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# Exploring the role of public transport in agglomeration economies and centres

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## Abstract

Agglomeration economies, the advantages of spatial concentration, are attracting increasing interest. While there is still debate over the mechanisms which deliver benefits, transport has a key role in creating and supporting agglomeration economies. Public transport is of interest because public transport use is highest to higher density concentrations of activity. There are two mechanisms by which public transport can contribute: firstly, through more efficient use of valuable land to deliver people to destinations, and secondly, through the increased opportunities for informal, unplanned interactions between people using public transport and walking rather than driving. The paper investigates two related research questions to help explore the possible role of public transport in supporting agglomeration economies: firstly, the relationship between industry concentration in centres of different types in Sydney and public transport use; and secondly, the possible role of public transport in supporting informal, unplanned interactions elicited through a pilot survey designed to test the methodology.

## 1. Introduction

Agglomeration economies, the advantages of spatial concentration resulting from scale economies, are attracting increasing interest internationally and in Australia. While there have been attempts to measure the value of agglomeration economies, there is still debate over the mechanisms which deliver benefits. Transport accessibility is recognised as having a key role in creating agglomeration economies. But in identifying and measuring agglomeration economies there is too often no distinction between the role of roads and the role of public transport in providing accessibility, even though public transport use is typically higher to higher density concentrations of activity. There are two broad mechanisms by which public transport may contribute more highly than roads to the creation of agglomeration economies: firstly, through more efficient use of valuable land to deliver people to destinations, and secondly, through the increased opportunities for informal, unplanned interactions between people.

The paper investigates these two related research issues in the Sydney context to help explore the possible role of public transport in supporting agglomeration economies:

- Which industry sectors locate in centres of different size in Sydney and whether there is a pattern between the types of industries and centre size. This will improve the understanding of which industries may benefit from agglomeration economies. This is addressed in section 3 and section 4.
- What type of informal, unplanned interactions workers have and whether these interactions are linked to public transport use and centre size and density. This will help understand the potential role of public transport in providing a mechanism for the delivery of agglomeration economies. This is addressed in section 5.

The paper is structured as follows: section 2 reviews the literature on agglomeration economies and public transport, sections 3 to 5 address the research questions posed above, and section 6 presents conclusions.

# 2. Agglomeration economies and public transport

## 2.1 Agglomeration economies and the shape and size of cities

Agglomeration economies have long been understood to underpin urban form and the distribution of the hierarchies of city size. Theories explaining the existence of cities stem from work by von Thunen (1826), Weber (1909), Christaller (1933) and Losch (1938) and all identify how transport is the determining factor in the creation of a distinct urban area thus providing a link between the centripetal forces of transport accessibility and agglomeration economies.

Scale economies have been studied for manufacturing industry. But whilst studies have empirically measured which industries locate in cities and on how industry and residential development is located within cities, there is less known about centres within cities. There is also no clear underlying theory to indicate which groups of industry or industry sectors, such as global economy or knowledge economy jobs or creative clusters, may experience more of these agglomeration benefits. Whilst there is empirical evidence to suggest that financial, business and professional services tend to locate in larger centres, it is not clear how intra-urban location of business might be influenced by strategic land use planning seeking to encourage a number of centres within an urban area, as with the 'City of Cities' concept for the metropolitan area of Sydney (NSW Government 2005). This has partly been addressed by Meijers and Burger (2010) who concluded on the one hand, that US metropolitan areas which were polycentric are associated with higher labour productivity but, on the other hand, a network of geographically proximate smaller cities cannot substitute for the urbanisation externalities of a single large city. There is also debate about whether higher rents in denser locations fully extract agglomeration economies to firms, or whether there are additional benefits (or externalities) to firms and to society.

## 2.2 The role of interactions

Scale economies of one form or another are used in the theories to identify the emergence of cities as markets. Separate from this, ideas such as those of Jane Jacobs (1969, cited in Mills 1980) suggest that, as cities are the primary drivers of economic development, part of the benefit of cities comes from the increased personal and networking opportunities offered by the higher spatial concentration of people. In turn this generates new ideas through higher levels of personal interaction. These inter-industry economies are different from the intra-industry economies arising from complementarity in labour supply and in production through the co-location of firms in the same industry.

There is increasing interest in social interactions and transport, as shown by the Special Issue of *Transportation Research A: Policy and Practice* May 2011 on Transportation and Social Interactions with research including the social interactions of getting a lift (Lovejoy and Handy 2011) and social influences on telecommuting (Wilton et al. 2011). For public transport, Wilson (2011) focused on how intercultural relations are developed, destroyed, and remade through every day bus travel, seeing public mobility spaces as key sites of encounter, while in Brisbane, a "I Just Want To Say" campaign to encourage people to talk to each other on buses prompted community debate (Hurst 2011).

## 2.3 The specific role of public transport

Early theories explaining urban size show that urban size is driven by relative transport costs for different goods which in turn define market size and give rise to a hierarchy of city sizes. More recent developments in the literature, for example Henderson (1974), Krugman (1991), Fujita and Krugman (1995) and Fujita and Mori (1997), highlight the way in which urban form

and size are affected by two opposing forces: centripetal or agglomerating forces which act to concentrate people and activity together, and centrifugal or dispersing forces arising from immobile factors and land rents. As transport costs underpin these forces it is not surprising that influences on transport costs, such as congestion, are important too and can be a limitation on the exploitation of agglomeration economies as identified by Graham (2007).

The potential limitation of congestion to the exploitation of agglomeration economies makes investigating the role of public transport in creating or supporting agglomeration economies important, particularly since public transport is more land efficient in 'delivering' people to destinations. Eberts and McMillen (1999) reviewed the theoretical and empirical literature on agglomeration economies and urban public infrastructure, such as transport, and note few studies of both topics together exist and that only a handful of studies have focused on the metropolitan level. Against this is the significant literature reported by Duranton and Puga (2004) who conclude that the mechanisms of agglomeration, particularly at the most detailed spatial scale, are not well understood.

Thus the literature is not clear-cut on the mechanisms of how public transport can lead to agglomeration economies. This paper hypothesises that there are two main ways in which public transport accessibility can contribute to agglomeration economies. First, in dense locations where land has a high value, public transport is an efficient use of space to carry more people to a location, either using road space for road-based public transport, or land for railways rather than roads. Thus public transport supports density of development as it improves access and it may also support a higher density threshold before the negative impacts of congestion serve to reduce agglomeration economies. Second, the nature of the public transport journey, with a greater density of people travelling together in close personal proximity and walking to and from common origins and destinations, provides the opportunity for more informal, unplanned interactions between workers as they travel, compared to workers who drive in individual vehicles. This potentially leads to higher interaction effects which encourages employers to locate in denser locations.

The Centre for Transit Oriented Development (2011) studied the composition of employment in areas served by fixed-guideway transit in 34 US metropolitan areas and concluded certain "knowledge-based" industries are more likely to locate in central business districts and higher density regional employment areas, while the government sector has the greatest affinity for transit locations. Kang (2010) studied the impact of Bus Rapid Transit on creative industries in Seoul Korea and concluded that the BRT system favourably influenced the location of creative industries and service sectors within 500 m of BRT stops, and BRT increased the employment density within 500 m of stops by more than 50%.

Better understanding both the nature of agglomeration economies and the potential role of public transport is important for transport investment and project evaluation. The accessibility impacts of new transport infrastructure are usually captured by valuing travel time savings to existing and new users. Some jurisdictions include agglomeration economies in their transport appraisal processes either routinely such as the UK or as an option such as New Zealand. In the UK there was a focus on agglomeration economies in the Eddington report (Department for Transport 2006) but in relation to disadvantaged urban regeneration areas in particular. The Australian Transport Council's *National Guidelines for Transport System Management* do not explicitly give guidance although pointers are given to the UK Guidance (Longworth 2008, p. 409). In the project evaluation literature, the inclusion of agglomeration economies is often referred to as the 'wider economic benefits' of the project.

## 3. Industry concentration in centres in Sydney

It is assumed that industries which are more concentrated in a centre are located there because they get value from the location. This section investigates this by calculating industry concentration in Sydney for different centre types to identify if there is a relationship between centre size and industry concentration. Sydney provides a good case study due to

its function as a Global City and due to the presence of a number of suburban centres in the context of a land use policy of a city of cities (NSW Government 2005).

## 3.1 Sydney

There has been some use of Australian Bureau of Statistics Census data to examine industry location and concentration in Sydney. Infrastructure Australia (2010, p. 65) identified capital city specialisations, with the top three industries by employment location quotient in Sydney being Internet Publishing and Broadcasting, Financial Services, and Air Transport. However there has been little focus on quantifying the scale of industry concentration in different types of centres. Maps of concentration of different industries produced by Transport NSW (2010) using 2006 Census data with the Australian and New Zealand Standard Industrial Classification at the 1-digit level, and the analysis that underpins the maps, are not sufficiently detailed to identify which industry sectors are under-represented or over-represented in centres of different sizes. But data on the number of jobs in each 1-digit industry by centre type shows that Sydney CBD has a high number of workers in finance, insurance and professional, scientific and technical services, while the Major Centres, as defined in the Sydney Metropolitan Strategy, have relatively high proportions of workers in retail (Transport Data Centre 2008). Longworth (2008) analysed productivity at the SLA level in Sydney, examining hours, income, and effective density of workers in different industries and occupations.

## 3.2 Jobs in centres in Sydney

Sydney is a polycentric city, containing centres of different sizes. The following analysis of industry concentration uses the hierarchy of Strategic Centres identified in the Metropolitan Strategy (NSW Government 2005) and updated Metropolitan Plan for Sydney 2036 (NSW Government 2010). The four types of Strategic Centres are:

- Global Sydney (five precincts of Sydney CBD, and North Sydney), defined as the main focus for national and international business, professional services, specialised shops and tourism, also a recreation and entertainment destination for the Sydney region with national significance.
- Regional Cities (Liverpool, Parramatta, Penrith and Gosford), defined as having a full range of business, government, retail, cultural, entertainment and recreational activities, and a focal point for regional transport and jobs.
- Major Centres (Bankstown, Blacktown, Bondi Junction, Burwood, Campbelltown, Castle Hill, Chatswood, Hornsby, Hurstville and Kogarah), defined as the major shopping and business centre for the district usually with council offices, taller office and residential buildings, a large shopping mall and central community facilities, with at least 8,000 jobs.
- Specialised Centres (Bankstown Airport, Macquarie Park, Norwest, Olympic Park/Rhodes, Port Botany, Randwick, St Leonards, Sydney Airport and Westmead) defined as places such as hospitals, universities and major research and business centres that perform vital economic and employment roles across Sydney.

The centres identified above differ from the Metropolitan Strategy centres in that the Major Centres of Tuggerah/Wyong on the Central Coast and Brookvale/Dee Why are not included in the following analysis as they are geographically separate centres.

The Bureau of Transport Statistics provided data on the location of jobs by industry from the 2006 Census using Journey to Work 2006 Table 4 and Table 9 (for NSW). Jobs data is categorised into industry using the Australian and New Zealand Standard Industrial Classification (ANZSIC) (ABS 2006) at the 1 digit level.

Table 1 summarises the location of jobs by centre type and industry, while Table 2 summarises the location of jobs by centre type. Sydney contains 60% of NSW jobs, while 40% of Sydney's jobs are located in the set of Strategic Centres.

**Table 1 Proportion of jobs by industry by centre type[1] in Sydney**

| Industry | No. of NSW jobs | % of NSW jobs | No. of Sydney jobs | % of Sydney jobs | % of NSW jobs in Sydney SD | % of Sydney jobs in Strategic Centres | % of Sydney jobs in CBD | % of Sydney jobs in Global Sydney | % of Sydney jobs in Regional Cities | % of Sydney jobs in Major Centres | % of Sydney jobs in Spec Centres |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture, Forestry and Fishing | 79,094 | 2.7% | 7,199 | 0.4% | 9% | 7% | 3% | 3% | 1% | 0% | 3% |
| Mining | 19,961 | 0.7% | 3,619 | 0.2% | 18% | 27% | 18% | 23% | 1% | 1% | 3% |
| Manufacturing | 276,706 | 9.6% | 174,774 | 10.1% | 63% | 17% | 3% | 3% | 1% | 1% | 11% |
| Electricity, Gas, Water and Waste | 29,204 | 1.0% | 15,133 | 0.9% | 52% | 37% | 20% | 21% | 5% | 1% | 10% |
| Construction | 211,142 | 7.3% | 91,779 | 5.3% | 43% | 20% | 7% | 8% | 2% | 2% | 8% |
| Wholesale Trade | 136,516 | 4.7% | 101,626 | 5.9% | 74% | 29% | 5% | 7% | 1% | 2% | 20% |
| Retail Trade | 322,703 | 11.2% | 189,979 | 10.9% | 59% | 33% | 8% | 8% | 5% | 12% | 8% |
| Accommodation and Food Services | 190,274 | 6.6% | 106,644 | 6.1% | 56% | 37% | 19% | 20% | 4% | 7% | 6% |
| Transport, Postal and Warehousing | 145,595 | 5.0% | 92,304 | 5.3% | 63% | 44% | 10% | 11% | 2% | 2% | 30% |
| Information Media and Telecomms | 68,358 | 2.4% | 54,119 | 3.1% | 79% | 67% | 36% | 43% | 3% | 7% | 13% |
| Financial and Insurance Services | 144,615 | 5.0% | 119,944 | 6.9% | 83% | 80% | 57% | 62% | 7% | 6% | 4% |
| Rental, Hiring and Real Estate | 50,307 | 1.7% | 34,204 | 2.0% | 68% | 37% | 16% | 18% | 5% | 6% | 9% |
| Professional, Scientific and | 211,149 | 7.3% | 162,888 | 9.4% | 77% | 59% | 34% | 41% | 3% | 5% | 11% |
| Administrative and Support Services | 89,758 | 3.1% | 55,041 | 3.2% | 61% | 51% | 27% | 31% | 5% | 5% | 9% |
| Public Administration and Safety | 168,910 | 5.8% | 103,149 | 5.9% | 61% | 52% | 24% | 25% | 13% | 8% | 6% |
| Education and Training | 218,397 | 7.6% | 132,083 | 7.6% | 60% | 25% | 11% | 12% | 2% | 4% | 7% |
| Health Care and Social Assistance | 302,627 | 10.5% | 179,196 | 10.3% | 59% | 39% | 9% | 10% | 6% | 8% | 14% |
| Arts and Recreation Services | 39,393 | 1.4% | 25,346 | 1.5% | 64% | 42% | 26% | 28% | 2% | 4% | 8% |
| Other Services | 109,361 | 3.8% | 66,001 | 3.8% | 60% | 28% | 10% | 11% | 3% | 5% | 9% |
| Inadequately described | 34,518 | 1.2% | 19,644 | 1.1% | 57% | 37% | 14% | 19% | 2% | 4% | 13% |
| Not Stated | 42,446 | 1.5% | 2,117 | 0.1% | 5% | 26% | 11% | 13% | 2% | 3% | 8% |
| **Total** | **2,891,034** | 100% | **1,736,789** | 100% | **60%** | **40%** | **17%** | **19%** | **4%** | **5%** | **11%** |

Source: 2006 Census, Journey to Work Table 4 and Table 9. Industry is 1-digit ANZSIC classification (ABS 2006).
Note: [1] Centre types are defined in section 3.2. Sydney is the Sydney Statistical Division.

**Table 2 Summary of location of jobs by centre type in Sydney**

| Location of jobs | No. of jobs | % of Sydney jobs | % of NSW jobs |
|---|---|---|---|
| Strategic Centres | | | |
| Sydney CBD | 300,167 | | |
| Global Sydney (Sydney CBD + North Sydney) | 335,965 | 19% | |
| Regional Cities | 69,256 | 4% | |
| Major Centres | 93,657 | 5% | |
| Specialised Centres | 188,821 | 11% | |
| Total Strategic Centres | 687,699 | 40% | |
| Total Sydney Statistical Division | 1,736,789 | 100% | 60% |
| Total NSW | 2,891,034 | | 100% |

Source: 2006 Census, Journey to Work Table 4 and Table 9.

## 3.3 Industry concentration in types of centres

### *Calculating industry concentration ratios*

Concentration ratios were calculated to show whether each industry (at the 1 digit level) was more or less concentrated than the average of all industries in different locations: in Sydney, in Strategic Centres, and in particular types of centre, where:

- A concentration ratio of 1 means an industry has the same proportion of its jobs in that location as that location has of all jobs.
- A concentration ratio of more than 1 means an industry is more concentrated in that location than average.

The maximum possible concentration ratio varies according to the location. For instance, if 100% of the jobs in a specific industry are located in Sydney CBD which has 17% of Sydney's jobs, the concentration ratio for that industry in Sydney CBD is calculated as 100/17 = 5.8. If 100% of an industry's jobs are located in Major Centres (which contain 5% of Sydney's jobs), the concentration ratio for that industry in Major Centres is 100/5 = 20.

Concentration ratios are discussed below, and summarised in Table 3.

### *Industry concentration in Sydney Statistical Division*

Table 1 and Table 2 show that of the 2.9 million jobs in NSW, 60% are located in the Sydney Statistical Division. The highest possible ratio for an industry with all its jobs in Sydney is 1.7 (100%/60%). The industry which is most concentrated in the Sydney SD is Financial and Insurance Services (1.38), reflecting that 83% of the Financial and Insurance Services jobs in NSW are located in Sydney, compared to 60% of all NSW jobs, which is 1.38 times higher than expected. This is followed by Information, Media and Telecommunications (1.32), Professional, Scientific and Technical Services (1.28) and Wholesale Trade (1.24).

### *Industry concentration in Strategic Centres*

Of the 1,736,000 jobs in Sydney Statistical Division, 40% are located in Strategic Centres, defined in the Metropolitan Strategy as Global Sydney, Regional Cities, Major Centres and Specialised Centres. Industries which are most concentrated in Strategic Centres in Sydney, compared to a highest possible concentration ratio of 2.5, are:

- Financial and Insurance Services (2.02)
- Information, Media and Telecommunications (1.69)
- Professional, Scientific and Technical Services (1.49).

A ratio of 2.02 means that 80% of all Finance and Insurance Services jobs in Sydney are located in Strategic Centres, compared to 40% of all jobs in Sydney, which is twice as high as expected.

### *Industry concentration in Sydney CBD and Global Sydney*

As Sydney CBD is so large relative to other Strategic Centres with 17% of Sydney's jobs, industries more concentrated in the CBD are similar to those concentrated in Strategic Centres. Industries which are most concentrated in Sydney CBD, compared to a highest possible concentration ratio of 5.8, include:

- Financial and Insurance Services (3.31)
- Information, Media and Telecommunications (2.06)
- Professional, Scientific and Technical Services (2.00).

When North Sydney is included with Sydney CBD to form the Global Sydney centre, the industries and rankings are similar, but with slightly higher degrees of concentration for the second and third ranked industries: Financial and Insurance Services (3.21); Information, Media and Telecommunications (2.22); and Professional, Scientific and Technical Services (2.11).

### *Industry concentration in Regional Cities*

4% of all jobs in Sydney are located in the four Regional Cities. The industry most concentrated in Regional Cities, compared to a highest possible ratio of 25, is Public Administration and Safety (3.24) as 13% of jobs in this industry are located in Regional Cities compared to only 4% of all jobs in Sydney. The next most concentrated industry in Regional Cities is Financial and Insurance Services (1.75), followed by Health Care and Social Assistance (1.58).

### *Industry concentration in Major Centres*

5% of all jobs in Sydney are located in the Major Centres. Retail Trade is the industry most concentrated in Major Centres, with 12% of the industry's jobs located in Major Centres. Health Care and Social Assistance (1.53) and Public Administration and Safety (1.48) are also industries more concentrated in Major Centres than expected.

### *Industry concentration in Specialised Centres*

11% of Sydney's jobs are located in Specialised Centres, which include a diverse range of centres from the business parks of St Leonards/Crows Nest, Macquarie Park and Norwest, the health and education precincts of Westmead and Randwick, and industrial areas of Sydney Airport, South Sydney Industrial Area and Port Botany. Despite the diversity of centres, industries most concentrated in Specialised Centres include: Transport, Postal and Warehousing (2.75), and Wholesale Trade (1.86).

These results of industry concentration by centre type are summarised in Table 3.

### *Industry concentration by specific centres*

Table 4 summarises the most concentrated industries by specific centre locations, with a concentration ratio of over 4. For instance, 20% of jobs in Central Sydney: Ultimo-Pyrmont are in the Arts and Recreation industry, compared to 1.5% of all jobs in Sydney, which is 14 times higher than expected. Of the 13 most concentrated industry occurrences, six (including four of the top five) are in Specialised Centres, which (as might be expected given their centre type) are more specialised and reflect the location of hospitals and universities.

**Table 3 Most concentrated industry by location (centre type) in Sydney**

| Location (centre type) and industry | Concentration Ratio | Maximum possible concentration ratio |
|---|---|---|
| **Sydney Statistical Division** | | 1.7 |
| Financial and Insurance Services | 1.38 | |
| Information Media and Telecommunications | 1.32 | |
| Professional, Scientific and Technical Services | 1.28 | |
| Wholesale Trade | 1.24 | |
| **Strategic Centres** | | 2.5 |
| Financial and Insurance Services | 2.02 | |
| Information Media and Telecommunications | 1.69 | |
| Professional, Scientific and Technical Services | 1.49 | |
| **Sydney CBD** | | 5.8 |
| Financial and Insurance Services | 3.31 | |
| Information Media and Telecommunications | 2.06 | |
| Professional, Scientific and Technical Services | 2.00 | |
| **Regional Cities** | | 25.1 |
| Public Administration and Safety | 3.24 | |
| Financial and Insurance Services | 3.21 | |
| Health Care and Social Assistance | 1.58 | |
| **Major Centres** | | 18.5 |
| Retail Trade | 2.16 | |
| Health Care and Social Assistance | 1.53 | |
| Public Administration and Safety | 1.48 | |
| **Specialised Centres** | | 9.2 |
| Transport, Postal and Warehousing | 2.75 | |
| Wholesale Trade | 1.86 | |
| Health Care and Social Assistance | 1.33 | |

Note: An industry concentration ratio of 1.38 means the industry has 1.38 times as many jobs as expected in that centre type.

**Table 4 Most concentrated industries by specific centre location in Sydney**

| Industry | Centre | Concentration Ratio |
|---|---|---|
| Arts and Recreation | Central Sydney: Ultimo-Pyrmont | 14.34 |
| Transport, Postal and Warehousing | Airport | 11.35 |
| Arts and Recreation | Sydney Olympic Park | 9.12 |
| Health Care and Social Assistance | Westmead | 7.26 |
| Transport, Postal and Warehousing | Port Botany | 5.38 |
| Health Care and Social Assistance | Kogarah | 5.16 |
| Information Media and Telecommunications | Central Sydney: Ultimo-Pyrmont | 5.14 |
| Education and Training | Central Sydney: Education and Health | 4.90 |
| Information Media and Telecommunications | Chatswood | 4.79 |
| Education and Training | Randwick | 4.35 |
| Health Care and Social Assistance | Randwick | 4.23 |
| Financial and Insurance Services | Central Sydney: CBD | 4.22 |
| Retail Trade | Castle Hill | 4.04 |

Note: Sydney CBD (Central Sydney) is divided into 5 precincts in the Metropolitan Strategy centre classification.

## 3.4 Summary of industry concentration in centres

Industries which have at least three times more jobs than expected for the type of centre are Financial and Insurance Services in the Sydney CBD, Public Administration and Safety in Regional Cities, and Financial and Insurance Services in Regional Cities. In Sydney CBD, the concentration reflects private sector decisions on location while in Regional Cities the concentration reflects public sector decisions. Some industries such as Retail, Health and Education are closely associated with their role in serving populations and these are concentrated in Major Centres. Understanding concentration in different types of centre

indicates which industries should be a focus for more work on gains from agglomeration economies.

Although not reported here, a similar analysis was conducted for concentration of occupations in centre types. This analysis highlighted relationships between industry and occupation concentrations in centres, particularly Retail industry and Sales Workers occupation; and Public Administration industry and Clerical Workers occupation in Regional Cities. The most highly concentrated occupation is Sales Workers in Major Centres, with a ratio of 2.08, meaning there are twice as many jobs in that occupation in that centre type than expected.

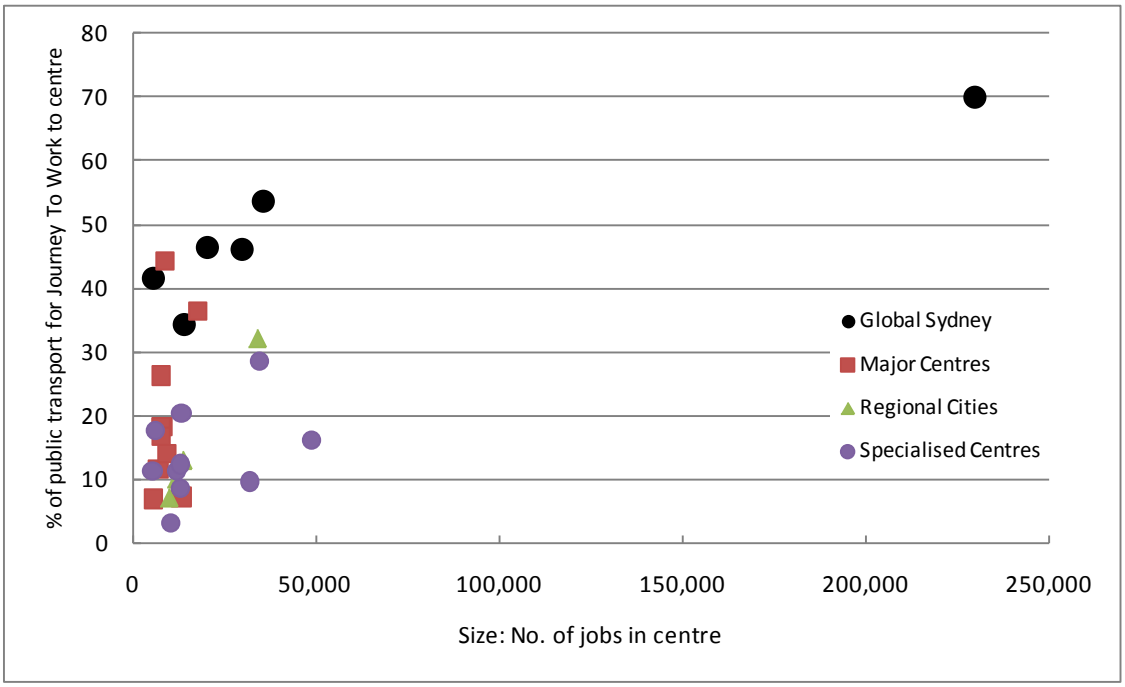
## 4. Public transport use by centre size, density and type

The following subsections consider how public transport use is affected by centre size and centre density with the final subsection considering the relationship between centre size and density. Data on public transport use is sourced from Transport Data Centre (2008) using 2006 Census data. Public transport (train and bus) mode share for the journey to work in Sydney is 21% and just under 40% to the set of Strategic Centres, ranging from 70% in Sydney CBD to less than 10% in centres further from the CBD (TDC 2008). It must be acknowledged that centre density and size reflect choices about the spatial definitions of centres, which are based on aggregations of travel zones. The Department of Planning uses spatially larger definitions of centres when setting targets for new employment and housing.

### 4.1 Public transport use and centre size

Figure 1 shows the association between public transport use and size of centre and suggests this relationship is not strong. Although the correlation between the percentage of public transport use for the journey to work and the number of jobs in a centre is significant (r=0.592, p=0.001), this is affected by the extraordinary performance of Sydney CBD. When the Sydney CBD outlier (Central Sydney: CBD precinct) is removed from the dataset, the correlation coefficient drops to 0.358 and is not significantly different from zero at a 5% level of significance.

**Figure 1 Public transport use for the Journey to Work by centre size in Sydney, 2006**




Data source: Transport Data Centre (2008). Note: Public transport = train and bus.

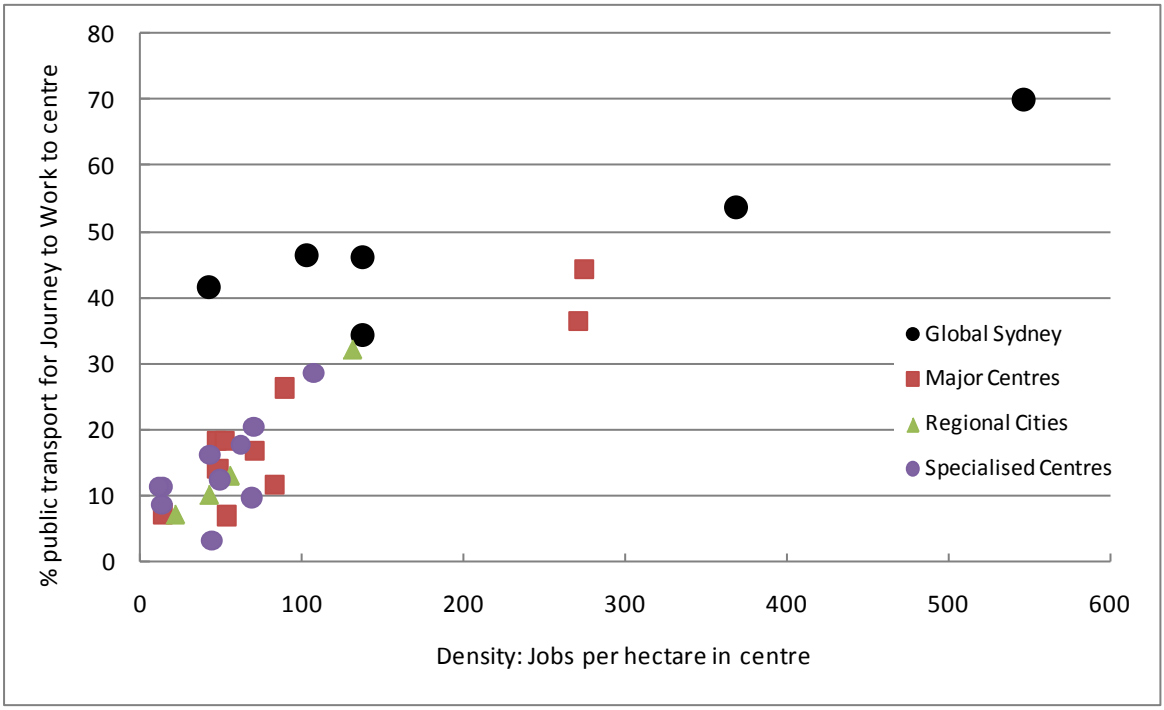
## 4.2 Public transport use and centre density

In contrast, Figure 2 shows a much stronger relationship between public transport use and centre density, with public transport use increasing with centre density. This is confirmed by a high correlation between the percentage of public transport use for the journey to work to the centre and the number of jobs per hectare in the centre of 0.838 (p=0.000). Again this data is dominated by the performance of Sydney CBD and whilst removing the Sydney CBD precinct from the Global Sydney data reduces the correlation coefficient to 0.772 (p=0.000), this is still highly statistically significantly different from zero.

The Central Sydney precinct of Redfern has high public transport use of over 40% despite having a relatively low density of 42 jobs per hectare. The area includes disused railway lands which are being redeveloped. The Major Centres of Bondi Junction (275 jobs per hectare) and Chatswood (271 jobs per hectare) are denser than four of the five Central Sydney precincts.

The correlation coefficient measured above gives some idea of overall association between density and public transport use. However, it is also of interest to identify whether a similar relationship between public transport use and centre density exists for the different types of strategic centres. A multiple regression, including Sydney CBD, of the percentage of public transport use for journey to work to centre explained by density and a set of dummy variables relating to the type of centre, had an adjusted $R^2$ of 0.846 (p=0.000). Evaluating the results at the mean of the dataset show that an increase in one job per hectare from the average of 102 jobs per hectare to 103 will lead to an increase in the average percentage of public transport use from 23% to 24%, everything else being held constant. All the dummy variables for the different strategic centre types were significant (p=0.000 for all) suggesting that whilst an increase in density leads to higher public transport use, these other centre types have significant but lower thresholds of public transport use than Sydney CBD for the journey to work.

**Figure 2 Public transport use for the Journey to Work by centre density in Sydney, 2006**




Data source: Transport Data Centre (2008). Note: Public transport = train and bus.

### 4.3 Relationship between centre size and density (and public transport use)

Centre size (the number of jobs in a centre) and centre density are often used interchangeably and it is often identified that public transport use for the journey to work is higher for bigger centres. The previous two sections identify that it is density of employment that appears to drive higher public transport use and not centre size in terms of the number of jobs. The correlation between centre size and centre density is however high at 0.750 and significant (p=0.000). But, as identified before, Sydney CBD dominates both the job numbers and the density data. Excluding Sydney CBD precinct from the dataset not only lowers the correlation coefficient to 0.348 but the association between the two variables becomes not significantly different from zero (p=0.65).

Causal relationships between centre size, density and public transport use are unclear. However, increasing job density appears more likely to increase public transport use than increasing the number of jobs in a centre.

## 5. Informal interactions in centres: an exploratory survey

This section reports an exploratory survey which was undertaken to test a methodology for understanding informal interactions between workers in centres, and the possible role of public transport in contributing to the agglomeration benefits of locating in centres.

### 5.1 Online pilot survey

As a possible mechanism for the delivery of agglomeration benefits is the increased opportunity for informal interactions, an exploratory survey was developed to test a methodology for identifying the nature of informal interactions (or unplanned interactions) between workers and their colleagues and friends over a week, separate from planned meetings with colleagues in the same or different organisation. Interactions were defined to include meetings during the day, meetings at lunch time, professional and social activities after work, as well as interactions with friends who work in other industry sectors.

The pilot survey titled “Your work and activities last week” had several sections including: activities conducted each day in the previous week, travel to work, and demographic information. There was also an opportunity for open-ended comments. The survey was approved by the University of Sydney’s Human Research Ethics Committee (Protocol No. 13158). The online survey was completed by three companies who were chosen for the pilot because of their location and type of business. The survey was distributed electronically by each company to its employees. Due to the distribution method, the response rate is difficult to calculate accurately for each company.

Company A is a private sector company in the Information, Media and Telecommunications / Professional, Scientific and Technical Services industry, located in Sydney CBD in the same building as one of its major clients. The survey was emailed to employees by the Managing Director’s executive assistant, with 16 usable responses received.

Company B is a state government agency in the Professional, Scientific and Technical Services industry located at Chatswood, a centre on the North Shore Rail Line. The survey was advertised on the Company’s intranet which was a relatively new feature launched 2-3 months before the survey. Employees see the intranet briefly when they log on each day, but may then move to other functions such as email. The survey was included on a scrolling bar under Company News. There were 34 usable responses from 238 full-time staff and approximately 91 contractors. The number of contractors varies daily and not all contractors work on site.

Company C is a private sector environmental services company with interests in the Waste Services industry as well as the Transport industry. The survey was emailed by a senior executive to employees at the head office location in Pyrmont, on the fringe of the Sydney CBD, with 26 usable responses received.

The survey referred to “your activities last week”, which was the week beginning Monday 25 October 2010 for Company A, and the week beginning Monday 8 November 2010 for Company B and C. The weeks were chosen to avoid public or school holidays or other unusual events. The survey was only open for a week to ensure respondents were able to recall their activities. There were a total of 76 usable responses.

The aim of the pilot survey was to explore whether:

- Respondents are able to recall their activities in the previous week.
- One week’s activities are representative of interactions.
- Workers who have more opportunities for interactions (by leaving the workplace) have more interactions.
- Workers who use public transport have more informal/unplanned interactions than non-public transport users.
- Longer-term workers and residents in Sydney have more informal/unplanned interactions than shorter-term workers and residents.
- Workers in a larger centre (CBD) have more interactions than those in a smaller centre (Chatswood).

To test the quality of recall, respondents were asked whether they looked at their calendar or diary and how easy it was to remember non-work activities (Table 5). Most respondents looked at their calendar or diary (52 of 76 respondents), and found it relatively easy to remember non-work activities (54 of 76 respondents).

**Table 5 Ability of respondents to recall activities in the survey week (“last week”)**

| | **How easy was it to remember your non-work activities** | | | |
|---|---|---|---|---|
| **Looked at calendar or diary to help answer questions** | Relatively easy | I had to think | Quite difficult | **Total respondents** |
| Yes | 36 | 13 | 3 | **52** |
| No | 18 | 6 | - | **24** |
| **Total respondents** | **54** | **19** | **3** | **76** |

## 5.2 Opportunities for interactions and frequency of informal interactions

### *Opportunities for interactions*

The key element of the survey was asking about opportunities for interactions, and the frequency of interactions. Table 6 summarises the frequency of different types of opportunities for interactions. It shows that while there were opportunities for unplanned interactions during the day as workers leave their workplace, there were few unplanned interactions. There were 457 opportunities for interactions (counted as the number of times people left the office in a week) and only 11 unplanned interactions. For instance, over half the respondents left the office at least one day a week for coffee/break (55%), for lunch with colleagues from the same organisation (49%), or for any other purpose (54%).

Only two of the 76 respondents met work colleagues from a different organisation unplanned during the survey week (one respondent on one day, and the second respondent on two days), and seven of the 76 respondents met friends unplanned during the survey week (six respondents on one day, and one respondent on two days).

The highest number of unplanned interactions reported in the week by a respondent was three. The respondent (male, 35-44 years, Chatswood, public transport user) met friends unplanned on one day and work colleagues from a different organisation unplanned on two days during the week. On both days the respondent met colleagues from a different organisation, he attended a social event after work. The respondent reported that the week was about usual in terms of meeting colleagues from a different organisation and friends unplanned.

**Table 6 Frequency of opportunities for interactions, and unplanned interactions**

| Activity | Freq. of activity (no. of days last week) 0 days | 1 day | 2 days | 3 days | 4 days | 5 days | Total activities | Respondents with activity No. | % |
|---|---|---|---|---|---|---|---|---|---|
| **Opportunities for interactions** | | | | | | | | | |
| Left workplace… | | | | | | | | | |
| for meetings | 38 | 25 | 6 | 3 | 3 | 1 | **63** | 38 | 50% |
| for coffee or break | 34 | 9 | 4 | 8 | 13 | 8 | **133** | 42 | 55% |
| for lunch with colleagues from same org | 39 | 22 | 4 | 5 | 6 | | **69** | 37 | 49% |
| for lunch with colleagues from different org | 68 | 8 | | | | | **8** | 8 | 11% |
| for lunch with friends | 64 | 9 | 1 | 1 | 1 | | **18** | 12 | 16% |
| for any other purpose | 35 | 25 | 10 | 6 | | | **63** | 41 | 54% |
| Went to work-related activity after work | 60 | 12 | 4 | | | | **20** | 16 | 21% |
| Went to social event after work | 32 | 21 | 11 | 8 | 4 | | **83** | 44 | 58% |
| Total opportunities for interactions | | | | | | | **457** | | |
| **Informal interactions** | | | | | | | | | 0% |
| Met colleagues from different org unplanned | 74 | 1 | 1 | | | | **3** | 2 | 3% |
| Met friends unplanned during the day | 69 | 6 | 1 | | | | **8** | 7 | 9% |
| Total unplanned interactions | | | | | | | **11** | | |

Note: Total respondents = 76.

### *Representativeness of the survey week*

To determine how representative activities in the survey week were, respondents were asked, for each activity, how typical the previous week had been (Table 7). For most activities, respondents reported that last week was about usual.

**Table 7 How typical was last week for activities**

| Activity | Representativeness of survey week: Less activity than usual No. | % | About usual No. | % | More activity than usual No. | % | Total resp. |
|---|---|---|---|---|---|---|---|
| **Opportunities for interactions** | | | | | | | |
| Left workplace.. | | | | | | | |
| for meetings | 24 | 32% | 43 | 57% | 7 | 9% | 76 |
| for coffee or break | 2 | 3% | 66 | 87% | 4 | 5% | 76 |
| for lunch with colleagues from same org | 11 | 14% | 57 | 75% | 5 | 7% | 76 |
| for lunch with colleagues from different org | 11 | 14% | 58 | 76% | 2 | 3% | 76 |
| for lunch with friends | 10 | 13% | 58 | 76% | 2 | 3% | 76 |
| for any other purpose | 13 | 17% | 51 | 67% | 8 | 11% | 76 |
| Went to work-related activity after work | 6 | 8% | 57 | 75% | 5 | 7% | 76 |
| Went to social event after work | 11 | 14% | 52 | 68% | 7 | 9% | 76 |
| | | | | | | | 76 |
| **Informal interactions** | | | | | | | |
| Met colleagues from different org unplanned | 10 | 13% | 55 | 72% | 3 | 4% | 76 |
| Met friends unplanned during the day | 6 | 8% | 61 | 80% | 1 | 1% | 76 |

Note: Not stated not reported.

Table 8 examines the representativeness of the two types of unplanned, informal interactions in detail. For meeting colleagues from a different organisation unplanned, the reported interactions in the survey week were about usual, but 10 of the 74 respondents with no interactions reported this was less than usual.

For meeting friends unplanned, five of the six respondents with an interaction on one day reported this was about usual and the one respondent with interactions on two days reported this was less than usual. 56 of the 69 respondents with no interactions reported this was about usual, and only four respondents reported that their no interactions were less than usual. This gives confidence that the survey week and the level of unplanned interactions

was representative. The anomaly that four respondents with no interactions reported this was more than usual may have arisen due to the order or separation of questions in the survey.

**Table 8 Representativeness of unplanned interactions in the survey week**

| | Representativeness of survey week* | | | | |
|---|---|---|---|---|---|
| **Unplanned interaction** | Less activity than usual | About usual | More activity than usual | Not stated | Total resp. |
| **Met colleagues from different organisation unplanned** | | | | | |
| 0 days | 10 | 53 | 3 | 8 | 74 |
| 1 day | | 1 | | | 1 |
| 2 days | | 1 | | | 1 |
| Total | **10** | **55** | **3** | **8** | **76** |
| | | | | | |
| **Met friends unplanned during the day** | | | | | |
| 0 days | 4 | 56 | 1 | 8 | 69 |
| 1 day | 1 | 5 | | | 6 |
| 2 days | 1 | | | | 1 |
| Total | **6** | **61** | **1** | **8** | **76** |

Note: *Respondents were asked “How typical was last week?” for each activity

### *Meeting and talking to people*

Although the survey focused on interactions in the previous week, the survey also asked about how often respondents meet and talk to people they know while travelling to and from work, and while out of the office. “Meet and talk” was used to focus on face-to-face interactions, not those by phone, online or other media, as face-to-face interactions are relevant for the informal interaction benefits of concentrations of workers.

Table 9 shows that while almost two-thirds of respondents almost never meet and talk to people while travelling either to or from work, about a quarter do meet and talk to people while travelling to work (and about 20% while travelling home). Travelling to work patterns are usually more regular than travelling home. Leaving the office during the day for coffee or at lunchtime provided more frequent opportunities: 40% of respondents spoke to someone about once a week at lunchtime, and 29% met and talked to someone while getting coffee or having a break. These are higher rates than reported for the activities in the last week. These results are different from the unplanned interactions in Table 6 because meeting and talking to people you know, such as retail staff and acquaintances, may not be considered ‘friends”. Table 9 also shows that about 20% of respondents (16 of 76) saw people about once a week which prompted them to contact them later.

**Table 9 Frequency of meeting and talking to people you know**

| | Frequency of activity | | | | |
|---|---|---|---|---|---|
| **Activity** | Almost everyday | About once a week | About once a month | Almost never | Total resp. |
| **Meet and talk to people you know while..** | | | | | |
| Travelling to work | 10 | 9 | 6 | 51 | 76 |
| Travelling home from work | 6 | 8 | 13 | 49 | 76 |
| Having a coffee or break | 19 | 22 | 17 | 18 | 76 |
| Out at lunchtime | 16 | 31 | 18 | 11 | 76 |
| | | | | | |
| **During the working day..** | | | | | |
| See people you know, don’t talk, but contact later | 4 | 16 | 9 | 47 | 76 |
| Meet people for first time and contact them later | | 9 | 26 | 41 | 76 |

### *Role of public transport in interactions*

Respondents reported the mode used for the journey to work each day in the survey week. Table 10 shows modes used for the journey to work in the survey week and how often respondents meet and talk to people they know while travelling to work. Meeting and talking while travelling to work was asked to perform a cross-check on earlier questions about interactions. Public transport users (4 or 5 days a week) were slightly more likely than car drivers to meet and talk to people they know at least monthly while travelling to work (38% compared to 26%). But 3 of the 6 walkers had at least monthly interactions. A design issue is that interactions while travelling in general are analysed by only last week's journey to work mode. More information is also needed on the type and quality of interactions on the way to work such as whether "people you know" could mean car passengers or retail staff.

**Table 10 Frequency of interactions while travelling to work by journey to work mode**

| | **Meet and talk to people you know while travelling to work** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Journey to Work mode in survey week** | Almost everyday | About once a week | About once a month | Almost never | Total resp. | At least monthly | Almost never |
| Public transport 4 or 5 days | 4 | 5 | 5 | 23 | 37 | 38% | 62% |
| Car driver 4 or 5 days | 3 | 1 | 1 | 14 | 19 | 26% | 74% |
| Walk or bike 4 or 5 days | 1 | 2 | 0 | 3 | 6 | 50% | 50% |
| All other | 2 | 1 | 0 | 11 | 14 | 21% | 79% |
| **Total** | **10** | **9** | **6** | **51** | **76** | 33% | 67% |

Note: "At least monthly" is the sum of "almost everyday", "about once a week", and "about once a month"

### *Further analysis: explaining frequency of interactions*

The survey collected other data to help explain the frequency of interactions. This included mode used for work trips during the day, size of centre (CBD or Chatswood), length of time working and living in Sydney and the nature of position in the company. However due to the sample size and the low level of unplanned interactions (8 respondents reported 11 interactions), it was not possible to further analyse the frequency of interactions such as high interactors vs low interactors for work colleagues and friends by these other characteristics. However, of the 8 respondents with unplanned interactions, twice as many workers in Chatswood (5 out of 34) reported an interaction as compared to respondents in the CBD (3 out of 42).

## 5.4 Lessons for future survey research

At the end of the survey respondents had the opportunity to add comments about the survey: how often and how you meet people during your working day including during travel and whether this helps you in your work. These comments were important due to the exploratory nature of the survey and will help inform further development of the survey. Issues to consider in any extension of the work to further understand informal interactions in centres, and the role of public transport include:

- achieving good response rates when the survey is administered in a workplace by the employer and not directly by the researchers,
- distinguishing between meeting new people in the course of work (such as attending work meetings or workshops) from meeting people outside of work but during the working day while away from home,
- taking into account work time spent away from the primary workplace including clarifying terms such as workplace and location, and recognising that contractors may work part-time for an organisation, work remotely or work at project sites,
- adding personality and work style questions (such as introversion/extroversion) to the survey, and

- investigating the role of electronic communication as a substitute or complement for face-to-face interaction. But face-to-face interaction is the focus, given the link to investigating the benefits of being in centres which involves face-to-face interaction.

A related extension would be to compare informal interactions of workers in centres to workers in regional areas. Centres in regional areas are smaller so it is more likely that workers will know each other, even if working for different employers. Against this, there are less likely to be new interactions in regional areas whereas city centres with many more people provide more opportunities to meet “strangers”. But the choice of centres would be critical as some regional centres are similar in size to some suburban centres in Sydney.

The low proportion of respondents who reported the two informal interactions of interest (8 out of 76 respondents), and the low proportion of interactions relative to opportunities for interactions (11 out of 457 in one week) suggests that a large sample size is required in future research to capture sufficient interactions for more detailed analysis.

## 6. Conclusions

Despite the well-established theories of centre formation, size and hierarchy and the role of transport, there are still questions about which industries benefit from agglomeration economies and the role of transport including if and why the contribution of public transport might be different from road transport. The paper presents three findings which contribute to greater understanding. Firstly, analysis of strategic centres within Sydney identified some industries were concentrated in different types of centres, indicating they are more likely to benefit from agglomeration economies. Secondly, in Sydney, there is a strong relationship between centre density and public transport use for the journey to work, with public transport use higher in higher density centres. Inter-industry economies arising from personal interactions and networking suggest that public transport may contribute through providing opportunities for informal interactions. Thirdly, the exploratory survey showed that, in terms of opportunities for and frequency of unplanned interactions which may contribute to the agglomeration economies of centres, respondents can recall the previous week’s activities relatively easily, and public transport users are slightly more likely than car drivers to report meeting and talking to people they know while travelling to work.

In terms of more fully understanding the mechanisms by which public transport supports agglomeration economies, future research directions for surveying the nature of workers’ unplanned interactions include extending the survey to workers in a range of industries, and centre sizes and densities. This will contribute to understanding why firms pay more to locate in larger centres, and whether they accrue a benefit from their employees informally interacting with other workers in centres, and from the interactions which may occur while travelling on public transport. This will allow public transport’s contribution to supporting centres and supporting agglomeration economies to be more fully considered in evaluation of transport projects and policies.

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