Exploring spatiotemporal variations in public library provision following a prolonged period of economic austerity: a GIS approach

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Abstract

This paper demonstrates the applicability of GIS tools for investigating the implications of changes in public service provision following a prolonged period of economic austerity in the UK. Using the example of geographical accessibility to public library service points in Wales, levels of provision are estimated for two cross-sections in time to gain an understanding of the potential implications of changes in service delivery models. Accessibility scores for small areas, generated using sophisticated floating catchment area (FCA) methods, enable complex spatial interactions between library service capacity and potential demand to be evaluated within realistic geographical service areas. Extending these models, we demonstrate how indicators of library service 'quality' can be incorporated into access measures using the example of library operating hours for sites in three bordering Welsh local authorities, each of which experienced different policy responses to library service reconfiguration. Overall, the level of geographical accessibility to public library provision in Wales was seen to decline on average between 2011 and 2018; coinciding with a notable reduction in public library funding over the same period. Whilst this finding is not unexpected, given an overall decrease in public library service points, this study reveals spatial inequalities in provision with areas of declining provision coinciding with pockets of greater economic deprivation. From a policy perspective, this paper demonstrates how network-based GIS tools can aid scenario/sensitivity modelling to inform public service decision-making processes. Our future research will extend these techniques to examine the implications of service reconfiguration strategies on potentially disadvantaged groups such as the elderly and the unemployed who rely on public libraries for access to e-government and broader IT services.

Keywords: Implications of Austerity; Public Services; Library Data; Geographical Information Systems (GIS)-network models; Wales

1. Introduction

Public libraries are considered to be important community assets that impact on levels of social cohesion and well-being (Carnegie UK Trust, 2017). Particularly in times of economic hardship, they may play a vital compensatory role through the provision of free educational resources, internet access and online learning opportunities, as well as job-seeking information and advice (Child and Goulding, 2012; Anderson and Whalley, 2015). Libraries have also been identified as important contributors to the establishment of generalized trust (Varheim et al., 2008), social inclusion (Aabo and Audunson, 2012), and more broadly to the development of social capital (Svendsen, 2013). However, the retreating public provision of local services in response to austerity has threatened both the extent and quality of library services in the UK. Since 2010, library opening hours in England have been reduced by an average of 6% (Thorpe, 2016), for example, while the number of library service delivery points across the UK (excluding Northern Ireland) has decreased by 15.7%, and employee numbers by 35% (Woodhouse and Dempsey, 2016; CIPFA, 2018a). During this time, both the management and delivery of library services have become more reliant on varying degrees of voluntary contributions (CIPFA, 2018a; Smith, 2019), leading to an uneven landscape of provision (Forbes et al., 2017). This is particularly evident in Wales where it has been suggested that one in ten public libraries are now delivered solely by volunteers (Ballinger, 2017a). After years of reduced public spending, a recent (failed) attempt was made to protect library funding from further cuts via petition to the UK Parliament, arguing councils were unable to maintain staffed libraries when faced with the competing demands of other services.[1]

The benefits of Geographical Information Systems (GIS) approaches to understanding the implications of changes to library provision have been extolled by previous commentators,

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[1] https://petition.parliament.uk/petitions/228742

with a small but developing literature demonstrating their use in identifying spatial inequities in library service delivery (Cole and Gatrell, 1986; Higgs et al., 2013; Donnelly, 2015; Guo et al., 2018; Higgs et al., 2018). This study adds to the literature by demonstrating how GIS-based techniques can inform future planning and policy decisions following changes to library service delivery models stemming from cuts to public spending. Applied to a case study of library provision in Wales, the paper highlights how spatial techniques can examine changes in the distribution of library services over both space and time, and explore the impacts of library service reconfiguration on the extent, quality, and spatial equity of provision following a prolonged period of economic austerity. Whilst the problems of developing such temporal databases at detailed spatial scales are far from trivial, this study shows how different models of delivery can be incorporated into a fuller analysis of changes in provision, and its potential implications for service users, in order to understand the impacts of cuts in local government budgets.

2. Literature review

2.1 Economic austerity and public library provision

Under the provisions of the 1964 Public Libraries and Museums Act, local authorities in the UK have a statutory duty to provide a 'comprehensive and efficient' library service (HMSO, 1964). However, following a decade of austerity brought about by the 2008 economic crisis, UK local authorities have experienced a dramatic fall in central government (Westminster) funding that has resulted in a substantial, and often geographically uneven, reduction in local spending power (Innes and Tetlow, 2015; NAO, 2018). The majority of Welsh Government funding comes from Westminster and the impact of austerity on Wales, according to figures for 2019/20, has meant an £800m reduction in central government funding compared to

2010/11 (Welsh Government 2018a). Public library provision has undoubtedly suffered due to these cuts: the budgeted expenditure (gross revenue) on public libraries in Wales in 2018/19 is a little over £40m (StatsWales, 2018a), representing a 28% decrease compared to 2011/12 outturn figures (£55.585m: StatsWales, 2018b) and a 36% decrease in real terms.[2] Recent figures for England suggest a similar situation with libraries experiencing a near 40% real-terms decrease in spending since 2009/10 (CIPFA, 2018b). As a result of this fiscal pressure, local governments have been forced to re-evaluate their library service delivery models (Hastings et al., 2015); often leading to service reconfiguration (e.g. reduced opening hours, reductions in full-time professional staff, co-production with local civil society or the co-location of services) or closure (BBC, 2018a; Ballinger, 2017b; CIPFA, 2018a). Consequently, this has led some commentators to question the future sustainability of library services in some areas (Forbes et al., 2017). In an attempt to move beyond a solely economic narrative, other commentators have highlighted the lived experience (and geographies) of austerity in everyday life (e.g. Hall, 2018); and in the context of public libraries specifically (Norcup, 2017; Hitchen, 2019). Norcup (2017), for example, speaks of the gendered impact of library closures/reconfigurations as many library staff are female. Further, given the reliance of some groups on libraries for access to free resources, she highlights the inclusivity that libraries provide with regards to knowledge production and education, and the damaging effects retreating provision levels may have on social and cultural mobility.

2.2 Investigating geographical accessibility using GIS

GIS-based approaches to measuring geographical accessibility have evolved from simple container-based metrics (supply-to-demand ratios computed within predetermined spatial

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[2] Real term change estimated using UK Consumer Price Index (September 2018: 106.6):
https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/september2018

boundaries) and straight-line distances, to more spatially advanced network-based approaches such as gravity models and floating catchment area (FCA) models, both of which evaluate complex spatial interaction between service supply capacity, demand volume, and time/distance constraints (Luo and Wang, 2009).

Despite a relatively small empirical literature, spatial analytical methods have been applied to evaluate trends in public library provision. Donnelly (2015) used average straight-line distance from census block group population centroids to the nearest public library when assessing regional variations in library access in the United States (US). His findings indicated a degree of spatial clustering, with areas of lower geographical accessibility to public libraries found predominantly in the South. Park (2012) used a network-based nearest distance measure to examine access to public libraries in northern Florida. Using the zip codes of registered library users, Park identified distance as an important determinant of library usage, particularly for Hispanic and African American populations. Higgs et al (2018) demonstrated the value of FCA-based techniques in exploring the impact of library service reconfiguration on library access in Pembrokeshire, South Wales. Reductions in library opening hours were found to lead to inevitable declines in accessibility, with library provision post-reconfiguration estimated as 83% and 61% of pre-reconfiguration levels in regards to static and mobile library sites respectively.

FCA models address many of the limitations of simpler accessibility measures, such as the failure to account for cross-border flows (container-based metrics), the neglect of physical impedance factors (straight-line distance metrics), and the lack of consideration given to supply quality and demand volume (both straight-line and network distance metrics). However, to date, the majority of studies that have used such tools have been concerned with examining patterns of provision at particular cross sections; few studies have analysed changes in access scores over time in order to assess the implications of policy changes or cuts in provision.

3. Data and methods

To explore recent spatiotemporal changes in library provision in Wales the locations of library service points were obtained for two time periods - August 2011 and October 2018. The former were obtained from the Welsh Government and derived from information available from individual local authority websites at that time. The latter were constructed by the researchers themselves using a combination of publicly available sources including local authority websites, freedom of information responses, and an online resource[3]. Information regarding the model of service delivery at each location was also recorded. Given that the 2011 library data was extracted from local authority websites, we assume all libraries contained in this data set were under local authority management at this time. In contrast, a concerted effort was made in the 2018 data to broadly distinguish between common service delivery models: specifically, 'local authority', 'not-for-profit', or 'community-managed'. Mobile and home delivery library services were omitted from our analysis, which focuses on changes in provision relating to 'static' service points over time. The number of days per week (full or half day) each library operates was included in the 2011 data as a supply-side characteristic. This was replicated for libraries in a sub-sample of Welsh local authorities in the 2018 data to allow an additional case study comparing temporal changes in provision by quality of service. The 2018 library service points were geocoded via their postcodes using an online service.[4] The 2011 service points were geocoded prior to receipt. All data were input into ArcGIS^{TM} v.10.4 (ESRI, 2015).

This study uses the enhanced two-step FCA (E2SFCA) approach to demonstrate GIS-based analyses of temporal change in library provision and its effects on spatial accessibility to Welsh public libraries over a significant period of austerity. As its name implies, E2SFCA involves

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[3] www.publiclibrariesreview.com
[4] https://www.doogal.co.uk/

two fundamental steps. First, catchment areas as defined by a maximum travel time are computed around each service provision point (i.e. static public library). This yields a supply-to-demand ratio calculated from a supply capacity measure (for example, the total book stock adopted by Cole and Gatrell, 1986) relative to the potential demand determined by the population count deemed to fall within the catchment. Second, similar travel-time catchments are computed around each demand centre (typically, a census tract population weighted centroid, or possibly a postcode). Service accessibility is established as the sum of all supply-to-demand scores found to fall within each demand-side catchment. Geographical friction is modelled by ensuring the demand placed on a given service point in step one diminishes as population centres become more distant, and likewise for the value of each service provision point contributing to a demand centre's accessibility score in step two. A more detailed description of E2SFCA is given in Luo and Qi (2009).

E2SFCA scores were calculated for both time periods using a road network derived from Ordnance Survey Open Roads data. The population-weighted centroids of Welsh lower super output areas (LSOAs; n=1,909) obtained from the Office for National Statistics (ONS) Open Geography Portal[5] were used to proxy for residential location, and corresponding LSOA population counts used to represent potential demand. Population counts from the 2011 UK census and 2017 mid-year estimates, both sourced from ONS, were used for the 2011 and 2018 accessibility calculations respectively. The limitations of using the centroid of census tracts to represent the origin of potential demand for services has been recognised (Apparicio et al. 2017), and whilst the use of population weighted centroids address some of these concerns (especially for large rural LSOAs), it is nevertheless acknowledged that their application in network-based models may not necessarily reflect the actual time taken to access library facilities from all residential locations. In addition, the models assume that travel is via private

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[5] http://geoportal.statistics.gov.uk/

transport only, due to a lack of openly accessible data on public transport routes and timetables at the all-Wales level. In reality, many library users do not drive to their local library, or may use a combination of transport options to access a library which is not necessarily their nearest service. In the absence of the modal splits of such users, assumptions have been made regarding the use of private transport to access services; nevertheless journey times for walking and public transport could be included if detailed library utilisation patterns were made available. In the absence of a national database of journey times to libraries, a 15-minute travel time was used to define catchments used in the FCA calculations (although this threshold can be easily changed in a sensitivity analysis to examine the implications of alternative travel times): the setting of this parameter was essentially a pragmatic decision given the absence of any reliable evidence on actual times users are prepared to endure in order to access a library. It has been reported, however, that residents of 1,509 Welsh LSOAs (79%) can make a return journey by car to their nearest public library in ten minutes or less, whilst 97% of residents can make the same journey in twenty minutes or less (Welsh Government, 2015a). This suggests the 15-minute threshold is an appropriate choice. E2SFCA scores were computed using a bespoke ArcGIS plug-in tool (Langford et al., 2014).

4. Exploring spatiotemporal changes in public library accessibility

Figure 1 shows the locations of public libraries in Wales as of October 2018, based on publicly available sources. Recent library closures are also identified, geocoded and included where possible to highlight reductions in library provision over time, whilst a similar effort was made to identify models of service delivery. In total, 257 public libraries were identified: with 192 delivered by local authorities, 36 by 'the community' (these include libraries in partnership with local authorities and autonomous services), and 25 as 'not-for-profit' where local

authorities have leased their library services to an external partner. Four other libraries are included which did not conform to this categorisation (e.g. the National Library of Wales which is funded centrally by Welsh Government). Overall, as might be expected, a clustering of libraries is seen in and around the most densely populated areas of south east Wales (which includes Cardiff, the capital of Wales).

Temporal changes in FCA scores between 2011 and 2018 are mapped in Figure 2. Overall, geographical accessibility to public libraries reduced across this time period but not in a spatially uniform manner. Those LSOAs shaded in the purple colour palette experienced a reduction in library service, while those shaded in the green colour palette experienced an increase. LSOAs shaded white experienced marginal temporal changes. Amongst those experiencing declining service levels, most resulted from a combination of nearby library closures and service reconfigurations (such as the co-location of library services as part of wider community 'hubs', for example). It is likely the same library service reconfigurations also caused increased access levels in other LSOAs due to additional service points arising in close proximity to these population weighted centroids. Some temporal differences in accessibility may have also resulted from changing demand levels over time, based on changes in the mid-year population counts used within the FCA algorithm, but these are thought to be minimal.

To give greater credence to these arguments, a more detailed examination of spatiotemporal changes in access was undertaken in three bordering Welsh local authorities; Bridgend, Neath Port Talbot, and Rhondda Cynon Taf (RCT). As is evident in Figure 3(A), a number of closures took place in RCT and across the neighbouring Bridgend border. As a result, library service accessibility in many LSOAs in RCT (and bordering LSOAs in Bridgend) inevitably reduced as the number of service points falling within a 15-minute travel time declined. To explore the potential impacts of these changes, the most recent Welsh Index of Multiple Deprivation

(WIMD) income domain ranking of each LSOA is shown in Figure 3(B) (Welsh Government, 2014). The mapping of these rank scores alongside the space-time variations in public library provision suggest that a greater loss in accessibility was experienced in some of the most deprived LSOAs in the study areas; and demonstrates the potential for GIS to link the outcomes of spatial analysis to other socio-economic indicator datasets (Hertel and Sprague, 2007). In respect to recent library closures, for example, the mean WIMD income rank of the LSOAs experiencing library closures was 562 out of a possible 1,909 in the three case study areas (higher ranks represented greater income deprivation). This compares to an average rank of 793 for all LSOAs, which implies a potential deprivation bias in library closures in these authorities. This is particularly so in Bridgend, where the mean WIMD income rank of all LSOAs is 859 as compared to 393 for those LSOAs experiencing library closure. No discernible deprivation bias was found to exist at national level, however – with the mean rank score of LSOAs containing library sites in 2011 found to be similar to the mean rank score of those experiencing closures in the 2018 dataset.

As demonstrated in Figure 4, a particular benefit of E2SFCA is that instead of computing access based solely on the presence or absence of service provision points, it can, when suitable data are available, incorporate detailed supply-side characteristics into the analysis. In this example, 2018 access levels are computed by using the number of days-per-week each site is open as a measure of service quality. Caution should be exercised if comparing this map to the all-Wales examples however, because unlike the previous FCA layers these scores do not account for cross-border service capacity and demand arising from outside the study areas. This limitation is due to incomplete data on library opening hours being currently available in other local authorities. Despite this caveat, Figure 4 demonstrates the richness of evidence obtainable from applying GIS tools in this context. For example, it suggests that whilst Bridgend experienced some library closures, the leasing of other library services to a not-for-profit

organisation generally prevented substantial reductions in service quality. This action largely maintained weekly library openings at pre-reconfiguration levels, with LSOAs in Bridgend reporting relatively high accessibility scores. The fact that libraries in Bridgend are geographically well distributed may also be a contributory factor here. In contrast, the clustering of public libraries in southern RCT meant that FCA scores in the north of the authority were lower in comparison, and are perhaps indicative of areas underserved by current library provision. Further research is required to include wider measures of 'quality' that might incorporate, for example, the number of fully qualified library professionals employed at each site and, in turn, the extent of volunteer input. Nevertheless, this example demonstrates how characteristics of public service facilities can be included whilst studying provision in response to changes in service delivery.

5. Discussion

The effects of austerity have been multifaceted; manifesting fiscally but also being felt and lived in everyday life – for example, in the context of relationships and relational spaces (Hall, 2018), and anticipated futures (Horton, 2016). The reduced availability, accessibility, and (arguably) quality of library services in the UK following a strategy of broader public sector retrenchment in response to increasing austerity (Hastings et al., 2015) serves to demonstrate this duality: budgetary restrictions have led to increased closures and a greater reliance on non-professional, voluntary-based labour (CIPFA, 2018a; Ballinger, 2017a); and in turn a decline in free access to supportive, learning, and online resources (Anderson and Whalley, 2015) that have lived consequences for social and cultural mobility (Norcup, 2017).

In this study, given the intrinsic community value of local public libraries, we sought to demonstrate how the increasing availability of detailed origin and destination data and open-

source road network layers can be used in a GIS environment to conduct sophisticated spatial analyses of accessibility scores to examine temporal changes in access to public libraries. This is the first UK-based study, to the authors' knowledge, to explore spatiotemporal changes in public library access using FCA techniques at a national level. It builds upon previous work that has examined the impacts of library service reconfiguration taking place within a single local authority (Higgs et al., 2018) and particular aspects of provision such as children's library services (Robertson and McMenemy, forthcoming) in the most recent period of austerity. In summary, findings presented here suggest a number of 'hot spots' exist in Wales where accessibility to public libraries post-2011 has declined to a greater extent than the all-Wales average. Moreover, there is a degree of overlap between areas of worsening accessibility and areas of higher economic deprivation that are worthy of further study using alternative measures of service quality.

Since 2002 the performance of public libraries in Wales has been monitored through the Welsh Public Library Standards (hereafter the Library Standards). Now in its sixth iteration, *Welsh Public Library Standards 2017-2020 – Connected and Ambitious,* the framework notes how "[t]he nature of the geography, distribution of population and other factors within authorities can cause significant variations in the approaches necessary to the planning and delivery of library services" (Welsh Government, 2017; p.8). A strength of FCA in this context is that it allows those factors outlined in the Library Standards as integral to the planning of library service provision to be incorporated into accessibility calculations. Unlike simpler metrics (basic container or nearest distance measures), this includes not only the locations of public libraries (which is one of sixteen quality indicators included in the Library Standards), but also the distribution and volume of potential library users as they relate to realistic library service areas. Moreover, as detailed data on supply-side characteristics (e.g. total book stock, operating

hours, or number of computer terminals) become available, it is readily incorporated into the FCA model to further enhance its accuracy and value.

Following the announcement of further real-term cuts to local authority budgets laid out in the most recent Welsh Government budget (BBC, 2018b), the vitality of public libraries is once again under threat. In Wales, additional funding is available through the Transformation Capital Grant Programme to develop and enhance local library services (Welsh Government, 2018b): this includes the creation of multi-service 'hubs', which have been suggested to represent a 'sustainable management and financial model to replace the traditional single service delivery model' (Welsh Government, 2015b: p.38). The programme aims to help local authorities (or partnered trusts) to develop more sustainable models of service delivery (with a particular focus on co-location) in order to maintain and advance the quality of library provision and other eligible services. The network capabilities of GIS tools mean high quality, evaluative resources are becoming increasingly available to assess the equity and quality of existing library provision. Given this, it would be relatively straightforward for the approach described in this paper to be replicated and applied to other contexts – such as assisting local authorities to tailor their service delivery points to best serve the needs of their communities, or to inform funding decisions by helping to identify potential gaps in library provision after recent closures (e.g. Koontz et al., 2009).

The collation of data for space-time analysis is rarely a trivial exercise, often demanding a significant time commitment, and thus a clear strength of this paper is the adoption of a spatiotemporal approach to the GIS analysis. This required the creation of an up-to-date data set of library locations and attribute information to compare with a historical database of Welsh libraries. However, following changes to library service delivery models, obtaining accurate library attribute data, such as library opening hours, was found to be increasingly difficult at the all-Wales level; and suggests wider lessons can be drawn from this study regarding the

14

limited availability of detailed public service provision data to inform future GIS modelling of service accessibility. There are, of course, notable limitations to our approach that must also be acknowledged. Whilst others have shown how mobile library service points can be incorporated into a wider FCA analysis (e.g. Higgs et al., 2018), such sites were not included in this study, nor was consideration given to implications arising from the presence of home delivery services in some local authorities. If included, this information would most likely have impacted on the accessibility scores generated, particularly regarding access in more rural settings where travel times to static libraries are greater than in urbanised areas (Welsh Government, 2015a).

Furthermore, these accessibility scores are based on private transport only. In a recent England and Wales-based survey, only 30% of library users sampled arrived via private transport, and most deprived users tended to arrive via foot or by public transport (CIPFA, 2017). Public transport options were not included in this study for reasons already described; however, multi-modal approaches to accessibility measurement have been demonstrated before using FCA (e.g. Langford et al., 2016) and could be explored in future studies of UK library provision if the necessary data were to become available. Drawing on available evidence, a travel time catchment of 15-minutes was used in the study to represent the geographical service areas of Welsh public libraries. However, the appropriateness of travel cost constraints may vary in different geographical contexts (McGrail and Humphreys, 2009) and further sensitivity testing using catchment areas of varying sizes would help to examine the impacts of varying such thresholds based on the findings of library utilisation surveys, for example.

6. Conclusion

Following reductions in national spending and an increased reliance on monies obtained through competitive grant capture, it is increasingly likely that the landscape of library provision in the UK will be subject to further change as local authorities look to cut the costs of provision. Alternative models of service delivery will emerge which may result in a reduction in service 'quality' despite the efforts of hard-working volunteers to maintain services in their local communities. This study demonstrates the value of GIS tools in helping to inform policy and planning decisions surrounding the provision of public library services, but has also drawn attention to the difficulties in collating data that can be used to 'populate' such models. As demonstrated here, assembling historical data to analyse change over time at detailed spatial scales can be problematic, and we have highlighted the types of data issues that need to be addressed to provide a fuller picture of public library accessibility. In particular, there is an urgent need for library utilisation data that could be used in future scenario/sensitivity tests to evaluate a wider range of service reconfiguration strategies. By investigating changes in geographical accessibility, and drawing attention to their impacts for 'at-risk' groups such as those most reliant on public libraries for the provision of e-government and broader IT services, network-based GIS models can be used to monitor the outcomes of such policies for those most dependent on such services.

Conflict of Interests

None declared.

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Figure 1: Locations of library service points and recent closures in Wales as of October 2018
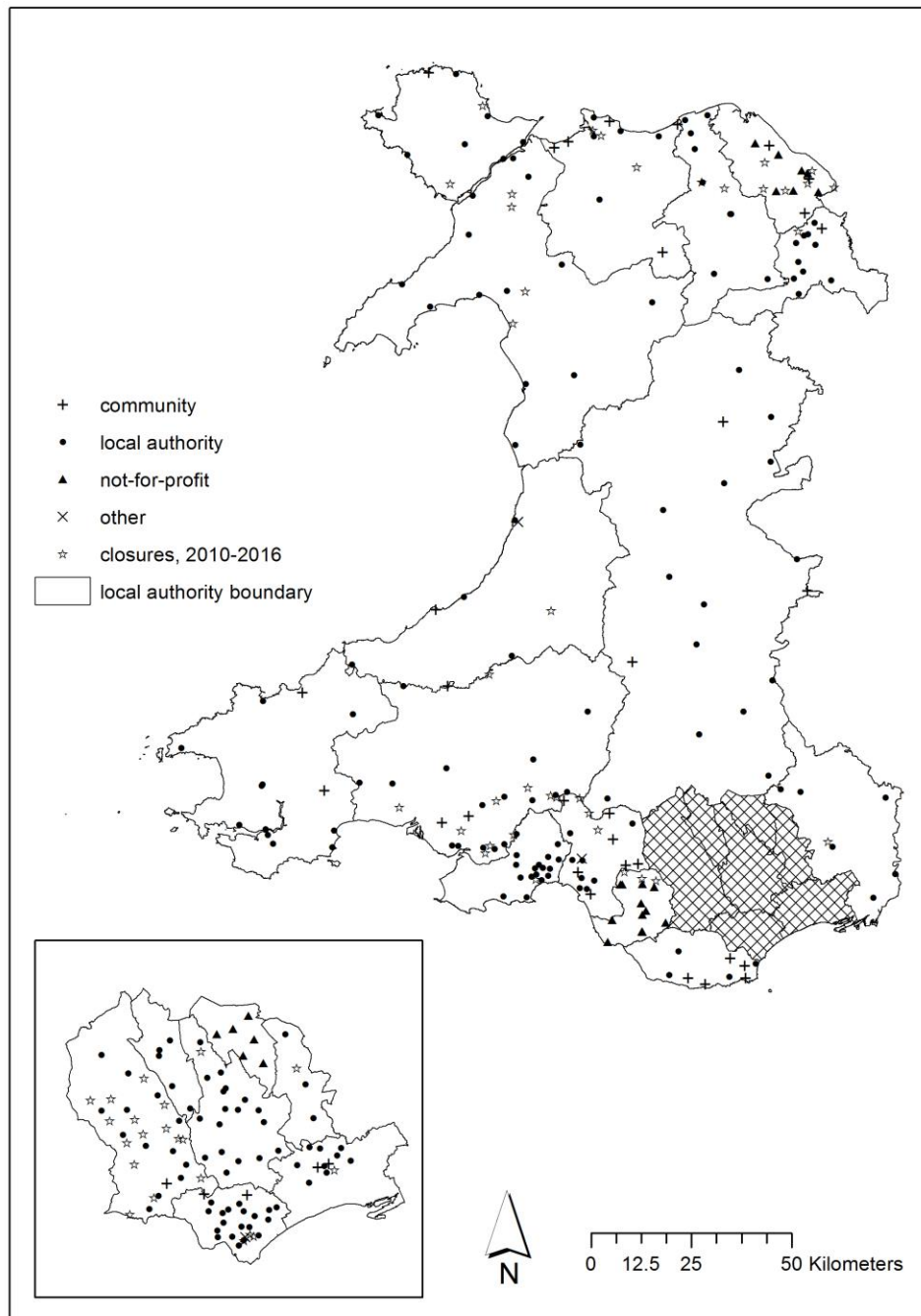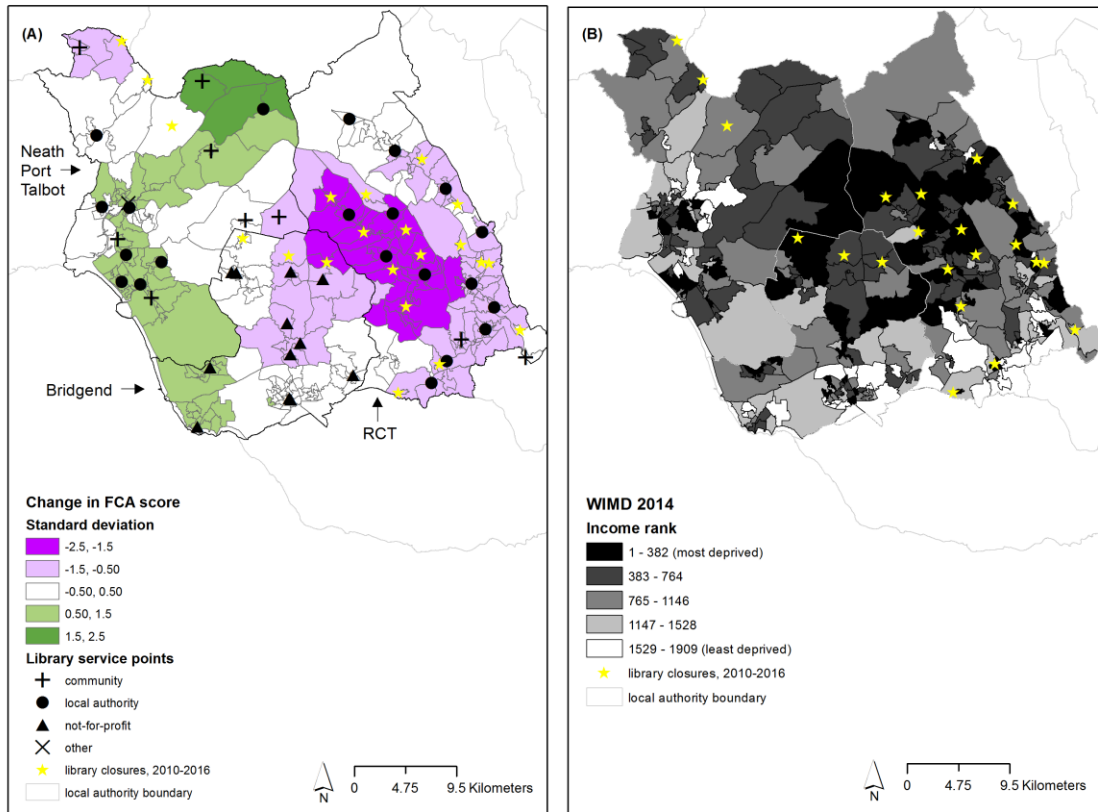
Figure 2: Spatiotemporal changes in geographical accessibility to public libraries in Wales between 2011 and 2018
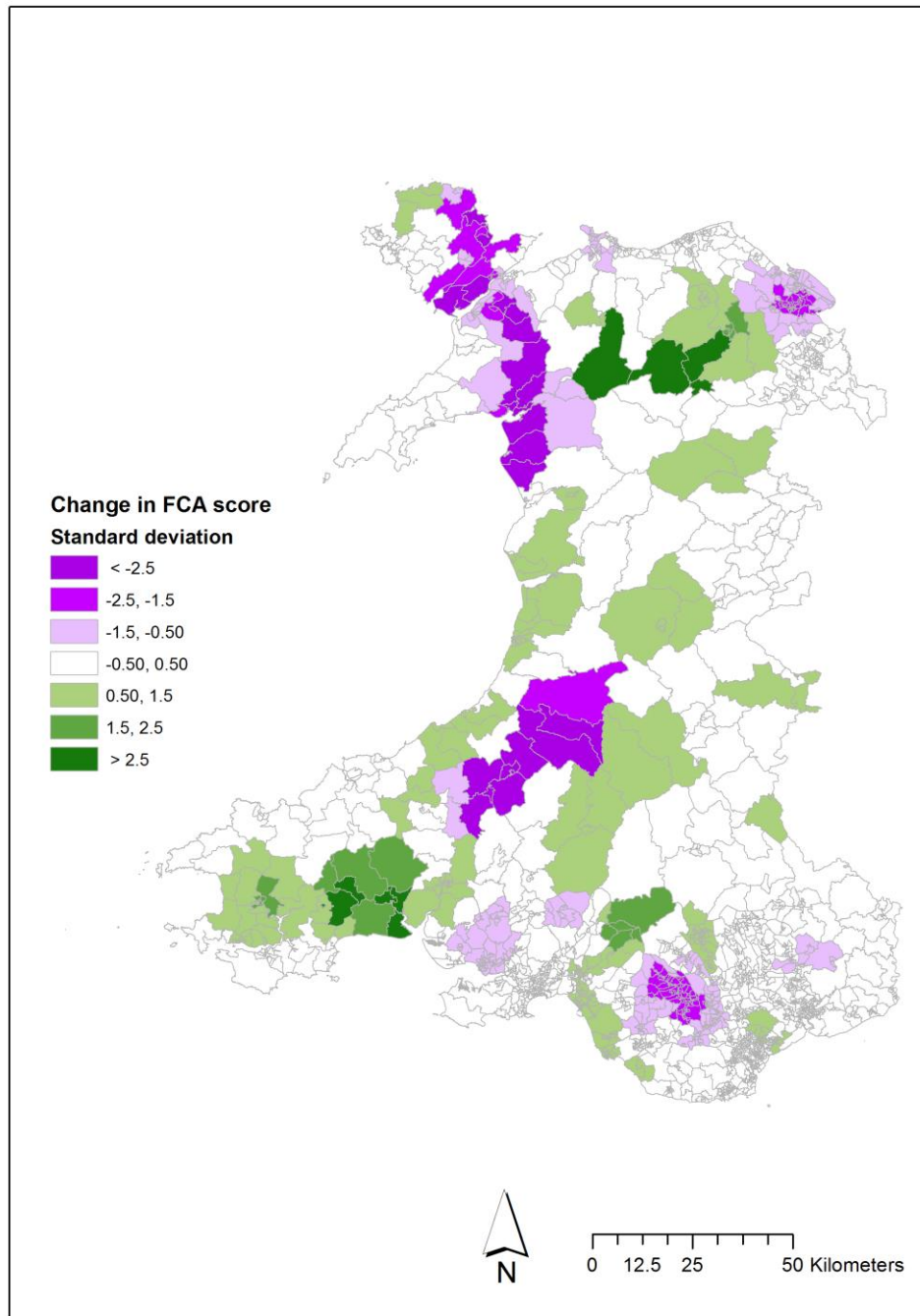
Figure 3: (A) Spatiotemporal changes in FCA accessibility to libraries between 2011 and 2018; and (B) Ranking on the Income Domain of the 2014 WIMD

Figure 4: Example FCA scores for accessibility to libraries in 2018 based on the number of days per week that each library operates