Understanding how future land use assumptions influence transport appraisal

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1 Introduction

The use of transport models as input to transport appraisal and the development of scheme business cases is well established. They may inform on the impact, of a scheme, on trip patterns and changing flows across the transport networks. Underlying this approach are assumptions on future land-use distribution and how this may influence travel demand. For Transport Scotland's suite of transport models, (the National Transport Model for Scotland (TMfS) and the regional transport models relating to the major City Regions), the future travel demand is informed by forecasts of land use change taken from Transport Scotland's national land use and economic forecasting model, TELMoS. Those forecasts of where new housing and new commercial floorspace will be built is influenced by information, provided by the local planning authorities, on the scale and distribution of likely planned development.

In this paper we consider this process and try to understand how the information provided by planning authorities ultimately influences the forecasts of land-use and transport demand. We identify inconsistencies in the planning data, that has been used within the process, and explore possible mitigation with the aim of improving future transport forecasts.

The following sections firstly provide an overview of TELMoS, paying particular attention to how future development is modelled. Secondly they review the information that has been provided by the planning authorities and used within TELMoS. This identifies several gaps in the coverage and considers the implications of this. In the third section we explore how the DELTA package's modelling of redevelopment and intensification of development that has the potential to address the gaps in planning data. Finally, we apply this functionality and gauge the extent to which it addresses shortcomings in the planning data.

2 TELMoS – a land use and economic forecasting model of Scotland

2.1 Overview

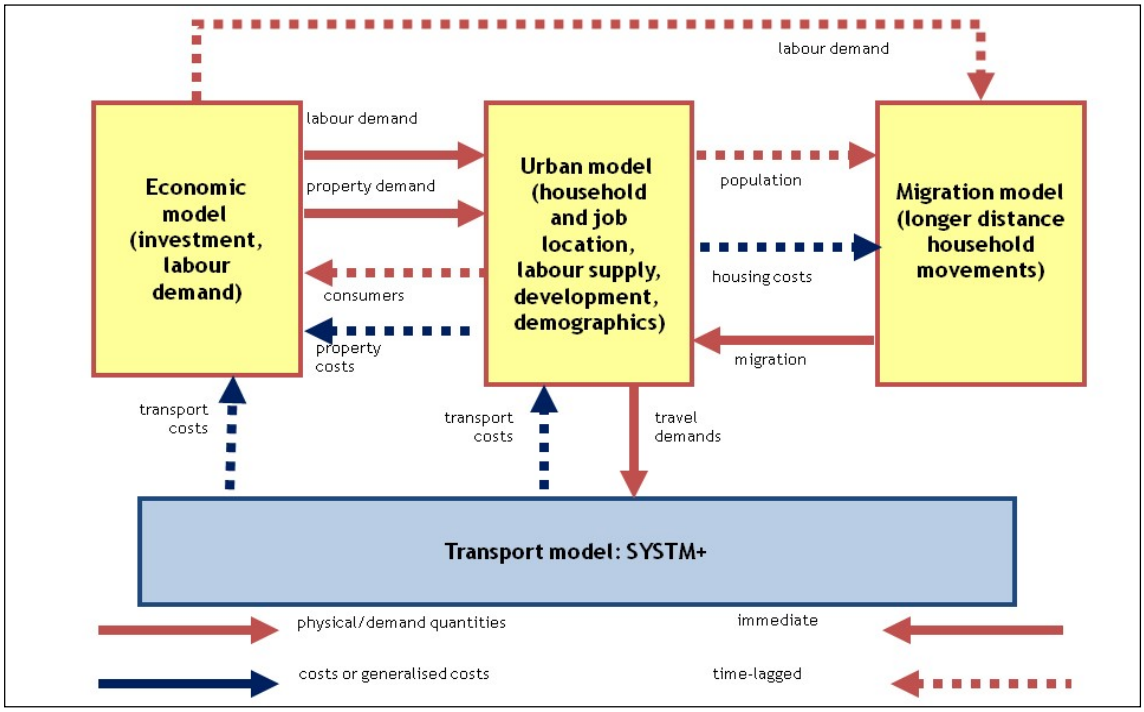
TELMoS is an application of David Simonds Consultancy's DELTA package. It forecasts changes in residential and commercial property and the households and jobs that relate to that land use. The model has coverage that extends across all of Scotland. The current version of the model was commissioned in 2015 although there have been several earlier versions of the model dating back to 2002.

2.2 The Model Structure

There are two spatial levels at which processes are modelled. The more strategic level is the Macrozone. These are based upon the 2011 Travel to Work area geography. There are 46 Macrozones covering Scotland. At the more local level there are 799 zones. These are based upon aggregations of Datazones. The zones nest within Macrozones.

The overall structure of TELMoS is show in Figure 1 where the three yellow boxes in the centre of the figure represent the model.

Table 1 Main components of TELMoS



The **economic model** forecasts growth (or decline) of sectors in the economy for each of the macrozones modelled. Its inputs include forecasts of overall growth in output and productivity. The forecasts by sector and area are influenced by:

- costs of transport (from the transport model);
- consumer demand for goods and services (from the urban model); and
- commercial rents (from the urban model).

Forecast changes in employment by sector and macrozone are passed to the '**urban' model**. This forecasts the zonal location of households and jobs. Locations are strongly influenced by the supply of built floorspace, and hence the urban model is a set of property models as well as a set of inter-related location models. Locations are also influenced by accessibility, with different measures of accessibility influencing different activities, and by environmental variables. Households are influenced by accessibility to workplaces and services. Businesses are influenced by accessibility to potential workers and customers.

The development model represents the process by which additions to (and demolitions of) the existing land-use stock is made. It is applied separately to six land uses: residential, retail, office, industrial, warehouse and leisure and hotel. It calculates change at zone level. The main input, to the development model is information on the scale and distribution of planned development. The source for this is information provided by the local planning authorities.

The development model calculates the total demand for additional development in each forecast year. This is based upon the increase in households and employment at the national level. It then considers the supply of permissible development (based on the site data provided by the planning authority) and models the process by which a proportion of these are brought forward to meet the demand for additional residential and/or commercial stock. Where the supply of permissible floorspace exceeds the demand then the permissible development in the most profitable locations (based upon the cost of construction and the return to developer) is brought forward and, in the model, added to the stock. Some sites may not be modelled as built, in this process. The details of those developments is carried forward and added to the supply of permissible development in the following year.

The locations of households and jobs are fed back to the transport model to generate travel demands. Household numbers are also used to calculate consumer demand for goods and services in each area,

for use in the economic model. The rents arising from competition for property in each area affect both the economic and migration models. Information on job opportunities is passed to the migration model.

The **migration model** forecasts migration **between** macrozones. Movements **within** macrozones are forecast in the urban model. The inputs to this model include job opportunities and housing costs from the urban model. Job opportunities are a strong incentive to migration; housing costs are generally a weak disincentive.

TELMoS forecasts future change in one-year steps. It starts from the Base Year (2014) and then forecasts change over the next 12 months. A database is output detailing the distribution of households, employment, land use for the new year. This is the starting point for forecasting change over the next 12 month period. The transport model is run less frequently. With TMfS14, it is run in 2017 and then in every fifth year through to the end of the forecast period (2041).

3 Planning Data

3.1 Overview

This section describes the inputs relating to the scale and distribution of planned development that are read into TELMoS.

3.2 Planning policy inputs

Transport Scotland and Scottish Water undertake a joint bi-annual exercise to collect details of planned development. The information gathered is used as an input to TELMoS and separately, by Scottish Water, to inform their capital programme. Details are sought from all thirty-four planning authorities (thirty-two local authorities and the two National Park authorities). They include information on sites for residential and commercial development that are likely to come forward and be made available for development over the period to 2037. They can include sites with planning permission, sites allocated in local development plans and other sites, identified by the planning authority that are likely to be developed.

The response to to the request for information is mixed. Some authorities supply a comprehensive dataset, others only provide partial data. There may be many valid reasons for this. For example, an authority's development plan may have a plan period that only extends to the mid 2020s and they may not have identified sites for development beyond the end of the plan period. Similarly if a development plan is under review, the authority may still be considering options for site allocation. They may be unable to provide a definitive list of sites where development may take place.

Information on the scale of residential development that is planned within each authority area is summarised in the Appendix.This is based upon data collected in 2016. It combines information on completions 2014-16 and sites where development is expected to come forward in future years. There are around 490,000 dwellings described in the table. The phasing of these is front-loaded. Just under 47% are expected to be available in the seven-year period from 2014 to 2021. Whilst fewer than 28% are expected to be phased in the ten years from 2027-2037.

In addition to the phasing there is also an uneven spread of planned development across the country. There are seven local authority areas for which there is no data for the period post 2026. Elsewhere, there is a generally lower levels of planned development post 2026, compared to the period upto 2026. The extreme example of this is in East Ayrshire where there is information on fewer than ten dwellings after 2026. This fall-off in planned development may reflect planning policy and a strategy that constrains growth however it seems more likely that planning authorities simply don't have a comprehensive picture of future development when you look more than 7-10 years into the future.

One possibility is that total planning inputs are broadly correct but that the phasing is front loaded. This would give more development in the early years and less in the later period. To check this we've looked at what proportion of the planned development that is phased to 2026 is actually built in that period. Appendix Table A2 shows, in the current TELMoS14 Do-minimum reference case, most of the

permissible development that is input in the period to 2026 is also built in that period. In most authorities over 75% of inputs are modelled as built by 2026. This suggests that firstly the level of planning inputs in the early years is broadly in line with demand and that there is no strong evidence of 'front-loading'. Secondly it suggests that the inputs in the later years may be underestimating demand.

4 Redevelopment and intensification

4.1 Overview

The previous section described the information on planned development provided by the planning authorities and concluded that there are concerns about both the overall quantity of development and the geographic coverage. In this section we describe the DELTA package's redevelopment and intensification functionality and consider whether it can address these concerns.

The two functions capture the processes by which sites:

- that are underused or vacant may be **redeveloped** for alternative land-uses; and
- Sites in areas of high demand may be redeveloped, with the same land-use and with a more **intensive** use of the plot.

In both cases, the development would be consistent with planning policy for the area.

An example of redevelopment would be where a former industrial site was converted to housing or office accommodation. An example of intensification would be where a large free-standing dwelling unit, in an area of high demand, was demolished and a block of flats built.

Currently this functionality is not implemented in TELMoS.

4.2 A brief description of redevelopment and intensification processes in DELTA

The two development processes are similar in execution, though with key differences. They both start with an assessment of the existing stock (of housing and commercial property) and a calculation of what proportion of the stock is occupied and what proportion is vacant.

For redevelopment, if the occupancy rate is below a prescribed level, then an assumption is made that some of the floorspace is superfluous to need and can be redeveloped for alternative uses. These uses can be defined by the user and should be consistent with planning policy and the types of development that would normally be permitted within a locality. If there is more than one possible alternative use, for example if a site might be redeveloped as either residential, office or retail then the model will select one of these based upon a calculation of the likely return to the developer. Finally the new permissible development is added to the stock of permissible development (based on the planning inputs) and made available for construction. Whether it is modelled as brought forward and developed will depend on the relative profitability of the development, compared to the other permissible development.

For intensification, if the occupancy level, within a zone, is above a pre-determined level then the assumption is that some of the floorspace will be redeveloped with the same land use but at a more intensive level. Again this should only occur in those localities where planning policy permits intensification. The redevelopment will involve an increase in the amount of floorspace within the zone.

The two processes are summarised in Table 2.

Table 2 Redevelopment and intensification processes

Redevelopment	Intensification
Identify trigger for re-development to occur when the occupancy rate is **below** a prescribed level.	Identify trigger for intensification to occur when the occupancy rate is **above** a prescribed level.
Calculate the proportion of the existing floorspace for a specific land use to **re-develop**, assuming there is a cap on the amount that can be developed in any one year	Calculate the proportion of the existing floorspace for a specific land use to develop at **more intensive level**, assuming there is a cap on the amount that can be developed in any one year

Select the **alternative space categories** that existing floorspace can be redevelop as, based upon a calculation of rents for each of the permissible end uses	
Calculate the amount of floorspace that may be built for a **different land-use type**.	Calculate the amount of **additional floorspace** that may be built

4.3 Consequences of applying redevelopment and intensification in DELTA applications

Applying these processes will result in changes in land-use patterns with increases in some areas and, because overall demand is fixed, decreases elsewhere. This change will impact on where households choose to live and where businesses chose to locate. This may have repercussions for trip patterns. For example if more residential floorspace is built in a central urban area then this may influence household location choices, perhaps with more people living in central areas and fewer on the edge of the urban area. If households assume the trip and mode split of existing residents in the same area, then locating more households in central locations may mean more public transport trips and lower car ownership compared to a scenario where the households were on the edge of the urban area, with lower public transport provision.

5 Applying redevelopment and intensification to address gaps in planning data

5.1 Overview

In this section we test the proposition that by introducing the redevelopment and intensification functionality we can overcome concerns about 'gaps' in the planning data.

Our approach is to run the TELMoS model three times. The first model run is of a Do-minimum reference test. This will be the benchmark test against which we compare two 'Do-Something' tests. The benchmark test does not include redevelopment and intensification.

The second model run, Do-something 1, has the redevelopment and intensification functionality switched on and applied to residential land use in those local authority areas where there clear gaps in the information on residnetial planned development for the period post-2026.

The final model run, Do-something 2, has the redevelopment and intensification functionality switched on and applied to residential land use across all of Scotland.

In analysing the model outputs we compare the Do-something tests with the Do-minimum. We look both at changes in the residential stock and at how these changes affect the number of households and cars available for residents in different locations. The differences between the two tests are the result of applying the redevelopment and intensification process.

5.2 Do-minimum test

The Do-minimum Reference test is known by the identifier, test AA. The inputs to this test run are:

- Base year information on population, households, floorspace and rent;
- Information on the scale of distribution of future development based upon the information provided by Local Authorities as described in Section 3 and the Appendix;
- A Scotland-wide demographic scenario, that determines the overall level of population and household growth at the national level, based upon NRS projections; and
- An economic scenario, that determines the overall level of economic growth across Scotland and its regions, based upon an independent economic forecast provided by Experian.

The model runs in single year steps, as described in Section 2, forecasting change over the period to 2037. Figure 1 shows the number of dwellings forecast to be built, within each local authority, in the two time periods, 2016-2026 and 2027-2037. There are fewer dwellings forecast to be built in the second of these two periods, in all authority areas. This is consistent with the earlier observation that there was less permitted development in the second period.

The difference is particularly marked in those local authority areas mentioned, in Section 3 and Appendix Table A1, as having no or few planning inputs post 2027. For example in Scottish Borders, East Ayrshire, East Renfrewshire, East Dunbartonshire and Stirling. (Note there are some local authority areas where there are dwellings forecast to be constructed post 2027, even though in Section 3 we reported that there were no inputs for these years. These were sites that were either under construction in 2027 or had been input in the pre2027 period but had not yet been taken up).

Figure 1 Absolute number of dwellings TEST AA

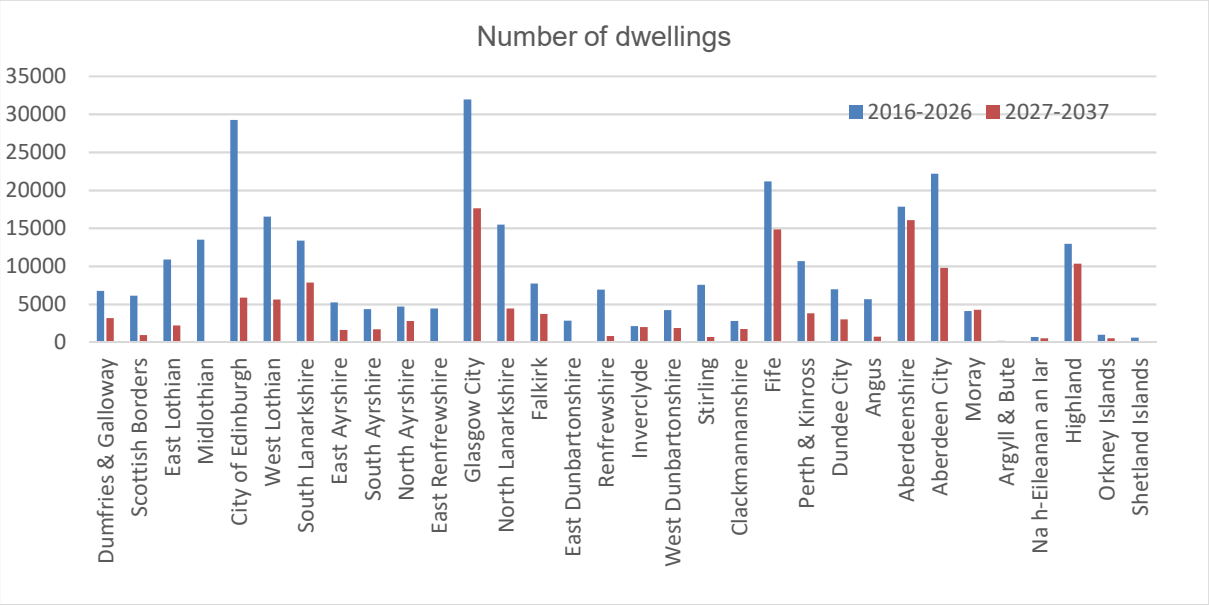


Figure 2 shows the forecast change in households within each local authority area in the Do-Minimum Reference Case in the same two time periods. At the national level, there is a lower rate of growth in households after 2026 compared to before that year. Between 2016 and 2026 a 6.4% increase in number of households is forecast for Scotland, between 2017 and 2027 the growth is 4.3%.

Below the national level, the distribution of households is calculated within TELMoS, and is based upon the processes described in Section 2. The forecasts show lower growth rates after 2026, for households, within the most of the local authorities except for Glasgow, Dundee, Aberdeenshire, South Lanarkshire, Clackmannanshire and Falkirk.

In Section 3.2 we identified a list of local authorities that either had supplied no information on or noticeably lower levels of planned development after 2026. A concern expressed at that point was that the lack of data would unduly constrain the forecasts of household growth for these areas. To explore this further we have looked at household growth within these authorities. The geographical distribution of the authorities is shown in Figure 3.

Table 3 shows the results. Of the 17 authorities, 11 have dramatically lower levels of household growth after 2027. The entries for these 11 authorities are shaded green in the table.

Figure 2 Absolute number of households TEST AA

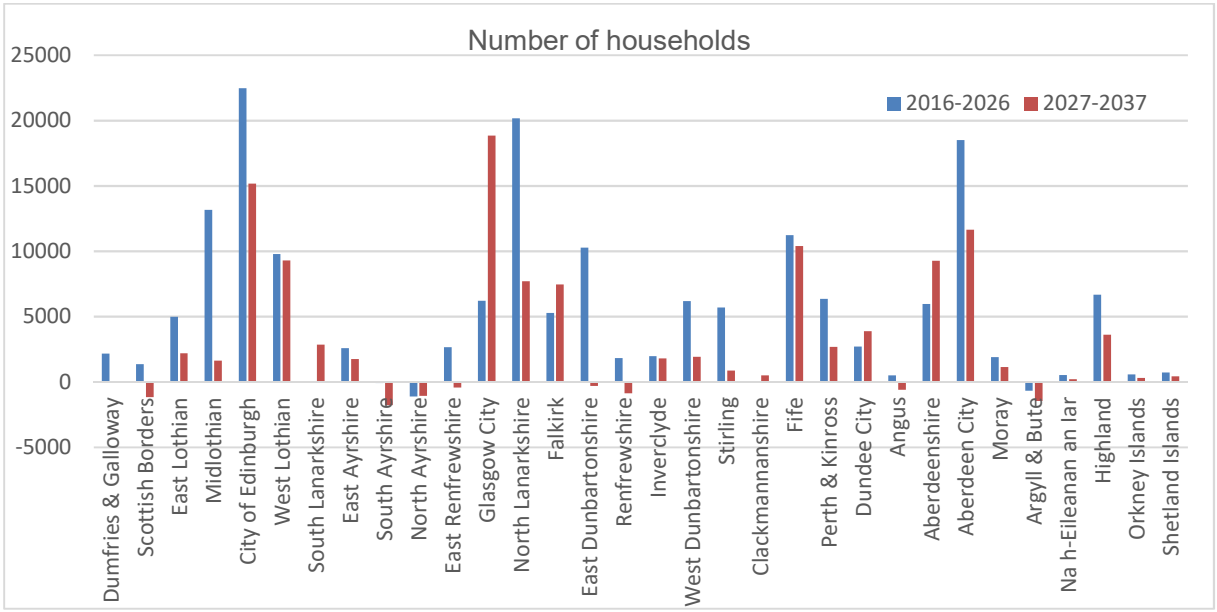


Figure 3 Local Authorities identified as having gaps in residential inputs

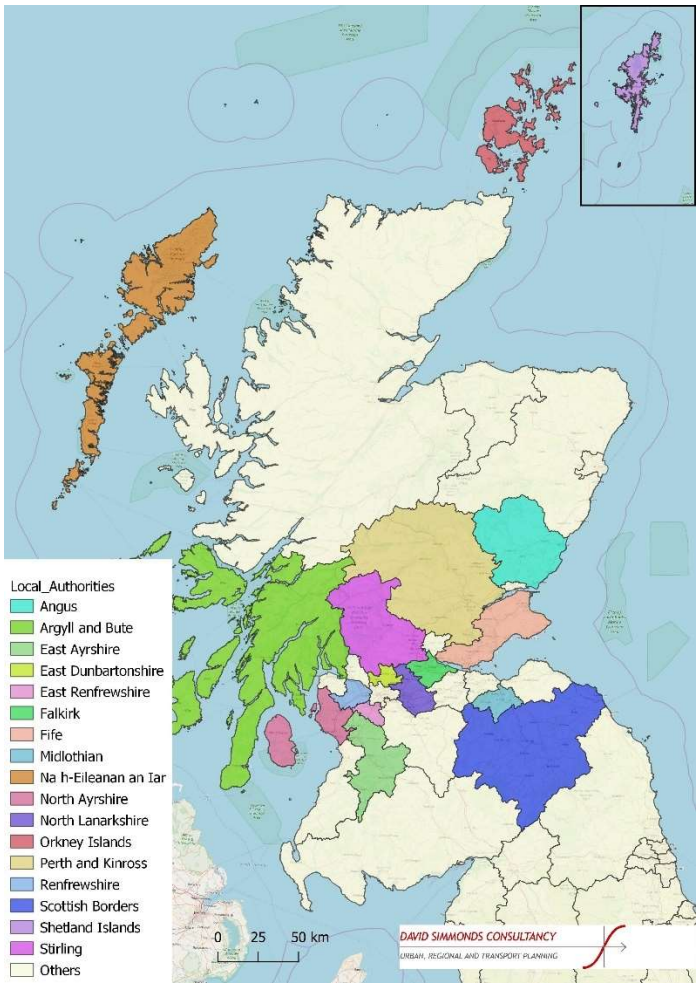


Table 3 TEST AA household forecasts for selected local authority areas

Local Authorities	Increase in households 2016-26	Increase in households 2027-37
Scottish Borders	1408	-1154
Midlothian	12145	1632
East Ayrshire	2497	1760
North Ayrshire	-978	-1061
East Renfrewshire	2807	-423
North Lanarkshire	18456	7712
Falkirk	5037	7458
East Dunbartonshire	9943	-307
Renfrewshire	1931	-873
Stirling	4787	869
Fife	10246	10392
Perth & Kinross	6046	2676
Angus	505	-590
Argyll & Bute	-554	-1457
Eilean Siar	496	220
Orkney Islands	537	304
Shetland Islands	661	436

5.3 Do Something Test 1: Modelling the impact of redevelopment and intensification in selected areas after 2026

The first Do-something test examines the impact of applying redevelopment and intensification within the 17 local authorities shown in Table 3 above. The objective of this was to explore whether this would result in a forecast of more residential development and produce a more balanced pattern of household growth across Scotland. The functionality was applied only in the period from 2027 to 2037.

The Do Something Test 1 was given the two-character identifier Test AB. The outputs from the model run have been compared with the Do-minimum Test AA. The two test runs are identical except for the introduction of redevelopment and intensification in Test AB.

Note: for this exercise TELMoS has been run as a LUMIT model (ie a Land Use Model influenced by Transport), with the same generalised costs being used for both Test AA and AB. As a result there is no feedback mechanism from the transport model to the land use model, in the way that there would be with a LUTI model.

The rest of this section presents the difference between test AB and AA. At the national level, the total levels of growth remain constant, below that level there is change in the distribution of households and, as a consequence, the number of cars owned in each authority area.

Figure 4 compares the number of dwellings forecast to be built in Test AA and AB. The blue columns represent the increase in dwelling units, over the 10 year period (2027-37) for each authority, the red columns the increase when redevelopment and intensification is introduced. The difference between the two columns is the impact on the local authority of introducing redevelopment and intensification. The three largest increases (when redevelopment and intensification are applied) are in Midlothian, North Lanarkshire and Renfrewshire with around 9,428, 22,122 and 8,730 additional dwellings respectively. Smaller increases are forecast in East Dunbartonshire, East Renfrewshire and Fife. In contrast, there are fewer dwellings forecast in some authority areas including Aberdeenshire, Highland, Glasgow and South Lanarkshire.

Figure 4 Difference in forecast number of dwellings 2027-2037 (Test AA and AB)

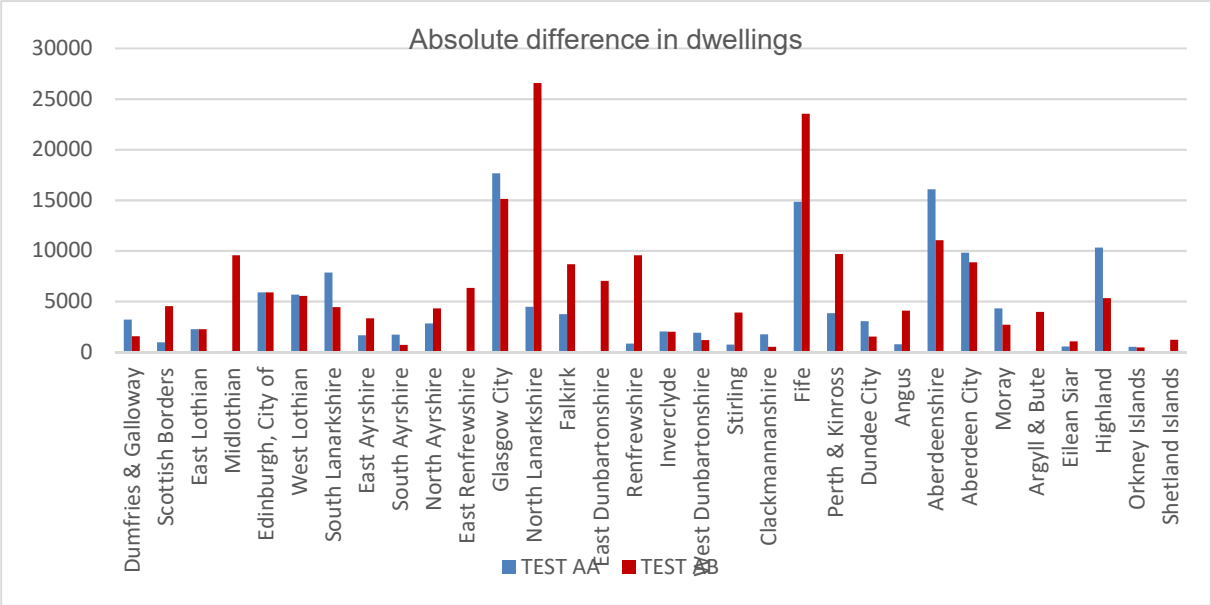


Figure 5 shows the change in numbers of households by local authority area over the same period. The application of the redevelopment and intensification results in more households in some areas and fewer in others. There are fewer in Edinburgh, Glasgow and South Lanarkshire (where intensification wasn't applied) and more in many of the authority areas where the redevelopment/intensification was applied. For example in Midlothian within the Edinburgh City Region and North Lanarkshire, East Renfrewshire and East Dunbartonshire in the Glasgow City Region.

Figure 5 Absolute difference in Households 2027-2037 (Test AA and AB)

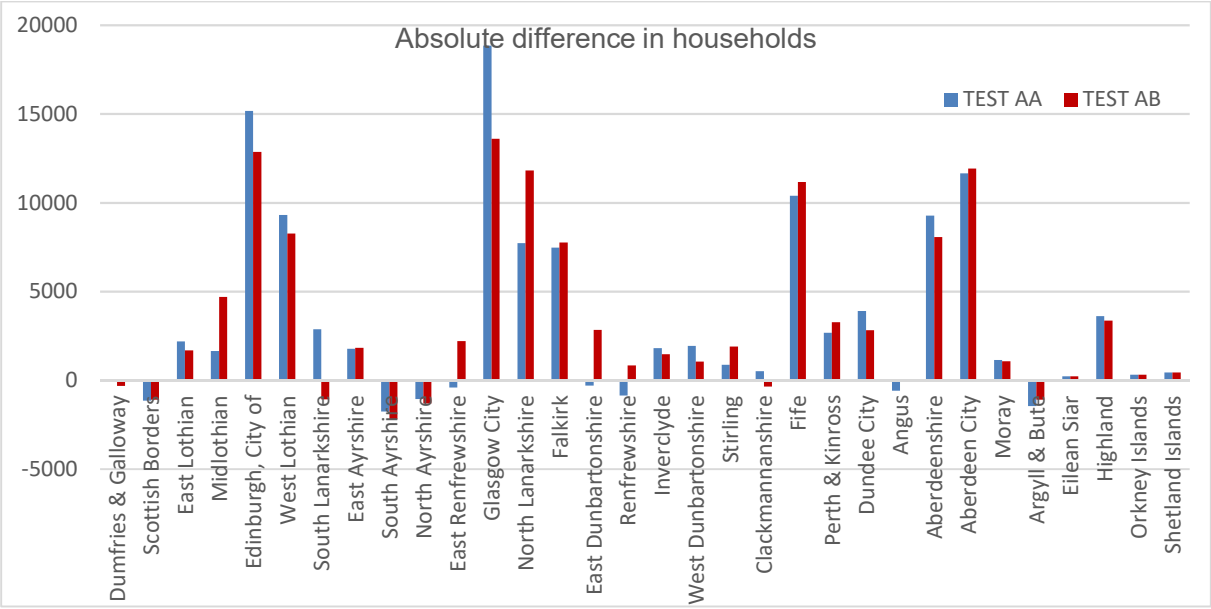
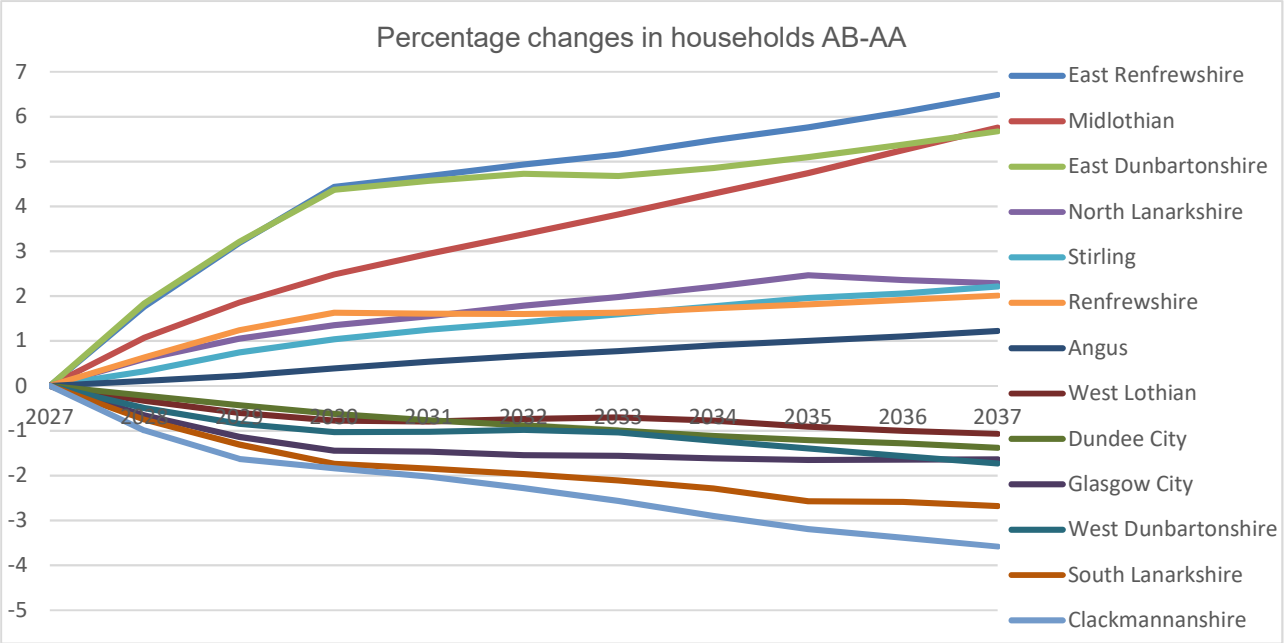


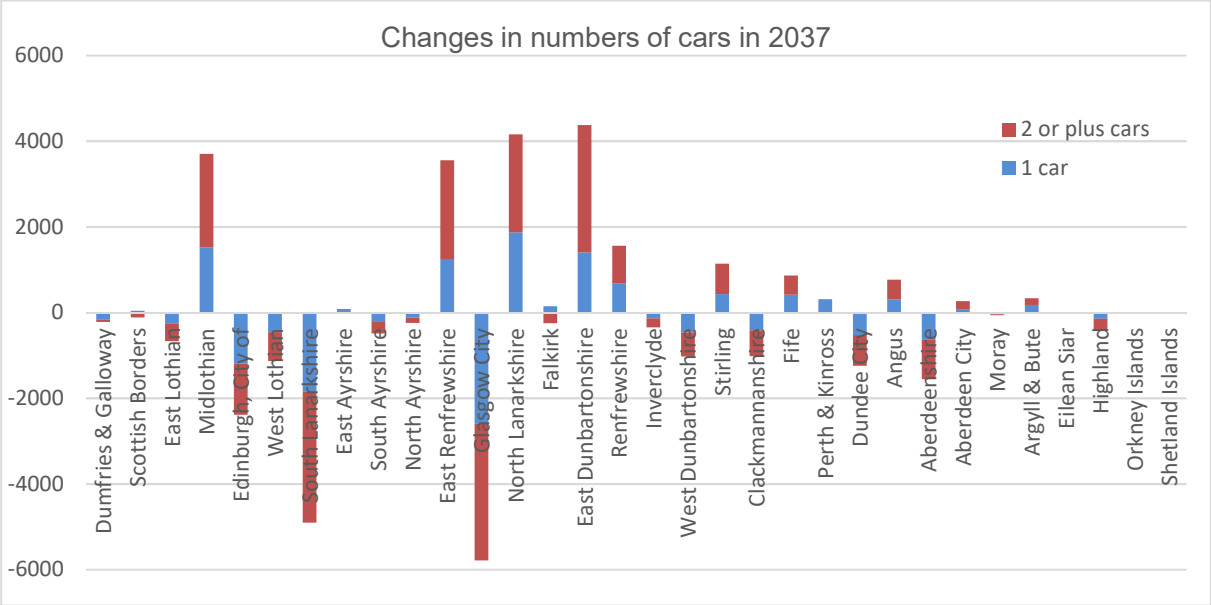
Figure 6 shows the percentage change in households, comparing Test AB and AA, over the period from 2027 to 2037. A value of 7 implies that the number of households in Test AB is 7 % higher than in Test AA. The Figure omits the trend lines for those authorities where the change, in 2037 was less than ± 1%. The largest percentage increases are in East Renfrewshire, East Dunbartonshire and Midlothian, whilst the largest declines are seen in Clackmannanshire and South Lanarkshire.

Figure 6 Percentage difference in Households 2027-2037 (selected authorities)



Within TELMoS, households moving to a new area are assumed to take on the car-ownership characteristics of the zone to which they move. A consequence of the changing pattern of households described above will be more cars owned in some areas and fewer in others. Figure 7 shows the absolute changes in the number of cars by 2037. There are fewer cars owned in some of the major urban authoritiess and increases in East Dunbartonshire, East Renfrewshire, North Lanarkshire and Midlothian.

Figure 7 Absolute difference in cars Test AB-Test AA in 2037



5.4 Do Something Test 2: Modelling the impact of redevelopment and intensification across all of Scotland after 2026

The second Do-something test applyies redevelopment and intensification across all of Scotland, rather than just in those areas where there were gaps in the planning data. Again, the functionality was applied only in the period from 2027 to 2037. The test was given the two-character identifier Test AC.

Figure 8 shows the forecast increase in dwellings over the period 2027-2037 for this test, along with both Tests AA and AB. There are two key points arising from this comparison. Firstly, the application of redevelopment and intensification across all of Scotland results in an increase in dwellings in the major cities of Edinburgh, Glasgow and Aberdeen. Secondly a comparison of the Test AB and AC outputs shows a re-distribution of growth. There is less in North Lanarkshire, Fife and some others, but more in some of the other authorities (for example South Lanarkshire) where redevelopment and intensification was not applied. Finally, the growth in dwellings in Aberdeenshire and Highland is less, when redevelopment and intensification are introduced. than in test AA.

Figure 8 Comparison of dwellings between the tests 2027-2037

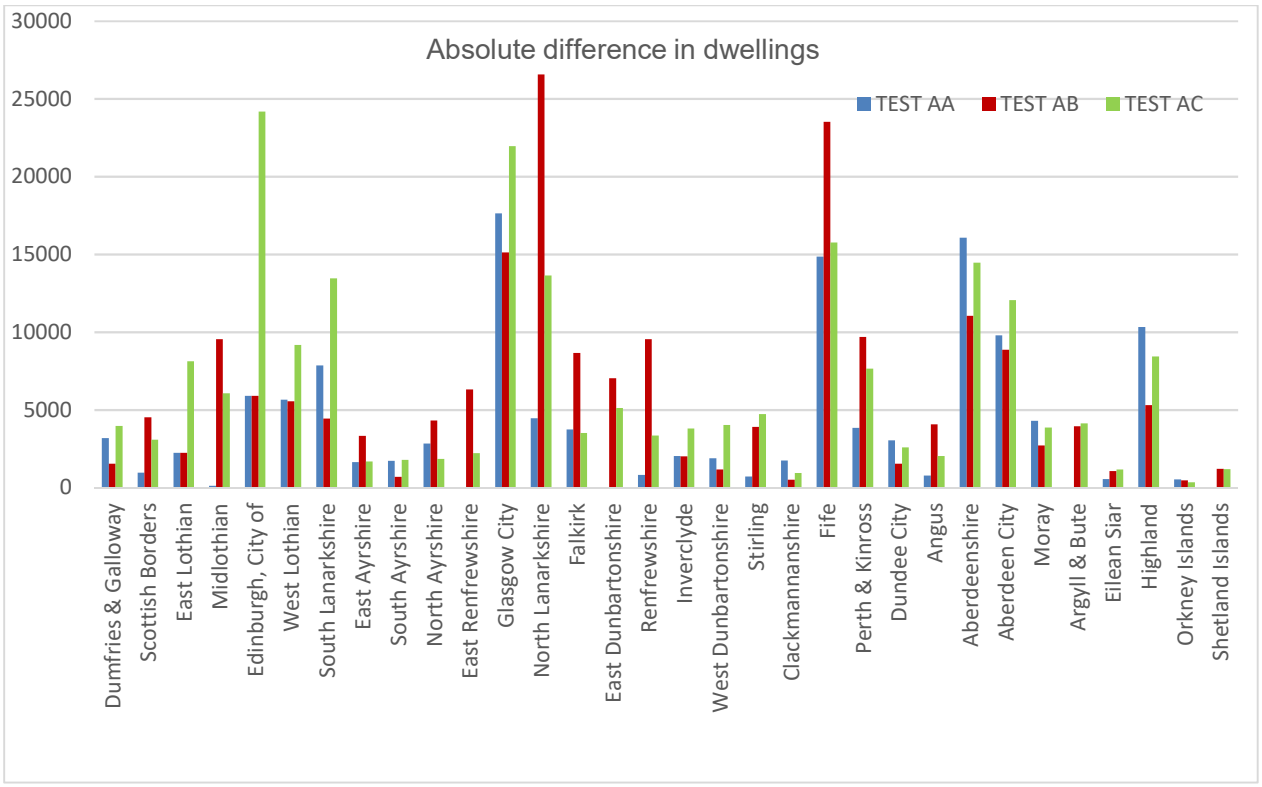
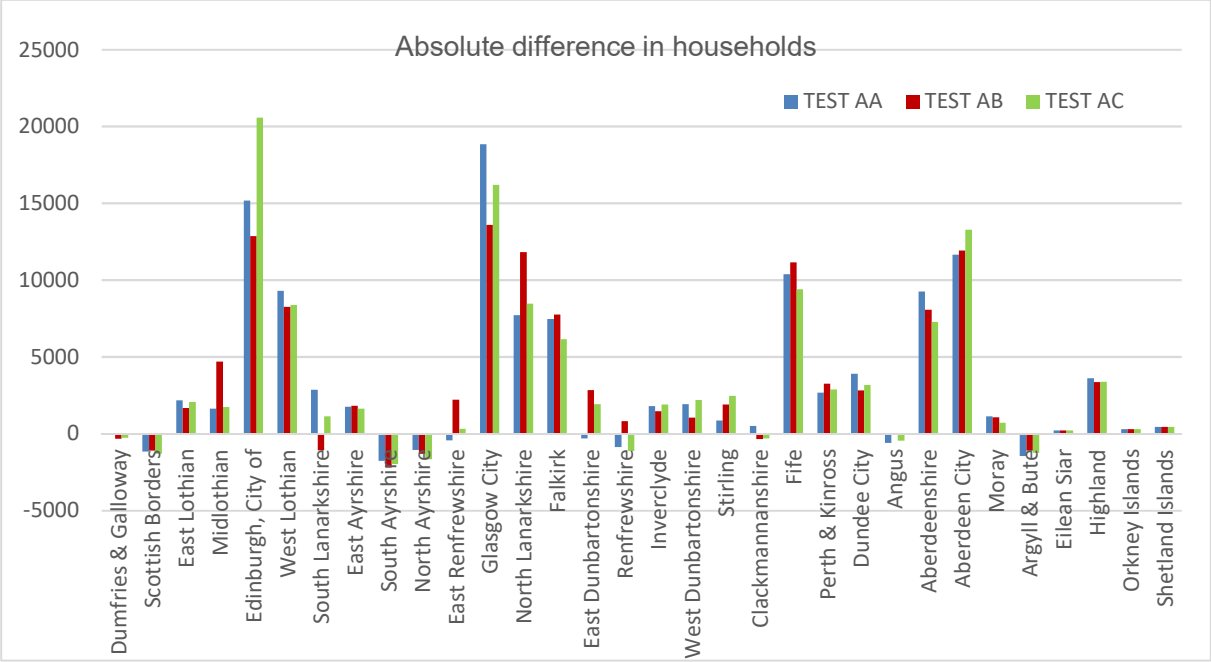


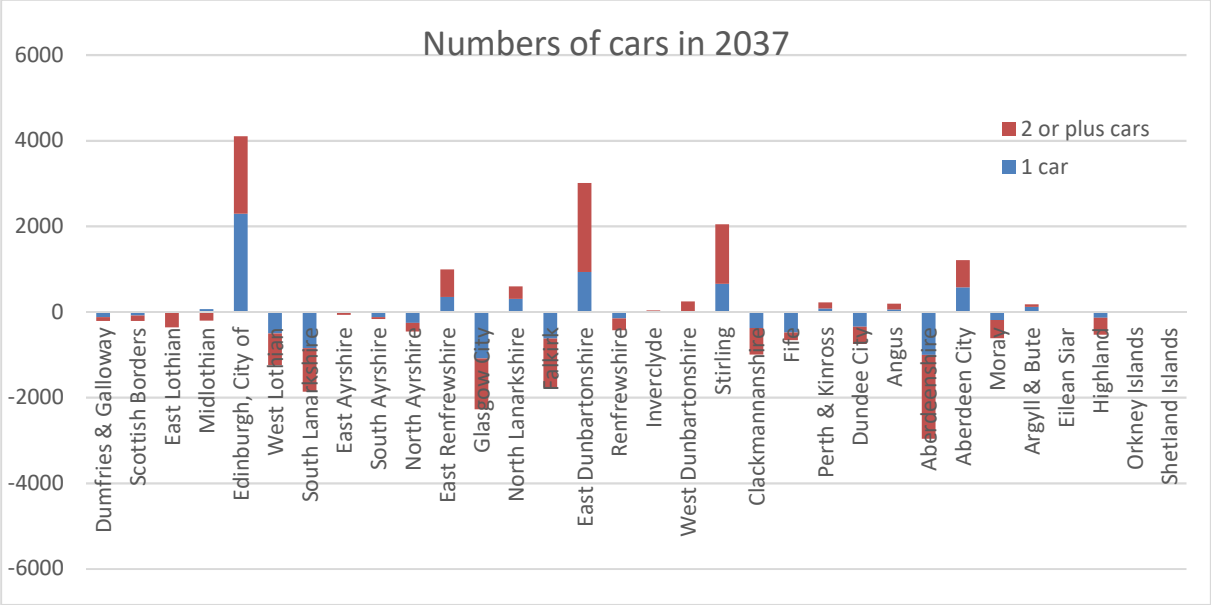
Figure 9 compares the increase in households over the period 2027-37 for the three tests. There are increases in Edinburgh and Aberdeen, reflecting the increase in dwellings described above. In the Glasgow City Region the picture is more complicated. There are increases in some parts of the Region but not in others.

Figure 9 Comparison of households between the tests 2027-2037



The application of the redevelopment and intensification functionality across all of Scotland results in more cars in some authority areas (see Figure 10). The largest increases are in Edinburgh, East Dunbartonshire, Stirling and Aberdeen City. There are fewer cars in Aberdeenshire, Glasgow, South Lanarkshire and some other authority areas.
Further analysis of model output and the running of a LUTI model where details of households and car ownership are passed from the land use model to the transport model to see how this change in car ownership levels impacts on trip patterns and congestion on the transport networks.

Figure 10 Absolute difference in cars Test AC-Test AA in 2037



6 Conclusions

In this paper we have looked at one of the key inputs to the land use and economic model, namely the information on planned development that has been supplied by the planning authorities. There are

concerns about the comprehensiveness of that data. We suggest that there are gaps in the data (and there may be very good reasons for these gaps), but they do impact on the forecasts of future population and households, adding more people in those authority areas where there are no gaps and fewer people to those areas with gaps. This may have an effect on travel demand and the number of trips across different parts of the transport network.

We've looked at one possible mitigation for these gaps; namely to apply DELTA's redevelopment and intensification function. This can provide additional floorspace in areas of demand. We've applied this functionality first to the areas where we have identified a shortage of information on planned development. The result is that there is more growth in households in these areas (and less elsewhere). Secondly we've applied it across all of Scotland. This produces additional growth in those major urban areas where there is strong economic growth and inward migration (from other parts of Scotland).

We conclude that allowing the model to build more where there is demand, in this way, can overcome some of the limitations of relying on incomplete planning inputs.

Taking this forward, there are two areas to explore. Firstly to validate the levels of additional development that these processes are generating by discussing the results with local planners, in key authority areas, are gauging their views on the likely levels of additional development that they would expect. Secondly, the model runs described in Section 5 have not involved passing the data to the Transport Model. We feel that this would be a useful next step to see how the land use changes described are likely to impact upon travel patterns.

Appendix

Table A1 Residential planning inputs (dwellings)

Local Authority	2014-2021	2022-2026	2027-2031	2032-2037
Dumfries & Galloway	5073	3134	1920	982
Scottish Borders	5895	1446	0	0
East Lothian	7646	3311	1470	1080
Midlothian	8011	5622	1197	0
Edinburgh, City of	26072	8462	5038	2156
West Lothian	15240	6184	1795	1002
South Lanarkshire	9261	8929	4236	1869
East Ayrshire	3756	3428	7	0
South Ayrshire	2944	3739	1208	699
North Ayrshire	3793	2692	2234	893
East Renfrewshire	2614	2184	0	0
Glasgow City	19419	14238	11925	8394
North Lanarkshire	9810	7487	4492	0
Falkirk	5470	5150	863	518
East Dunbartonshire	3200	379	0	0
Renfrewshire	5946	3712	1490	0
Inverclyde	1952	892	1234	1293
West Dunbartonshire	3041	1569	1018	1098
Stirling	3667	2778	2251	226
Clackmannanshire	1372	1703	895	870
Fife	14690	9558	6871	8325
Perth & Kinross	7285	4015	2150	2079
Dundee City	5905	2172	1395	1674
Angus	4271	1667	576	0
Aberdeenshire	15573	6773	10696	9138
Aberdeen City	17316	7155	5466	4211
Moray	2882	2484	2484	2981
Argyll & Bute	207	11	0	0
Eilean Siar	1792	0	0	0
Highland	9198	7533	6120	4546
Orkney Islands	2097	0	0	0
Shetland Islands	877	0	0	0

Table A2 Take up of residential planning inputs by 2026

Local Authorities	% of permissible development input 2015-2026 modelled as built be 2027	% of permissible development not modelled as built in 2027
Dumfries & Galloway	76%	24%
Scottish Borders	90%	10%
East Lothian	100%	0%
Midlothian	99%	1%
Edinburgh, City of	100%	0%
West Lothian	83%	17%
South Lanarkshire	74%	26%
East Ayrshire	75%	25%
South Ayrshire	67%	33%
North Ayrshire	65%	35%
East Renfrewshire	100%	0%
Glasgow City	99%	1%
North Lanarkshire	89%	11%
Falkirk	70%	30%
East Dunbartonshire	100%	0%
Renfrewshire	72%	28%
Inverclyde	73%	27%
West Dunbartonshire	99%	1%
Stirling	94%	6%
Clackmannanshire	85%	15%
Fife	83%	17%
Perth & Kinross	93%	7%
Dundee City	95%	5%
Angus	93%	7%
Aberdeenshire	86%	14%
Aberdeen City	97%	3%
Moray	78%	22%
Argyll & Bute	92%	8%
Eilean Siar	51%	49%
Highland	82%	18%
Orkney Islands	64%	36%
Shetland Islands	99%	1%