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Non-Technical Summary

This deliverable (D28 – The role of growth in sustainability) reports on the use of MuSIASEM (Multi-Scale Integrated Analysis Societal Ecosystem Metabolism) approach, one of the DECOIN[1] tools, and is part of the project Synergies of Multi-Level Integrated Linkages in Eco-social Systems (SMILE)[2]. D28 is a contribution to WP4: *Synergies and Trade-off Analysis and Scenario Building*. The report builds on the previous work by the MLURI team in the *Scottish Case Study* (D16) and the *Utility of tools to Stakeholders* analysis (D23).

The analysis undertaken in D28 was an assessment of the linkages between growth as measured by gross value added, energy consumption and population using the MuSIASEM approaches. These derive indicators of sustainability that combine assessment of both the extents and intensities of resource use. The analysis was conducted at Scotland and regional scales and also for the Cairngorms National Park (CNP). The CNP is a new institution where the responsible authority has a novel role in promoting sustainable development.

The findings of the research are that

- There is significant complexity in the relationship between growth and sustainability and thus gross value added alone is a poor indicator of the nature and consequences of growth.
- The mix of sectors and differences in populations mean that overall Scotland level averages are poor guides to understanding the sustainability of the system. Regional analyses are more informative but are undermined by lack of granularity, particularly with regard to measures of value added and the use of energy beyond electricity and gas.
- There is little or no evidence of dematerialisation within the paid work sectors of the Scotland or CNP economies, but there is evidence of some reduction of the energy intensity within the household sector.
- The outputs of the research, particularly local case studies that are contextualised by regional and national data are seen as relevant to policy and management decisions but there are significant obstacles to be overcome in mainstreaming the MuSIASEM approach.

The MuSIASEM-based research within D28 will continue to be developed within the new Scottish Governments research programme (2011-16).

[1] http://www.decoin.eu
[2] http://www.smile-fp7.eu/

Contents

List of Figures

1 Introduction

The Synergies of Multi-Level Integrated Linkages in Eco-social Systems (SMILE)[3] project seeks to further develop and apply the DECOIN[4] tool kit. This toolkit consists of three models: SUMMA (Sustainability Multi-criteria Multi-scale Assessment); MuSIASEM (Multi-Scale Integrated Analysis Societal Ecosystem Metabolism) and ASA (Advanced Sustainability Analysis). The ambition of the SMILE project is to combine these tools into a system of sustainability accounting that provides a useful insights into the dynamics of the sustainability of complex coupled eco-social systems (Giampietro et al. 2009a).

This report (D28) is a contribution to WP4: *Synergies and Trade-off Analysis and Scenario Building*. The report builds on the previous work by the MLURI team in the Scottish Case Study (D16) and the Utility of tools to Stakeholders analysis (D23). In D16 a case-study of sustainable development within the Cairngorms National Park (CNP) was developed in partnership with the Cairngorm National Park Authority (CNPA). In D23 the utility of outputs from the SUMMA and MuSIASEM tools[5] were assessed, again with the CNPA. Neither analysis was seen a lacking in merit or as being irrelevant to the CNPA deliberations on sustainability. The MLURI research team, however, recognised that neither approach had overcome the "implementation gap" and neither would feature strongly as an evidence base for decision making in relation to the next Cairngorms National Park Plan (the aspiration at the start of the SMILE research). This partially reflects the inexperience of the MLURI team in using the DECOIN tools and the challenges of using a non-standard statistical region, but also the challenge in resource terms of a single SMILE partner making operational two of the DECOIN tools for a single case-study[6]. The importance of taking the tool kit beyond the academic community and demonstrating its policy relevance, however, was highlighted in the external review of the SMILE project by Redclift in 2010. In the light of these findings and the limited resources remaining to the project team[7] the scope and nature of the analysis for D28 was modified, still retaining the objective of assessing linkages between growth and other objectives but doing so with a strong emphasis on analyses that were seen as relevant to the cast-study stakeholders. The rationale and objectives for the D28 report are set out below.

In D23 it was possible to identify some high priority issues and modification to the analyses that would greatly increase the salience and credibility of the outputs. These issues were prioritised rather than opening up new avenues of research. Not all of the issues identified in D23,

[3] http://www.smile-fp7.eu/
[4] http://www.decoin.eu
[5] The ASA tool was not implemented in the Scottish case study, as its requirement for specific data to be available as time series were unable to be met for the Cairngorms National Park (CNP).
[6] The MLURI team have also been less able to devote additional resources to SMILE within the SG funded research programme as higher priority policy research has been commissioned.
[7] The analysis has been heavily supported by the MLURI core research funds as well as RTD.

however, have been addressed by the MLURI research team due to limitations on the staff time available. For D28 the MuSIASEM analysis is the most relevant looking at the macro-relationships within the Scotland and CNP level economies. Drawing on experience in undertaking D16 and D23, the MuSIASEM analysis has been substantially improved as noted in the materials and methodology section and is now more reliably informative on the relationship between growth and other indicators of sustainable development. The D28 analysis is complemented by the D29 analysis of synergies and trade-offs that uses the outputs from the SUMMA analysis. Policy implications of the two analyses are reported in D30.

2 Materials and Methodology

This section briefly outlines the improvements made to the MuSIASEM analysis since the completion of D23. For more detail see the original Case Study report (D16) and the updates within the Utility report (D23).

Following the D23 work with the CNPA it was clear that one of the main limitations to the credibility of the MuSIASEM analysis was that the time series of data was too short to show definitive trends and the uncertainties in the processes of aggregating and disaggregating the datasets were too great. The mismatches in classification systems – particularly for employment and the other measures (GVA and energy use) means that the sectoral analysis was also weak. For the MuSIASEM analysis to pass a credibility test the underlying datasets and their recombinations needed to be improved.

2.1 Population and Employment

For population it was possible to draw on a more detailed dataset with a longer time series. This was the General Register of Scotland (GRoS) mid-year population estimates. This dataset is available at the data zone level. This is a small unit (~500 persons) that is spatially explicit (i.e. can be mapped to link to land). The time series is from 1991 to present and thus supports the Total Human Activity (THA) analyses required by MuSIASEM. The GRoS dataset could also be further exploited to look at trends in the age-gender distributions. However further research is needed to assess if this is possible at small unit scales that can support within-CNP analysis and be aggregated back to the CNP.

For employment the previous source of data had been the Scottish Neighbourhood Statistics. These have a long time series and are appropriately resolved (again at data zone level) but the classification used is both limited (7 classes) and non-standard. For the analysis reported here the MLURI team were granted access to the Annual Business Inquiry (ABI) dataset, which is an annual, UK wide survey of employment, recorded on a residential and workplace basis. The time series runs from 2001 to 2009, but can be supplemented by other similar datasets. The key feature of the ABI dataset is that it uses the Standard Industry Classification (SIC) a five level

classification that is the definitive means of disaggregating employment. From this detailed classification it is possible to ensure that employment is compatible with the other key datasets.

There is a significant discontinuity in the ABI dataset, with the introduction in 2007 of a new system of classification for employment replacing the 1992 version. Since the MuSIASEM analysis is using only the highest level classes none are lost, but while names remain the same in some cases their composition has changed. This may mean that it would be preferable always to take the most detailed classes and impose a MuSIASEM specific aggregation. This was beyond the MLURI team's resources on this occasion and would have required special permission from the Office for National Statistics (ONS). ONS expectation is that the data supplied will either be very detailed but only for a subset of geographical regions or more generalised for all. Such difficulties maybe overcome but not within the timeframe of current SMILE programme.

2.2 Gross Value Added

Gross value added (GVA), despite being such a key indicator for policy development, remains weak in terms of the MuSIASEM analysis. GVA figures are available in time series for more recent years (2005+). In these cases data is available with detailed sectoral breakdowns (NUTS1) or at smaller units (NUTS3) but with very limited sectoral detail. The inference may be that while the data must exist to support both NUTS3 and sectoral breakdowns, the associated uncertainty means that statistical agencies are reluctant to make such datasets publicly available. The NUTS3 breakdown does provide some useful regional comparisons but does not help in the case of the CNP which is made up of segments from four (and prior to 4th October 2010 three) NUTS3 regions. This means that for the CNP there is reliance on specific modelled results e.g. those from the Economic Report on the State of the Park (Cogent Strategies International 2011). However this is a snapshot, (the previous report was in 2002) rather than an on-going time series with standardised methods employed. Other commercial datasets had been expected to assist in disaggregating the GVA figures for the CNP but these have proven unreliable. GVA for the CNP has relied on interpolation of national trends using the single modelled year as the basis of disaggregation. With SMILE colleagues at VU we are continuing to investigate how well a CNP specific Social Accounting Matrix (SAM) can be generated but results to date have not been encouraging.

2.3 Energy Throughput

Energy data remains a significant challenge. The time series of data begins in 2005, with experimental efforts by the government analysts to generate data for earlier periods (2003-04) resulting in a datasets that are incompatible (at sectoral level) with later years. There is also a significant lag in the availability of the data such that the 2009 figures have only become

available early in 2011. Spatially the energy datasets are available at two scales. One is the data zone (see above) but this is only for gas and electricity (metered supplies). In this case the sectoral breakdown is also limited (4 classes) and these classes reflect specific policy goals (renewables, transport, domestic and industrial) rather than providing a systematic basis for a MuSIASEM type analysis. Other energy data (e.g. transport, fuel etc) is reported on a local authority basis. This is different from the rest of the UK where NUTS3 units are used. This makes the energy data incompatible with the GVA figures for several cases (8 Local Authorities (LA)). Given there is no simple and reliable basis for disaggregation of energy from LA and re-aggregation to NUTS3 the incompatibility has had to be accepted. This means there is also a severe challenge in disaggregating the LA figures to provide a meaningful consumption figure for the CNP. Further investigation is required here.

2.4 Land

Compared to other datasets, the challenge for land data is not to find the small scale detail but how the available detail can be aggregated in a coherent and computationally feasible way for regions and Scotland. For the CNP analysis it has been possible to create a comprehensive land use map based on the Ordnance Survey Master Map base map supplemented by other datasets. The methods used are those of the UK National Land Use Database[8] and involved the recoding of map features into appropriate classes and the assessment of when overlaps in the datasets are real and when they are an artefact of the mapping process[9]. The availability of historical time series of data is yet to be resolved so in effect land-based analyses can only be undertaken for the current situation. It is, however, possible to link individual business information to the mapping to begin to make possible spatial MuSIASEM analyses with GVA and employment (and with some significant caveats to energy as well). Proof of concept results are reported here but a full implementation will occur beyond the scope of SMILE.

2.5 Meso-scale analysis

The original intent for the MuSIASEM analysis was to use two scales, Scotland and the CNP, with Scotland as the external referent for comparative purposes. The availability of further scales of data (LA and NUTS 3 summaries) has meant that it is possible to add an intermediate scale. This was strongly welcomed by the CNPA stakeholders as while they are interested in comparing the performance of the Park with Scotland they are particularly keen to see comparisons with one or more of the neighbouring regions as a comparative basis for performance evaluation. The addition of the LA/NUTS3 scale also better allows for a systematic

[8] http://www.communities.gov.uk/documents/planningandbuilding/pdf/142619.pdf

[9] The energy infrastructure (pylons) can stand on land that remains available for grazing and is thus a legitimate double-counting that needs to be accounted for in both mapping and summaries whereas there are numerous cases where mismatches in the underlying dataset that need to be eliminated.

decomposition of the Scotland level analysis. More insights on the nature of the overall Scotland levels figures can be gained by demonstrating the mix that underlies them.

2.6 Other Issues

Despite the best efforts of the MLURI research team the MuSIASEM analysis is not in our view definitive. The CNP analysis would be substantially strengthened by a within CNP level analysis (n-1). To that end two commercial survey datasets were purchased, one for all businesses (~800) within the CNP and another for one eighth of the households (~2000). The intent was to use the business dataset to enhance the sectoral and spatial breakdown of GVA within the Park using turnover, profitability and employment data supplied. The household data was intended to enhance the THA and TAL analyses, particularly identifying the working population underpinning the services and tourism sectors. The supplied data has, has however, proved to be thoroughly unreliable, in some cases being significantly out of date (when checked against address data from the UK post office) or are verifiable with official statistics (e.g. checking the employment results against those provided in ABI). Efforts to definitively assess which datasets are correct through cross-checking using a postal survey have not been successful. Therefore while it would be possible to present the n-1 analyses of the CNP using MuSIASEM, until the issues with the small scale datasets can be resolved it was thought unwise to do so. Working with the CNPA, the small-scale MuSIASEM analysis will continue until the conclusion of the SMILE project.

3 Findings:

Despite the challenges of datasets and data integration it has been possible to generate several MuSIASEM analyses that provide useful insights at Scotland, LA/NUTS3 and CNP level.

3.1 Exosomatic metabolic rate

Exosomatic metabolic rate (EMR) is one of the key indicators generated by the MuSIASEM analysis. This shows the intensity of energy use per hour of human activity (Mj/hr). The time series of EMR for Scotland, its regions and the CNP reveal interesting patterns of intensity and trends that provide information on the changing sustainability of Scotland's economy. A series of graphs illustrate these time series at the end of this section.

Figure 1 shows a time series for the societal average of EMR, that is EMR_{SA}. The graph shows the time series for 2005 to 2009. Scotland, the local authority regions and the CNP are all graphed but it is clear one region of Scotland is very distinctively different – Falkirk. This has an EMR_{SA} over three times the next largest. Falkirk hosts a very large petrochemicals complex. The pattern of EMR_{SA} suggests that the recession has seen lower demand or an impressive increase in efficiency.

Figure 2 removes the Falkirk region so that it is possible to see the pattern of EMR_{SA}. From the figure it is possible to see that there is an overall downward trend in EMR_{SA}, though with some unusual exceptions (Clackmannanshire in particular but see Figure 4 below). There is considerable variation in the in EMR_{SA} between the regions (~8 MJ/h to ~16MJ/h) and the regions are fairly evenly spread between these bounds. Regions with otherwise very different characteristics can have very similar outcomes in terms of EMR_{SA} (e.g. Edinburgh City and the Orkney Islands). The Scotland and CNP values for EMR_{SA} are similar but with the CNP is not keeping pace with the reduction in EMR_{SA} in 2009.

Further characterisation of the distribution of the EMR_{SA} is provided by supplementary graphs in Figure 3, Figure 4 and Figure 5. In Figure 3 the EMR_{SA} values for the cities of Scotland are shown. Here it is possible to interpret the graphs as showing differences in the nature of the cities. The larger cities (Edinburgh and Glasgow) are perhaps seeing economies of scale in terms of energy consumption in the provision of housing and other services. Figure 4 highlights two unusual cases of regions with significant increase in EMR_{SA}. These increases were short lived (2006-7) but relatively large (at least in terms of the other changes seen). More investigation of these particular phenomena is required. Finally for EMR_{SA} the local authorities that make up, or bound the CNP are highlighted in Figure 5. From this it is clear that the CNP is made up part of local authorities that have distinctively different characters, i.e. with higher and lower EMR_{SA} values.

Beyond EMR_{SA} it is useful to characterise the systems in terms of their EMR for the household (EMR_{HH}) and paid work sectors (EMR_{PW}). This (n-1 sectoral) analysis can be supported by the population, employment and energy data available and is presented for Scotland and the CNP (and could be extended to include all local authority regions). It had been hoped to break down EMR beyond paid work but to date this has not been possible. Figure 6 shows both EMR_{PW} and EMR_{HH} with Figure 7 and Figure 8 showing the paid work and household trajectories in more detail. Note the contrast in the magnitude of the EMR rates with the household sector having much lower intensity of energy use but this is balanced by their greater extent of hours spent in household activity. See Section 3.4 where extents and intensities are combined. In both cases there is a downward trend in EMR of ~10%.

In Section 3.2 the second of the MUSIASEM indicators, economic labour productivity is examined.

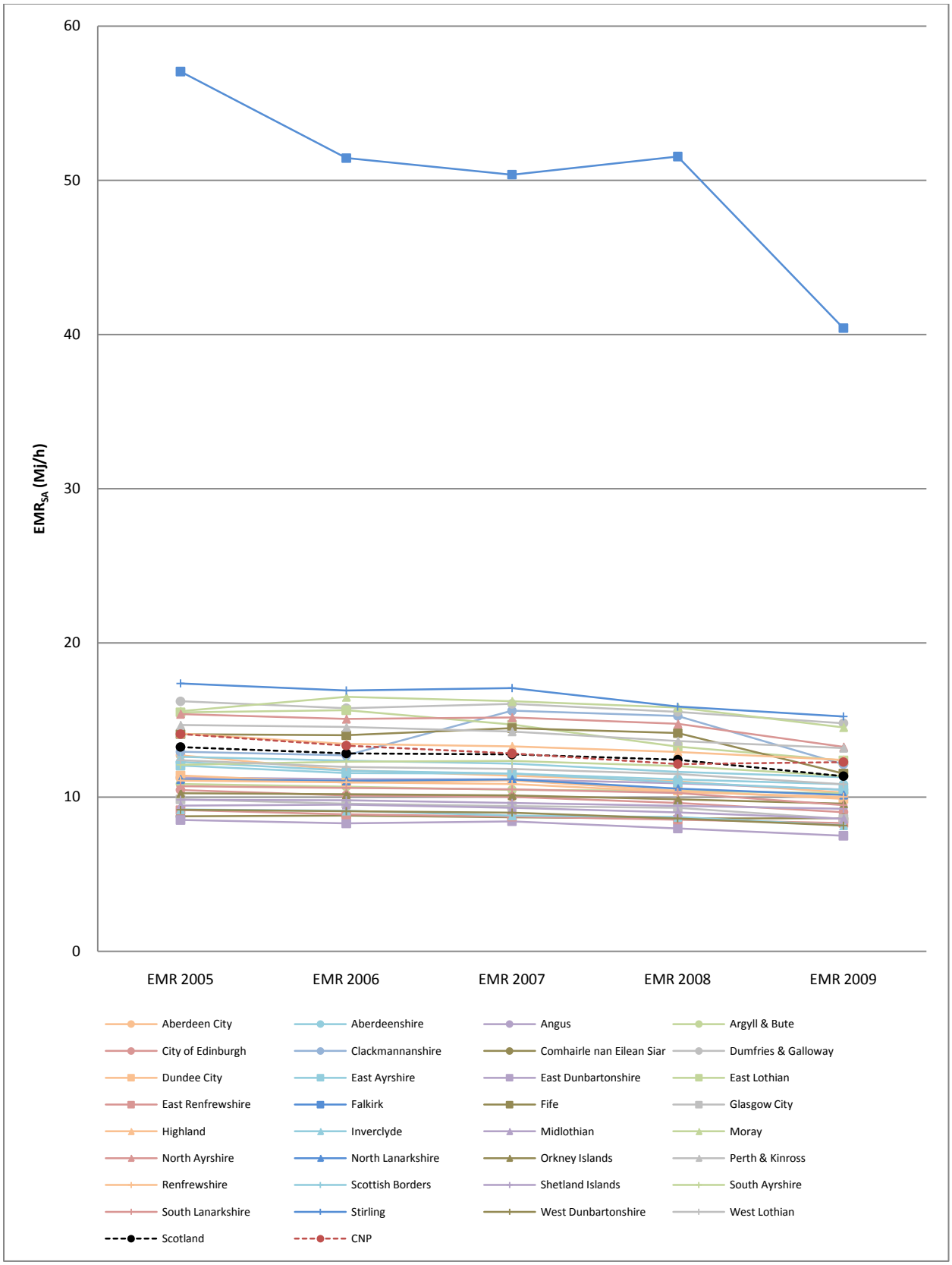


Figure 1: EMR_{SA}: Scotland, Regions and CNP

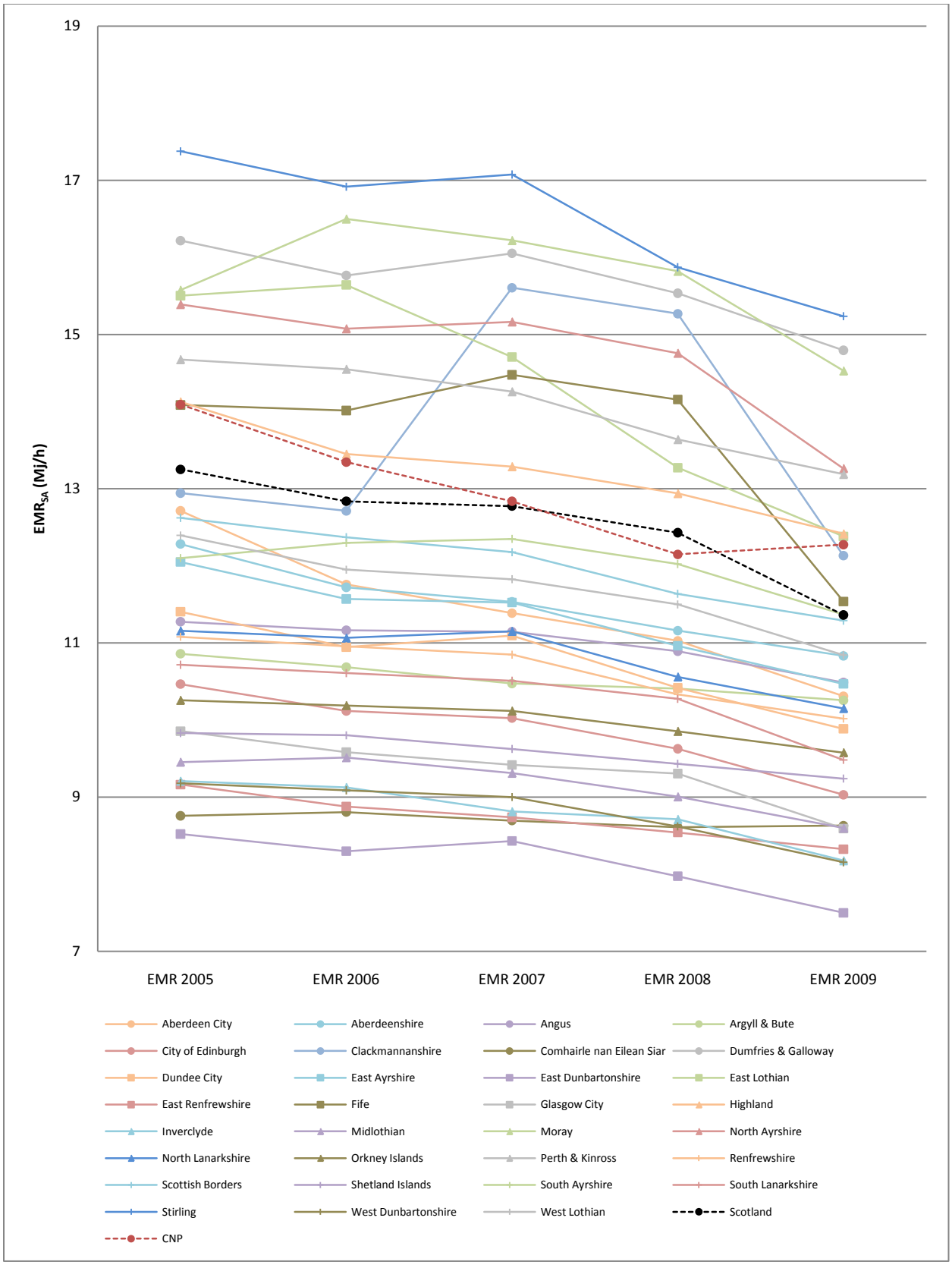


Figure 2: EMR$_{SA}$: Scotland, Regions and CNP minus Falkirk outlier

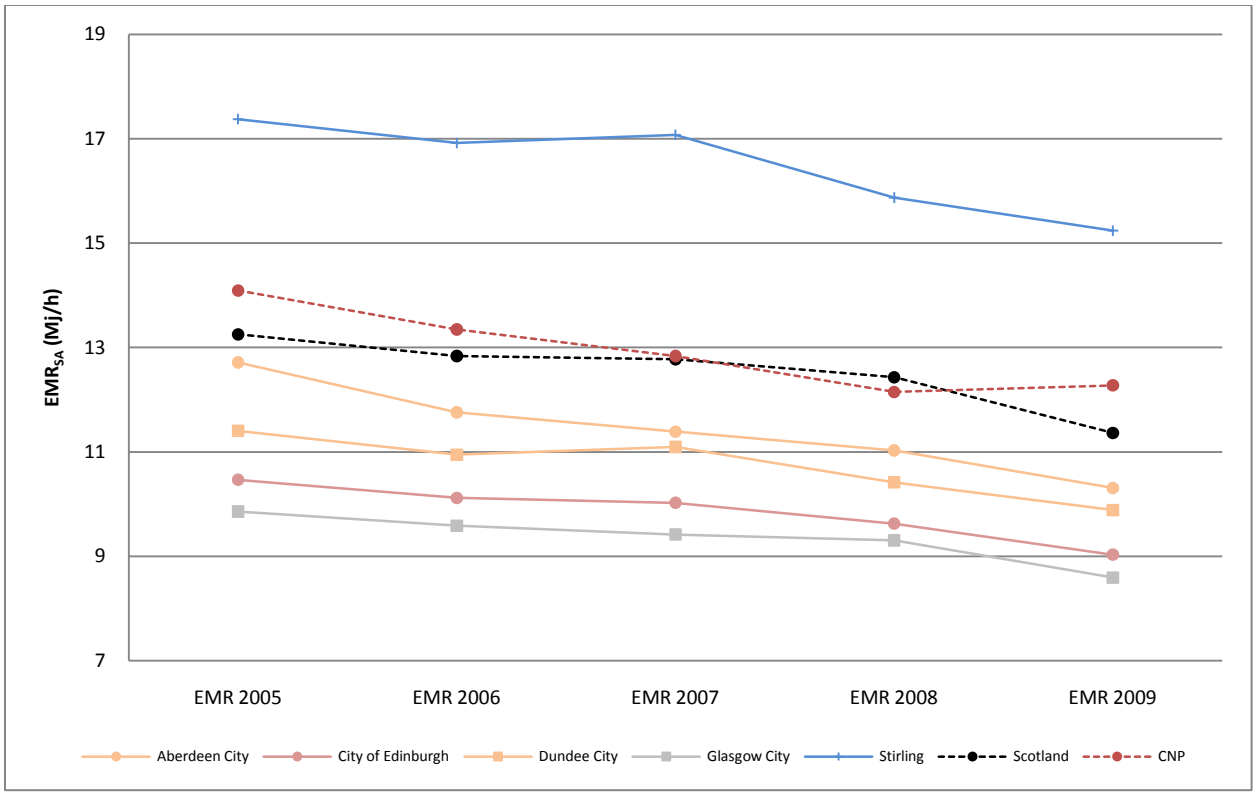


Figure 3: EMR_{SA} for cities of Scotland

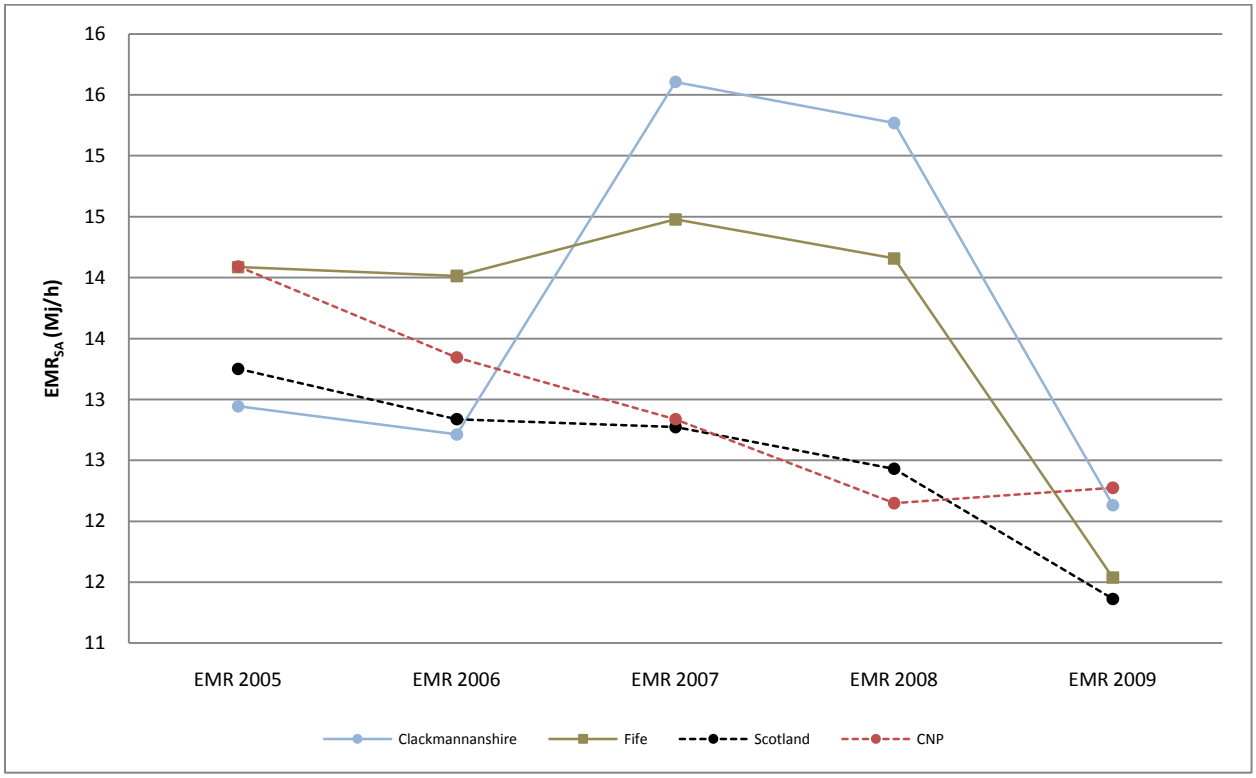


Figure 4: Atypical patterns of change in EMR_{SA}

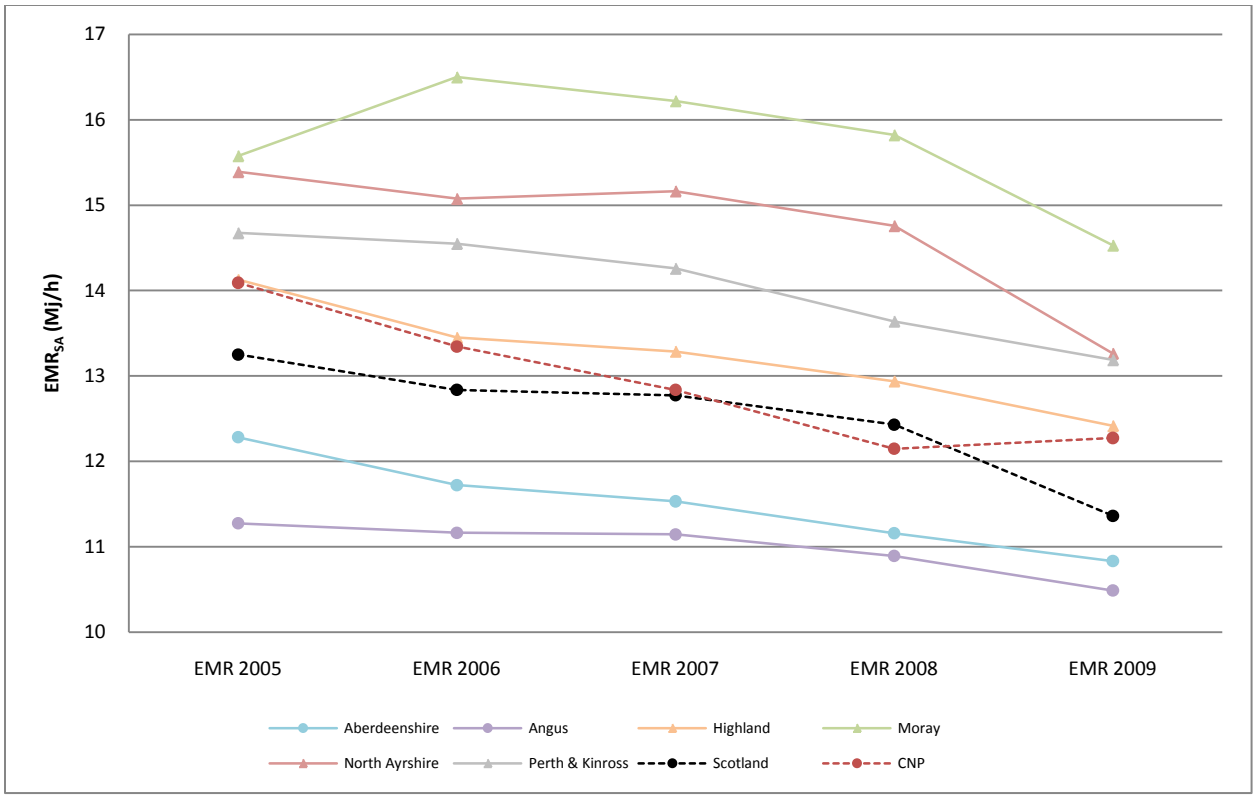


Figure 5: EMR$_{SA}$ for Local Authorities within or bordering the CNP

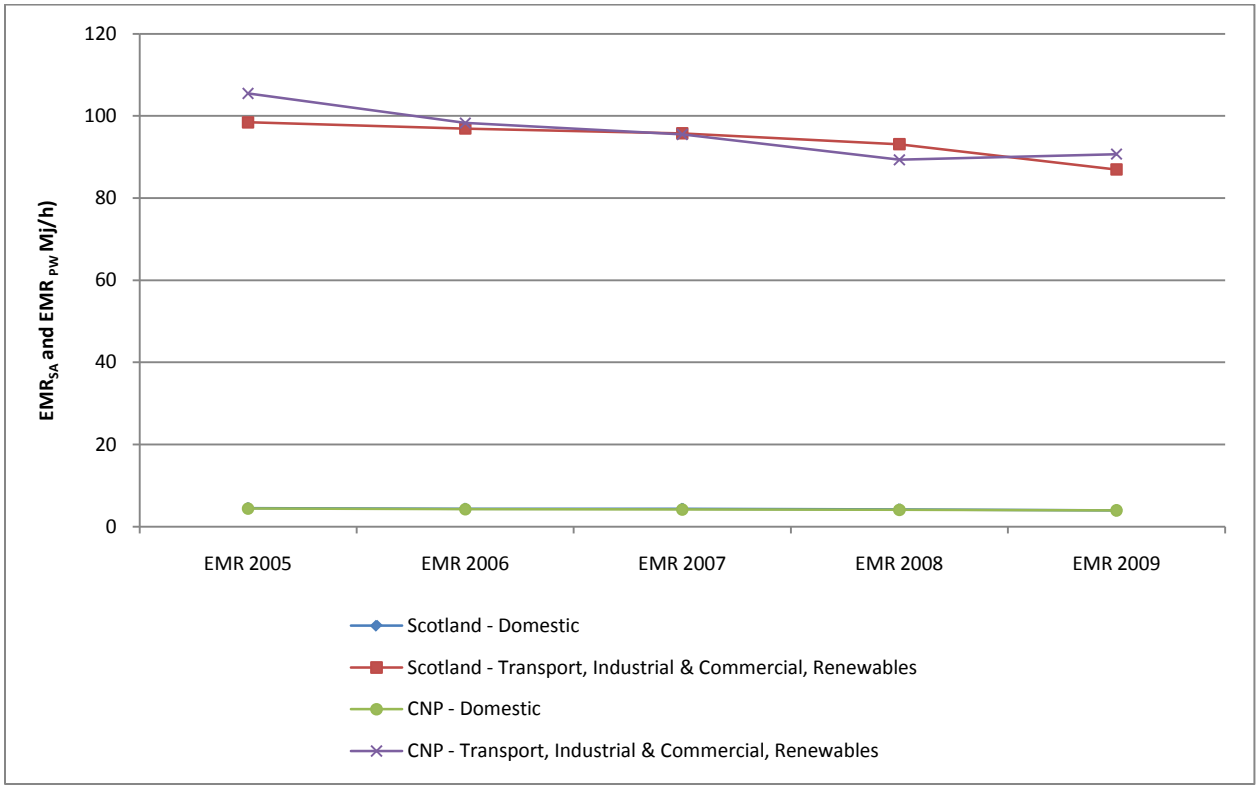


Figure 6: EMR Scotland and the CNP Paid Work and Household

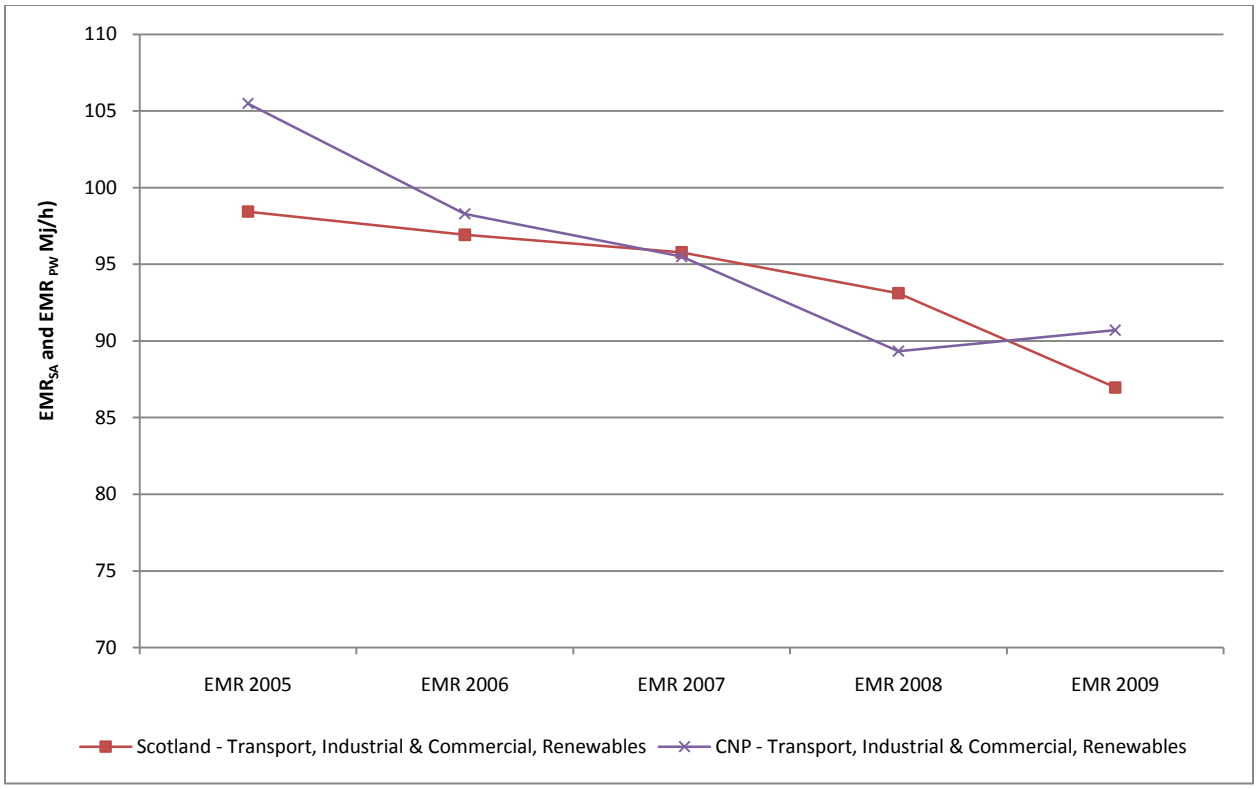


Figure 7: EMR$_{PW}$ - Scotland & CNP

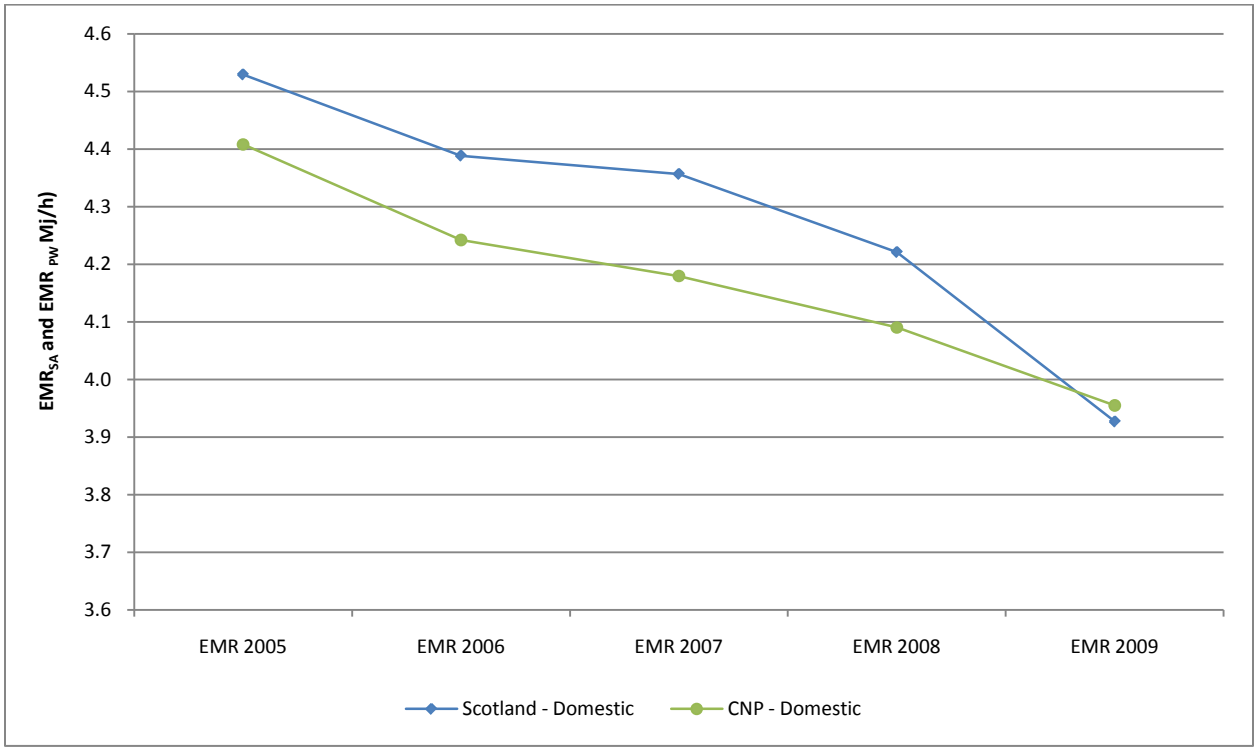


Figure 8: EMR$_{HH}$ - Scotland & CNP

3.2 Economic Labour Productivity

Economic labour productivity (ELP) is the second key indicator used in MuSIASEM analysis. ELP is the productivity in added value produced per hour of human activity. This is another intensity variable that provides useful insights into the sustainability of Scotland's economy and society. As with EMR a series of graphs is used to illustrate the trajectory for ELP with breakdowns for different regions and sectors.

3.2.1 Economic labour productivity – societal average

Figure 9 presents a time series (as for EMR from 2005 to 2009) for the societal average of ELP. That is the gross value added (£) per hour including all human activity. As with EMR there is an overall trend for all regions for a progressive increase in ELP_{SA}. This is broken in 2009 for all regions with a downturn in economic activity. This decrease would have been larger had it not been for a small decrease in population anecdotally associated with the return home of migrant workers. There are two distinct groups of regions. With higher ELP_{SA} values the first group are Scotland's three main cities (Edinburgh, Glasgow and Aberdeen). Close to the Scotland average are Falkirk and the Shetland Islands, both special cases of regions whose economy is dominated by single industries linked to the petrochemical sector. Below these are the smaller city regions of Dundee, Perth, and Stirling. The remaining rural Scotland regions cover a range of ELP_{SA} values from £1/h to £2/h. The lower values of ELP_{SA} tend to be associated with regions defined as multiply deprived or remote rural with low populations and more dependence on primary production and services. The ELP_{SA} for the CNP is surprisingly high but is explained by the low dependency ratio for the CNP with a population profile closer to that of urban areas (younger workers without dependents). The CNP figure is, however, inflated by the accounting for significant revenues from distilling and bonded warehousing of spirits within the CNP, money that however generates little employment or wealth.

3.2.2 Economic labour productivity – paid work

Figure 10 recasts ELP in terms of the paid work that generates the added value. This gives a different view of the sustainability of the system, with higher values (~10 times higher). ELP for paid work (ELP_{PW}) is also a useful benchmark in terms of an overall indicator of productivity without regard to the wider population that the productivity supports. The overall pattern is as with ELP_{SA} for a steady increase with a degree of flattening from 2008. The pattern for individual regions is however, more variable than for ELP_{SA} with particular events reflected in the time series. For ELP_{PW} the highest values (see Figure 11) are associated with the Edinburgh City (a financial / legal services hub) and Falkirk (a highly capitalised centre of petrochemical production). The second tier of regions are those associated either with the best performing regions (E and W Lothian are the hinterland for Edinburgh) or are city regions containing both a city and it rural hinterland (e.g. Aberdeen City and Aberdeenshire). This result points to the undesirability of using standard statistical units for some of the MuSIASEM analysis as they can

introduce artefacts. The lack of high quality GVA data at smaller units means this is in the main unavoidable.

The lower values for ELP_{PW} are seen to cluster in groupings (see Figure 12). The very lowest is the Western Isles, a particularly remote rural area. Just above these are the Orkney and Shetland Islands, Caithness and Sutherland and Skye, Lochaber and Lochalsh. In Appendix 1 (Maps) it can be seen how these all form a remote rural fringe with economies dominated by lower productivity sectors such as agriculture and tourism. The three regions above these (Borders, Inverness and Dumfries form a second tier of peripherality, less dominated but still dependent on low productivity sectors. A notable feature is the Shetland Islands that were closer to the Scotland average for ELP_{SA} but have a low value for ELP_{PW}. The GVA is accounted for in Shetland but the employment data is residence based and thus off-shore workers are accounted for elsewhere. The CNP value for ELP_{PW} is again high (higher than all component or boundary regions) reflecting the lower dependency ratio but also the inflation of the distilling industry; see Figure 13.

3.2.3 Economic Labour Productivity – paid work – sectors

The ELP_{PW} analysis can be further pursued in terms of the sectors that make up paid work. The limiting factor in terms of the ELP_{PW} for sectors is the GVA figures available. Six sectors are recorded in published figures, Agriculture, Forestry & Fishing (AFF), Business Services & Finance (BSF), Construction(Con), Production (Prod), Public Administration, Education, Health & Other Services (shortened to Public Administration & Services in titles, and abbreviated to Pub), and Wholesale, Retail, Hotels, Restaurants, Transport, Storage and Communications (shortened to Retail, Recreational & Transport in titles and abbreviated to RRT). These sub-sectors do allow for a more in-depth analysis of the basis of the economy for regions and their sustainability. Within the scope of SMILE it has only been possible to undertake the ELP_{PW} analysis for sub sectors at Scotland and CNP levels, but further analysis of the NUTS3/LA regions of Scotland would clearly be valuable based on experience of the ELP analyses presented above.

Figure 14 shows the trajectories for the individual sectors for Scotland and the CNP. In two cases the sectors for Scotland and CNP are remarkably similar in their ELP_{PW} (Pub and RRT). This perhaps reflects national scale systems of which the CNP is simply an instance. In others there is a consistent out performance of Scotland by the CNP. For Prod this is likely to be the distortion of GVA figures for the CNP by the distilling. For AFF, despite the apparent lack of natural bio-physical productivity in the CNP it has a highly profitable sporting sector (hunting and fishing) with good access to major population centres and an internationally known brand. For others such as BSF and Con it less clear why there is a difference in performance.

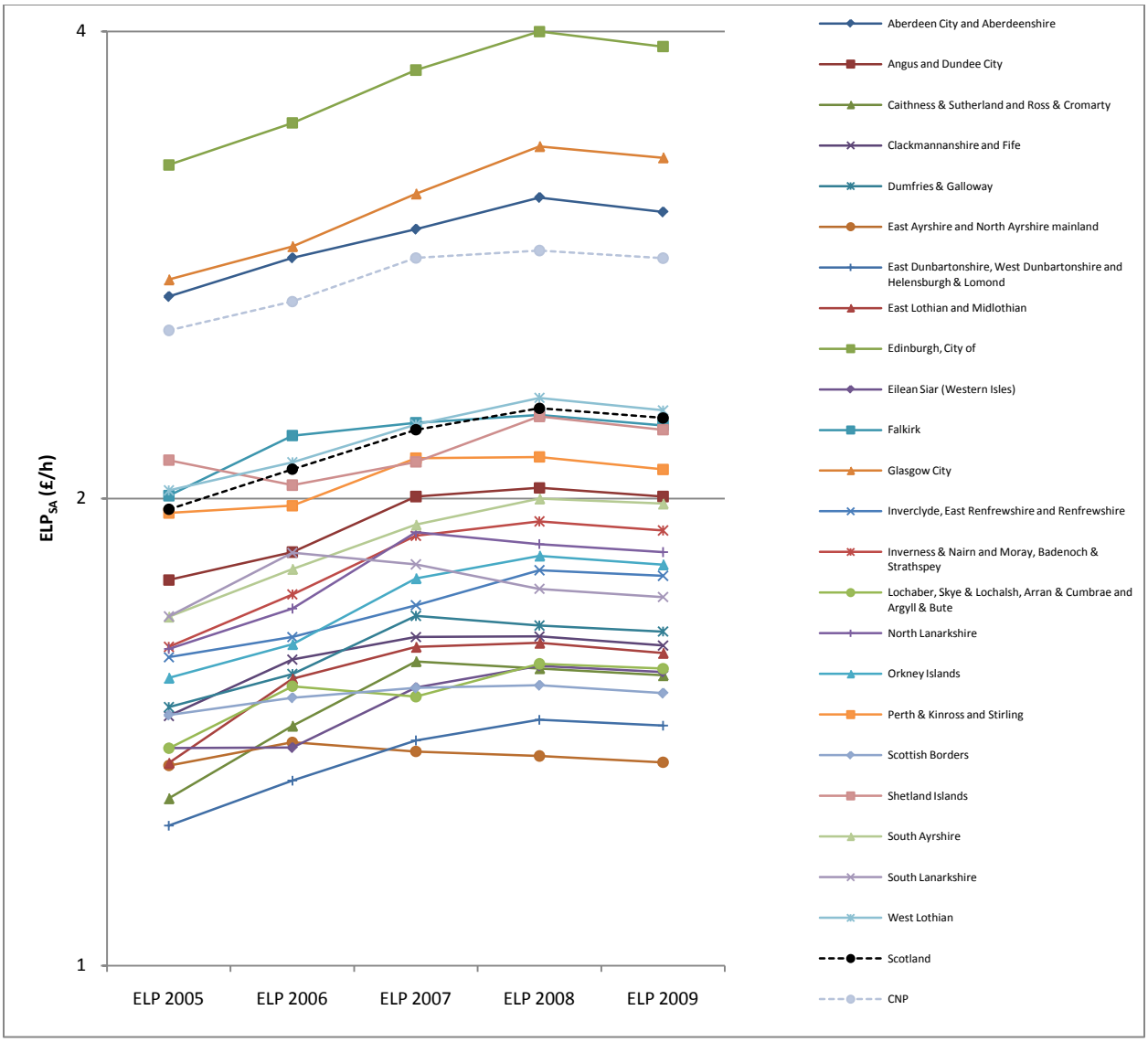


Figure 9: ELP$_{SA}$ for Scotland, Regions & CNP

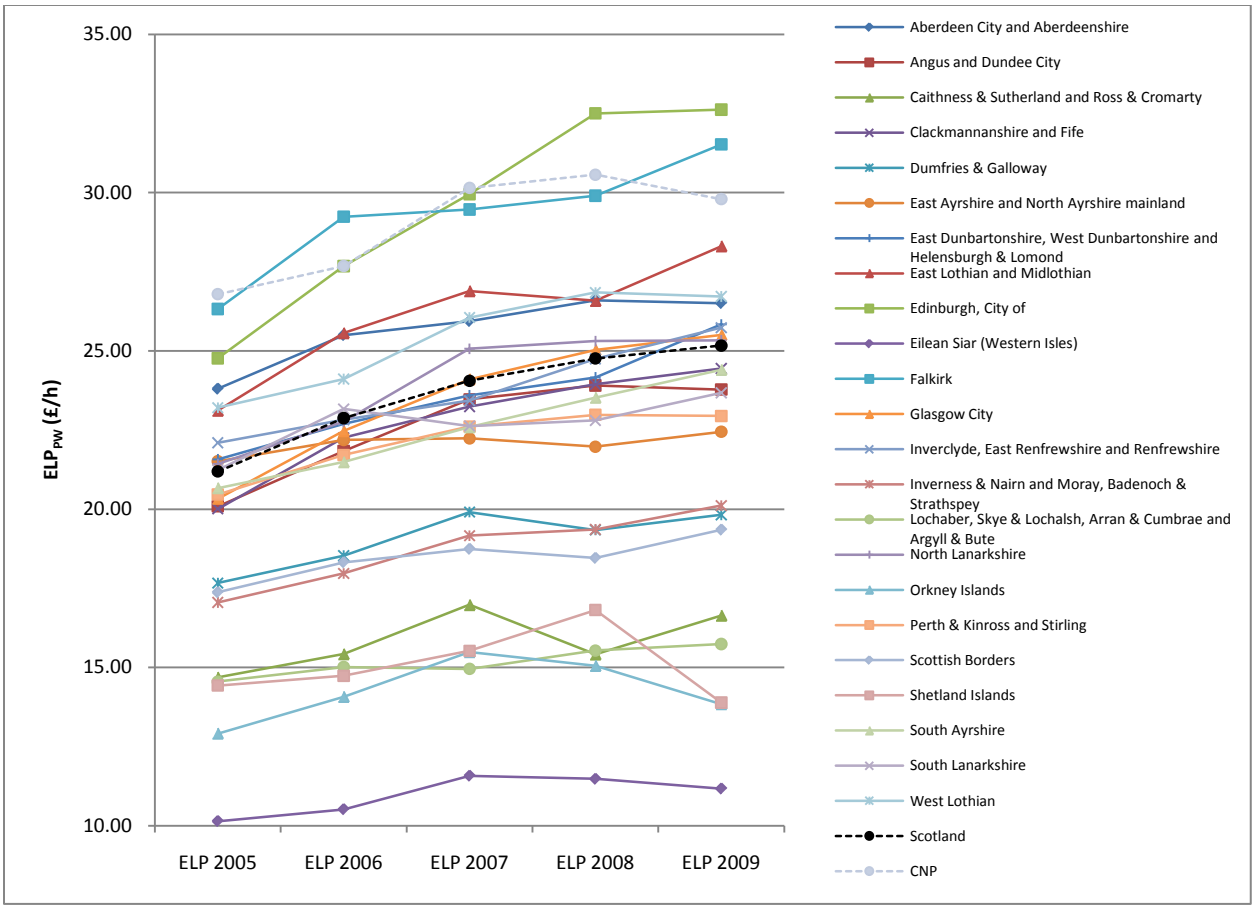


Figure 10: ELP_{PW} for Scotland, Regions & CNP

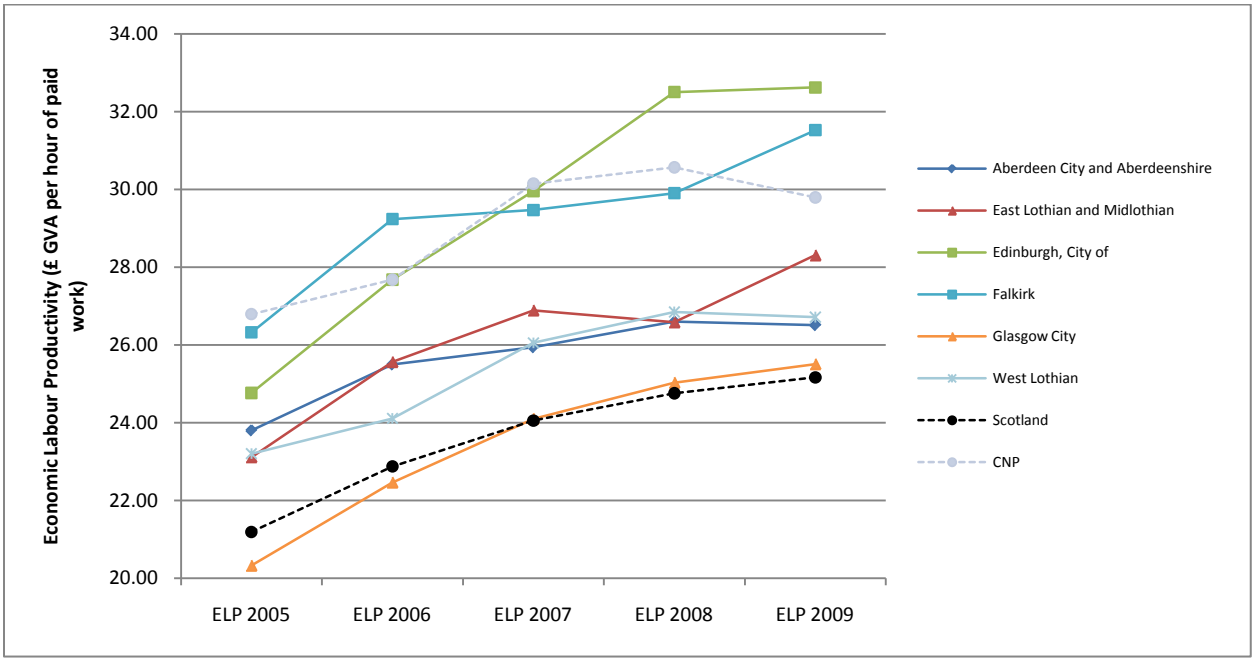


Figure 11: ELP_{PW} for Scotland, City Regions, higher performing regions & CNP

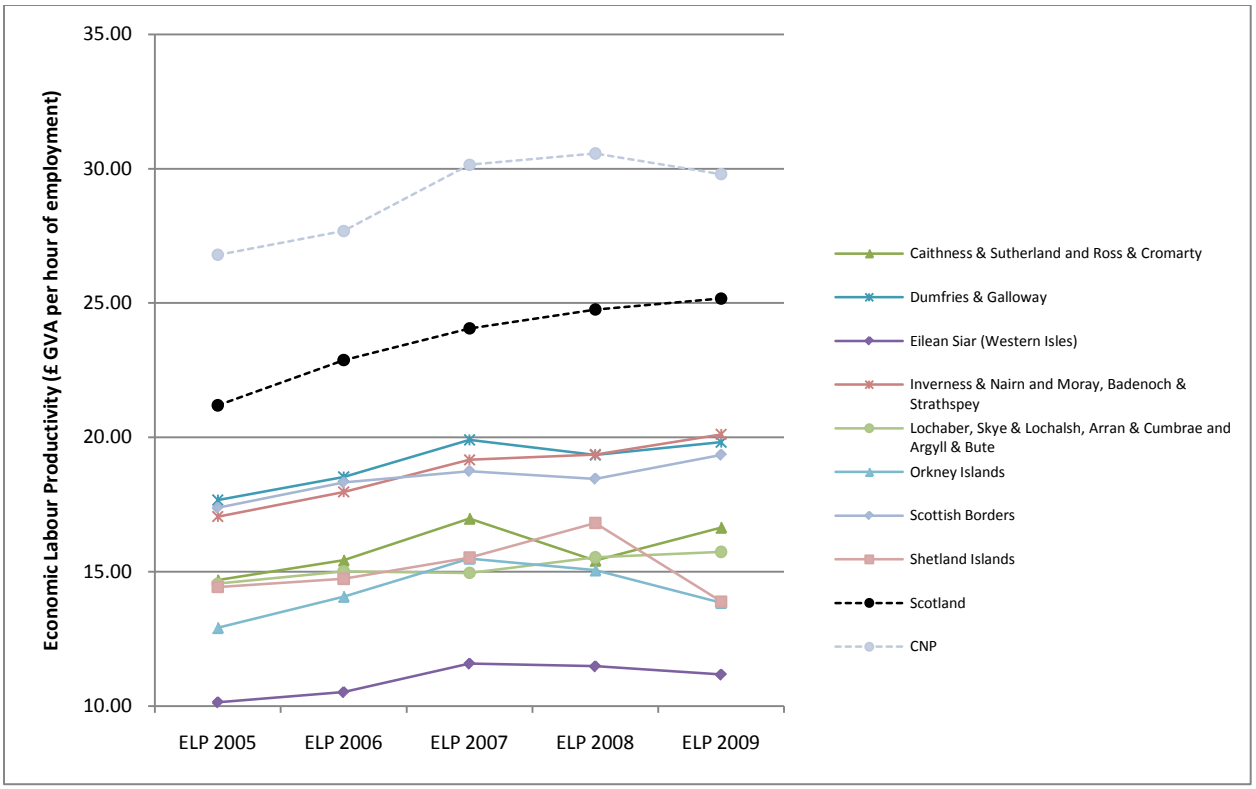


Figure 12: ELP_{PW} for Scotland, Remote Rural Regions & CNP

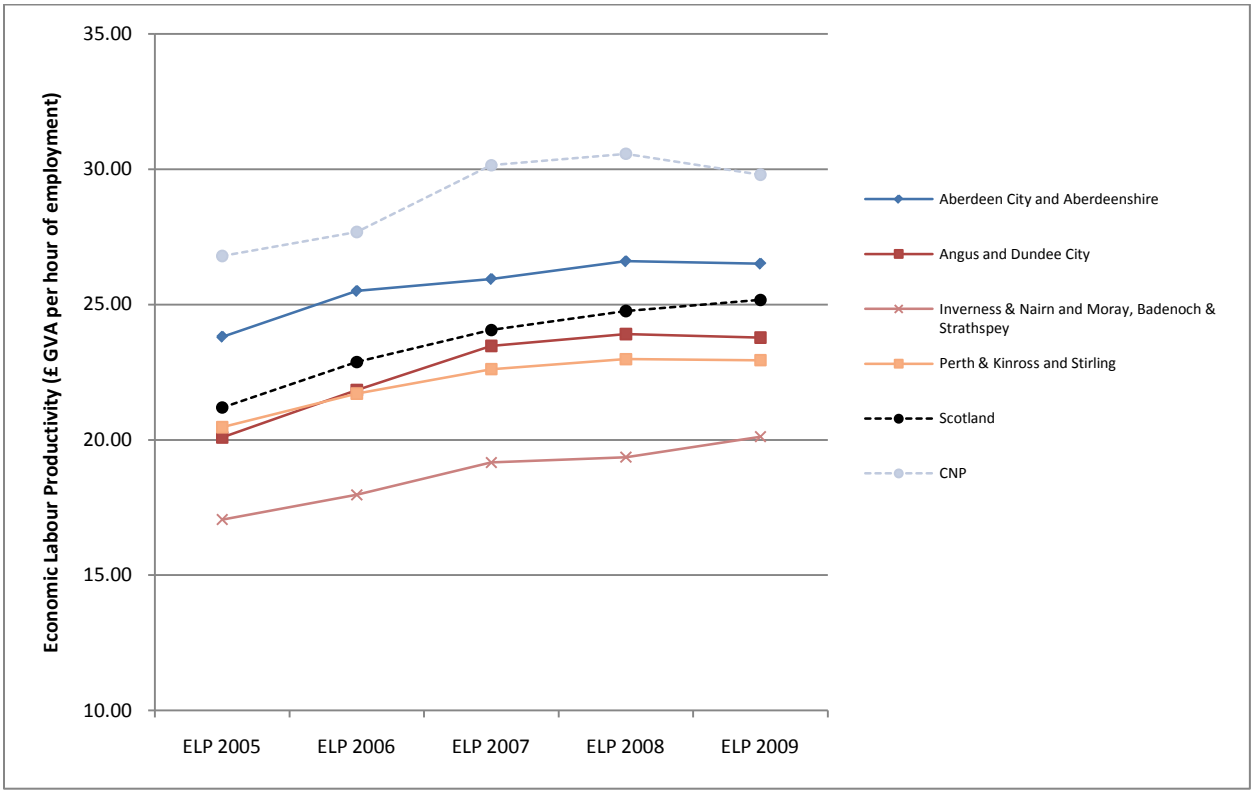


Figure 13: ELP_{PW} for Scotland, Regions bordering the CNP & CNP

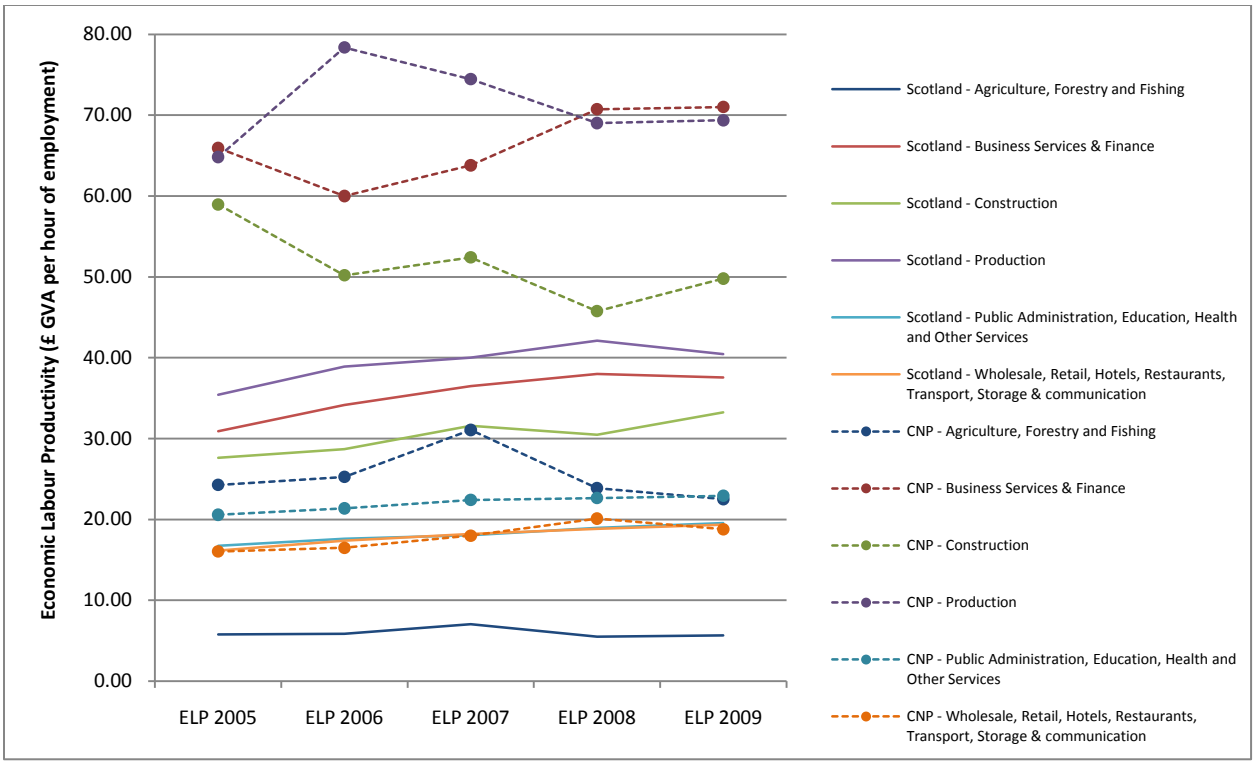


Figure 14: ELP_{PW} for Scotland & CNP by Sector

3.3 Combined EMR and ELP analysis

3.3.1 EMR/ELP Societal Average

Within the MuSIASEM analysis approach the combination of EMR and ELP has shown to be a particularly useful compound indicator of the sustainability trajectory of an economy and society more widely. The combined EMR/ELP analysis has been conducted for Scotland, the local authority/NUTS3 regions where these match[10] and for the CNP. These combined analyses reveal more complex systems behaviour in terms of trajectories and also different groups of the regions that can be considered together. Two versions are presented on the societal average and the paid work basis.

Figure 15 shows the trajectories for the time series of EMR_{SA} versus ELP_{SA} (using arrows to indicate time from 2005 to 2009). This figure is included principally to again show the Falkirk outlier. In this case it is clear that there has been a substantial decrease in the EMR_{SA} without an associated decrease in ELP_{SA}. This could indicate an increase in the efficiency of production, though further investigation would be required at a sectoral level to ensure that this did not represent a substantial change in the sectoral mix within Falkirk. Alternatively increasing

[10] Where the local authority and NUTS3 regions do not match it is not possible to combine the energy data that underpins EMR and the GVA data that underpins ELP. Where the regions do not match they have been included as a single compound region (Other NUTS3 regions).

petrochemical prices within a recession could also mean that there could be reduced production (decreased EMR) while maintaining ELP. This is a good example of MuSIASEM analyses identifying key areas for further research.

Figure 16 presents the same data without the Falkirk outlier, making it easier to see the patterns of change for the other regions. Overall there is a pattern of increasing ELP_{SA} with (in nearly all cases) no increase in EMR_{SA}. There is a distinctive pattern to the trajectories, with increases in ELP_{SA} between 2005 and 2007 followed by stagnation (or even decline). For EMR_{SA} the pattern is of either consistent reduction or fairly constant values for EMR_{SA} (2005 to 2007) followed by reductions (2007 to 2009). For regions with lower values for ELP_{SA} the increases in ELP are smaller and in some cases the reductions in EMR are significant (e.g. Clackmannanshire and Fife perhaps reflecting further deindustrialisation). Contrast this with the main population centres (Edinburgh, Glasgow and Aberdeen with its hinterland) where there is significant increase in ELP_{SA} combined with reductions in EMR_{SA}. An overall interpretation from Figure 16 could be that at a societal average level there is a trend to more sustainable growth (albeit to a limited extent). Such societal averages, while useful, need to be further explored particularly as societal average indicators contain both paid work and household sectors that may be behaving quite differently.

3.3.2 EMR/ELP paid work

For the paid work sector the analysis of EMR/ELP has similarities to the societal average but some distinct features. Two figures are again used both show the same national, regional and CNP values for EMR_{PW}/ELP_{PW}, As before in Figure 17 the Falkirk outlier is included and in Figure 18 it is excluded for clarity. In Figure 17 the Falkirk outlier sees both an increase in ELP_{PW} and a decrease in EMR_{PW}. With the same caveats as before this would seem to imply a more sustainable paid work sector for Falkirk but an increasing dependency ratio since the ELP_{SA} value sees no increase. Comparing the paid work (Figure 18) and the societal average (Figure 16) it is clear that for some regions the improved performance for EMR at societal average level is an improvement in the household sectors not in the paid work as the EMR_{PW} value is near constant (e.g. Edinburgh and Glasgow). Note that for both these cities despite near static EMR values there has continued to be growth in ELP_{PW}. Figure 18 also shows the value of combining EMR_{PW} and ELP_{PW} in terms of distinguishing distinctive clusters of regions with common sustainability characteristics. These clusters include the main cities as noted above, the Scottish Islands (Orkney Shetland and Western Isles), city regions (Aberdeen and Dundee but also the Greater Glasgow area) and regions that retain industry or intensive agriculture (East and Mid Lothian, Clackmannanshire and Fife, Perth, Kinross and Stirling and Dumfries and Galloway).

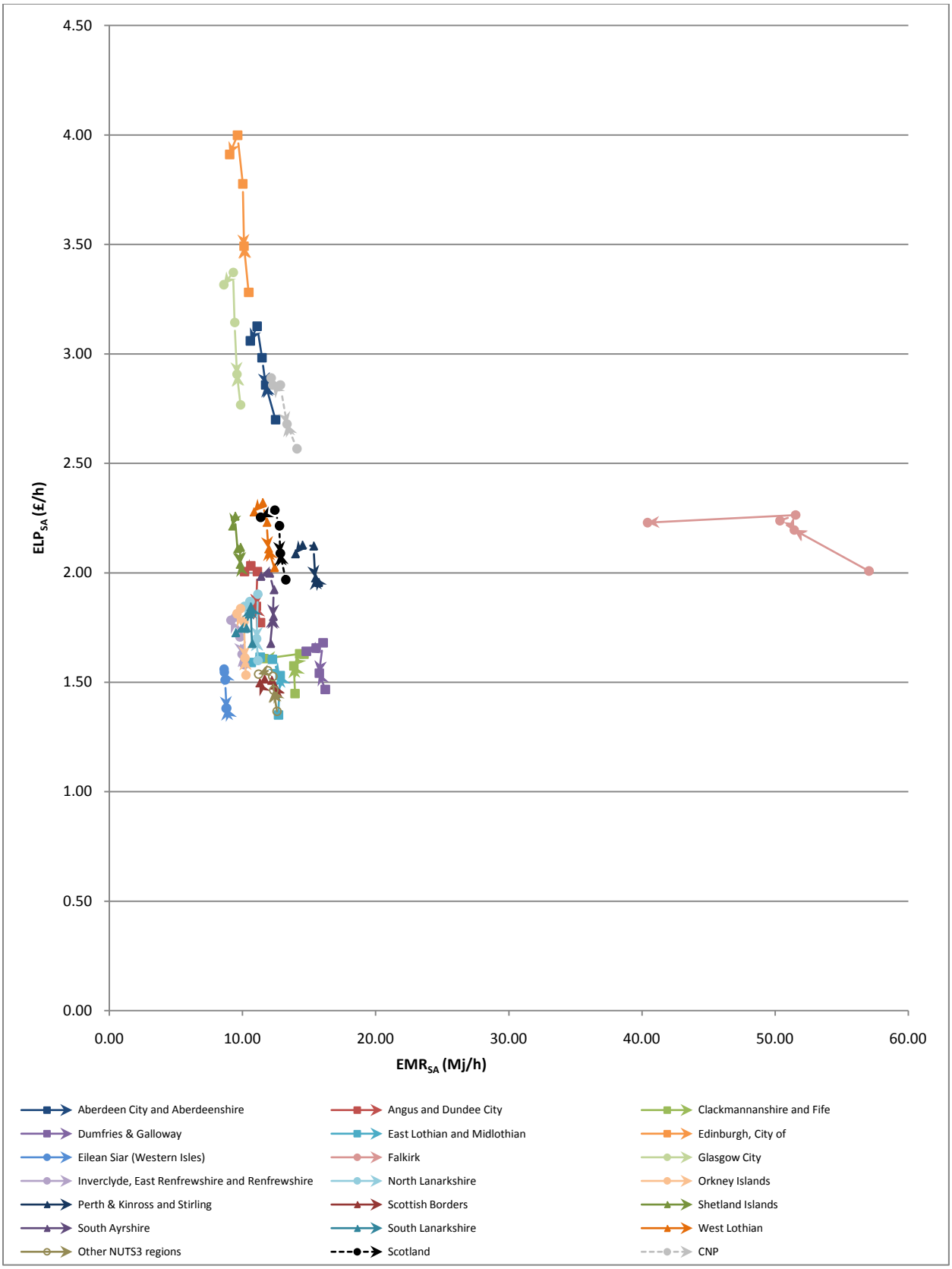


Figure 15: ELP$_{SA}$ vs. EMR$_{SA}$ for Scotland, CNP & NUTS3

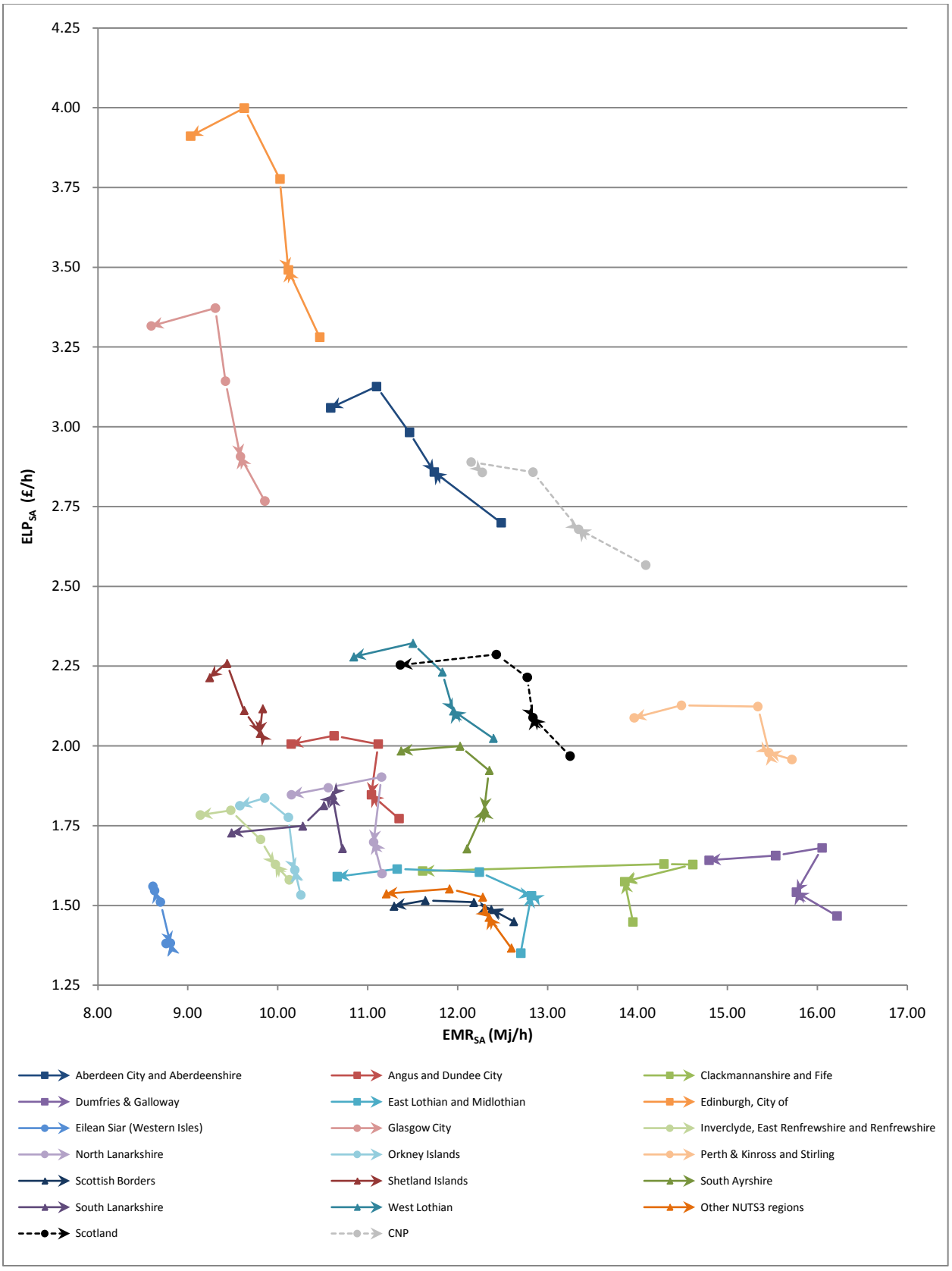


Figure 16: ELP$_{SA}$ vs. EMR$_{SA}$ for Scotland, CNP & NUTS3 (omitting Falkirk)

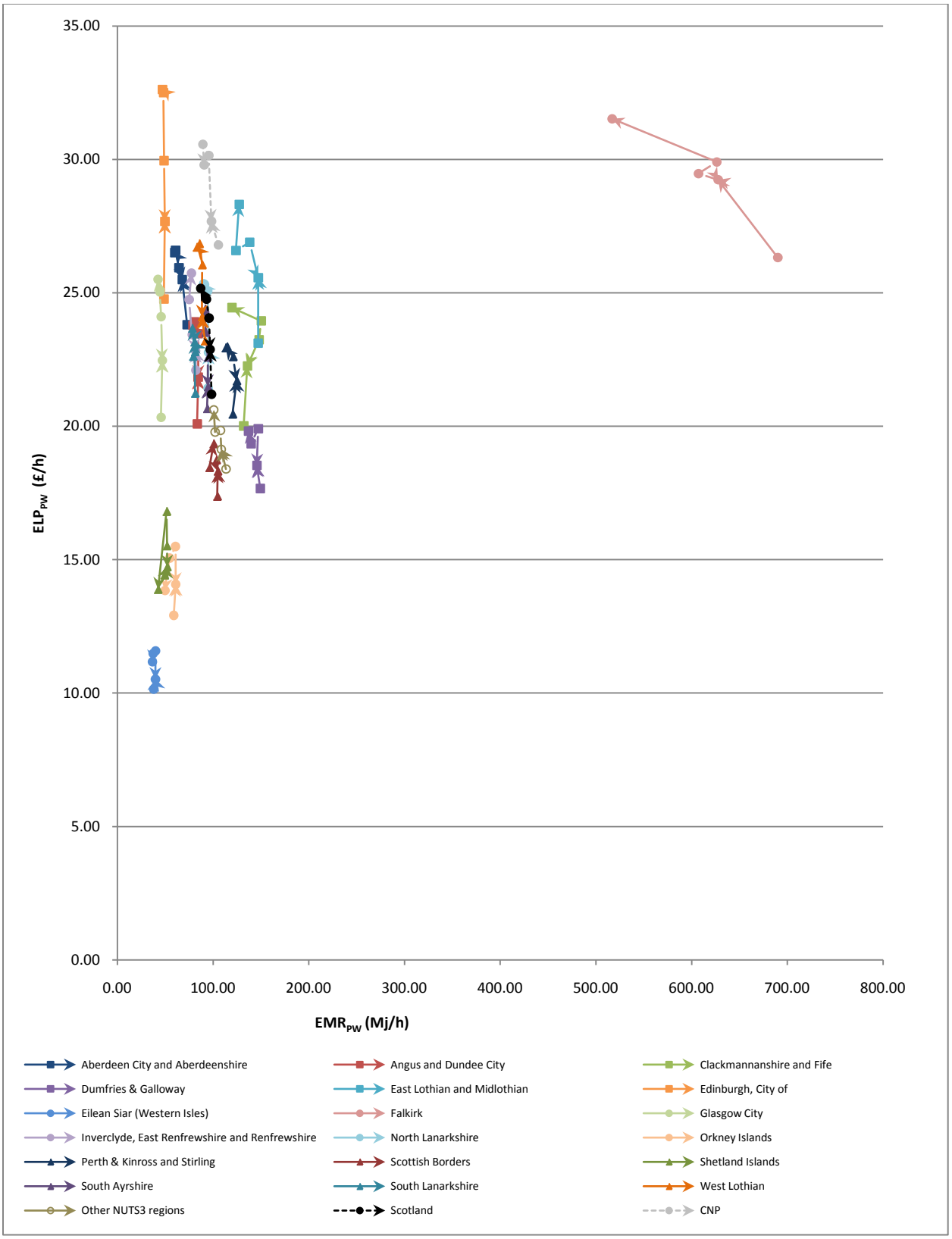


Figure 17: ELP$_{PW}$ vs. EMR$_{PW}$ for Scotland, CNP & NUTS3 - Paid Work

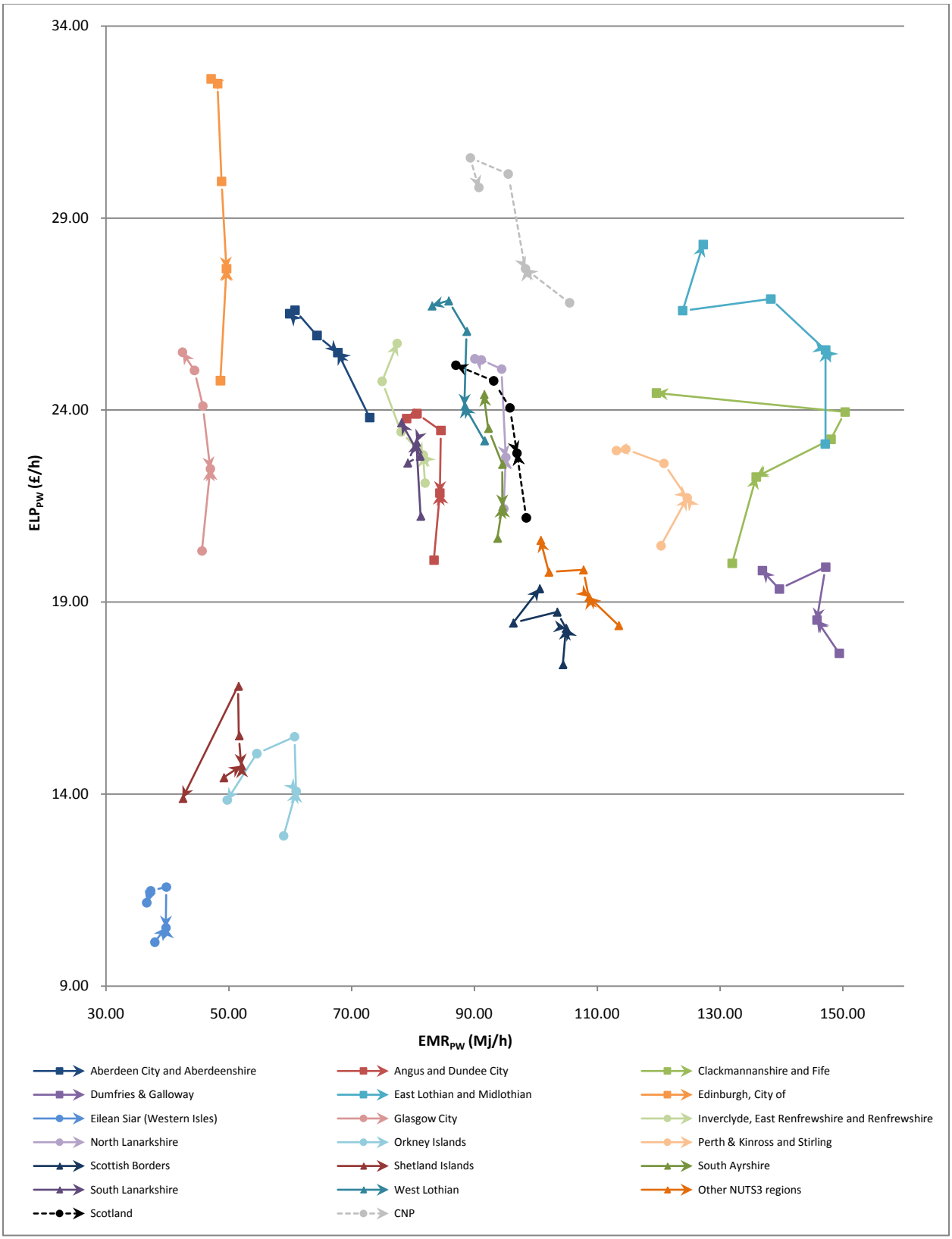


Figure 18: ELP$_{PW}$ vs. EMR$_{PW}$ for Scotland, CNP & NUTS3 - Paid Work (omitting Falkirk)

In all of the analyses presented so far the indicators have all been rate or intensity variables. As noted by (Giampietro et al. 2009b) to fully assess the sustainability of systems it is necessary to assess both the intensity of resource use and the extent. This is accomplished using the *fund-flow* diagrams in the following section.

3.4 Fund-Flow Diagrams

The fund-flow (FF) diagram is a means of simultaneously presenting the relationship between a fund (e.g. human activity) and a flow (e.g. energy throughput) and at two scales (e.g. societal average and paid work, or paid work and sectors of the economy). The FF diagram is helpful in presenting both the extent (on the axes) and the intensity (on the diagonals) of resource use Two sets of example FF diagrams are presented in this report, being those found most useful by the CNPA stakeholders (though they had reservations about their complexity).

Figure 19 presents a comparison of Scotland and the CNP using total human activity for the whole society (THA_{SA}) and total energy throughput again for the whole society (TET_{SA}) in 2005 and 2009. Comparing Scotland and the CNP it is remarkable the similarity between the two areas despite the CNP being two orders of magnitude smaller for THA_{SA}. There are differences, with CNP maintaining its share of THA_{PW} in line with the increase in THA. For Scotland there has been an increase in THA_{SA} but a decrease in THA_{PW} meaning an increase in the dependency ratio with the paid work percentage of THA falling from 9.29% to 8.95%. For TET_{SA} and TET_{PW} both Scotland and the CNP see falls with in their extent but with a limited change in % of TET used in TET_{PW} for both. The reductions in intensity (TET per unit of THA) on the other two diagonals are very similar. Scotland's TET_{PW} was reduced from ~98MJ/h to ~87Mj/h (-12%), with the CNP reduced from ~105 Mj/h to ~91 Mj/h (-13%). For TET_{SA} the reduction for Scotland was from ~13 Mj/h to 11 Mj/h (-15%) and for the CNP from ~14 Mj/h to 12 Mj/h (-14%). These figures can usefully be compared with an OECD average (in 2005) of 16Mj/h for TET_{SA} and 150 Mj/h for TET_{PW}. Further analysis using data for all the Scottish regions and sectors would be useful in establishing the regional variability in these figures.

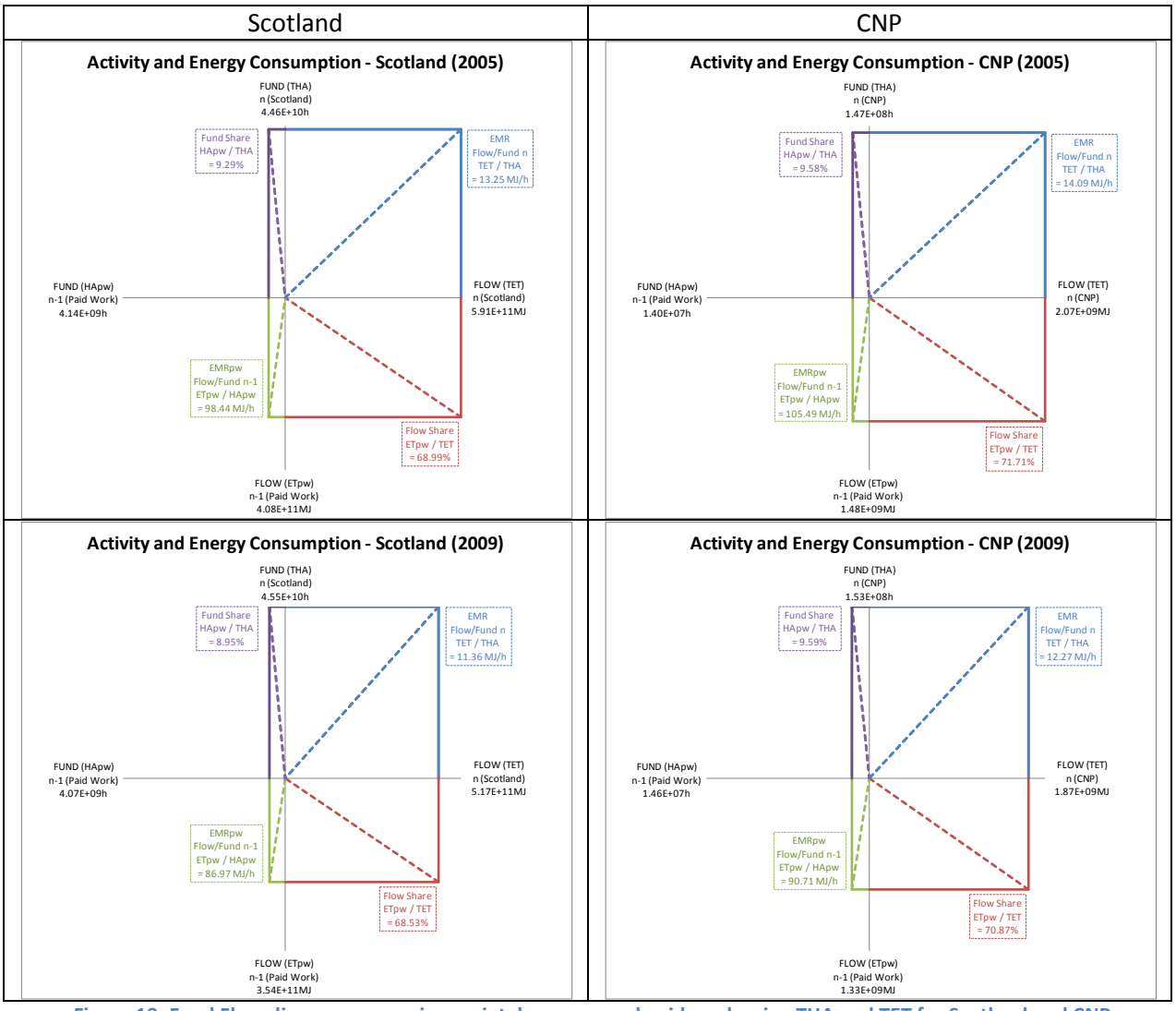
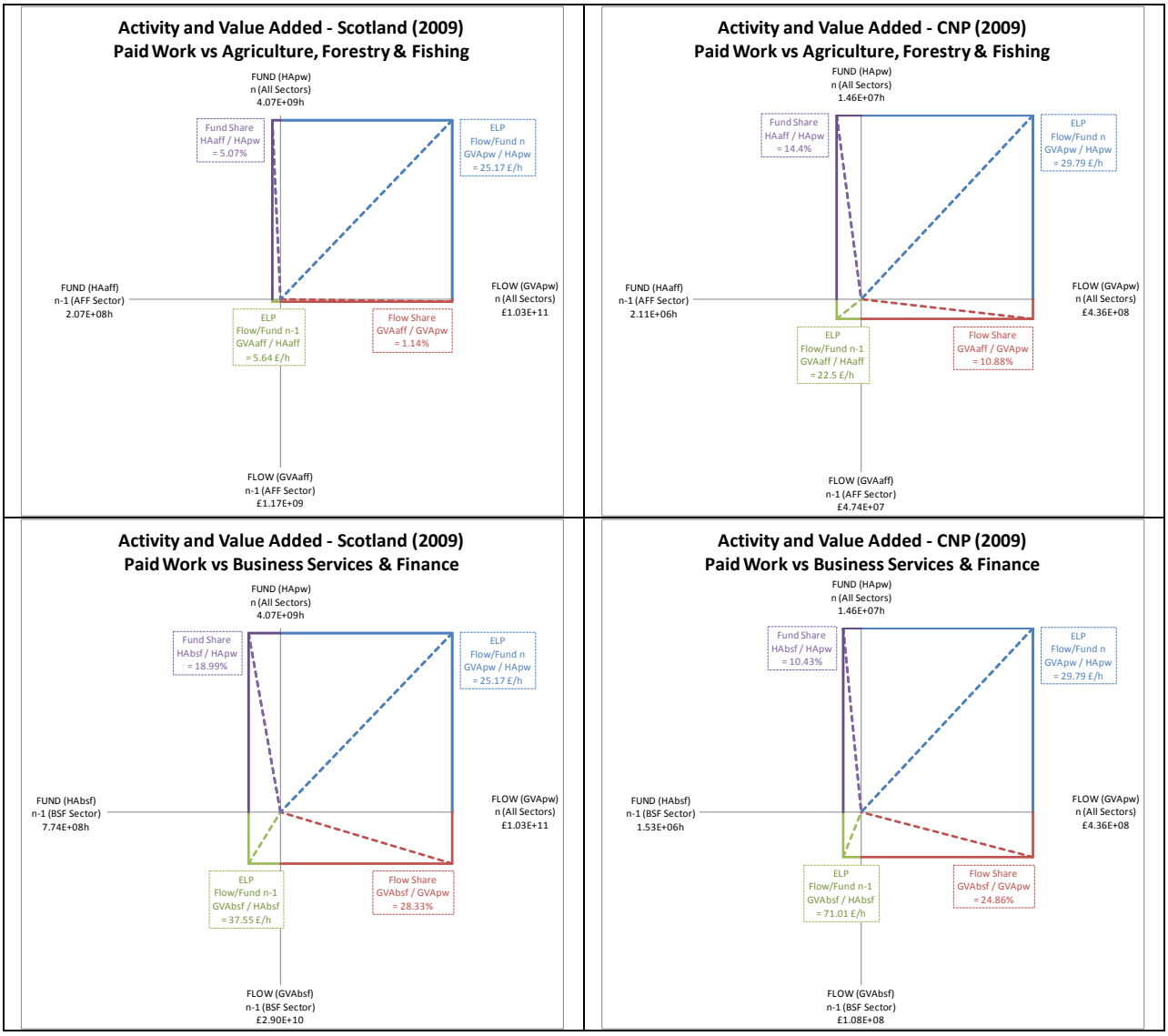


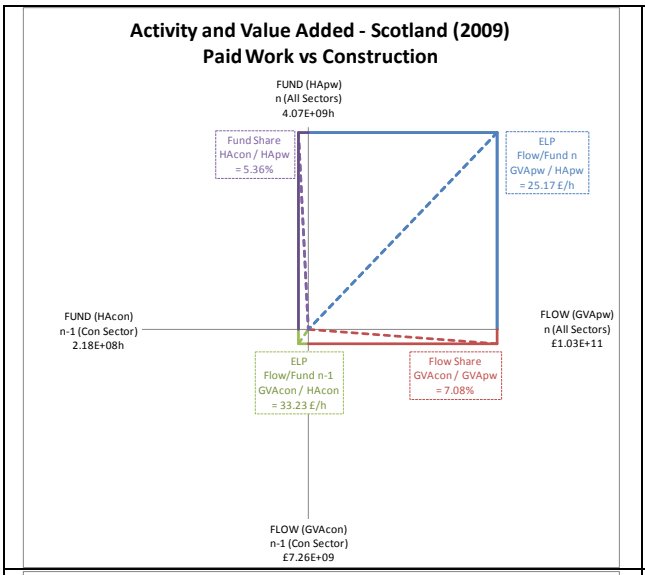
Figure 19: Fund Flow diagram comparing societal average and paid work using THA and TET for Scotland and CNP

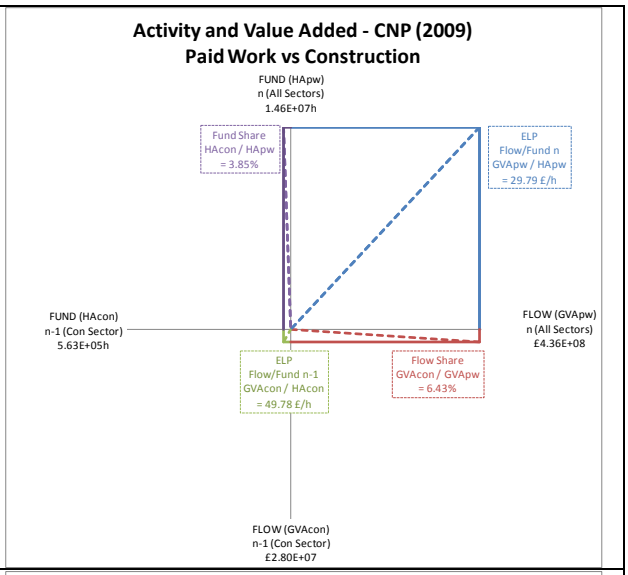
Figure 20 presents a similar analysis but using THA and GVA, in this case for overall paid work[11]. The sub-sectors defined in the GVA dataset. The indicators in this case are ELP_{PW} (top right) compared with ELP_{SECTOR} (bottom left), with relative shares of THA and GVA in top left and bottom right quadrants respectively). The individual FF diagrams allow for the comparison of the performance of a sector against the paid work sector as a whole, in terms of ELP and its share GVA relative to its share of THA. Comparison between the sizes of the quadrants of the FF diagrams in each column gives an indication of the relative importance of the sector to each of Scotland and the CNP[12]. The most striking structural differences between the two cases are for AFF, BSF and Prod, though the ELP of most sectors in the CNP exceeds that of the Scotland average.

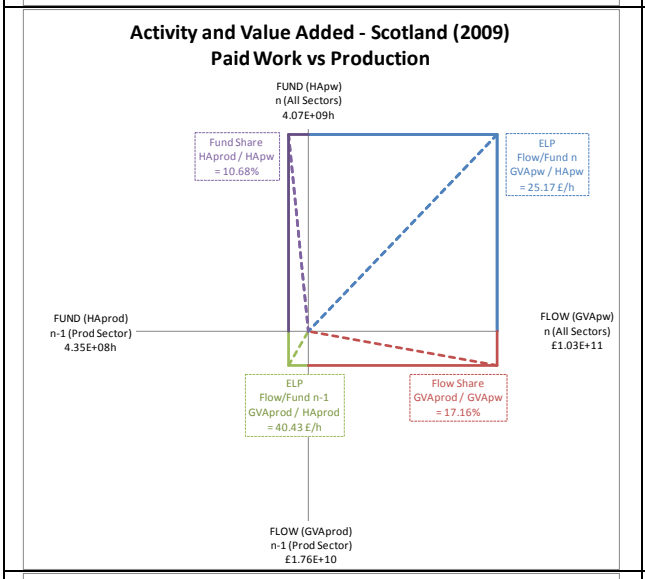
[11] This analysis begins at the paid work level as households are assumed to generate zero GVA.

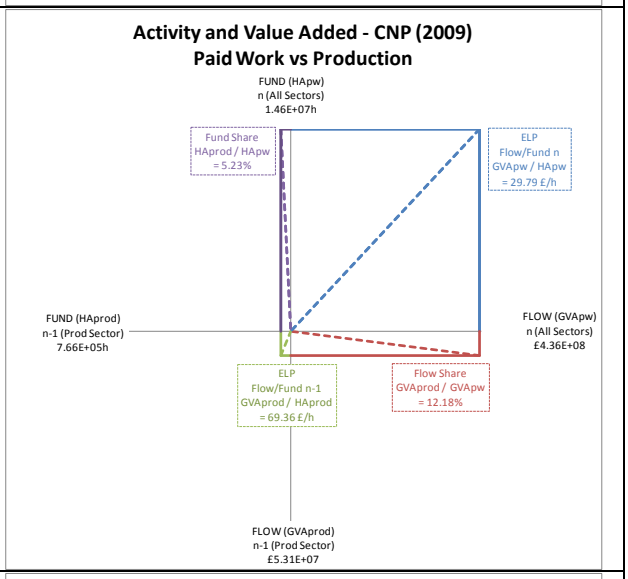
[12] Note the quadrants are scaled relative to the paid work sector in each case so the proportion of Scotland made up of the CNP is not assessed (see Figure 21)

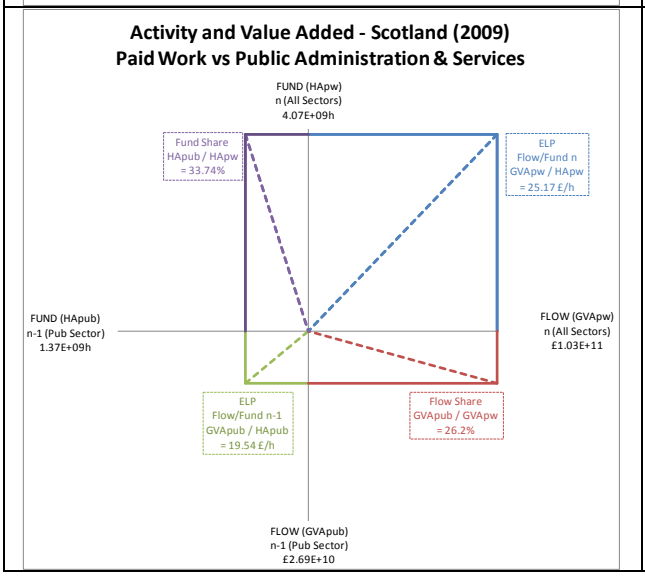

Activity and Value Added - Scotland (2009)
Paid Work vs Agriculture, Forestry & Fishing
FUND (HApw)
n (All Sectors)
4.07E+09h
Fund Share
HAaff / HApw
= 5.07%
ELP
Flow/Fund n
GVApw / HApw
= 25.17 £/h
FUND (HAaff)
n-1 (AFF Sector)
2.07E+08h
FLOW (GVApw)
n (All Sectors)
£1.03E+11
ELP
Flow/Fund n-1
GVAaff / HAaff
= 5.64 £/h
Flow Share
GVAaff / GVApw
= 1.14%
FLOW (GVAaff)
n-1 (AFF Sector)
£1.17E+09
Activity and Value Added - CNP (2009)
Paid Work vs Agriculture, Forestry & Fishing
FUND (HApw)
n (All Sectors)
1.46E+07h
Fund Share
HAaff / HApw
= 14.4%
ELP
Flow/Fund n
GVApw / HApw
= 29.79 £/h
FUND (HAaff)
n-1 (AFF Sector)
2.11E+06h
FLOW (GVApw)
n (All Sectors)
£4.36E+08
ELP
Flow/Fund n-1
GVAaff / HAaff
= 22.5 £/h
Flow Share
GVAaff / GVApw
= 10.88%
FLOW (GVAaff)
n-1 (AFF Sector)
£4.74E+07
Activity and Value Added - Scotland (2009)
Paid Work vs Business Services & Finance
FUND (HApw)
n (All Sectors)
4.07E+09h
Fund Share
HAbsf / HApw
= 18.99%
ELP
Flow/Fund n
GVApw / HApw
= 25.17 £/h
FUND (HAbsf)
n-1 (BSF Sector)
7.74E+08h
FLOW (GVApw)
n (All Sectors)
£1.03E+11
ELP
Flow/Fund n-1
GVAbsf / HAbsf
= 37.55 £/h
Flow Share
GVAbsf / GVApw
= 28.33%
FLOW (GVAbsf)
n-1 (BSF Sector)
£2.90E+10
Activity and Value Added - CNP (2009)
Paid Work vs Business Services & Finance
FUND (HApw)
n (All Sectors)
1.46E+07h
Fund Share
HAbsf / HApw
= 10.43%
ELP
Flow/Fund n
GVApw / HApw
= 29.79 £/h
FUND (HAbsf)
n-1 (BSF Sector)
1.53E+06h
FLOW (GVApw)
n (All Sectors)
£4.36E+08
ELP
Flow/Fund n-1
GVAbsf / HAbsf
= 71.01 £/h
Flow Share
GVAbsf / GVApw
= 24.86%
FLOW (GVAbsf)
n-1 (BSF Sector)
£1.08E+08

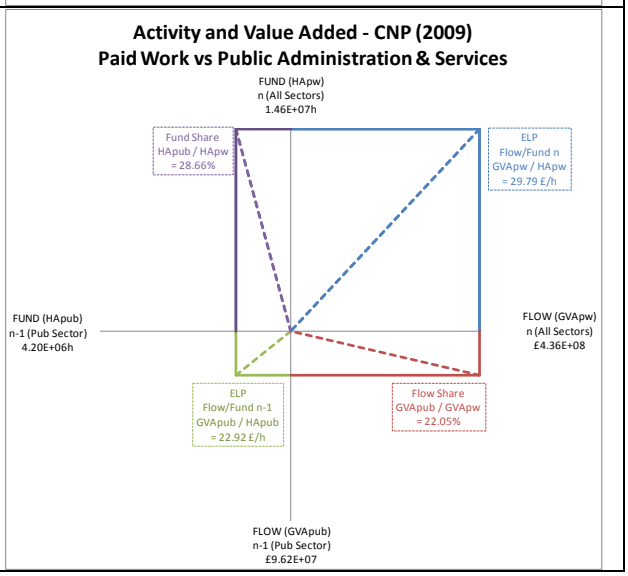

Activity and Value Added - Scotland (2009)
Paid Work vs Construction
FUND (HApw)
n (All Sectors)
4.07E+09h
Fund Share
HAcon / HApw
= 5.36%
ELP
Flow/Fund n
GVApw / HApw
= 25.17 £/h
FUND (HAcon)
n-1 (Con Sector)
2.18E+08h
FLOW (GVApw)
n (All Sectors)
£1.03E+11
ELP
Flow/Fund n-1
GVAcon / HAcon
= 33.23 £/h
Flow Share
GVAcon / GVApw
= 7.08%
FLOW (GVAcon)
n-1 (Con Sector)
£7.26E+09


Activity and Value Added - CNP (2009)
Paid Work vs Construction
FUND (HApw)
n (All Sectors)
1.46E+07h
Fund Share
HAcon / HApw
= 3.85%
ELP
Flow/Fund n
GVApw / HApw
= 29.79 £/h
FUND (HAcon)
n-1 (Con Sector)
5.63E+05h
FLOW (GVApw)
n (All Sectors)
£4.36E+08
ELP
Flow/Fund n-1
GVAcon / HAcon
= 49.78 £/h
Flow Share
GVAcon / GVApw
= 6.43%
FLOW (GVAcon)
n-1 (Con Sector)
£2.80E+07


Activity and Value Added - Scotland (2009)
Paid Work vs Production
FUND (HApw)
n (All Sectors)
4.07E+09h
Fund Share
HAprod / HApw
= 10.68%
ELP
Flow/Fund n
GVApw / HApw
= 25.17 £/h
FUND (HAprod)
n-1 (Prod Sector)
4.35E+08h
FLOW (GVApw)
n (All Sectors)
£1.03E+11
ELP
Flow/Fund n-1
GVAprod / HAprod
= 40.43 £/h
Flow Share
GVAprod / GVApw
= 17.16%
FLOW (GVAprod)
n-1 (Prod Sector)
£1.76E+10


Activity and Value Added - CNP (2009)
Paid Work vs Production
FUND (HApw)
n (All Sectors)
1.46E+07h
Fund Share
HAprod / HApw
= 5.23%
ELP
Flow/Fund n
GVApw / HApw
= 29.79 £/h
FUND (HAprod)
n-1 (Prod Sector)
7.66E+05h
FLOW (GVApw)
n (All Sectors)
£4.36E+08
ELP
Flow/Fund n-1
GVAprod / HAprod
= 69.36 £/h
Flow Share
GVAprod / GVApw
= 12.18%
FLOW (GVAprod)
n-1 (Prod Sector)
£5.31E+07


Activity and Value Added - Scotland (2009)
Paid Work vs Public Administration & Services
FUND (HApw)
n (All Sectors)
4.07E+09h
Fund Share
HApub / HApw
= 33.74%
ELP
Flow/Fund n
GVApw / HApw
= 25.17 £/h
FUND (HApub)
n-1 (Pub Sector)
1.37E+09h
FLOW (GVApw)
n (All Sectors)
£1.03E+11
ELP
Flow/Fund n-1
GVApub / HApub
= 19.54 £/h
Flow Share
GVApub / GVApw
= 26.2%
FLOW (GVApub)
n-1 (Pub Sector)
£2.69E+10


Activity and Value Added - CNP (2009)
Paid Work vs Public Administration & Services
FUND (HApw)
n (All Sectors)
1.46E+07h
Fund Share
HApub / HApw
= 28.66%
ELP
Flow/Fund n
GVApw / HApw
= 29.79 £/h
FUND (HApub)
n-1 (Pub Sector)
4.20E+06h
FLOW (GVApw)
n (All Sectors)
£4.36E+08
ELP
Flow/Fund n-1
GVApub / HApub
= 22.92 £/h
Flow Share
GVApub / GVApw
= 22.05%
FLOW (GVApub)
n-1 (Pub Sector)
£9.62E+07

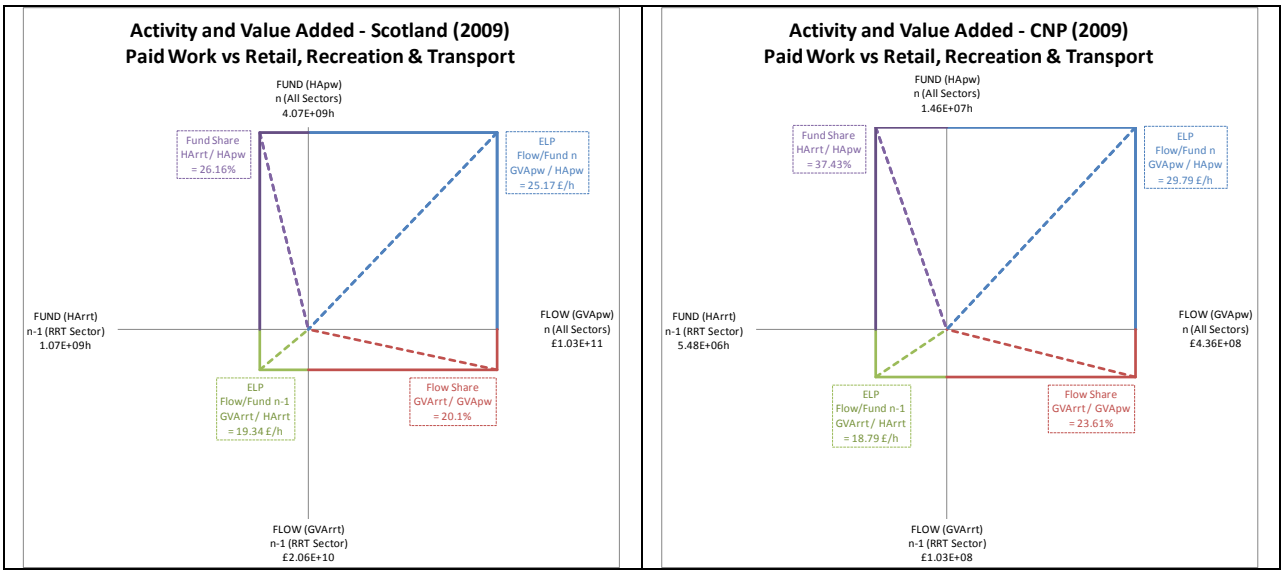
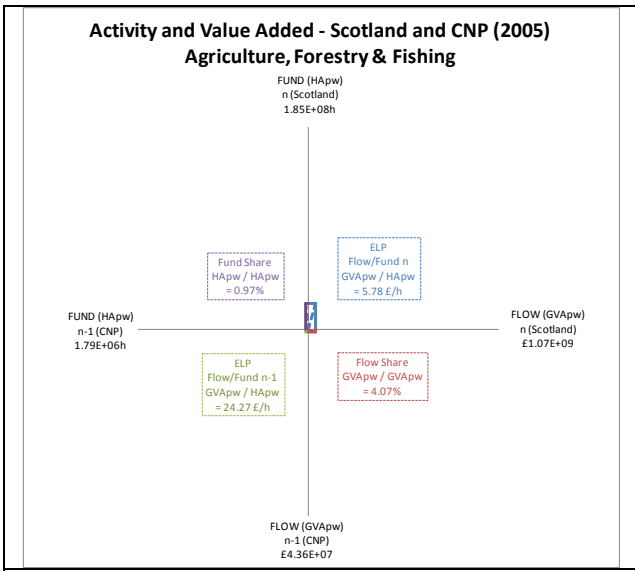
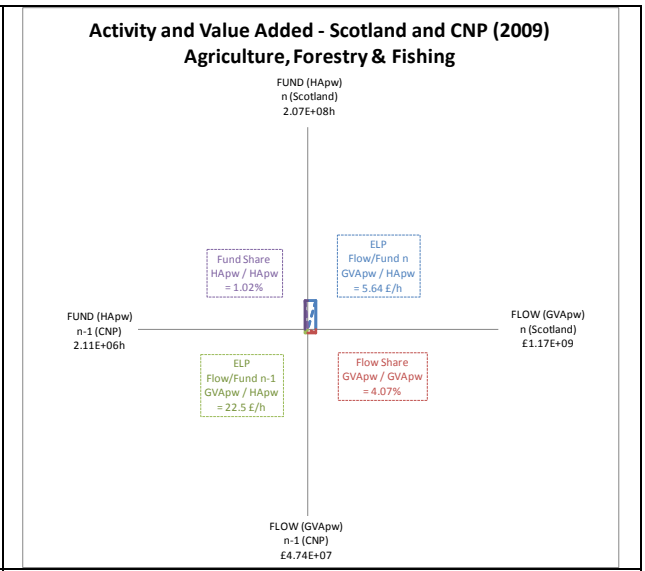


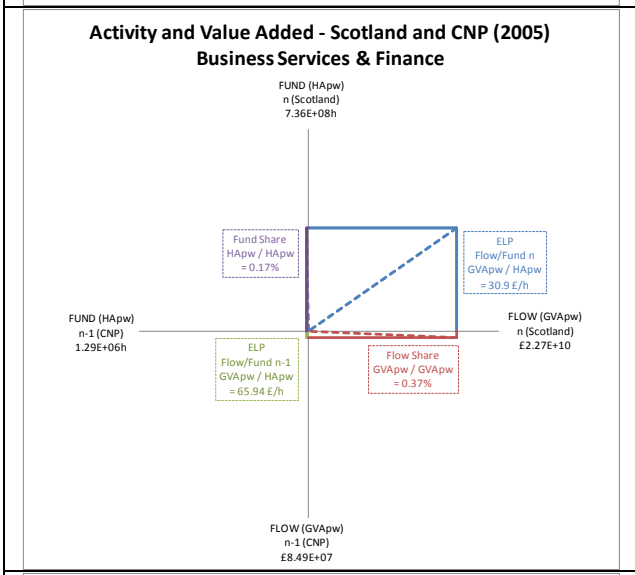
Figure 20: Fund Flow diagram comparing Paid Work and Sub sectors using THA and GVA for Scotland and CNP in 2009

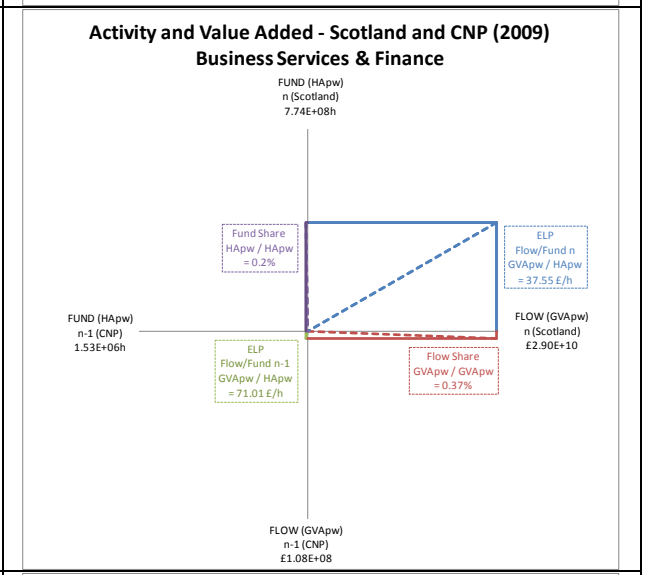
Figure 21 compares the CNP and Scotland for each sector using THA, GVA and ELP. Two versions are presented one for 2005 and one for 2009. Within each FF figure it is possible to assess the relative importance of each sector (by size) and the relative efficiency as defined by the ELP. Comparing FF diagrams within each column the balance of sectors within both regions is apparent. Note that all the FF diagrams are scaled in both THA and GVA relative to the largest sectors present. This allows structural comparisons both in the columns and across the rows. Comparing across each pair of FF diagrams in the rows the changes per sector between the two time-periods can be evaluated (e.g. the reduction in the THA for Pub but at the same time the increase in reported GVA which would certainly run counter to the political rhetoric on the sustainability of public services within the UK). Note that the shape of the quadrants provides a visual representation of the balance between THA and GVA. Where the proportions are equivalent the quadrant is a square (e.g. construction), where longer in the x-axis the sector generates more GVA than its proportion of THA would predict (e.g. BSF), where longer in the y-axis the sector generates less GVA than the THA would predict (e.g. AFF, Pub in 2005 and RRT again in 2005)[13]. It is notable that by these measures the CNP outperforms the Scotland average in terms of ELP efficiency in all sectors except Distribution (and then only in 2009). The CNP is, however, only a very small part of the Scotland "average" in terms of GVA and THA so performance significantly different from the "average" is perhaps not unexpected.

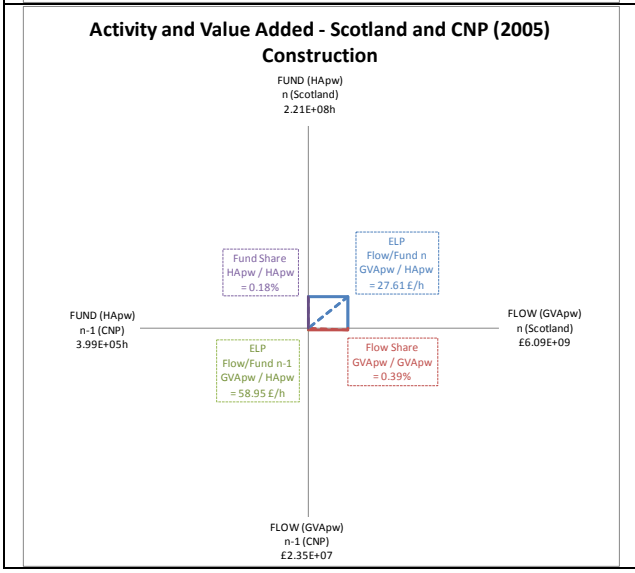
[13] Note the Public Administration & Services sector has seen a substantial shift toward balance of THA and GVA between 2005 and 2009.

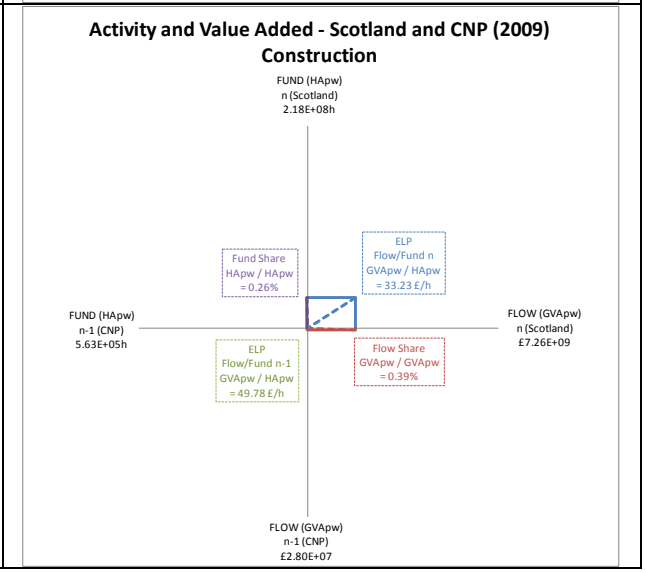

Activity and Value Added - Scotland and CNP (2005)
Agriculture, Forestry & Fishing
FUND (HApw)
n (Scotland)
1.85E+08h
Fund Share
HApw / HApw
= 0.97%
ELP
Flow/Fund n
GVApw / HApw
= 5.78 £/h
FUND (HApw)
n-1 (CNP)
1.79E+06h
FLOW (GVApw)
n (Scotland)
£1.07E+09
ELP
Flow/Fund n-1
GVApw / HApw
= 24.27 £/h
Flow Share
GVApw / GVApw
= 4.07%
FLOW (GVApw)
n-1 (CNP)
£4.36E+07


Activity and Value Added - Scotland and CNP (2009)
Agriculture, Forestry & Fishing
FUND (HApw)
n (Scotland)
2.07E+08h
Fund Share
HApw / HApw
= 1.02%
ELP
Flow/Fund n
GVApw / HApw
= 5.64 £/h
FUND (HApw)
n-1 (CNP)
2.11E+06h
FLOW (GVApw)
n (Scotland)
£1.17E+09
ELP
Flow/Fund n-1
GVApw / HApw
= 22.5 £/h
Flow Share
GVApw / GVApw
= 4.07%
FLOW (GVApw)
n-1 (CNP)
£4.74E+07


Activity and Value Added - Scotland and CNP (2005)
Business Services & Finance
FUND (HApw)
n (Scotland)
7.36E+08h
Fund Share
HApw / HApw
= 0.17%
ELP
Flow/Fund n
GVApw / HApw
= 30.9 £/h
FUND (HApw)
n-1 (CNP)
1.29E+06h
FLOW (GVApw)
n (Scotland)
£2.27E+10
ELP
Flow/Fund n-1
GVApw / HApw
= 65.94 £/h
Flow Share
GVApw / GVApw
= 0.37%
FLOW (GVApw)
n-1 (CNP)
£8.49E+07


Activity and Value Added - Scotland and CNP (2009)
Business Services & Finance
FUND (HApw)
n (Scotland)
7.74E+08h
Fund Share
HApw / HApw
= 0.2%
ELP
Flow/Fund n
GVApw / HApw
= 37.55 £/h
FUND (HApw)
n-1 (CNP)
1.53E+06h
FLOW (GVApw)
n (Scotland)
£2.90E+10
ELP
Flow/Fund n-1
GVApw / HApw
= 71.01 £/h
Flow Share
GVApw / GVApw
= 0.37%
FLOW (GVApw)
n-1 (CNP)
£1.08E+08


Activity and Value Added - Scotland and CNP (2005)
Construction
FUND (HApw)
n (Scotland)
2.21E+08h
Fund Share
HApw / HApw
= 0.18%
ELP
Flow/Fund n
GVApw / HApw
= 27.61 £/h
FUND (HApw)
n-1 (CNP)
3.99E+05h
FLOW (GVApw)
n (Scotland)
£6.09E+09
ELP
Flow/Fund n-1
GVApw / HApw
= 58.95 £/h
Flow Share
GVApw / GVApw
= 0.39%
FLOW (GVApw)
n-1 (CNP)
£2.35E+07


Activity and Value Added - Scotland and CNP (2009)
Construction
FUND (HApw)
n (Scotland)
2.18E+08h
Fund Share
HApw / HApw
= 0.26%
ELP
Flow/Fund n
GVApw / HApw
= 33.23 £/h
FUND (HApw)
n-1 (CNP)
5.63E+05h
FLOW (GVApw)
n (Scotland)
£7.26E+09
ELP
Flow/Fund n-1
GVApw / HApw
= 49.78 £/h
Flow Share
GVApw / GVApw
= 0.39%
FLOW (GVApw)
n-1 (CNP)
£2.80E+07

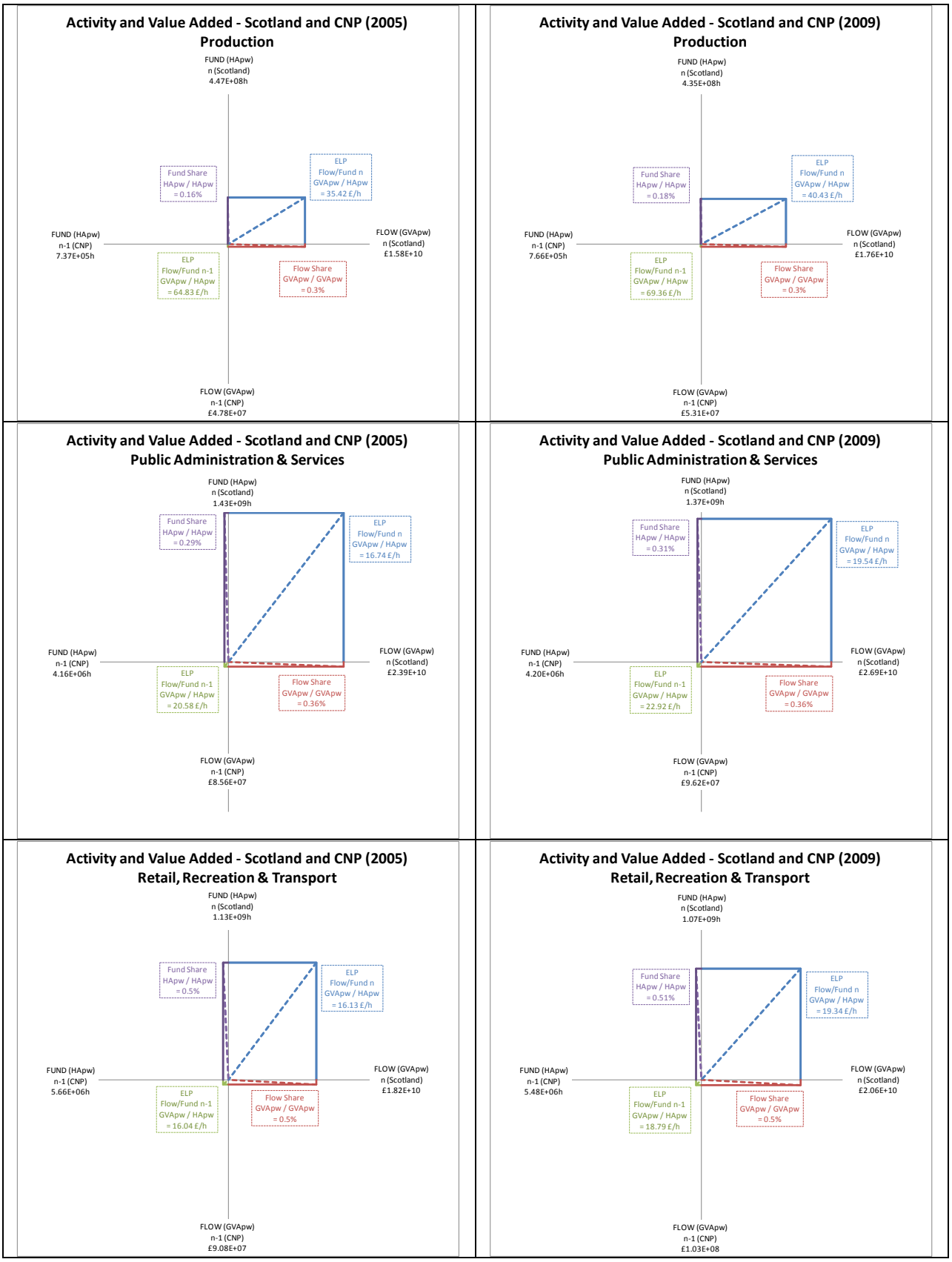


Figure 21: Fund Flow diagram comparing Scotland and CNP using THA and GVA for paid work and sub sectors in 2005 & 2009

The limitations of the software being used to produce the FF diagrams means that individual diagrams are currently limited to a single year and with a fixed scaling for largest fund. This makes it more difficult to interpret change but the FF diagram is still the best way to assess both extents and intensities within the same figure. Developments of the software to generate multiple FF's on the same diagram and to scale FF diagrams relative top one another are planned. While the FF diagrams are an effective way of combining several metrics, they are still an unusual form of communication and are seen by the CNPA analysts as being too "technical" to be used in presenting results to their management groups.

3.5 Land as a factor

When completed the land use analysis will allow for a decomposition of land areas to assess the "take" associated with populations, paid work or other breakdowns. This will enable extent and intensity analyses to be completed in line with the EMR and ELP indicators. Progress has been made in this regard but had not been completed to the MLURI team's satisfaction for inclusion in this report.

4 Discussion:

4.1 The role of growth in achieving sustainability objectives

The MuSIASEM analysis has shown that there is a complex relationship between economic growth and the other indicators of sustainability. This complexity is in terms of the distribution (spatial, sectoral and between social groups) but also in terms of the nature of the growth. In some cases growth simply means increasing extent with more people supported at the same standard of living. In other cases there are changes in the intensity (productivity of labour and energy). From within this complexity it has been possible to begin to identify groupings of regions, their trajectories in terms of growth and the other indicators and to use these to better understand the overall Scotland level assessment and to contextualise the CNP.

The results for the CNP are significantly different from the a priori expectations of the research team. That the CNP sits so close to the Scotland average for many indicators was unexpected for such a rural area (where expectations would be of a less dynamic economy). That the CNP has features in common with the cities of Scotland was also unexpected. The importance within the area of tourism and recreation means that the CNP has a significant retail and recreation sector. The attractiveness of the area in terms of its physical environment also means that there is a larger than expected business sector with businesses located in the CNP but providing services outward beyond the park boundary. That the CNP has a more city-like population distribution, retaining young adults, could indicate a successful and sustainable rural economy. It could also mean that the CNP supports a minimum-wage based service economy based on the immigrants from the transition economies.

As noted in the results section, the ELP values for the CNP are "inflated" by the distilling industry and bonded warehouses that generate GVA but little wealth for the population though employment of recirculation of funds. This may seem to undermine the findings of similarity between the CNP and the cities of Scotland. It is, however, possible to argue that "GVA gaps" are perhaps more common phenomena than would be comfortable for a politician to admit to. How much of the GVA accounted for within Scotland's cities (that boosts their ELP values) actually has any effect on the wealth or wellbeing of the populations within the city? Particularly in the light of the banking crises in Scotland and elsewhere it is legitimate to question whether the "spectacular" growth of GVA figures in sectors such as banking and financial services is fully translated into benefits for local populations. It is fairly certain that given recent events it has not proven to be sustainable. The MuSIASEM analysis, while in no way definitive, can be argued to have been successful in starting to open up a debate on the nature of the relationship between growth and sustainability and to make a small contribution to the emerging paradigm of beyond GDP science and policy.

Of particular note in this regard are the energy intensity analyses. As expected from other research by Giampietro et al., in the Scotland and CNP analysis there is little or no evidence of real dematerialisation, that is a break in the fundamental relationship between energy use and wealth (or at least GVA) generation. Lower values of EMR simply reflect a post-industrial sectoral mix that has the net effect of exporting the energy and environmental footprint elsewhere (most often to China). Given Scotland's commitment to an 80% cut in green house gas emissions by 2050 it is difficult to see how this can be achieved in other than accounting terms with the current (or larger) population size and/or standard of living, without fundamentally rethinking and reorganising patterns of production and expectations of consumption.

The MuSIASEM analysis is an effective tool to open up the black box of the economy and to assess the relative size of its component parts and to some degree how its functioning is supported by a demographic pattern and a work-life balance. The form of analysis is inductive and empirical and as such it tends to generate as many questions as answers. The approach is thus potentially fruitful in structuring and justifying more in-depth analysis within a research context. In a policy and management context it has the potential to act as a boundary object around which parties with differing views can deliberate. In terms of the process of using MuSIASEM this will be a key test in crossing the science-policy or science-management gap: is it possible to deliver research outputs that are engaging without losing their specificity and rigour?

4.2 Strengths and weaknesses of the analysis

MuSIASEM provides an approach to the systematic evaluation of sustainability, linking evaluations of economic growth to population, energy and land use. It is effective in combining both extents and intensities within its appraisals, avoiding the trap of Jevon's Paradox when improvements in efficiency ultimately undermine the sustainability of the system by promoting additional non-renewable resource use. The use of a decomposition approach (differentiating for example household and paid work, sectors and sub-sectors, or spatially) is effective in ensuring that "average" values are fully understood as being the outcomes of mixes at regional or sectoral level. The approach is also effective in demonstrating the dependencies between productive and consumptive sectors and the degree to which some systems, particularly in the developed world, are supported by resources from other regions.

For MuSIASEM to be fully effective it does require access to data at smaller units (spatial or in terms of classification, and best both). Time series of data are also preferred if the dynamics of change in the system are to be understood. The strongly empirical nature of the MuSIASEM analysis is grounded in reality as perceived by stakeholders. This has been effective in making it accessible to the CNP stakeholders but it's more challenging conceptual basis and the unusual

ways in which the outputs can be presented have been barriers to credibility. The MLURI team have found significant challenges in sourcing adequate data to support some of the MuSIASEM analysis despite significant experience and expertise in data integration and manipulation. As with other sustainability analyses this tends to lead to undesirable compromise in terms of the indicators used (data shaping the modelling rather than the other way round).

As with SUMMA, the strength of MuSIASEM case studies to date has been in the economic and environmental sphere (mainly land and energy). MuSIASEM analyses that have incorporated strong household and demographic components within their studies have opened up some of the social aspects of sustainability. Distribution by age, income and gender can all fit within the MuSIASEM approach and thus address key criticisms of primarily economic focused sustainable growth assessments. Issues of culture, non-use and existence values within the social sphere are significant for rural Scotland but are likely to require a mixed methods approach combining MuSIASEM and other more qualitative and participatory analytical approaches.

4.3 Implications for mainstreaming the use of MuSIASEM

In common with SUMMA, MuSIASEM still faces an implementation gap in terms of seeing the approach, or its outputs, used for policy-making or management. There are challenges in terms of access to data, in terms of how the data can be integrated in the face of varying spatial and temporal resolutions and classifications. There are also challenges in how best to communicate the outcomes of the research in a form that is succinct and accessible but does not lose the rigour or oversimplify to the point that the data becomes meaningless. These are serious challenges partly as MuSIASEM questions established orthodoxy in both what is important in policy terms (growth) and how it is measured and interpreted. There are significant and powerful vested interests that would be undermined by a more holistic view of sustainability and a more nuanced view of the benefits and disbenefits of growth.

From previous experience in the climate change domain (where similar issues arise) there are approaches that can be successful in mainstreaming the use of novel analytical approaches (Matthews et al. 2008;McCrum et al. 2009). Mainstreaming MuSIASEM will require the undertaking of transdisciplinary research, that is research projects including both the research team and the stakeholders, with the stakeholders having a more formal role in the shaping of the research. Such projects ensure the salience of the research and build credibility for the methods and data through processes of stakeholder peer-review.

To this end further research will be undertaken using the MuSIASEM approach within the new Scottish Government research programme “A rural economy resilient to global and local change”. The research will specifically examine the structural aspects of transition to a low carbon rural economy assuming the 80% reduction in greenhouse gas emissions by 2050. This will provide the opportunity to further develop the MuSIASEM approach in the context of a

research project that has good access to senior policy makers and analysts and expectations of policy relevance. Through the inclusion of stakeholders within the research programme it is anticipated that the MLURI team will be able to overcome the "implementation gap" by familiarising the policy teams with the MuSIASEM "grammar" and the research team will be able to incorporate stakeholder feedback into the choice of indicators, cases and how they are presented to be effective in communication. Limited funding has also been provided by Scottish Government to continue collaborations with key SMILE partners and efforts have been made to secure EU FP funding to continue to develop the DECOIN tools in the context of the Beyond GDP research theme.

5 Further developments

For MuSIASEM the priorities will be to: include the spatially explicit land use analyses and to investigate the theoretical and practical issues of including other quality of life metrics within a MuSIASEM framework – e.g. wage rates and house-prices.

To make more definitive statements on the sustainability of the paid work sector it will be necessary to extend the analysis further to look at the mix of sectors activities to ascertain the degree to which increased headline sustainability is being achieved simply through the substitution of higher EMR activities by lower, (e.g. Production by Services) with demand exported beyond the boundary of the system. The limited sectoral breakdown of the energy use datasets and their incompatibility with the GVA datasets means that to date this has not been possible.

The following specific investigations were also seen as useful by the CNPA.

MuSIASEM Scotland analysis next steps	Commentary
Include a sub-CNP (n-1) analysis that differentiates Deeside (oriented to the city of Aberdeen) from the Speyside/Highland parts of the CNP.	Feasibility assessed but not implemented for this iteration of the MuSIASEM analysis
Include non-GVA metrics. Questions were raised on whether GVA is a useful metric for the CNP. One industry (distilling) generates large revenues but almost none remain within the CNP (small employment and little other spill over). Other issues raised included the need to quantify pension income flows for the significant retired population within the CNP and the balance of income from activity outwith the park (residents who work outwith the CNP) versus the incomes generated within the CNP that are spent elsewhere (non-resident works).	Adaptations to the GVA figures are perhaps possible based on local survey datasets. The other issues remain to be investigated.
House prices are an interesting indictor where growth is seen as desirable by some but can also have significant social downsides for quality of life.	Data is available but would be best incorporated within a household sector analysis. This was beyond the capacity for the MLURI team within SMILE.
Mapping of land take and energy consumption at sub-CNP level were seen as useful. It was essential that any metrics be sensitive to fine grained differentiations in alternative scenarios, for example not 0 vs. 5000 house but the consequences of 0 vs. 50 or 0 vs. 100 houses in several locations.	The land take data for the CNP is close to completion. This dataset is compatible with the employment and the household datasets. Options for its use will be discussed with stakeholders in the meeting to follow up from reports D28-30. Small scale energy data is available for gas and electric but this is not adequate for a full analysis as other sources of domestics and paid work sector energy are significant in the CNP.

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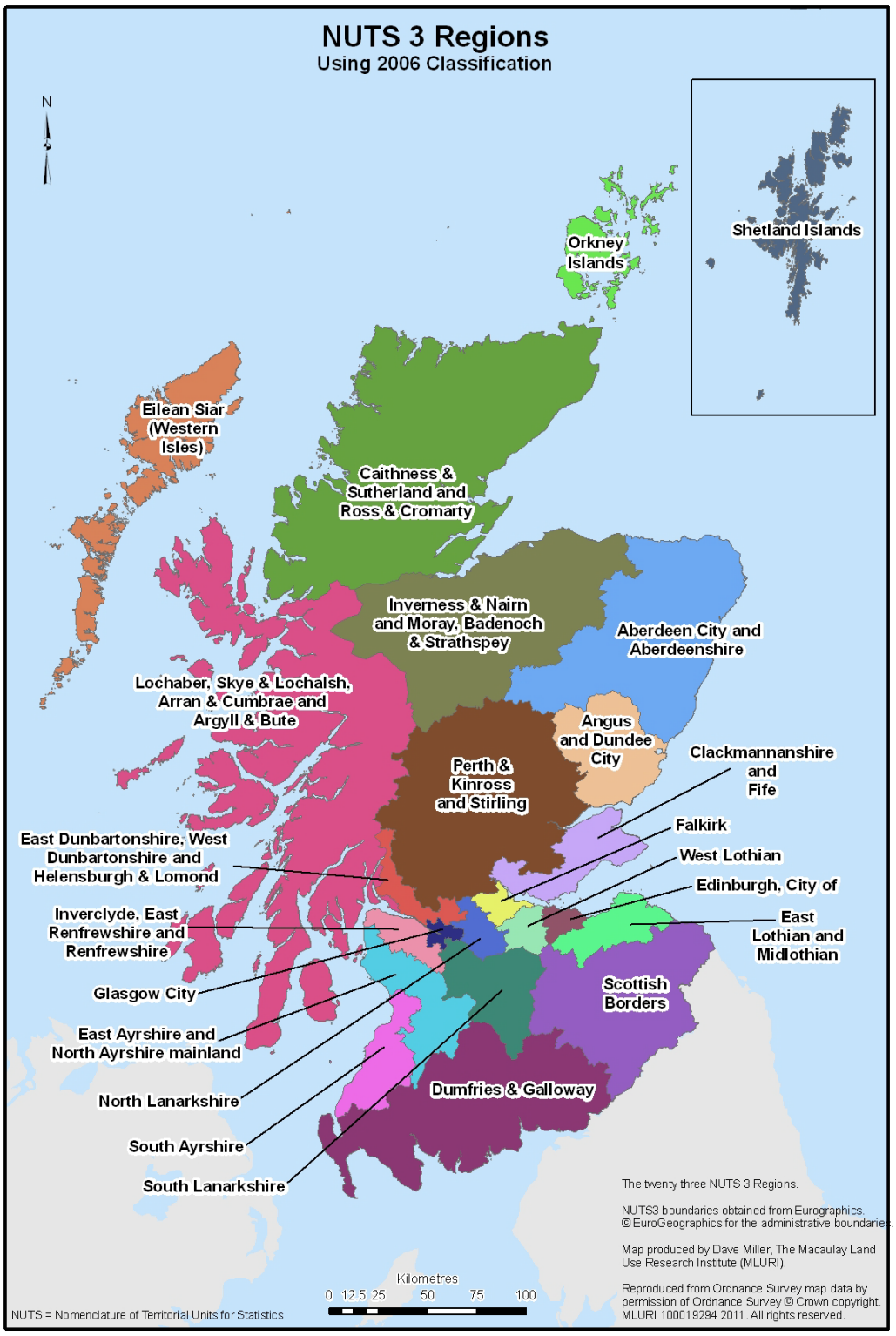
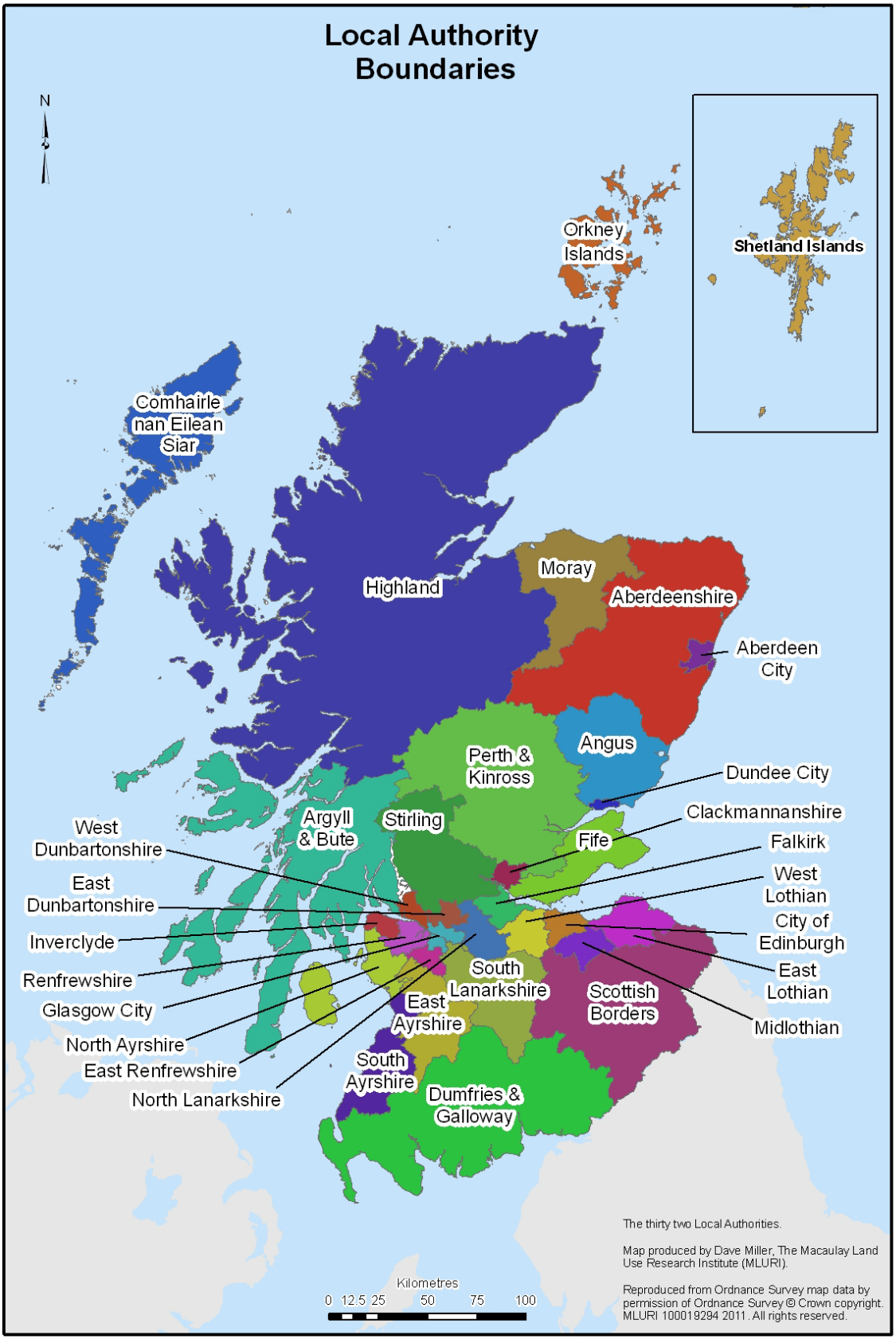
Appendix One: Maps of NUTS 3 regions and Local Authority areas




Local Authority Boundaries
N
Orkney Islands
Shetland Islands
Comhairle nan Eilean Siar
Highland
Moray
Aberdeenshire
Aberdeen City
Angus
Perth & Kinross
Dundee City
Argyll & Bute
Stirling
Clackmannanshire
Fife
Falkirk
West Dunbartonshire
East Dunbartonshire
West Lothian
Inverclyde
City of Edinburgh
Renfrewshire
South Lanarkshire
East Lothian
Glasgow City
East Ayrshire
Scottish Borders
Midlothian
North Ayrshire
East Renfrewshire
South Ayrshire
North Lanarkshire
Dumfries & Galloway
The thirty two Local Authorities.
Map produced by Dave Miller, The Macaulay Land Use Research Institute (MLURI).
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Kilometres
0 12.5 25 50 75 100