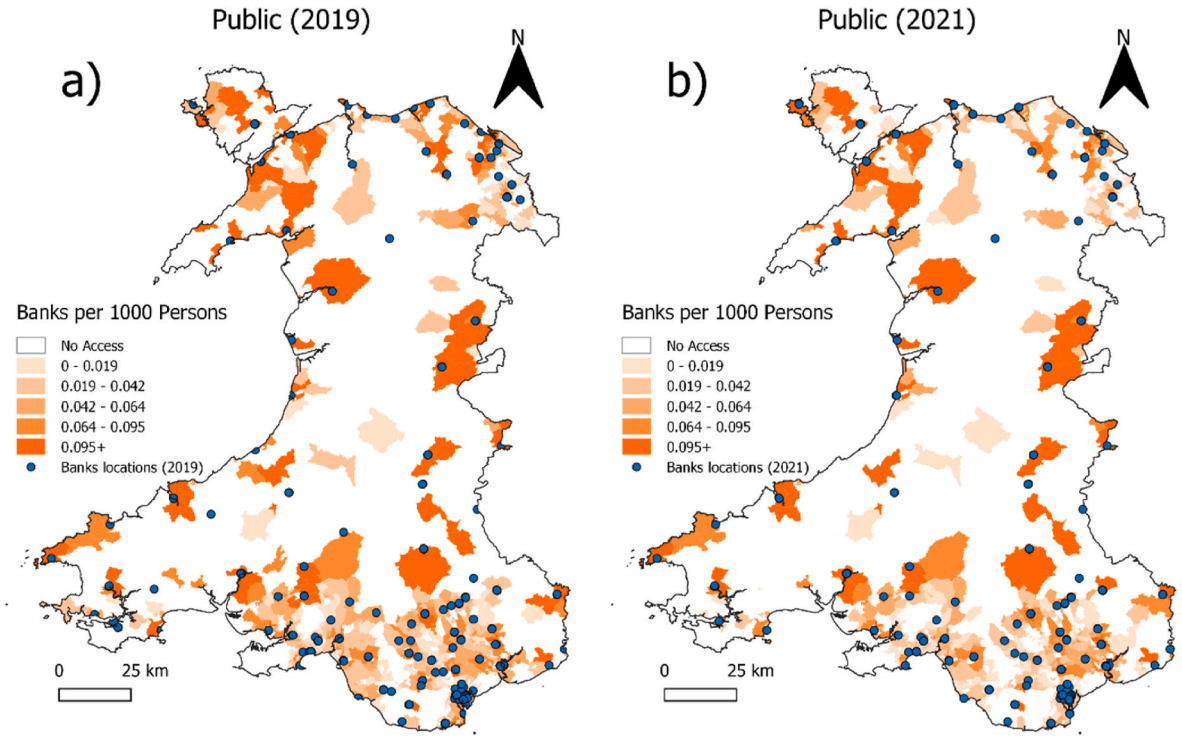

Fig. 3. Changes in access to banks via public transport.

2021, a percentage change was computed using 2019 scores as the base reference; a similar approach was taken by Williams and Wang (2014) to highlight changes in access between time frames. This provided targeted insight into where accessibility had decreased or increased, calculated as follows:

$$D = \left(\frac{N - O}{O}\right) x\ 100$$

D is percentage difference, N the 2021 accessibility score and O the 2019 accessibility score. These are mapped in Fig. 5 (public travel) and Fig. 6 (private travel), to show which parts of Wales experienced the greatest relative change over the two-year period.

Figs. 5 and 6 suggest complex patterns arise in terms of where accessibility has changed for public and private transport users over the reported time-period. In seeking to interpret or understand the

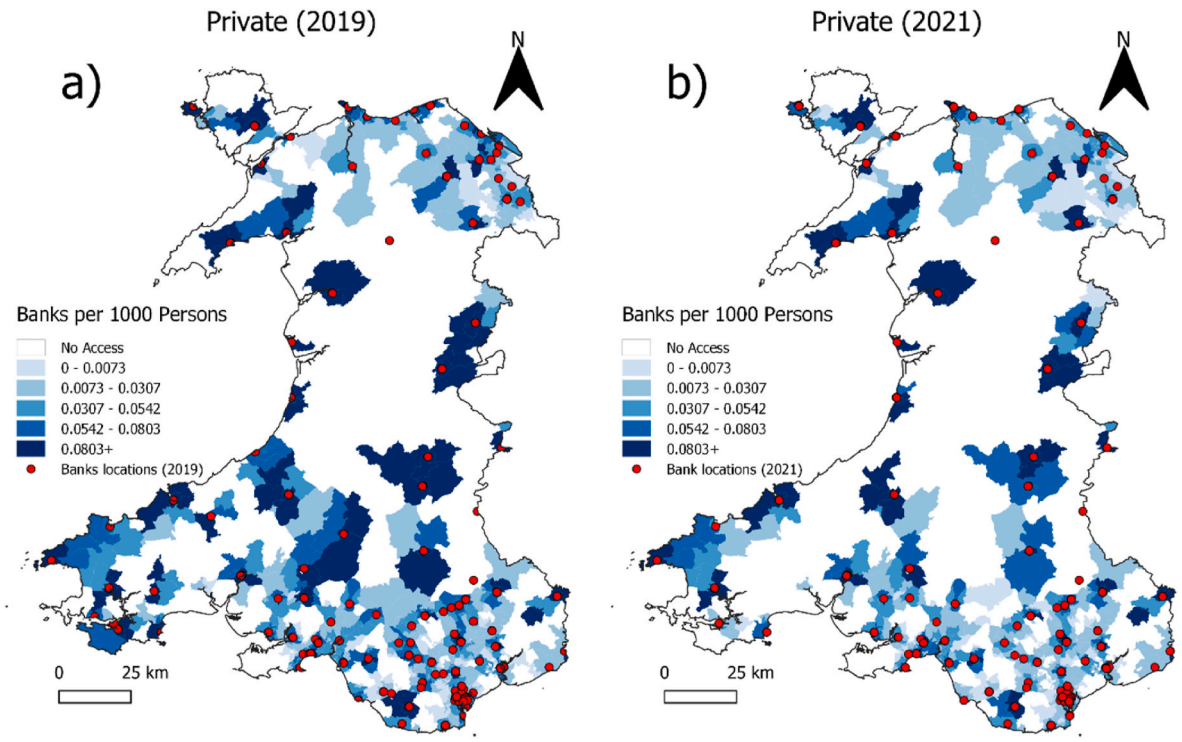

Fig. 4. Changes in access to banks via private transport.

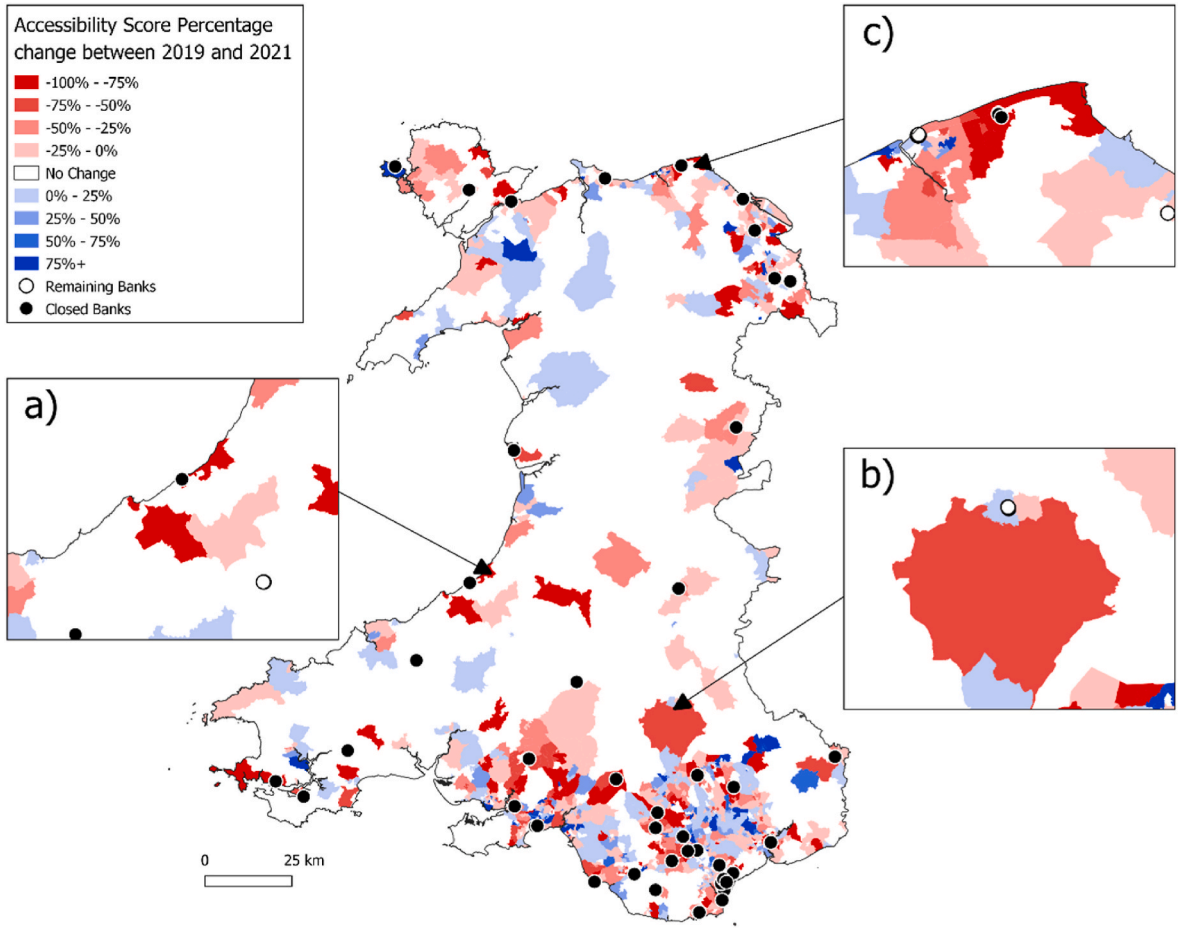

Fig. 5. Percentage difference in accessibility score (public transport).

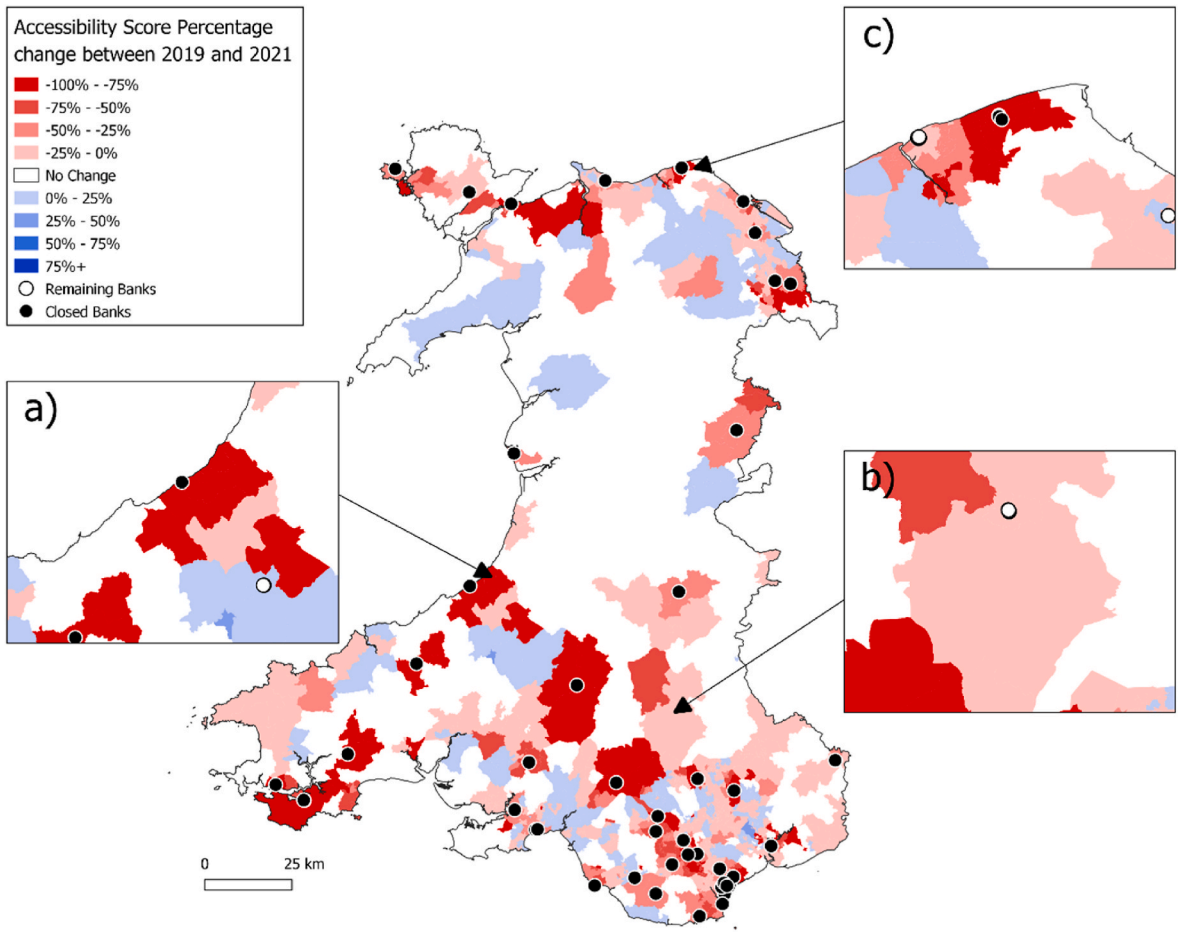

Fig. 6. Percentage difference in accessibility score (private transport).

information conveyed in these maps it should first be understood that in a multimodal model although the separate demand cohorts travel via independent transport systems, they nevertheless seek access to a common set of service supply points. This means that any change in access reported via one mode of transport and for whatever reason will also impact upon the scores of the other. Clearly, branches that close are likely to impact both public and private transport users in their immediate vicinity, as discussed above. Less obviously, bus routes that are withdrawn or which have a reduced frequency of service imposed upon them will not only influence reported public accessibility scores. If branches become unable to be reached by bus travellers, their relative availability may increase to any car travellers still able to reach them. This complex interplay between competing demand groups, along with changes made to the configuration of service supply points, and revisions to public transport services, ultimately leads to the sorts of detailed patterns of local winners and losers revealed in these maps. It also demonstrates the need for such modelling to better understand the potential consequences of both branch closures and public travel reconfigurations.

In Fig. 6 the distribution of LSOAs that show a decline in accessibility appears to be quite closely correlated with the locations of closing bank branches. Those showing an increased score tend to be located between towns, rather than in the most rural areas of Wales, and are most likely the result of the effect described above whereby the relatively distant bank branches that they rely upon have remained open and have become less accessible to bus travellers. There is, disputably, some degree of association with areas of reduced bus frequencies and withdrawn routes as identified in Fig. 2, but the strength of this evidence is highly debatable. In Fig. 5 it is much less clear that declining accessibility for bus users has been driven directly by bank branch closures. This implies that they are more likely to be the result of reduced transport opportunities, but they could in some circumstances be due to greater competition arising from car owners directly affected by branch closures who must redirect their attention to other points of provision. We suspect that our difficulty in unpicking the causes of accessibility changes to banks from these maps largely arise because there is no simple, single, uniform origin for their occurrence. Instead, it is more profitable to consider individual case studies, where circumstances can be more closely analysed and understood, as in the examples that follow.

5.3. Example interactions between bank closures and public transport reconfigurations

5.3.1. Aberaeron locality (inset A)

The first case study considers the impacts of the closure of the bank branch located in the rural town of Aberaeron along the west coast of Wales in the early part of the study period and shown as inset (a) in Figs. 5 and 6. This presents an example whereby reductions in LSOA level accessibility scores recorded in the local region can be attributed simply to the closure of a bank. This branch was the archetypal 'last remaining bank in the town' (Davies 2019; Barclays 2019) and its closure appears to have impacted negatively on both public and private transport users in the area. In some surrounding LSOAs that fall within the designated FCA catchment areas, access was lost entirely, particularly so for public transport users. Bus routes were withdrawn in the local area also, but they are not believed to be the root cause of the changes seen amongst public transport users; put simply, the presence or absence of the bus route is rendered irrelevant when there is no branch

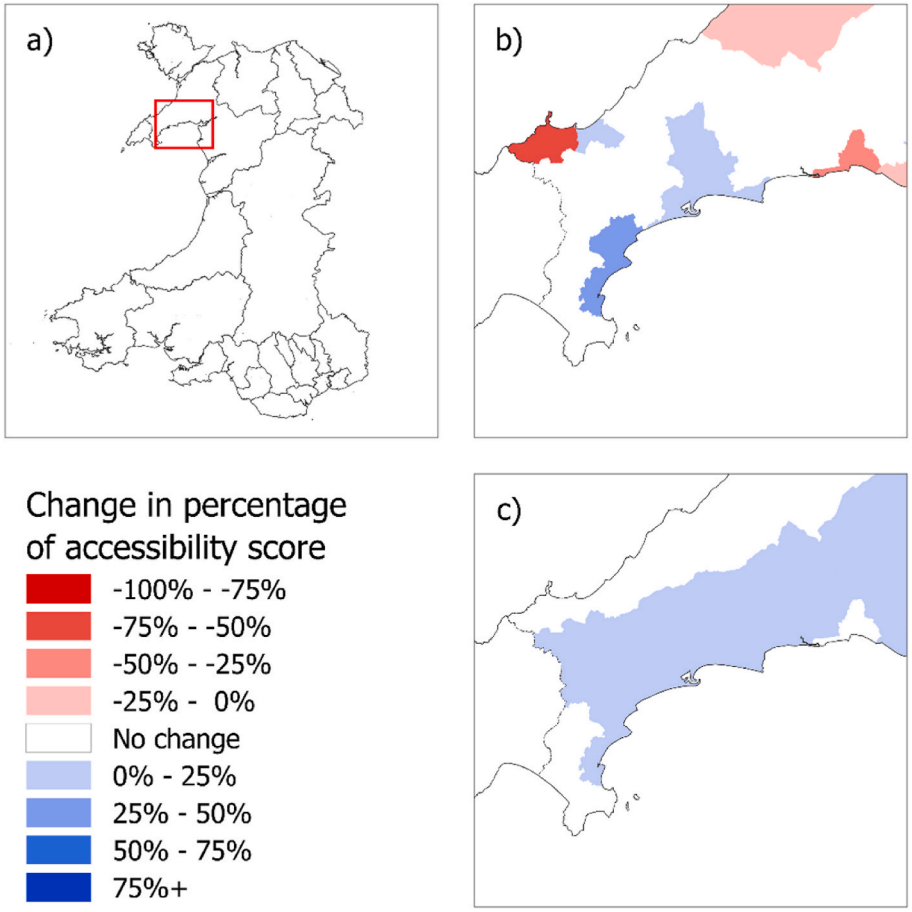

Fig. 7. Positive increase of accessibility for private transport due to changes in public transport (Llyn peninsula). a) Case study area; b) Percentage change in accessibility for public transport; c) Percentage change in accessibility for private transport.

present in town. Given the rural setting, those able to draw upon the use of a private car were also unable to reach an alternative bank within the 15-min travel time limit set in the model.

5.3.2. *Brecon locality (inset B)*

The second case highlights a decrease of access to banking services in the market town of Brecon in mid-Wales. In this example the decline is believed to be attributable to changes in public transport provision. Analysing the availability of public transport in the surrounding locality showed that several bus routes had been withdrawn here or else had experienced a notable reduction in the frequency of buses operating along the route. This resulted in lower levels of access to branch services even though none of the banks themselves had closed during the study time-period. As reported above, a decrease of accessibility via public transport can often lead to an increase in reported accessibility for private car users when service supply remains unchanged within a region. However, in this case car owners were able to reach additional banks lying outside of the town in 2019, some of which were closed by 2021, thus the reported accessibility for both bus and car travellers decline in this instance in the 2019–2021 period.

5.3.3. *Prestatyn locality (inset C)*

The third scenario considers the situation experienced in the town of Prestatyn on the North Wales coastline. The main reasons here for changes in recorded accessibility over the study time-period is believed to be the loss of four banks that were originally clustered within the area. Although Fig. 2 indicates there were also changes in public transport here, a deeper investigation proved that it was still possible to access the bank sites from surrounding areas within the given 30-min public transport time frame. The number of active bus routes in the area declined over the study period, but the frequency of service on those that remained had actually increased. This meant that those living in the '*rural town and fringe*' classified area would be made to travel a greater distance, and for a longer period, to reach the next available bank branch located in Rhyl (which is located 6 km straight line distance from the closing banks' location). An increased travel distance is not the only burden placed upon those who live locally to the closed banks, as there will also be a higher demand predicted for those who do transfer their banking activities to the remaining provision in Rhyl.

5.3.4. *Llŷn Peninsula locality (Fig. 7)*

Our final case study is used as evidence to support the argument that even when the bank infrastructure itself remains unchanged over a given period, changes in accessibility for public transport users can still arise purely because of changes to local bus schedules and routes. Fig. 7 shows a map of the Llŷn Peninsula in Gwynedd, where the reported changes in E2SFCA levels of accessibility to banks can only be explained through transformations in the availability of public transport. Public transport accessibility was seen to have decreased in some LSOAs in the region and increased in others (panel b) while scores relating to private transport either remained unchanged or increased (panel c). There were no bank branches in the immediate area, so the loss of access recorded for bus travellers could only be attributed to the removal of services that had previous transported them to branches located in Bangor. Given that there were no new bank branches opened anywhere in Wales over the study period, and that the road configuration remained static, the improvement recorded in car users' accessibility can only have been caused by a diminished level of competition from public transport users

amongst the Bangor branches.

6. Discussion

6.1. Summary of findings and study limitations

The loss of bank branches will obviously impact directly on users of its services but can also influence the vitality/vibrancy of town centres as customers often combine trips to avail themselves of other services. However, since 2015 nearly half of all the bank branches that were then present in Wales have either closed or have been earmarked for closure in 2022. More widely a recent survey found that in the UK as a whole approximately 740 branches closed in 2021 (Which, 2021). Whilst this continues a longstanding trend in retail bank closures, the early stages of COVID-19 also led to changes in branch opening hours, and ultimately to instances of temporary closures during lockdown periods. The impacts on vulnerable groups such as the elderly, those on low incomes, on small businesses, and on others likely to be more dependent on local provision of banking services have been highlighted by consumer groups in the UK and have been the subject of parliamentary enquiries in the respective government institutions.

The focus of such discussions has largely been on bank branch provision, with much less consideration given to various facets of public transport provision that can also impact on overall accessibility levels to banking services. Previous research has drawn attention to the need to include daily changes in service capacity as part of an overall approach to including temporal elements of provision of facilities in relation to the prevailing transportation network (Paul and Edwards, 2019). In this study we attempt to incorporate such information by drawing attention to changes in public transport availability during the early stages of the COVID pandemic in Wales that should provide a wider appreciation of the impacts of closures for those faced with long and costly travel distances. Findings from the study have relevance for those interested in examining the social and financial impacts of service losses (banks and bus services in this instance) and highlight potential implications for those groups that need such banking facilities but who are not currently using on-line or mobile means to access financial services.

Drawing on accessibility maps to banking services in 2019 through to 2021 it is possible to identify communities in Wales that have been severely impacted by branch closures. In many instances, these spatial patterns heighten the loss of provision that impacted on towns and hinterlands such as those in mid-Wales that had lost their last remaining banks prior to 2019. Even where some towns have managed to avoid bank closures our analysis points to instances such as Brecon in mid-Wales where changes in public transport provision can still impact on overall patterns of accessibility in areas that have, to date at least, retained retail banking facilities. It remains to be seen if such services are resumed post-COVID, however the value of the models described here is that they allow such temporal changes to be incorporated into the analysis to monitor future patterns. Finally, the analysis revealed communities such as Prestatyn that have been severely impacted by multiple closures over this two-year period and where vulnerable members of the community may be disproportionately affected by the loss of financial services. In such instances, detailed maps of accessibility should be used to help plug gaps in access to cash through proactive attempts to address the loss of financial services and ensure vulnerable groups are not adversely impacted by the closure of their local bank branches. More research is needed to examine potential associations with neighbourhood characteristics in those areas that have lost banking services. A recent study in Toronto, Canada (Avera et al., 2022 forthcoming) examined the relationship between physical topography, road networks, and socio-demographic factors and bank branch locations. Whilst the focus of their study was on access to financial institutions and gaps in provision at the city-level, in our future research we aim to examine whether similar types of associations are found amongst those communities that have lost bank branches in both urban and rural areas of Wales. Investigating the correlation between bank closures and the age-structure of local communities for example could be a fruitful avenue of further research, given assumptions regarding higher uptake of digital services amongst younger age groups.

There are several limitations of the approach taken in the present study that need to be acknowledged. For example, whilst the focus here has been on geographical factors that may influence patterns of access, consideration needs to be made of those who seek financial services from other institutions such as building societies, post offices (White et al., 1997; Comber et al., 2009; Langford et al., 2010) or through mobile banking provision or who have used alternatives sources of cash such as ATMs or cashback options (where available). From a methodological perspective, compiling and cross checking these data sets across various sources is a far from trivial task even for a relatively small timespan and this is complicated further when bank closure and public transport data is needed for longer time periods. No data is available regarding the banks that individuals are accessing, and how frequently they use their services, or through which means they conduct personal banking, suggesting that more research is needed to explore the importance of changes in demand-side parameters within these models. Such findings could for example benefit from data on the degree of use of local (banking) facilities and trip-chaining behaviour and how this varies by social groups/different places. In addition, whilst COVID-19 has almost certainly influenced utilisation behaviour, further research is needed to examine the impact of the opening times of branch services, including weekend availability, and that also acknowledges changes in bus service timetabling during this period.

In addition, parameters within the models should be further refined by analysing factors such as the modal split of bank users, the availability of a car within a household and actual driving speeds that recognise the impacts of traffic congestion levels. Despite advances in incorporating network data in GIS models, researchers have still traditionally relied on average or static driving speeds, based for example on road classifications, to calculate travel times in network-based calculations. More recently, a recognition of the dynamic nature of transportation systems have led to enhancements to multimodal FCA approaches using online map Application Programming Interfaces (APIs), such as those supplied by Google Maps or Baidu Maps, and real time navigation services. These have improved travel time estimation by accounting for fluctuations in travel impedance throughout the day and have been incorporated into studies that add temporal dimensions to measuring access to a wide range of facility types (Guo et al., 2017; Hu et al., 2020; Khakh et al., 2019; Ma et al., 2019; Zhou et al., 2020). This points the way to potential enhancements of the approach taken in the present study. In all likelihood, the modal split will depend on a whole host of factors such as the type of facility and the social groups accessing opportunities and we therefore draw attention to the importance of some of the assumptions that are needed in the absence of such information. However, a key strength of this approach is that it can be adapted to examine variations in access to other types of services with varying modal splits for facility types (including those more likely to be accessed daily by public transport) and public transport availability. The findings also point the way to how these tools could be used in conjunction with other network structures such as cycle paths and walking routes to examine the role of active travel opportunities in accessing services that are currently being widely promoted in Wales, as elsewhere.

6.2. Policy relevance

The methods of communicating closures to bank branch customers, and the (limited) extent of public consultation involved, have been criticised in the evidence given to parliamentary enquiries as well as by politicians themselves (The Scottish Parliament Economy, Jobs and Fair Work Committee 2018; National Assembly for Wales Economy, Infrastructure and Skills Committee 2019). This study illustrates the value of

including the state of public transport provision alongside such information to provide a fuller understanding of the potential impact of any closure program on potential accessibility. Such research is timely given the types of recommendations made in recent town centre regeneration reports relating to the importance of access to public transport and the promotion of active modes of travel in the recently developed national transport strategy (Welsh Government, 2021a). It also addresses the continued recognition of the importance of good access to such services in the daily lives of those living in rural areas described in the Welsh Governments' national development plan, *Future Wales* (Welsh Government, 2021b). We suggest that such interactions are often overlooked when researchers consider the potential impact of changes in service configuration but ignore the vital role of public transport in enabling access. Unlike the situation with post offices, there are no geographical access criteria that apply to the location of bank branches. By considering bank branch closures alongside changes in the availability of bus services, lessons can be learnt from a fuller understanding of changes in spatial patterns of accessibility that could guide the future design of a wider range of public and private services that often fail to consider the needs of those lacking access to private transport.

Findings from GIS-based approaches to mapping access to services can also be used to support measures that help address gaps in banking provision in rural areas, including attempts by the banks to promote the use of digital means of accessing financial services through the types of outreach and educational programmes described earlier. In addition, some banks have trialled initiatives such as 'Bank on Wheels' services, which travel to towns and villages to provide mobile van services in communities that have lost facilities. Looking to potential responses to these closure programmes within Wales, there are proposals to address some of these gaps through the potential establishment of a community bank (Banc Cambria) which although not a like for-like replacement for those services lost, the planning for which could benefit from the type of approach adopted in this study. Geographical tools that incorporate the means of travel to facilities have the potential to aid decision making around the choice of sites and to monitor changes in coverage. Finally, these maps also draw attention to the potential implications of the withdrawal of funding support for bus services – any cuts in bus service and loss or reductions/alterations to services would be expected to impact on these potential accessibility measures regardless of changes to the levels of facility provision. This can further inform the development of community transport schemes or demand responsive flexi-bus services that could help fill the gaps in public transport provision or provide a service that accounts for passenger's transport needs to access a wider range of facilities.

7. Conclusions

The UK continues to experience a widespread loss of bank branch services; trends which are mirrored widely in other international contexts. The reasons stated by the banks for enacting these closures are well rehearsed and include the increased use of mobile and on-line banking, and by signposting alternatives the banks claim to help customers who may be facing access to cash issues. In the longer term, the major banks continue to promote the benefits of digital banking services aimed at those social groups who to date may have been reliant on face-to-face contact regarding their financial services. For the foreseeable future however, there will still be those who are dependent on local services that are easily accessible by alternative modes of transport. To date, assumptions have been made that access is predominantly through private means of transport (i.e., the car). Recent trials aimed at addressing gaps in provision following independent assessments of the cash needs of communities have proposed alternatives such as new ATMs, improved cash services in post offices and shared banking hubs for some types of transactions. In this paper, we point the way to methods whereby changes in public transport availability can be included as part of a more holistic analysis of the impacts of bank branch closures that, at the request of impacted groups, could also feed into assessments of current and projected levels of community provision (Link, 2021).

Whilst the overall approach to examining the provision of services continues the theme of adopting a spatial definition of 'access', by including an element of choice of provision in relation to potential demand this approach does provide a potentially more nuanced measure of accessibility. The value added of inclusion of alternative modes of transport into the analyses of changing patterns of service configuration adds an additional level of complexity but nevertheless is ultimately more likely to reflect the circumstances of those groups without access to private modes of transport. Whilst acknowledging that access should consider wider perspectives than those based on location or transport availability alone, for example by encapsulating social justice and structural dimensions (Farrington and Farrington, 2005), the findings from such studies could sit alongside those that consider the impact of factors such as personal preferences and needs, financial resources, as well as the types of journey-making opportunities available to individuals that impact on daily activity patterns, so as to gain a greater understanding of trends in utilisation behaviour.

Author contributions

Gary Higgs: Conceptualization, Project Administration, Writing original draft preparation, Writing – Reviewing and Editing; **Andrew Price**: Data curation, Methodology, Software; Validation, Writing original draft preparation, Writing – Reviewing and Editing, **Mitchel Langford**: Conceptualization, Formal Analysis, Software, Visualisation, Writing – Reviewing and Editing.

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