The Architecture of Mixed Uses

Laura Narvaez
Space Syntax Laboratory
The Bartlett School of Architecture, UCL

Alan Penn
Faculty of the Built Environment
The Bartlett, UCL

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Introduction

This research investigates the relationship between architecture and economy, focusing on the notion of ‘mixed uses’. The concept of mixed uses has been recognised as essentially requiring three elements: two or more significant revenue producing uses, a significant functional and physical integration, and conformance to a coherent plan (ULI, 2011). If we think about a layperson’s decision to set up a shop, where would be the best place – a corner location or along an urban block? Within one’s home or at a different location? Informing all of these questions, there is a spatial, architectural and an economic rationale of where, what and why we combine commercial and residential functions.

The mixing of uses requires an appropriate combination of multiple uses, inside a single structure or place within a neighbourhood where a variety of different living activities (living, working, shopping) are in close proximity (walking distance) to most residents (Foord, 2010; Penn et al., 2009; Davis, 2009; Evans, 2005). Drawing on these conceptions of mixed land use, three urban design qualities are explored that derive from the spatial and economic processes of mixing uses: spatial location; the combination of uses that a building is able to accommodate, mainly commercial and residential functions; and the spatial form in which the mixing of uses takes place.

The design qualities of location, use and form are elements that are also susceptible to change in the built environment. Change is a constant and one of the most powerful drivers in design. The change process is often one in which social shifts require a spatial–physical–reaction (Törmä et al., in press; Schmidt and Austin, 2016; Jacobs, 1969).

Space syntax theory has extensively examined the role of socio-economic processes in cities, whereas in spatial economics, location and distribution of land uses are modelled to understand urban processes. It is suggested that neither field has been robustly based on a more fully conceived level of local city design, and often overlooking the morphological conditions in which space and economics intermix. This article explores the relationship between architecture and economy, and questions the extent to which they work together. In particular, the paper focuses on the concept of mixed use by considering urban and architectural conditions that relate to spatial and economic functions, namely in terms of location, use and form. It is found that these three interrelated factors indicate varying typologies of mixed uses depending on their urban location and, in turn, defining different forms of spatial adaptability when commercial and residential use are combined. The paper reflects on the implications of mixing uses and suggests the need for urban design and economic theories to consider the bottom-up processes of socio-economic conditions through architecture and in the overall urban configuration of the city.

Keywords: location, adaptation, mixed uses, urban form, space syntax
The resulting condition of the ability to accommodate change is what we term spatial adaptability. Recent works by Holliss (2015) and Davis (2013) on building adaptability and mixed living/working functions have demonstrated the symbiotic relationship between building and economy, whereby functional and design flexibility respond to locational context. Therefore, this research examines whether urban configuration affects the adaptability of mixed uses in terms of location, use and form. We argue that the way in which morphology gives rise to the mix of uses is first and foremost at the local design city scale, which in turn informs the wider city scale and urban dynamics.

In space syntax research, there has long been interest in understanding how socio-economic activities are distributed in an urban region; what forces influence their spatial patterns, and how their functions and spatial structure are mutually dependent (Vaughan, 2015; Marcus, 2010; Hillier, 2009; 1999). In urban economics, location theory addresses the questions of who produces what goods and services and in which locations, and why (Losch, 1952; Isard, 1956; Alonso, 1964). Economists have addressed this theory to understand the optimal location of production given the factors of production and transport costs to consumers (Hutton, 2008; Glaeser, 2001; Krugman, 1995).

A wide range of empirical research has advanced on using location theory to analyse the street network configuration, showing the effects of spatial structures on a diverse range of economic values (Chiaradia et al., 2009; Desyllas, 2004) and land use mix (Netto et al., 2012; Krafta et al, 2011; Crucitti et al, 2006; Porta et al., 2006; Cutini, 2001). More recent work has suggested that land use mix follows changes in accessibility patterns over time in the spatial structure (Iacono and Levinson, 2015), and that urban form has an effect on land value change (Narvaez et al., 2015; Law et al., 2013). Yet, these studies still remain as examples of urban dynamics where a micro-scale of urban analysis is yet to be addressed. The urban configuration provides different kinds of structures and morphologies, with different characteristics at different scales. We suggest that certain architectural conditions play a vital role in how the mixed land use responds to patterns of accessibility, which in turn could help inform how the architectural bottom-up hardware – the individual building level – works in alignment with economic functions.

Whilst the physical morphology of street layouts may change slowly over time, land use occupancy of buildings and their development change more rapidly, partly due to the result of markets and partly to the different actors or agencies that influence planning and design decisions (Chapter 3, Oliveira, 2016; Larkham and Conzen, 2014; Whitehand, 1983). In a rapidly evolving economy, buildings are being re-used or re-built as patterns of land value change. In this context, we argue that the spatial adaptability of mixed uses is an effect of location depending on its use and morphological flexibility to change over time.

The paper presents an empirical case study of Cardiff in Wales. Cardiff has transformed over time into a multi-centric city forming sub-centres that have acquired different spatial structures bound to their own local socio-economic conditions. Cardiff is explored within an historical context focusing on how the sub-centre’s high streets have changed over time; particularly, in the way mixed uses came about within their own local context and within the district’s economic life. We suggest that certain activities are accommodated in buildings at corner locations, closer to busier roads, or along the middle block of streets depending on the morphological structure of the local urban area, therein offering different possibilities for architectural adaptability. As a consequence, this empirical work presents a novel method linking configuration and morphological measures with economic theories of location.
The paper is divided into four sections. The first part explores the concept of mixed uses and spatial adaptability with a particular focus on the commercial-residential building (CRB). The second section introduces the methodology and data used for the case study. The third part expands on the analysis of location, use and form of CRBs, from an historical context of mixed uses to the different morphological situations hindering the mixture of land uses at the urban and architectural scales. The last section of the paper offers a discussion of the findings and its implications in urban design practice.

Mixing uses

The term ‘mixed use’ is largely based on the place-making of the built form, which is an approach in urban design and planning concerned with creating social life in cities (Jacobs, 1961; Rowley, 1996; Coupland, 1997). The concept is commonly referred to the development of a street, an urban block or a building which physically and functionally integrates different uses in the same location. They enable a place to be a connector of pedestrians, ‘living, moving and working’ as Rowley describes (1996, p.1), linking and integrating social and cultural qualities in an urban area.

From a broader perspective, the conceptualisation of mixed uses has been raised in urban policies in order to stress the need for delivering sustainable growth and diversity of urban neighbourhoods. The Commission of European Communities (CEC, 1990) emphasised avoiding ‘strict zoning [regulations] in favour of mixed uses of urban space, favouring in particular housing in inner city areas’ (p.30). Furthermore, in the UK the White Paper entitled *Our Towns and Cities: The Future – Delivering an Urban Renaissance* (DETR, 2001) advocated the promotion of mixed uses, arguing that the economic success of urban areas should envision the physical management of ‘housing and local amenities – providing an efficient, attractive and safe environment within which to live and work’ (sec 4.2.2).

However, the mixing of uses depends on several factors. One such is scale – building, block, street or neighbourhood (Kropf, 2011). A mixed use building may have multiple uses in a single structure (Figure 1), but a single use commercial building could be part of a mixed use complex. A second factor is the existing and future residential and commercial demand (Evans, 2005). Building use demands pedestrian footfall in order to achieve the required intensity of activities and to sustain an active economic life (Hiller, 2009; Jacobs, 1969). This prompts an issue in urban design regarding the level of accessibility in a local area – for example, the way a street might either be designed for a higher degree of vehicular traffic with lesser pedestrian movement, or to be predominantly pedestrian.

Mixed uses also need to be understood in terms of urban grain, density and permeability. The distinction between private (residential) and public (commercial) spaces is defined by the typomorphic structure of building fronts and backs (Samuels, et al., 2004; Moudon, 1986), which can enable a transition to the public street life through private buildings addressing the street (Rowe and Koetter, 1984). Moreover, processes by which the mixing of uses takes place is important, such as diversity, conservation and regeneration (Aldous, 1992; Törmä, 2011). The diversity of activities in a street ‘is a product not simply of the mix of activities within the buildings and blocks that abut a street but also of the design and public use of the street itself’ (Rowley, 1997, p.87). The issue is not only of design or the position of entrances in buildings, but also concerns how the street becomes an active space of mutual collaboration between the private and the public realm (Chapter 7, Vaughan, 2015; Evans et al., 2009) (Figure 2).

The combination of all these factors in mixing uses provides the character, quality and socio-
economic life to an urban place. Allied to the conceptualisation of mixed uses is the physical change of the built form. Change in the built form occurs over time and is largely mediated by a range of choices and other variations (Kropf, 2001) – changes in markets, consumer preferences, urban regulations, technological progress, and so forth. Yet in essence, what we see as change in the built form is, in fact, its capacity to respond flexibly to the needs and desires of its users (Schneider and Till, 2007). Such flexibility is, like change, multiscalar and multidimensional. It has the capability to adapt to a variety of circumstances – be they physical, functional or social qualities, either in the morphology (modification) or the movement (accessibility) of the built environment (Törmä, 2011). This begs the question of what the conception of adaptability entails in spatial form.

Adaptability and mixed use

The definition of adaptability in design can be looked at from different standpoints. The etymology of the word ‘adapt’ comes from the Latin apere (to bind, to attach) – its past form, aptus, forming the root of the verb adaptare (to adjust to, in provision of) (Rey, 2006).¹ According to Simonet (2010), adaptation takes its conception from the theory of evolution that refers simultaneously to an action (process) and a finality (state) requiring a sense of time.

Schmidt and Austin (2016) define adaptability as ‘the capacity of a building to accommodate effectively the evolving demands of its context, thus maximizing value through life’ (p.5). It is, therefore, a ‘design characteristic’ that embodies spatial, structural and service qualities to allow the physical object of design to be malleable in response to changes over time (ibid). Adaptability, then, is con-

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¹ Quoted in Simonet (2010).
cerned with the ability to alter itself or its responses to the changed circumstances or environment. In essence it means a response to change. At the start of this paper, we defined spatial adaptability as the resulting condition of the ability to accommodate change. ‘Spatial’ here, in terms of ‘spatial adaptability’, is framed through the groundwork of Hillier and Hanson’s theory (1984), in addition to the conceptualisation of adaptation:

How, then, does spatial adaptability respond to the combination of uses, embodying social and economic functions, in architecture? From an operational design point of view, the mixed use building acts as a space that interrelates trade and living. Holliss’ work (2015) demonstrates extensive research that the distribution and architecture of working and living – the ‘workhome’ as she calls it – interrelate in ways we often overlook. Working above, next to, in, or in front of a home, which has occurred for many years in the UK, can challenge the question of what kinds of homes we should be building and how many of them would make a ‘good mix’.

Reconversion of ground floor use of a home to a non-domestic use has been on the rise over many years in different cultures (Davis, 2013). Yet working from home in the UK has not been sufficiently acknowledged by government bodies where ‘regulatory frameworks are at best unsupportive and at worst punitive to the sector, despite its growth and modernity’ (Holliss, 2015, p. 148).

An example of work and living in the same building is the typical merchant’s house in the UK, which serves the sales of goods or the production area of a shop at the ground floor, with internal spatial arrangements that consist of storage facilities at the lower ground floor of the house and communal family use over the shop (Coupland, 1997). The mixture of uses results in a form of concentration of diverse activities that produces a ‘generalised pattern of zoning by occupation’ (ibid, p.34). This pattern is reflected in how functions tend to be separated vertically within the building, with retail use and craft activities on the ground floor, and family living on the upper floors. Sjoberg (1960) explains that the ‘localisation of particular crafts and merchant activities in segregated quarters or streets is intimately linked to the society’s technological base. The rudimentary transport and communications media demand some concentration if the market is to operate: in this way producers, middlemen retailers and customers alike can more readily interact’ (p.101).

From the point of view of a generic design, the mixed use building is a unit that forms part of a single development, a city block that provides different means of shared access. The different ways in which the façade can provide access to commercial or residential uses influences how accessibility can be changed and priced in different forms depending on the building’s location in the urban network. The façade represents the interface between the privacy of living and the microeconomic qualities of the public realm within a street. Therefore, the permeability of the façade regulated as a ‘device of transition’ (Talen, 2012) of street accessibility and building use is based on the socio-economic incentive that the CRB can provide (Davis, 2009).

While there is some flexibility in the internal design of a mixed use building, design regulations have the capacity to be the tool for change of use and building adaptability (Talen, 2012). The same logic of developing a vertical integration of mixed uses within an urban block can be applied to developing the site to its maximum extent horizontally. This shows a transformation of buildings in terms of the façade being set back, placing shops on the back of pavement lines. However, sometimes the form of development is reversed by extending the façade to the street. Shops are extended forwards on the ground floor in front of residential spaces. As a result, the residential ground floor is converted into a retail space. This conversion is commonly

2 Quoted in Coupland (1997, p.34).
found on main high streets or primary routes where the demand for inter-accessibility is higher (Davis, 2009). The advantage of this new form of building configuration is that it gives residential spaces more privacy in terms of access and affordances of the public street (e.g. noise).

The commercial-residential building as an exemplar of spatial adaptation and economic flexibility

The existence of the CRB, which we relate here to the concept of the shop/house, has been historically present in various cultures that emerged in different cities partly as an economic condition of living and working in the same place (Davis, 2012). The CRB is a spatial unit that results from an architectural transformation influenced by economic necessity as well as cultural adaptation. Rules of building form provide the flexibility to adapt a dwelling into a unit of work. Davis (2012) argues that this kind of change over time depends on the cultural and economic background of a city:

This fluid attitude toward building use is essential to the lives of people who inhabit shop/houses, for whom the building’s flexibility allows them to develop businesses in their houses with a minimum of financial investment, and to expand and contract the space devoted to the business as necessary. It is also important to larger buildings, in which dwellings and business owner may optimize rent by not restricting use. (p.13).

Working and living is a relation of how access and location complement each other through changes in building use (Figures 3 and 4). When non-residential use is adopted in a dwelling, location becomes crucial and so too the price of accessibility in an urban neighbourhood. For example, retail and commercial functions require a degree of pedestrian catchment area. Therefore, a CRB will need to be located on streets that allow a more public use (busier streets) than more private ones (quieter streets). The strategic decision regarding where public use should be located in close proximity to private use is relevant.
to how distances are shaped within the architecture of the street network.

The accessibility to a CRB and its connectivity to the wider urban district can significantly impact on how different activities are reached or how frequently a specific location is likely to be used as a route to pass through (Hillier and Iida, 2005). The relevance lies in the way two functions - residence and commerce, the public and the private – are optimised in the same location and how a single property can have a financial return that then leads to a mixed use district (Davis, 2009).

Architecturally, the CRB is suggested to have the spatial capability to adapt to different functions. Shops are located on the ground or street level and dwellings on the upper floors, causing the separation and combination of uses to influence how access is provided either to a shop or a residence. The differentiation of commercial and residential use is also an issue of topological relations. Both types of uses relate to the same street (e.g. the clustering of shops for mutual competition), the position and morphology of the urban block that provides close proximity to other complementary uses (e.g. the location of storage facilities of a shop within two blocks from a high street), and the unit of the building (e.g. residential and commercial tenures). From an economic perspective, the CRB represents the requirement for people to minimise distances, as well as time and transport costs, by working from home, in particular the self-employed, microbusinesses and start-ups, along with the financial gains of maximising rents.

If commercial uses are located alongside residential use then housing rental tends to increase, rendering location a highly valued asset of the property that favours the CRB due to its commercial and residential profitability. An important requirement of the CRB is having the residential densities to support retail shops (Davis, 2012). The issue lies in balancing how living can be kept away from the public realm of the street for reasons of privacy or even safety. The CRB needs to satisfy the demands of each function by having sufficient residential density to support itself, and to fulfil the demands of housing affordability by being located near services.

Methodology

The CRB is studied in two types of building forms: mixed use buildings that are located at corners in an urban block and those that are located along streets. In particular, these two building forms are given special attention in local districts rather than the city centre area. The city centre area was not included because it comprises mixed use developments (i.e. high-rise developments) rather than typologies of building adaptations. Therefore, CRBs in local neighbourhoods were taken into consideration for this study as building typologies in which the function of the working-living relationship is brought together relating to either a building in which the family owns the shop and lives in the same property, or a building which takes on the independent functions of shop and dwelling. In both cases, the CRB is part of an architectural adaptation influenced by a given economic situation, such as renting a house or a retail space.

The CRBs in Cardiff were mapped using two extensive sources of data: Council Tax band values contained in mixed use properties and land uses. Council Tax bands refer to a tax indicator that is only assigned to residential properties, which are divided into categories (bands) according to the residential value of a property (Table 1).

<table>
<thead>
<tr>
<th>BAND</th>
<th>Value (£)</th>
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<tbody>
<tr>
<td>A</td>
<td>Up to 44,000</td>
</tr>
<tr>
<td>B</td>
<td>44,000-65,000</td>
</tr>
<tr>
<td>C</td>
<td>65,001-91,000</td>
</tr>
<tr>
<td>D</td>
<td>91,001-123,000</td>
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<tr>
<td>E</td>
<td>123,001-162,000</td>
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<tr>
<td>F</td>
<td>162,001-223,000</td>
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<td>G</td>
<td>223,001-324,000</td>
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<tr>
<td>H</td>
<td>324,001-424,000</td>
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<tr>
<td>I</td>
<td>424,001-above</td>
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</tbody>
</table>
This tax indicator is defined by a government agency, the Valuation Office Agency (VOA, 2013). Each tax band is defined by the VOA and is estimated according to spatial factors that contribute to the value of a residence: its location in the city, size of the building and its age. According to the VOA, tax bands are included in either purely domestic or in mixed use properties. These were obtained from the Council Tax valuation list that contains a list of purely domestic use properties, and properties with part domestic and part business functions – thus considered as mixed use. Tax bands referring to mixed use properties include those in which residential spaces are banded within a mixed use building.3

For the purposes of this paper, tax bands are not used as part of the analysis. Rather they form part of the research method to identify where dwellings that are banded within mixed use properties are located. Land uses were then compared with the location of Council Tax bands of mixed use buildings in order to identify which kinds of uses are associated with those properties, allowing us to map the location of CRBs in different parts of the city.

It should be noted that an observation survey of CRBs conducted by the author was added to the data of mixed use properties. The information was gathered through informal interviews with the owners of the shops. This informed whether the shopkeeper was living and working in the property, or the CRB had separated functions through renting the space for the shop or the dwelling. A total of 924 mixed use buildings were assessed, which include 679 mixed use properties from the tax band data plus 245 properties that were mapped. As expected, CRBs located along a street or at middle blocks were found to be more common than corner types (Figure 5). In the same way, we distinguished the types of uses for each typology of mixed use building (Figure 6). Most of the types of uses for both corner locations and along street types showed similar trends of functions – most of the types of uses were dedicated to general commercial land use, office and shopping in both typologies.

3 Council Tax bands are used to correlate spatial accessibility metrics in Cardiff as a separate analysis. Refer to: Narvaez, L. (2015) Architecture, Economy and Space: A study on the socio-economics of urban form in Cardiff, UK, Chapter 5, PhD Thesis, Space Syntax Laboratory, Bartlett School of Architecture, University College London.
In the case of 147 corner shops, the data has been deemed to be a good indicative to explore the analysis of mixed use patterns across the city and possible differences between a location on a corner of a street compared to a mixed use building along a street – be it a high street or not. The types of non-domestic land uses found in CRBs showed the dominant use to be general commercial, followed by shopping, office and takeaway shops. Furthermore, the types of land uses are distinguished between the two types of CRBs, as corner shops and along street types.

The approach to selecting mixed use buildings at corner locations and along streets was based primarily on the data provided that combined Council Tax values and land uses. The distribution of Council Tax band values as residential data underpinned a preliminary platform database to correlate them with non-domestic land use (Table 2). A large number of the CRBs located along street or middle blocks were found within band values C and D, a range of residential values between £65,001 - £91,000 and £91,001 - £123,000, respectively. This was similarly the case for corner locations. However, these were only found amongst tax bands A–F, showing that higher valued residential properties do not feature existing non-domestic land uses within their properties (Figure 7).

*Land uses were obtained by Ordinance Survey as an information layer called ‘Address Layer 2’ (AL2). According to the Ordinance Survey agency, the classification of ‘General Commercial’ is assigned as a general remark that can denote either office or retail use.*
A second criterion for choosing these two typologies is also the morphological and configurational differences of the location itself. Locations along a street or middle block lend themselves to suggest that mixed uses will tend to be found on busier roads where commercial activities often occur, as opposed to residential streets. It is hypothesised that a corner location may offer more options for spatial adaptability than a location along a street.

CRBs located at corners are predominantly of general commercial use (see Figure 6) – businesses that can either be professional services or retail use, such as shopping or takeaway restaurants. The type of land use on corners reflects the kinds of activity allowed in locations that have residential streets and commercial activity at close proximity. Even more interesting is the spatial qualities that the corner as a location itself involves. For instance, in terms of accessibility, a corner is a location with more than one alternative route to reach or pass through it; it is part of an urban path among multiple competing alternatives. Similarly, a corner has the advantage of the visibility of its location. A corner that is located on an urban block that forms part of a large main high street has the advantage of being visibly accessible from the high street as well as from local streets of greater residential use that connect to the high street.

The observation of these two typologies was carried out in three local centres of Cardiff: Canton, Plasnewydd and Grangetown (see Figure 8). These local centres were also chosen due to their location in the wider urban street network. Syntactical analysis of closeness centrality (Integration) and betweenness centrality (Choice) showed that the high streets sustain a high advantage in accessibility both globally and locally within the city, shown in Figure 9. This figure shows a matrix describing the local centres relating different variables. Each sub-centre is analysed and compared in terms of a) land uses – distribution of retail, office, light industry, residential and leisure; and b) spatial accessibility.
of the street network, which include analysing the global accessibility and connection of the main high street of each sub-centre, i.e. global choice and integration (Rn), and the local accessibility or ease of reaching the high streets within an 800-metre radius (Integration R800m).

From the analysis of global and local integration, we can see that the local high streets for each sub-centre have a good advantage in terms of accessibility. In the particular case of Grangetown with its radial road patterns, only the street in the north-south direction, providing a connection to the city centre and the docklands respectively, has higher accessibility at a global scale. In a similar way, the same street becomes important in relation to the global connection of the street as a passing through-route across the city (Choice Rn), connecting the city centre to the industrial area of the docklands.

Along with the configurational analysis and its relation to land use patterns, a morphological analysis approach is emphasised as, we argue, this helps the progression from an urban analysis of the street network to a more in-depth analysis of architectural morphology. Whilst configurational metrics can inform about the advantages of accessibility and location, a morphological approach can inform how the geometric configuration of location distributes and adapts to different forms of activity.

Investigating location, use and form

Depth distance and centrality
The location of CRBs is investigated by correlating them with their topological distances (depth distance) from the high street of a local urban district. Four main districts were examined: Plasnewydd, Canton, Grangetown and Butetown (Figures 10 and 11). The value of zero in the x-axis in the graphs means step depth 0, which corresponds to the high street as the point of origin for each sub-centre. In this way, the study is able to establish how these types of CRBs tend to distribute themselves across the city and how they develop in terms of their location. Topologically, corner shops tend to be located at one step depth from a main high street. In particular, Plasnewydd represents the area with the highest amount of CRBs at corners, followed by Grangetown and Canton.

If we compare the three types of distances, taking into account only corner locations, then the largest number of corner shops are found at the most proximate location from the high street, rather than in direct connection to the high street. The graphs in Figure 12 show the differences in corner locations, comparing topological, metric and angular distances from the high street to all other spaces.

The graphs illustrate the case of corner shops as ranked by their type of activity. Relating location and type of use, corner shops are found to contain a variety of activities at one turn of direction from a high street; the most consistent type of activity is general commercial, followed by shopping, public houses and takeaway shops. Other businesses such as hairdressers, chemists or restaurants are less frequently proximate to the high street. In terms of physical distances, at less than 500 metres from the main street, we find the same kinds of activities as in one topological turn. This suggests that at one single turn of direction from a block that is possibly less than 500 metres away from the high street, we are able to find a CRB at a corner that is likely to combine residential use with a general commercial or retail use.

The previous analyses of corner shops have shown how these are distributed in local centres. Each local centre has contrasting forms, mainly radial and non-radial structures. The following analysis focuses on how corner shops have developed in gridiron/linear urban forms, such as the case of Plasnewydd and Canton, and in a radial morphology, as in the case of Grangetown.
Figure 8
The geography of mixed uses across the city and in sub-centres (highlighted in red). Background map: Ordnance Survey Edina Crown Copyright.
Figure 9
Matrix showing analysis and comparison of each local sub-centre or district in terms of: a) land uses: retail (red), office (blue), commercial (light blue), industry (purple) and residential (yellow); b) spatial accessibility metrics of global integration and choice (Rn) and local integration within 800 metres (by author).
Figure 10 (left)
Graph comparing number of CRBs at corner locations with topological distance from each local centre: Butetown (blue), Canton (green), Grangetown (red) and Plasnewydd (orange).

Figure 11 (right)
Graph comparing number of CRBs at middle block/along a street with topological distance from each local centre: Butetown (blue), Canton (green), Grangetown (red) and Plasnewydd (orange).
Figure 12
Corner shop locations compared with topological, metric and angular depth distances from local high streets.
A common trend identifiable in the topological distance graphs from the previous section is the high number of CRBs located between 10 and 13 topological steps across the city. These results mean that at those distances, from 10 topological steps onwards, the local centres begin to overlap, and so eventually the number of CRBs from one location starts to fall into the spatial territory of another local centre. In order to isolate the cause of this finding, the analysis takes only the first 5 topological step depths from each local centre and their corresponding high street in order to only account for corner shops within the boundaries of the centre.

Indicators of centrality in mixed use buildings – Findings

Table 3 presents a taxonomy of regression analysis presented in two models: Model 1 uses along street type CRBs; and Model 2 uses CRBs at corner locations. In both models, the same predictors are applied: accessibility metrics of closeness centrality (Integration) and betweenness centrality (Choice). In space syntax analysis, these two measures represent intuitively an overlapping distribution of movement in the street network – one which quantifies how a location can be a potential destination in relation to all other locations, which in space syntax terms is understood as to-movement (Integration); the other estimates how well a location is positioned to be passed through, known as through-movement (Choice) (Hillier and Iida, 2005).

Both integration and choice were used with global Rn (no radius restriction) and within a radius of 400 metres and 800 metres, which represent a 5-minute and 10-minute walk respectively. As a consequence, we can compare local relationships in the street configuration to the rest of the larger-scale network in the city.

The results of Model 1 demonstrate that all variables remain positively correlated and significant at the 95% level for mixed use buildings that are located along streets or middle blocks. We can assume that mixed uses along the street tend to be located on the high streets of local districts, which in turn also show a presence of through-movement (represented statistically as choice) for local pedestrian footfall (0.553, p>0.05). The significance of the results in Model 1 is confirmed with the ANOVA test results, showing evidence that both integration and choice impact on the clustering of CRBs in locations along a street rather than at corners.

The local predictors of integration and choice are also shown to have an effect on CRBs at corner locations (Model 2). In contrast, the movement flows at the larger scale in the street network (represented statistically as the global measure Rn of integration and choice) do not represent a significant correlation to CRBs at corner locations. Therefore, CRBs are influenced more by the passing trade of local accessibility – as in, ease of getting to or passing by corner locations where mixed use is found.

Differentiating mixed uses and their urban morphologies

Orthogonal and linear urban forms

The morphology of Plasnewydd has transformed over time into a commercial district composed of its two main streets, Albany Road and City Road. Historically, Plasnewydd's form evolved as a regular pattern of blocks that developed from an extensive housing construction during the twentieth century (Figure 13). However, part of the urban transformation of Plasnewydd has been shaped by the lack of space in the area, where properties are not particularly large or spacious and the demand for a higher concentration of commercial activity began to increase over time (Morgan, 2003). Albany Road, the main shopping street in Plasnewydd, is composed of large frontages on the north side of the street with fewer plots; whereas on its south side the length of the block is parallel to the street, having more plots with smaller frontages.
Table 3
Summary of regression models for locations of CRBs along a street (Model 1) and corner locations (Model 2).

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>ALONG STREET</th>
<th>CORNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration Rn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R Square</td>
<td>0.384</td>
<td>0.059</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.148</td>
<td>0.002</td>
</tr>
<tr>
<td>Sig. F change</td>
<td>0.000*</td>
<td>0.150</td>
</tr>
<tr>
<td>Sig (p-value)</td>
<td>0.000*</td>
<td>0.150</td>
</tr>
<tr>
<td>Model Summary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficients:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>8.602 (37.919)</td>
<td>4.571 (5.250)</td>
</tr>
<tr>
<td>B (t-value)</td>
<td>Integration Rn</td>
<td>-0.002 (-23.204)</td>
</tr>
<tr>
<td>Integration R400m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R Square</td>
<td>0.494</td>
<td>0.241</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.244</td>
<td>0.057</td>
</tr>
<tr>
<td>Sig. F change</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Sig (p-value)</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Constant</td>
<td>4.788 (88.520)</td>
<td>3.997 (30.800)</td>
</tr>
<tr>
<td>Integration R400</td>
<td>-0.008 (-31.625)</td>
<td>-0.004 (-6.016)</td>
</tr>
<tr>
<td>Choice Rn</td>
<td></td>
<td></td>
</tr>
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<td>0.045</td>
</tr>
<tr>
<td>Adjusted R Square</td>
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<td>0.000</td>
</tr>
<tr>
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</tr>
<tr>
<td>Sig (p-value)</td>
<td>0.000*</td>
<td>0.274</td>
</tr>
<tr>
<td>Constant</td>
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<td>3.345 (47.495)</td>
</tr>
<tr>
<td>Choice Rn</td>
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<td>-3.791E-9 (-1.096)</td>
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<tr>
<td>Choice R800m</td>
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<td></td>
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<tr>
<td>R Square</td>
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<tr>
<td>Sig (p-value)</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Constant</td>
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<td>4.507 (31.470)</td>
</tr>
<tr>
<td>Choice R400</td>
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<td>-0.002 (-9.205)</td>
</tr>
</tbody>
</table>

Dependent Variable: MorphotypeCRB
* significance p<0.05
The blocks from the north side of Albany Road have experienced the least changes over time in terms of conversions from residential to commercial use. Mixed use buildings combining dwellings and takeaway shops are found at corners that connect the main high streets and local streets, shown at step depth 0 (see Figure 10). These corner shops have the advantage of the accessibility of the commercial Albany and City Roads, whilst also connecting to residential streets (Figure 14). A higher number of corner shops in the immediate proximity of the high streets include mixed use buildings combining residence with activities of general commercial and shopping. These two types of uses are the most persistent ones within the boundaries of Plasnewydd, followed by corner shops containing office use, hairdressers and a supermarket.

A second example of a non-radial form is Canton. The morphology of Canton is largely organised through its single long shopping thoroughfare. The proximity of the area to the city centre has been an attraction for young professionals to establish themselves in Canton, which has partly resulted in the development of more commercial uses around the area, influenced by the local population and creative industry (Morgan, 2003).

The development of the main street, Cowbridge Road (Figure 15), has kept dwellings along the street, most of them delimiting their entrances using front gardens and car parking, in contrast with other commercial units that have a direct entrance to the street with commercial extensions in their frontages. The CRBs at corners in blocks along the thoroughfare, indicated at step 0 in the graph (see Figure 10), include uses such as a bank, office, takeaway, restaurant and public houses. At one step depth from the high street we find takeaway shops and specialised services, such as a veterinarian surgery. General commercial and shopping remain the predominant use in corner shops within the vicinity of the high street.

Drawing from the observation survey in Canton, it was found that most of the dwellings are at one or two steps away from the main street, yet adjacent to retail activities that involved restaurants, cafes and food markets. In some cases, the restaurants were found to be fast-food places like pizzerias, sandwich bars and a Chinese restaurant where the owners of the shop also lived in the building (Figure 16).

Radial urban form
Grangetown represents an example of a radial urban form. Historically, the area has attracted large ironworks businesses and large industrial companies. The radial form of the district has allowed the transformation of large-scale facilities into shopping retail stores, sporting facilities and retail parks that link to Butetown and the Docklands in the south east of Cardiff (Figure 17). The radial organisation of Grangetown has also acquired a relevant connection to other towns in the south west of Cardiff. One of its main thoroughfares, Penarth Road, provides connections from the city centre of Cardiff, crossing Grangetown and leading to the upmarket town of

Figure 13 (left)
Plasnewydd in 1920s
(Ordnance Survey/ Edina
Crown Copyright 2014)

Figure 14 (right)
Section of Albany Road
as the main high street
(ArcGIS ESRI).
Penarth in the south of Wales. The road has gradually been filled primarily with car dealers, fast food outlets and warehouses.

The spatial geometry of Grangetown is argued to have a major morphological influence on the location of mixed use buildings. For example, the configuration of the street layout only allows access to residential streets from other secondary roads and not directly from the main high streets. So it is expected that the major flow of vehicular movement occur in these main radial routes of the district. Along these routes, the vehicular access is restricted by elements like trees, bus stops and urban furniture, allowing only pedestrian traffic. The restriction of vehicular access suggests a matter of control, keeping more private residential streets from the more commercial and busier high streets. The control of access then depends on the configuration of the street network (Figure 18).

The analysis of corner shops in Grangetown demonstrates that these types of CRBs are not found along the radial routes, but rather in local streets. Some of the activities found at one change of direction from the high streets were specialised uses, such as a surgery facility with specific working hours; whereas offices, restaurants, shopping and general commercial uses were the most common types of use in the surrounding area. Grangetown presents the corner shops with the most diverse activities in comparison to Plasnewydd and Canton.

These findings suggest the likelihood that a corner shop distributed in a radial urban form will more frequently be found in back streets, rather than connecting directly to the main streets. It is argued that this is partly due to the control of accessibility to direct the movement, at least vehicular, through secondary roads. Corner shops, therefore, are in locations where they can retain customer demand from their neighbourhoods with more diverse or even specialised activities than those found in non-radial forms, where corner shops have primarily retail and general commercial use (Figure 19).

**Spatial adaptability of mixed uses**

We now turn to describe the two types of CRBs according to their location and architectural morphology. The first types of adaptation are those mid-block on a street (Figure 20). Positioned at a location on a plot that is in the middle of a row of properties, the building changes mainly occur in two ways: in the front façade and the back side of the building. The dwelling on the upper floor is removed from the traffic and noise at street-level, having access via a separate staircase from the shop or double access from the exterior of the building (Figure 21).

Examples of these spatial adaptations are shown in Figure 22. Along Albany Road in Plasnewydd, we find a supermarket chain at the corner of the block, which includes storage facilities accessed through the rear of the building. The property located next to the large supermarket is a CRB. The CRB includes a local supermarket. The owner of the shop also lives in the property, but the access to the dwelling is separated from the shop. The commercial addition...
to the local supermarket includes its own access; the shop functions at particular days/times.

The second phase of adaptation in the property is the dwelling space. The dwelling on the upper floor is removed from the traffic and noise at street-level, and has access via a separate staircase from the shop. The dwelling maximises its living space by extending the house to the façade of the shop. The nature of the shop in the CRB presents an interesting case. The local supermarket has the benefit of co-locating with a larger supermarket chain, so taking advantage of the number of customers attracted to the shop and being on a highly commercial road. However, while these kinds of examples illustrate an adaptation of a CRB along a street, there are also CRBs on corners with shops that may benefit more from residential streets than commercial ones.

Corner locations bring more possibilities of spatial adaptation. Figure 23 shows four types of spatial adaptability of a CRB on a corner of a street. A corner shop can take full advantage of the plot by including commercial additions on the front or the rear sides of the building, and subsequently these can be combined and extended upwards.

Type 1 shows a typology that has only one commercial addition at the front of the building. This type can subsequently be adapted by expanding the space in the upper floor. Type 2 refers to the same addition but at the rear side of the building without altering the front façade. The choice of using the rear side of the property can also allow using the backside of the plot for the shop. The combination of having these two additions at the same time is indicated in Type 3, in which the additions are included at the ground floor but the house is kept in its original state. Type 4 shows that two or more combined additions are also possible. The adaptation of the building can combine the additions of commercial use on the ground floor and the extension of the upper floor either at the rear or at the front, or both. The use of the back side of the property is also an alternative for adapting the building with commercial or residential use.

Every type of spatial adaptability has the option of including two entrances to the building. The entrance to the property also depends on whether the corner shop is placed at the beginning of the block, assuming that the block connects to a high street; or whether the corner shop is at the end of the block, in which case it is assumed the corner is in between two residential streets. Figure 24 shows the most common case of a corner shop – that which is directly linked to a main street, with the shop entrance linking to the high street and a secondary entrance for the house. The second most common case is the corner shop between two local streets,
Figure 19
Topological locations of corner shops in radial and non-radial urban forms (by author).
Figure 20
Types of commercial additions in CRBs along streets (by author).

Figure 21
Spatial adaptation of a middle-block shop located along the main high street (by author).
Figure 22
Comparison between a large retail store and a local shop (by author).
usually consisting of mainly residential use. The adaptability of the building and its use can be similar to the first case – two different entrances, one for the shop and one for the dwelling. The difference is that the entrances to the property can be altered depending on where the owner wants to capture more visibility towards the location of the shop.

**Lessons learned**
The four types of adaptations and their locational characteristics shown in Figures 23 and 24 have different consequences from different perspectives. Firstly, drawing on the findings from centrality measures, the adaptability of corner locations is likely to be affected by the local footfall in connection to main high streets as well as residential streets. Therefore, one of the consequences of these additions is permeability. Whether an addition is at the rear, front or upwards of the building, the degree of privacy of the dwelling in relation to the more public commercial use of the property is mediated by such additions. The owner has the advantage of choosing whether to completely separate the residence from the street, or to do so internally. In line with this,
there is also a matter of visibility, not only to attract pedestrian footfall but also having local character in the neighbourhood.

Secondly, there is a morphological flexibility that results from changes in the building. As Schneider and Till propose (2007), housing flexibility adapts to the changing needs of its users. Figure 25 illustrates this core idea through two examples – a mixed use home with a shop and a ‘working from home’ situation. In accordance with our methodology, we show the differences in Council Tax band (which marks the domestic space) and the commercial use. Equally for having a shop or working from home, there are situations where the family lives in the whole property, having independent functions with or without additions, and in single use (e.g. one single property) or multiple occupations (e.g. sub-division of the house into flats). Ultimately, this empowers the users to make choices about how change needs to be enacted. From an urban morphological perspective, this means that the additions and uses of the homes are adjusted over
time to new working patterns, in turn maximising local accessibility. This, naturally, brings together the economic side of architecture – more efficiency in space usage with less cost of reconfiguration and mobility.

Conclusions
This paper has presented a discussion on the location, use and form that supports the architecture of mixed uses. The paper argued that an economic point of view in architecture, from a bottom-up approach, contributes to understanding wider urban scale processes. Location, use and form were presented as core ideas to show why the spatial adaptation of mixed uses is an effect of morphological and configurational characteristics that depend on where, what, and how different functions interrelate.

Our findings showed that buildings that include both business and residential uses at corner blocks were created by their proximity to key streets. Moreover, corner shops tend to be located at the first change of direction from a high street, also having an advantage in accessibility by potentially favouring pedestrian footfall from both residential and main high streets. Drawing from the results of our two regression models, no correlation is shown between location of ‘corner locations’ and global configurative properties. There is also not enough evidence to demonstrate that corners are influenced by global centrality. Moreover, it seems that corner locations only correspond to positions where a) streets have a high footfall location for attracting passing trade at a local scale, i.e. a 5-10 minute walking distance, (local choice), and b) streets have closer proximity to local residential areas and places of employment (local integration).

Mixed use buildings at middle blocks are favoured by the street’s connection to the wider urban network and remain part of a high street’s socio-economic function. Overall, local integration and choice are more important than global values with respect to mixed use buildings. The differences of locations, however, hindered multiple variations of spatial adaptation that lends itself to impacting on how and where we live and work, which could explain why local accessibility becomes more important than having global accessibility or easiness of reach to a local district.

In terms of adaptation, recent developments in configurational and morphological research are pushing the agenda concerning the relevance of adaptability in spatial forms (Kostourou, 2015), and the fundamental challenges of balancing people-centred and top-down urban design (Larkham and Conzen, 2014; Vaughan, 2015). Whilst learning from current urban research in these fields, the economic value of spatial forms deriving from its local architecture is yet to be addressed. Drawing on the findings of this paper, the emergence of mixed use buildings, as a form of adapting economic needs and demonstrating the design flexibility to accommodate change, is clearly a product of historical conditions but also highlighting the need towards better practice in urban design within the planning system. The Department for Communities and Local Government in the UK (2012) have responded to consultation with communities through an assessment that considers views from the communities regarding changing rules from either residential to commercial or the reverse, stating that ‘[the change from residential to commercial use] would allow greater flexibility in responding to changing market conditions’ (ibid, pp.7-8).

In this respect, local government recognises that making it easier for a space above shops to be of residential use would contribute to an increase in the supply of housing and encourage owners to look carefully at the potential offered by their properties. In addition, helping more people to live in the town centres will contribute to wider regeneration, reduced commuting and ensuring town centres remain vibrant places (ibid). The assessment shows
Figure 25
Examples of adaptability of mixed uses (by author).
the ‘relaxed rules’ in which changes of use can be adopted. Such forms of initiative, no longer central planning approaches but rather focused on bottom-up practices perceived by a community, can be a glimpse into whether spontaneous ordering can be designed.

Dr Laura Narvaez (l.zertuche@ucl.ac.uk)
Laura is a London-based architect, writer and educator with working experience in UK and Mexico. She holds a PhD in Architecture and the Built Environment from Space Syntax Laboratory, Bartlett School of Architecture, UCL and she is an Editor of The Bartlett’s magazine LOBBY. She previously obtained a Bachelor in Architecture and a MArch in Urban Design and Sustainable Development at Tecnologico de Monterrey in Mexico, and further obtained a MSc in Advanced Architectural Studies in UCL. Her doctoral work investigated the location of economic patterns in urban form through an empirical case study of Cardiff, focusing on the relationship between spatial centrality, the mixing of uses in urban design and architectural adaptation through the associations of the building-street scale and the neighbourhood-city scale. She has presented her work internationally across Europe, Asia, North America and South America; she has taught studios and seminars at the Bartlett School of Architecture, the London College of Communication and Tecnologico de Monterrey. Her main interest concerns bridging between academic research and professional practice particularly in the fields of architectural and urban morphology, urban design, space syntax and design research. Laura is currently working as an urban designer and researcher in the London-based office Foster and Partners.

Prof Alan Penn (a.penn@ucl.ac.uk)
Alan is the Dean of the Bartlett faculty of the Built Environment, a HEFCE Business Fellow and a founding director of Space Syntax Ltd., a UCL knowledge transfer spin out with a portfolio of over 100 applied projects per year, including whole city masterplans, neighbourhood development plans and individual buildings. He is a member of the Space Syntax Laboratory in UCL. He was the founding Chair of the RIBA’s Research and Innovation Committee, and served in that role until 2006. He was the lead academic on the £5m Urban Buzz: Building Sustainable Communities knowledge exchange programme which promoted more sustainable forms of urban development and intensification in London and the greater South East Region of the UK. He is was Principal Investigator on the City History and Multi-scale Spatial Master-planning UK-China Research Network, funded by the UK’s Engineering and Physical Sciences Research Council. Alan is a trustee of the Shakespeare North Trust and of the Institute for Sustainability.

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