GLAECONOMICS

More residents, more jobs?

The relationship between population, employment and accessibility in London

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GLA Economics provides expert advice and analysis on London's economy and the economic issues facing the capital. Data and analysis from GLA Economics forms a basis for the policy and investment decisions facing the Mayor of London and the GLA group. The unit is funded by the Greater London Authority, Transport for London and the London Development Agency.

Contents

Introduction

It often makes sense to think about demographics and employment trends separately. *Population increase* is affected by birth and death rates and by migration patterns, all of which are only indirectly the result of economic pressures. Jobs however are the result of business investment, public spending decisions and economic opportunities which do not appear to have much to do with population trends.

However, this brief summary misses some important dynamics. It is obvious that where there are more residents there will be more opportunities. From health centres to gyms to schools to estate agents; more activity is associated with areas with more people. Moreover, local residents setting up in business may prefer to establish their business near their homes, even if their customers are in a different part of the country (or abroad).

Identifying the job-population association is a complicated task. A prescriptive approach (e.g. how many estate agents a residential development will require) should be avoided. Furthermore, the approach needs to capture investments by residents that are not for local consumption. This paper develops a methodology for looking at these issues and for identifying the job creation potential that is associated with different levels of residential activity.

This paper extends earlier work by Volterra Consulting[1] about the role of accessibility in creating potential for employment and population expansion. The complicated interactions between all three variables (employment, population and accessibility) are examined in more detail with a view to more precisely explaining the location and spread of employment in London.

Impact assessment studies for residential and commercial developments can often be used to estimate changes to employment and population levels in the local area. This will typically be based on the ratio of employment to population in the surrounding region, a method that works well for discrete and well defined, smaller urban areas.

However, due to the size and nature of London, levels of both public transport and highway accessibility influence the location of employment and population. Most London workers expect to commute to work; principally by either car or public transport. Therefore, this paper explores how accessibility and the location of population influence employment location, and how these three variables interact.

[1] Volterra Consulting are a private consultancy contracted by GLA Economics to provide economic analysis and the services of a consultant chief economist.

The paper concludes by noting that land turned over for housing will have associated with it employment growth in the locality. Taking the coefficient of employment density regressed alone on population density in areas of low accessibility, it can be deduced that an increase to the resident population of 1000 will on average have the potential to give rise to a further 230 jobs in the locality.

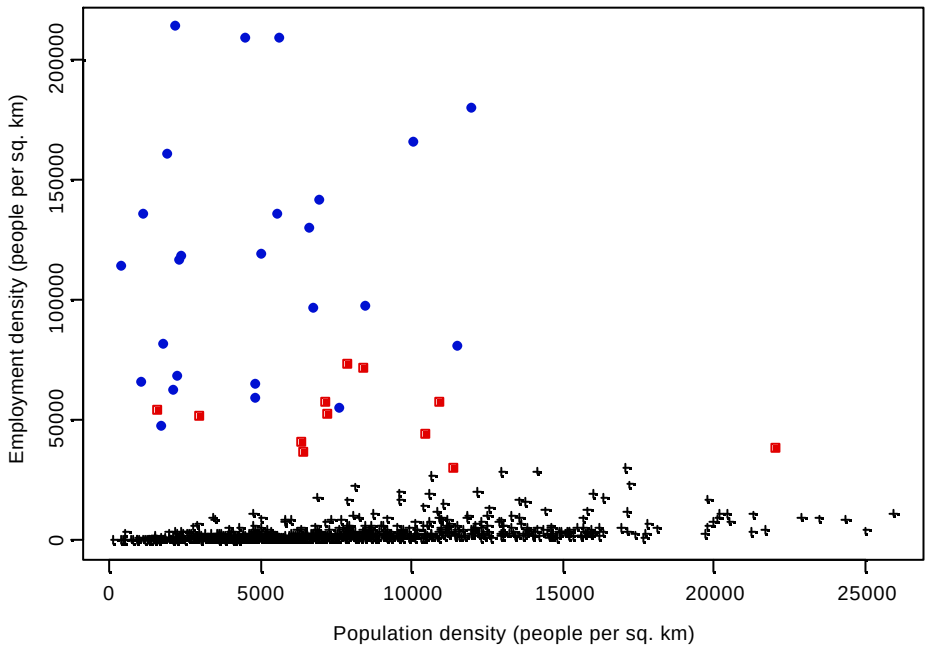
Employment and population

Figure 1 plots the relationship between employment and population density for London at ward level[2]. It can be seen that the majority of wards have relatively low employment densities, below around 30,000 people per square kilometre (sq km), but a small selection of wards have significantly higher values.

Highlighted on the graph are two sub-selections of wards. The blue circles at the top of the graph are from the wards in the City of London. The red squares (Cluster 1 wards) represent the wards around the City of London fringe that share similar characteristics to the City of London wards. These fringe wards were identified as being distinctive in previous Volterra work by using a technique known as fuzzy clustering.

Fuzzy clustering allows for the identification of wards that share similar social and economic characteristics. In this case, the red squares represent the members of the most extreme group in the fuzzy clustering which predominantly share the characteristics of high employment density, low population density and small physical land area.

Figure 1: Population density against employment density, by ward
Blue circles = City of London, red squares = Cluster 1 wards



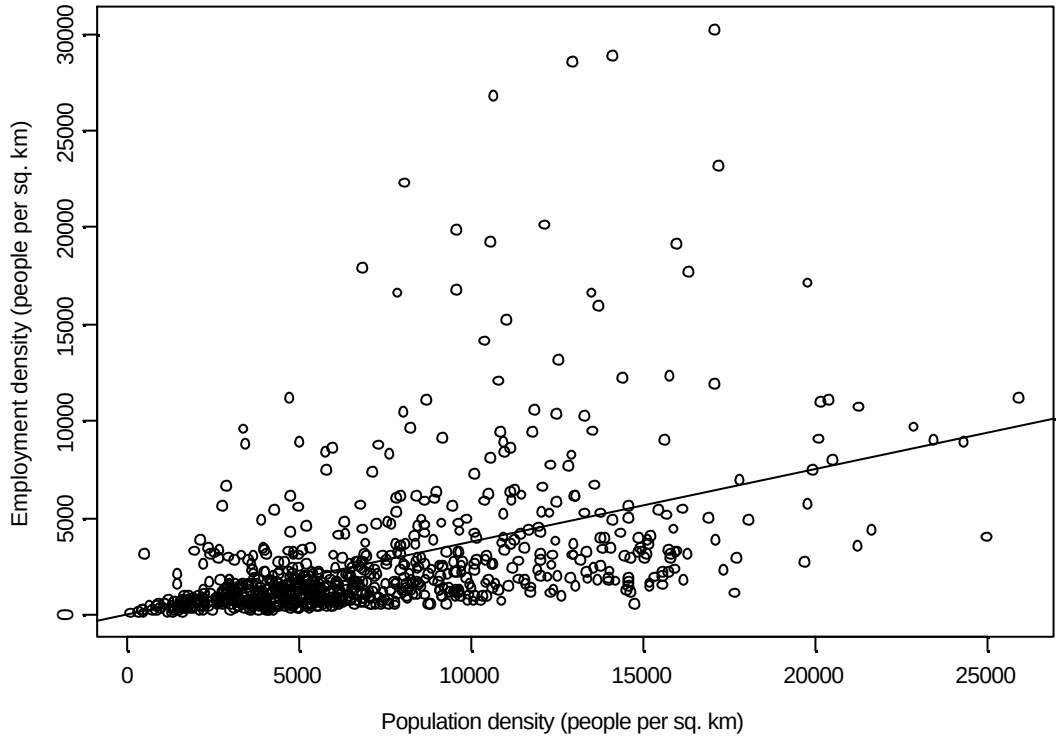
Source: Volterra

[2] Based on 1991 ward definitions (782 wards in total). Employment data from the 2000 Annual Business Inquiry. Population data from the Office of National Statistics 2000 mid-year estimates. It is hard to be more up to date because of the timeliness of data sets and changes to definitions. However, while total numbers may change, the relationships here move much more slowly.

Volterra's fuzzy clustering analysis revealed that the highlighted wards exhibit properties that are completely unique, not just in London, but throughout Great Britain. In these wards there exists a minimal relationship between employment and population density. Employment has risen in these areas to such an extent that housing has effectively been pushed out over time. As the trend for these 37 wards completely opposes the trend for the other 745 in London, they are excluded from the analysis.

Figure 2 re-plots the same graph with the central London employment cluster removed. A much more clearly defined, positive relationship between the two variables can now be seen. Overlaid on the plot is the fitted line from a linear regression of employment density on population density[3].

Figure 2: Population density against employment density, by ward
Excluding previously highlighted wards, with linear fit



Source: Volterra

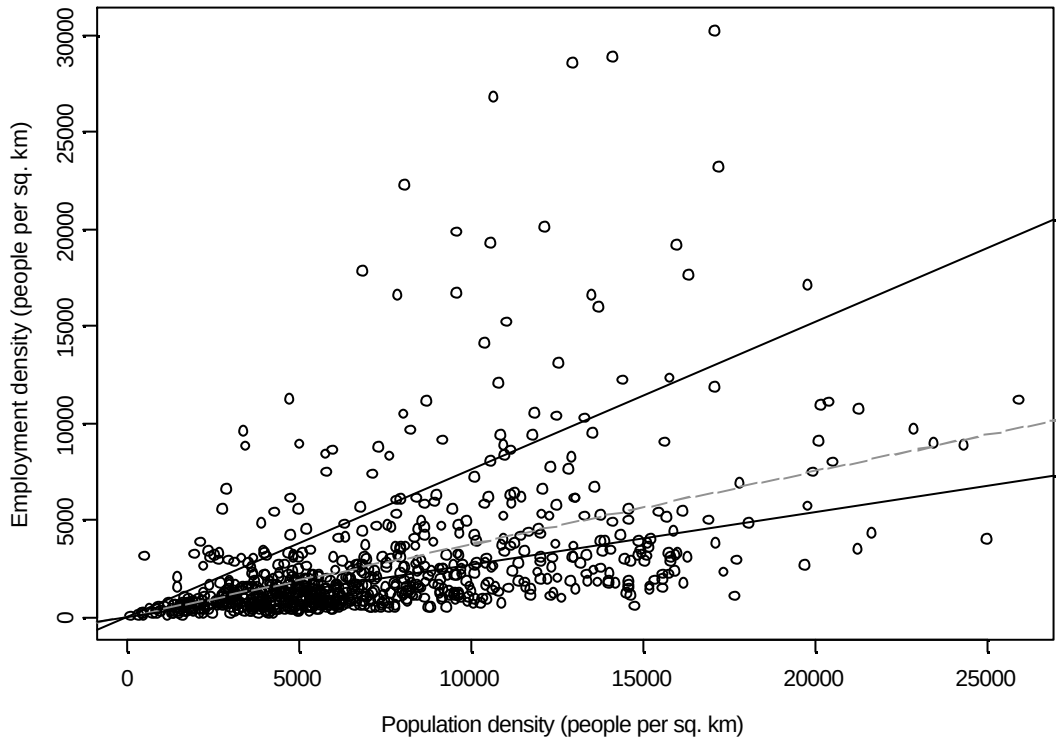
As there is no evidence for inclusion of an intercept term in the linear regression, the gradient coefficient that emerges is 0.38. The direct implication of this result therefore would be that for each additional person living in a ward there are approximately 0.38 jobs. Conversely, for each job in a ward there would be approximately 2.6 people living in that ward. There is, however, a problem with this result.

[3] Details of all regressions can be found in the appendix.

The relationship between population and employment is a two-way relationship. It is not possible to assume causality in either direction. If the relationship was stable, it would be possible to swap the variables around and find the gradient coefficient of regressing population density on employment density to also be around 2.6. However, on doing so the coefficient of 1.3 is actually discovered.

This problem is highlighted in Figure 3. The same plot can bee seen in Figure 3 as in Figure 2, with the dotted line now representing the simple linear fit of employment density regressed on population density. The steeper solid line shows the fit from swapping the variables around. To further complicate the problem, the shallower solid line shows the fit from a robust linear regression of employment density on population density. The gradient of these lines ranges from 0.27 to 0.76.

Figure 3: Population density against employment density, by ward
Dotted line = simple linear regression of employment density (ED) on population density (PD); Upper line = simple linear regression of PD on ED; Lower line = robust linear regression of ED on PD (M-estimation)



Source: Volterra

With such a wide margin of variation in the coefficient estimates, there is little confidence with using any of these relationships directly to predict either of the variables on the basis of the other[4]. Cleary there are other factors that affect both employment and population location. This paper therefore turns to accessibility as a possible third variable to be included in the analysis.

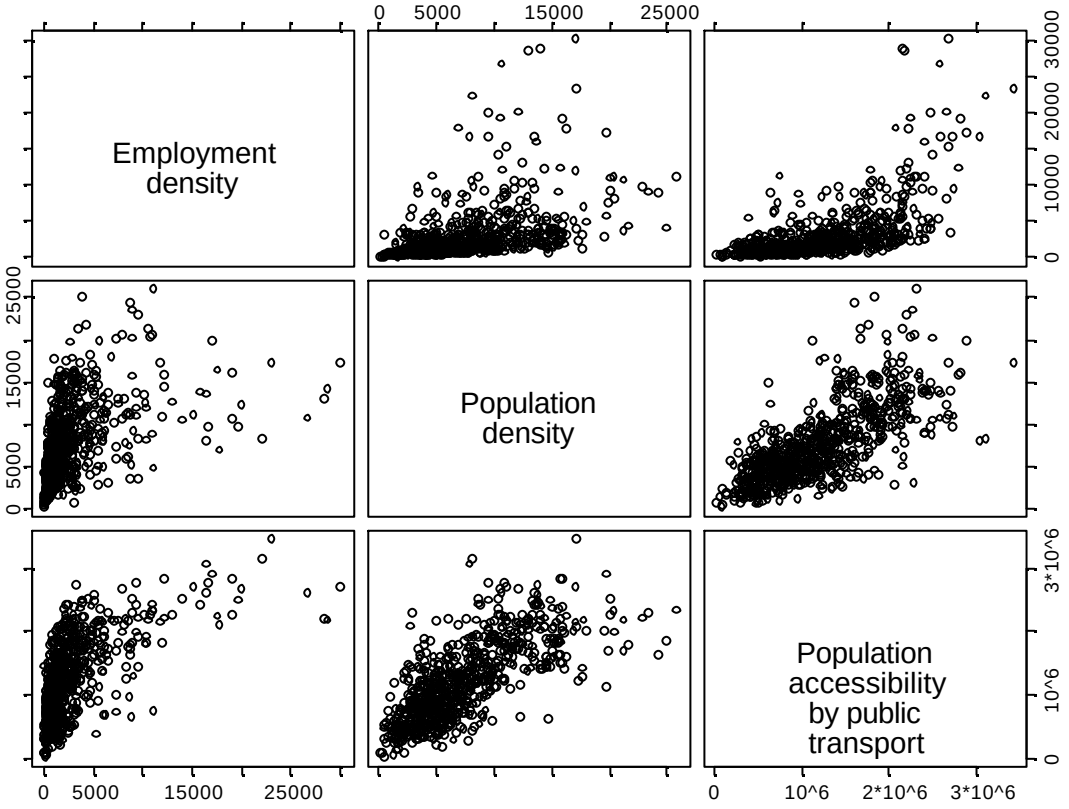
[4] This is also demonstrated if the plots of the residuals against the fitted values for any of these three regressions is examined, a standard statistical test of validity. All exhibit strong degrees of heteroscedasticity, both in the mean and variance.

The interaction of accessibility

The measure of accessibility is supplied by Transport for London, and measures population catchments by public transport within 45 generalised minutes[5]. This particular series was used – instead of series that details employment catchments and travel by highway – as this has the highest correlation with the variables of interest. This is not surprising as the majority of commutes in London are made by public transport.

Figure 4 presents a Pairs plot of the three variables against each other. The x and y axis labels of each individual sub-graph are given by the corresponding labels in that sub-graphs row and column. For example, the sub-graph in the top centre position plots employment density against population density, as seen in Figure 3.

Figure 4: Pairs plots of employment density, population density and population accessibility by public transport



Source: Volterra

[5] Generalised time is the total time spent on a journey, weighted to account for traveller preferences.

The strong mutual correlation of the three variables is immediately apparent. The question therefore is how to disentangle the relationship between any two while accounting for the third. Accessibility is arguably the most independent of the variables, with public transport schemes theoretically being able to be introduced without direct causation from employment or population levels. Accessibility, therefore, is taken to be an independent variable.

Conventionally, employment or population density could be regressed on the other two variables to find the predominantly influential variable. However, there is an added complication here of strong non-linearities in the individual relationships. For example, as accessibility increases, employment density appears to rise at an increasing rate. Strong multiple linear regression results will simply highlight the pair of variables with the most linear relationship.

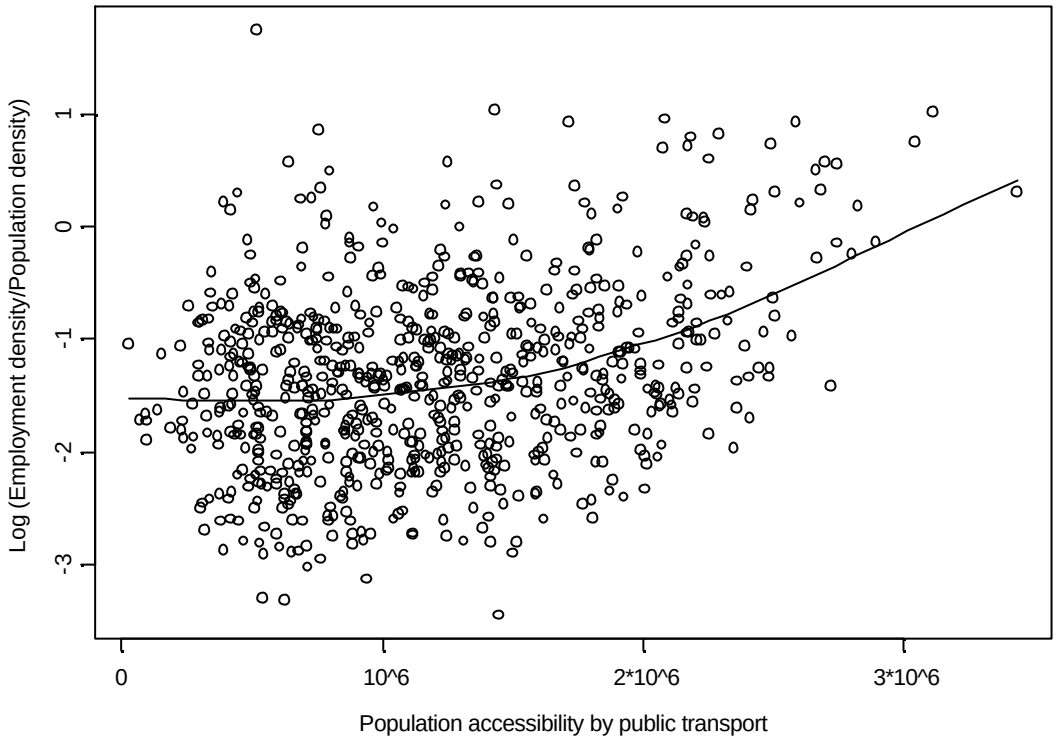
If corrections are made for non-linearities between any pair by transforming one of the variables, there is an added complication of distorting relationships with the third variable. It is therefore difficult to provide a useful interpretation to the results from a multiple regression.

The approach chosen, therefore, is to reduce the three variables back down to two. This is done by looking at the relationship between accessibility and the ratio of employment density to population density. On average, this derived ratio represents the gradient of lines in Figure 3.

Figure 5 plots public transport accessibility against the log of the ratio. The ratio's values are logged in order that a few of the very high absolute values do not dominate the chart. To highlight the non-linear relationship between these two variables, a locally fitted regression curve is overlaid on Figure 5. This graph shows that for lower levels of accessibility the ratio of employment density to population density remains relatively constant, although still with a relatively high variance. However, as accessibility increases this ratio also increases.

Figure 5: The logged ratio of employment density over population density plotted against population accessibility

Non-linear local regression curve, span = 2/3



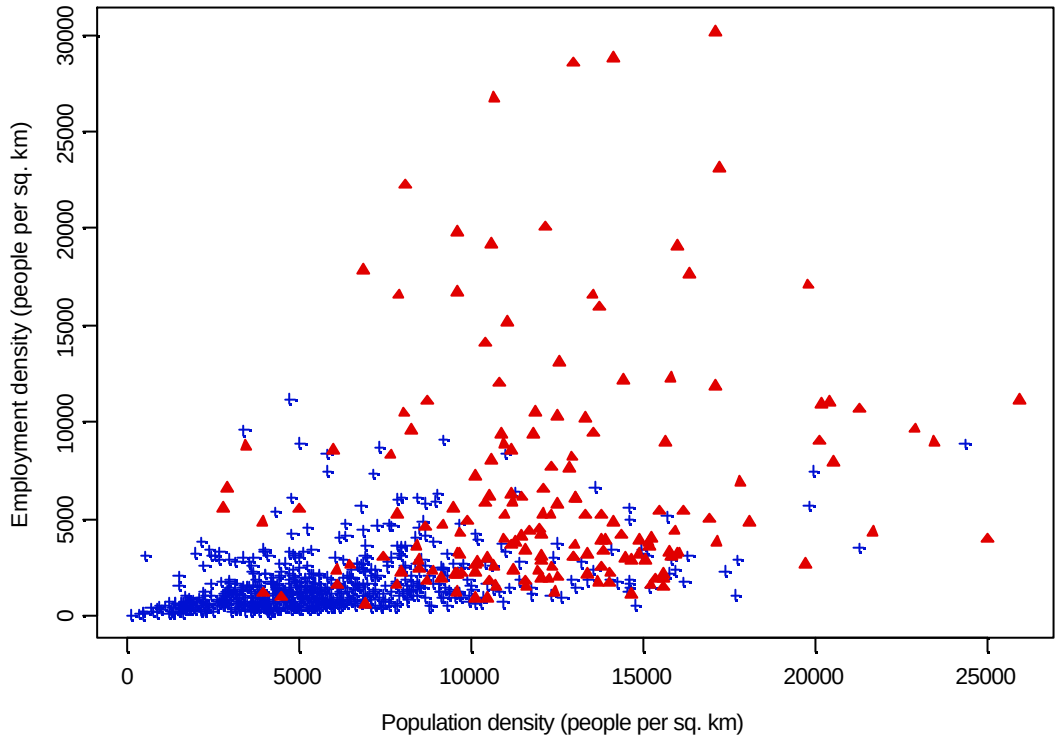
Source: Volterra

Examining a topographic map of public transport accessibility, as seen in the Appendix, reveals that lower values tend to be in outer London. In these areas a significant proportion of employment will be serving the local population. The relationship between employment density and population density therefore is relatively stable.

However, as accessibility increases, this relationship breaks down, and employment density begins to rise with respect to population density. Areas with the highest accessibility are in the centre of London. In these areas the proportion of employment that is serving the local population is lower. People are willing to commute to these places from further away in order to reach more specialised and higher paid employment.

In Figure 6 the points of Figure 2 are re-plotted but now split by levels of accessibility. An accessibility threshold of 1.7 million people was chosen as this appears to be approximately the break point of the relationship in Figure 5. If all three variables were moving in unison, Figure 6 would show a division in the points similar to a concentric circle around the intersection of the axis. Instead, it shows that nearly all the areas of high employment density are areas with high accessibility. This is true even for those areas with lower population density.

Figure 6: Population density against employment density, by ward
Blue points = population accessibility by public transport < 1.7 million; Red points = population accessibility by public transport > 1.7 million

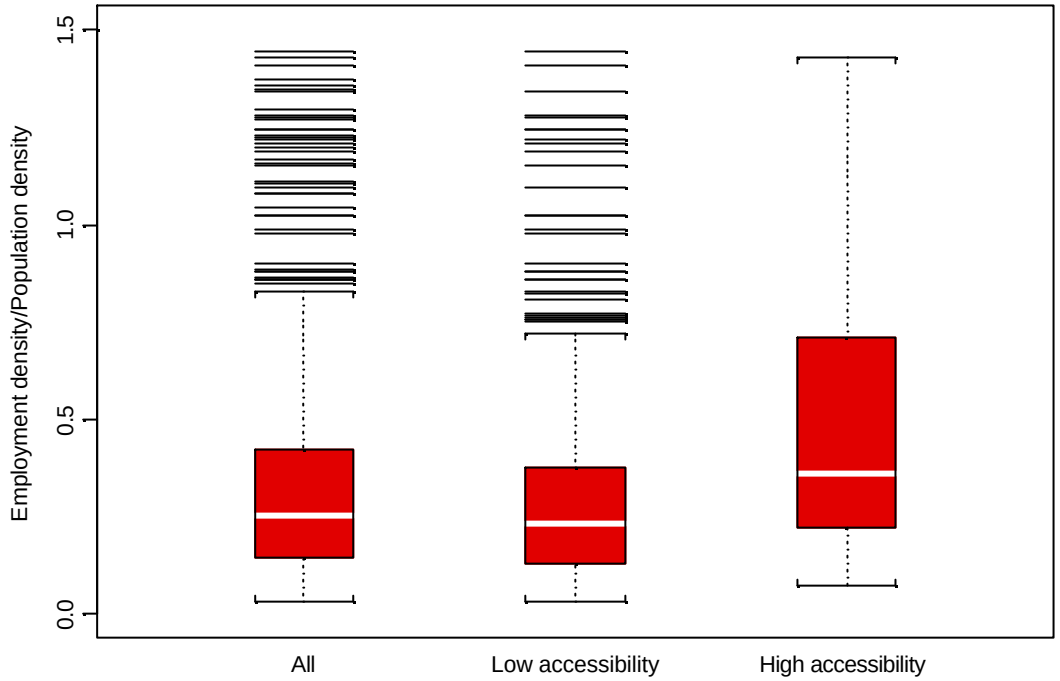


Source: Volterra

Returning to the problem of estimating the average ratio of employment density to population density, the difference can be seen by looking at boxplots of the ratio, split by the 1.7 million threshold in accessibility.

Figure 7: Boxplots of ratio of employment density to population density, split by accessibility (truncated at ratio of 1.5)

All = All data; Low accessibility = population accessibility by public transport < 1.7 million; High accessibility = population accessibility by public transport > 1.7 million



Notes: Red boxes represent the inter-quartile range (IQR) of the selected data, with the white central line representing the median value. The 'whiskers' extend to the first point outside range of 1.5 x IQR from median. Beyond the whisker range, outlying values are indicated individually.
Source: Volterra

The ratio results here are given in the un-logged format. The left hand boxplot of Figure 7 shows distribution of the ratio for all the wards. The mean ratio with all the data is equal to 0.38 (very close to the coefficient estimate of the regression of employment density on population density), but due to the skewed nature of the data the median is equal to 0.25.

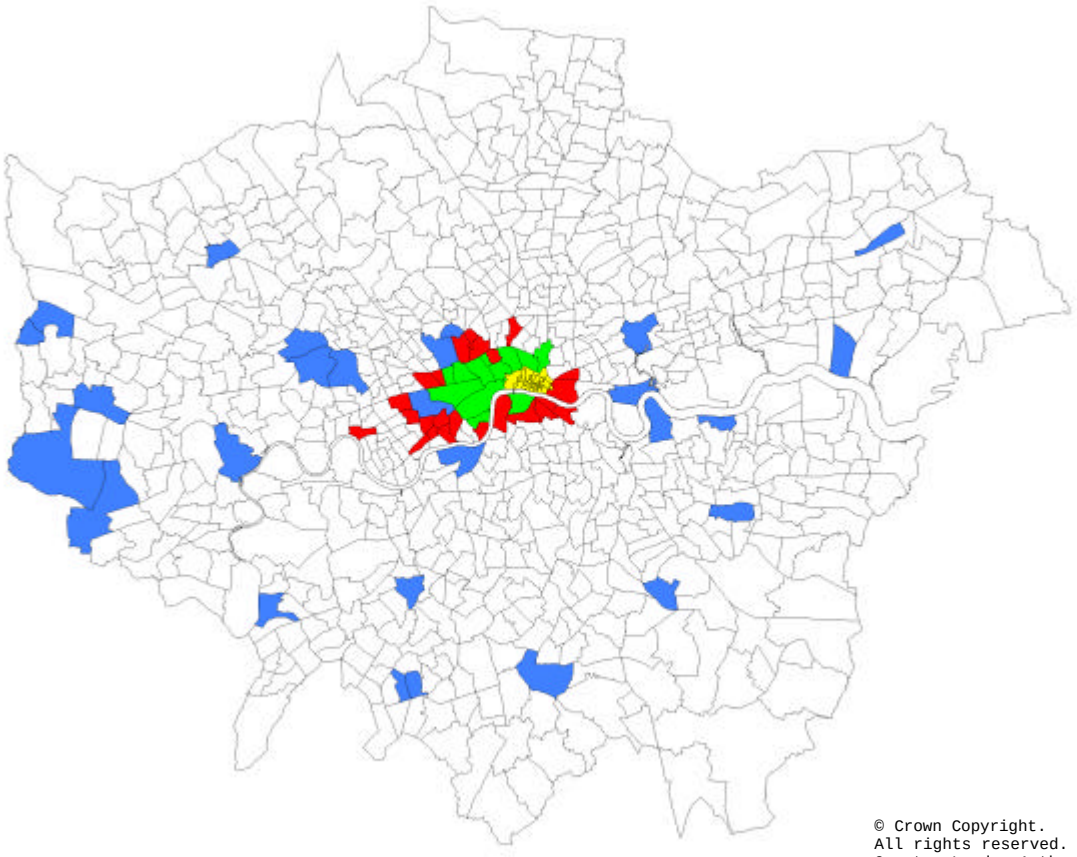
When the whole dataset was split into two groups, high and low accessibility, this distribution shifts. The areas with low accessibility have a mean ratio of 0.31 and a median value of 0.23. The high accessibility areas have a mean ratio of 0.59 and a median of 0.36.

The regression of employment density on population density was then split into two regimes, for high and low levels of accessibility. Dependency on accessibility and accessibility squared is also allowed for. For low levels of accessibility (generally seen in Outer London) employment density holds the strongest relationship with population density. For high levels of accessibility (seen in Central London), the population density becomes insignificant, and accessibility itself drives the employment density.

In Figure 1, the areas with the highest ratio of employment density to population density were in the very centre of London. Excluding these wards, Figure 6 showed that those areas with the highest accessibility also had a high ratio of employment density to population density. Mapping accessibility reveals that the most accessible areas are in the centre of London. A natural conclusion therefore would be that all those areas with a high ratio of employment to population density are in the centre of London. Predominantly this is the case, but interestingly there are areas in Outer London with a high ratio.

To illustrate this phenomenon, Figure 8 highlights all those wards in London with ratio of employment to population density of greater than one. This is not a specific break point, but does represent the point at which there are more jobs per hectare than residents within each ward. Figure 7 shows that wards with a ratio above one represent the top end of London's distribution.

Figure 8: Areas of London with employment to population density ratio > 1
Yellow = City of London; Green = 'Cluster 1' wards; Red = (employment density + population density) > 17,000; Blue = (employment density + population density) < 17,000



Four groups of different areas have been highlighted on Figure 8. In yellow are the 25 wards from the City of London. The surrounding 12 green wards are those defined to be in 'Cluster 1', as described above. The blue and red wards cover all the remaining areas in London that have an employment to population density ratio above one, split by absolute levels of employment and population density. A graph showing the exact construction of this split can be found in the Appendix.

The red wards have a high ratio of employment to population and have high absolute population and employment. These wards are indeed very central, where accessibility is high. The blue wards have a high ratio but low absolute values, and are dispersed across Outer London. These high employment areas are relatively easy to identify. In the far west, for example, is Heathrow airport. In the south are the retail centres of Kingston, Wimbledon, Sutton, Croydon and Bromley. Despite having lower accessibility these Outer London areas maintain high relative levels of employment. It is hypothesised that these jobs are sustained to a greater extent by the local resident populations.

Conclusion

Previous work has established strong links in London between employment density, population density and levels of transport accessibility. In this report these relationship have been broken down to better understand the interactions between them.

Areas within London with low levels of accessibility exhibit a strong relationship between employment and population density. These predominantly Outer London areas have a high proportion of employment that serves the local population. Taking all areas with a *public transport 45 minute population catchment area* that is below 1.7 million, results in a median ratio of employment to population density of 0.23.

For areas of high public transport accessibility, above 1.7 million people, the relationship between population density and employment density breaks down. Here instead, accessibility itself becomes a stronger determinant of employment density. In these areas of high accessibility, a lower proportion of employment exists to serve the local population. In its place more specialised and higher paid employment is found, access for which is predominantly gained by public transport.

Despite finding a significant relationship for areas of London with low public transport accessibility, there is still a large margin of variation around the employment to population density ratio. The median value of the ratio is equal to 0.23, but the 33 and 66 per cent quantiles of the distribution are equal to 0.16 and 0.31 respectively.

This suggests one of two things. Either there are unknown variables that are unaccounted for, or at this low level of geographic disaggregation there is an inherent degree of randomness in the data. The reality is probably a combination of the two. Consequently care must be taken to not draw conclusions for geographic areas that are too small. Attempting to estimate the impact of population or employment change at the ward level would not provide realistic results. At a borough or equivalent level however, average ratios could be used, provided that the accessibility was suitably low across the geography.

In terms of policy decisions for the Greater London Authority (GLA) however, there is reasonable evidence to suggest that land turned over for housing will have associated with it employment growth in the locality. Taking the coefficient of employment density regressed alone on population density in areas of low accessibility, it can be deduced that an increase to the resident population of 1000 will on average have the potential to give rise to a further 230 jobs in the locality.

Appendix

Regression Summaries

Simple linear regression of employment density on population density, no intercept term

Call: lm(formula = emp.dens.00 ~ pop.dens.00 - 1, data = dat)
Residuals:

Min	1Q	Median	3Q	Max
-5586	-1517	-600.9	154.8	23755

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
pop.dens.00	0.3763	0.0140	26.9560	0.0000

Residual standard error: 3308 on 744 degrees of freedom
Multiple R-Squared: 0.4941
F-statistic: 726.6 on 1 and 744 degrees of freedom, the p-value is 0

Simple linear regression of population density on employment density, no intercept term

Call: lm(formula = pop.dens.00 ~ emp.dens.00 - 1, data = dat)
Residuals:

Min	1Q	Median	3Q	Max
-24515	1629	3698	6164	19798

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
emp.dens.00	1.3130	0.0487	26.9560	0.0000

Residual standard error: 6179 on 744 degrees of freedom
Multiple R-Squared: 0.4941
F-statistic: 726.6 on 1 and 744 degrees of freedom, the p-value is 0

Robust linear regression of employment density on population density, no intercept term (M-estimator)

Call: rlm.formula(formula = emp.dens.00 ~ pop.dens.00 - 1, data = dat)
Residuals:

Min	1Q	Median	3Q	Max
-3731	-818.9	-85.28	818.9	25546

Coefficients:

	Value	Std. Error	t value
pop.dens.00	0.2714	0.0058	46.5617

Residual standard error: 1214 on 744 degrees of freedom

Simple linear regression of employment density on population density, accessibility and accessibility squared for wards with public transport accessibility less than 1.7m people

Call: lm(formula = emp.dens.00 ~ pop.dens.00 + pop.2001.pt + (pop.2001.pt^2) - 1, data = dat[dat$pop.2001.pt < 1700000,])

Residuals:

Min	1Q	Median	3Q	Max
-2371	-764.6	-271.6	274.5	9868

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
pop.dens.00	0.1120	0.0211	5.3071	0.0000
pop.2001.pt	0.0010	0.0003	3.9312	0.0001
I(pop.2001.pt^2)	0.0000	0.0000	-0.0760	0.9394

Residual standard error: 1412 on 575 degrees of freedom
Multiple R-Squared: 0.6169
F-statistic: 308.6 on 3 and 575 degrees of freedom, the p-value is 0

Simple linear regression of employment density on population density, accessibility and accessibility squared for wards with public transport accessibility greater than 1.7m people

Call: lm(formula = emp.dens.00 ~ pop.dens.00 + pop.2001.pt + (pop.2001.pt^2) - 1, data = dat[dat$pop.2001.pt > 1700000,])

Residuals:

Min	1Q	Median	3Q	Max
-10175	-2883	-995.9	1811	21814

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
pop.dens.00	0.0572	0.0940	0.6077	0.5442
pop.2001.pt	-0.0043	0.0014	-3.1521	0.0019
I(pop.2001.pt^2)	0.0000	0.0000	6.6016	0.0000

Residual standard error: 4826 on 164 degrees of freedom
Multiple R-Squared: 0.7084
F-statistic: 132.8 on 3 and 164 degrees of freedom, the p-value is 0

Figure A1: Population accessibility by public transport within 45 generalised minutes

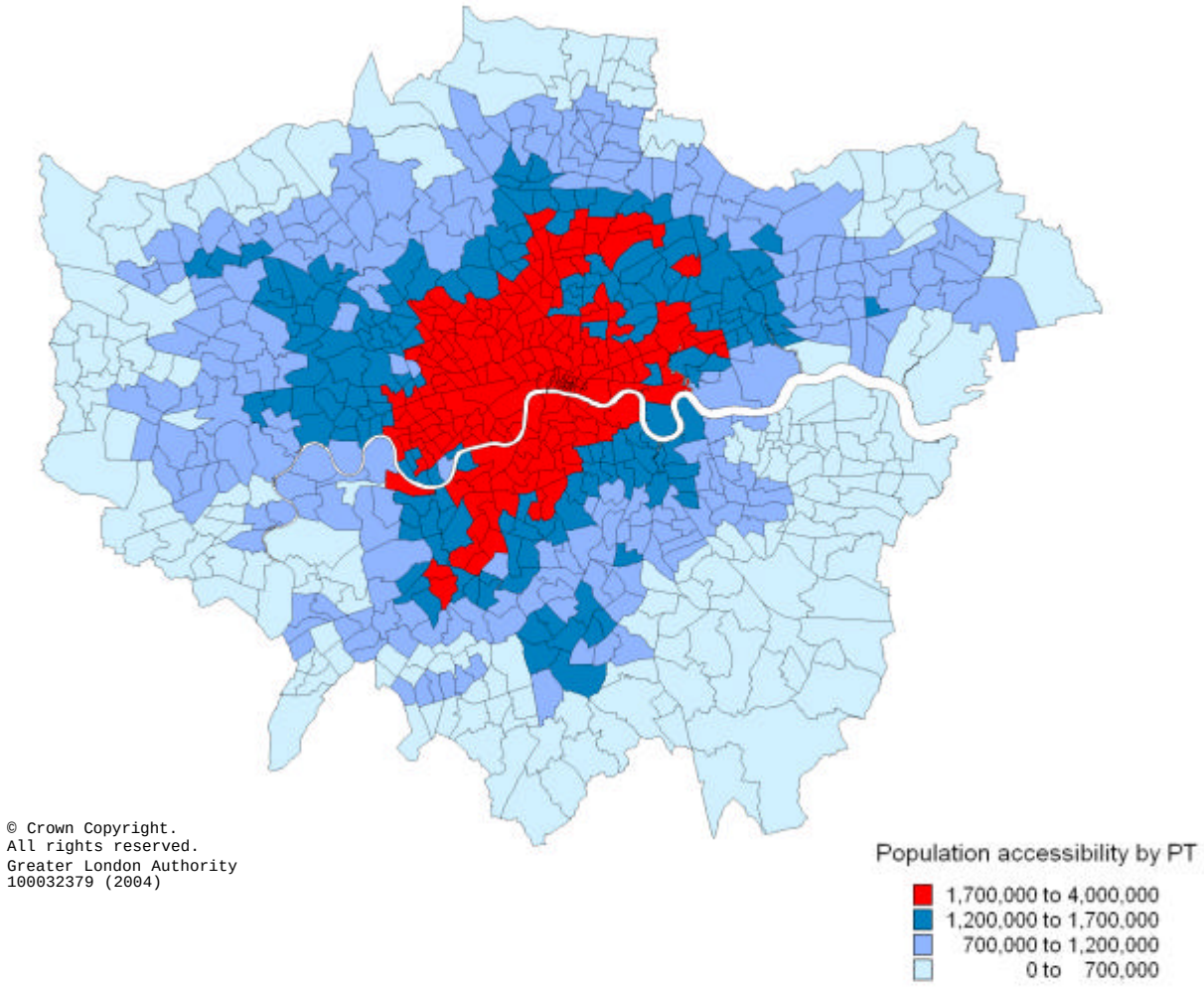
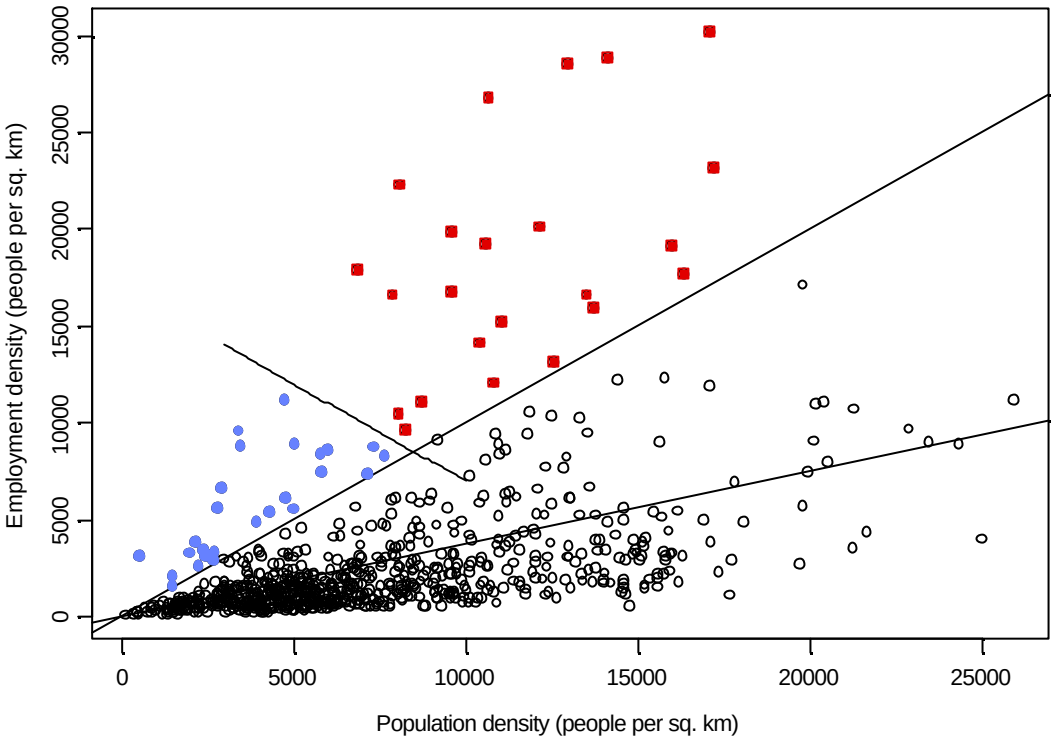


Figure A2: Segregation of London wards for Figure 8

Shallow fitted line = gradient 0.38
Steep fitted line = gradient 1
Red = (employment density + population density) > 17,000
Blue = (employment density + population density) < 17,000



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Chinese

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Hindi

यदि आप इस दस्तावेज की प्रति अपनी भाषा में चाहते हैं, तो कृपया निम्नलिखित नंबर पर फोन करें अथवा नीचे दिये गये पते पर संपर्क करें

Vietnamese

Nếu bạn muốn có văn bản tài liệu này bằng ngôn ngữ của mình, hãy liên hệ theo số điện thoại hoặc địa chỉ dưới đây.

Bengali

আপনি যদি আপনার ভাষায় এই দলিলের প্রতিলিপি (কপি) চান, তা হলে নীচের ফোন্ নম্বরে বা ঠিকানায় অনুগ্রহ করে যোগাযোগ করুন।

Greek

Αν θέλετε να αποκτήσετε αντίγραφο του παρόντος εγγράφου στη δική σας γλώσσα, παρακαλείστε να επικοινωνήσετε τηλεφωνικά στον αριθμό αυτό ή ταχυδρομικά στην παρακάτω διεύθυνση.

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں چاھتے ھیں، تو براہ کرم نیچے دئے گئے نمبر پر فون کریں یا دیئے گئے پتے پر رابطہ کریں

Turkish

Bu belgenin kendi dilinizde hazırlanmış bir nüshasını edinmek için, lütfen aşağıdaki telefon numarasını arayınız

Arabic

إذا أردت نسخة من هذه الوثيقة بلغتك، يرجى الاتصال برقم الهاتف أو مراسلة العنوان أدناه

Punjabi

ਜੇ ਤੁਹਾਨੂੰ ਇਸ ਦਸਤਾਵੇਜ਼ ਦੀ ਕਾਪੀ ਤੁਹਾਡੀ ਆਪਣੀ ਭਾਸ਼ਾ ਵਿਚ ਚਾਹੀਦੀ ਹੈ, ਤਾਂ ਹੇਠ ਲਿਖੇ ਨੰਬਰ 'ਤੇ ਫ਼ੋਨ ਕਰੋ ਜਾਂ ਹੇਠ ਲਿਖੇ ਪਤੇ 'ਤੇ ਰਾਬਤਾ ਕਰੋ:

Gujarati

જો તમને આ દસ્તાવેજની નકલ તમારી ભાષામાં જોઈતી હોય તો, કૃપા કરી આપેલ નંબર ઉપર ફોન કરો અથવા નીચેના સરનામે સંપર્ક સાધો.

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