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National and local labour force projections for the UK

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Abstract
Labour force forecasts are required by local planning, legally guided in the UK by regulations on land use. Methods of forecasting the labour force, and data available for UK practice, are reviewed here. A best strategy for sub-national forecasts of the labour supply is found empirically to involve an accurate national forecast with a local starting point. Key trends are the decreasing economic activity of young adults, the increasing activity of older adults and the impact of changing state pension age. However, there exists neither an acceptable national forecast of economic activity nor a standard approach to local forecasts. Software for implementation of sub-national forecasts is described, and six types of scenarios are listed to aid local planning, which reflect uncertainty about current trends and the impact of changes in policy. Research and development of forecasting the national and the local labour force is urgently needed.

Keywords
economic activity, forecast, labour force, projection, small areas, UK

Introduction

This paper is methodological in its content but practical in its purpose. It proposes and tests candidate methods for achieving a standard set of demographic forecasts of economic activity for sub-national areas in the UK, where the need for them is particularly clear but is not currently satisfied by government statistics.

This introductory section reviews the need for forecasts of local economic activity, poses key questions about future trends and sets out the research questions about forecasting methods that the paper seeks to answer. The following substantive sections describe current practice through a review of methods, the limitations of national projections for the UK, an analysis of the stability of local economic activity over time, a test of strategies using harmonised data from the past three censuses, practical issues of software availability and appropriate scenarios in a planning context. The final section outlines remaining questions which demand an academic or government programme of research to improve

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national as well as local forecasting. Throughout this paper, forecasts and projections will be used interchangeably, as both are intended to reflect likely future conditions.

Need for local forecasts of economic activity

Economic activity, the proportion of the population that is working or seeking work, is a fundamental indicator of the level of participation in the formal economy. All those economically active make up the labour force. Taken together with a forecast of population, a forecast of economic activity shows the future supply of labour. In social terms, it indicates the need for jobs. In economic planning, it indicates the availability of labour to satisfy the needs of development. Most governments promote expectations and policies that seek to increase levels of participation, seen as indicators of integration and of potential economic production. Policy interest in economic activity focuses on the impact of an ageing population that reduces the overall rate of activity, on the compensating increases of activity possible among women and at younger or older ages and on unemployment that discourages entry and increases exit from the labour force (International Labour Organisation (ILO), 2015). The issues are similar in developing countries but with different emphases (Fields, 2010).

For local investigations of the labour market, forecasts of the economically active population (the labour supply) based on demographic and economic activity trends are usually made independently of forecasts of employment (the labour demand) based on economic trends. The gap between labour supply and demand identifies policy issues. In England, Local Enterprise Partnerships (LEPs) of local government and businesses undertake regular reviews, taking some of the functions of the Regional Development Agencies abolished in 2012. As an example of the many comparisons of forecasts of labour supply and demand, a report for the LEP based on the Isle of Wight and Hampshire concluded that

> The strong growth in employment over the forecast period coupled with flat growth in the working age population will squeeze the labour market in the years ahead. The labour market tightening should push down unemployment rates from current levels, though additional demand for labour in Solent LEP will increasingly have to be satisfied by the inflow of migrants or a rise in the level of commuters into the area. (Oxford Economics, 2014: 7)

Any country that attempts to regulate land use according to social needs must logically integrate demographic, labour force and household forecasts. In Britain, forecasts of supply and demand are required to be made consistent by government guidance that has legal status overseeing the Local Plans that each district must make. The guidance stipulates a starting point of official projections in which recent demographic levels of fertility, mortality and migration are assumed to continue, along with recent levels of household formation, or foreseeable changes in each of these factors. The Local Plan (which has come under varied names of strategic, structure, or development plan) must identify the land that will be available to developers to satisfy the forecast number of households.

However, the Cameron government since 2010 has changed the guidance for Local Plans in England in a number of ways to make it more likely that land will be released beyond the demographic forecast (CLG, 2015). This guidance has been translated into practical steps for implementation by the Planning Advisory Service (2014). The implementation of the guidance is interpreted in legal fashion when draft Plans are contested. Draft Plans almost

always are contested, not least by developers whose incentives include maximising the land released, to reduce the price of housing land and to increase their choice of the most profitable sites. Although the guidance stipulates that the government's own demographic forecast of local population and households should be the starting point for assessment of need for housing, and may be constrained by physical or national legal obligations so long as the shortfall is taken up by neighbouring areas, no other reductions from the demographic forecast are allowed. On the other hand, the Local Plan must cater for more than the demographic demand to make up for past 'undersupply' and to meet local policies that may include targets for future growth in the number of jobs (CLG, 2015: paras 14–20). New planning guidance expected in 2017 is unlikely to change the importance of labour force forecasting (Johnston, 2017).

The allowance for an aspirational target of jobs has been taken up as the 'new normal' and has created a focus on the future of economic activity. All other things being equal, a growth in jobs beyond that expected from demographic change would require more land for housing to accommodate the extra workers and their families. However, if economic activity were to continue to increase as in the past decade in Britain, or if the rising age of entitlement to a state pension were to lead to significant increases in older people's economic activity, then those extra jobs would be taken by the existing population without any requirement for extra housing. Thus, realistic jobs growth and future economic activity have become much more central to the examination of Local Plans than hitherto (for examples of the debate, see Peter Brett Associates, 2014, especially Appendix D and Shropshire County Council, 2014).

The demographic modelling that integrates population, the labour force and households has long been documented (Davis and Lloyd, 1984; Field and MacGregor, 1987; Harding, 1986). The feedback to allow a target number of jobs to influence future population and housing need has been documented (Simpson, 2016) and is implemented in the industry standard software for local demographic planning in the UK, POPGROUP (Edge Analytics Ltd., 2010, 2013; University of Manchester, 2014). Population and household projections are regularly produced by the government statistical agencies for all local authority districts in the UK (ONS 2015; Welsh Government, 2011).

The missing ingredient is an official forecast of economic activity. National forecasts were discontinued by the Office for National Statistics after their 2004-based round (Madouros, 2006) and were never implemented for areas smaller than Regions, much larger than local authority districts. As described below, current practice for Local Plans is to assume no change in economic activity, to calculate scenarios based on qualitative assumptions, or to hide assumptions about economic activity within demand-led models.

Trends in economic activity

Figure 1 shows the evolution of economic activity at different ages for males and females in England and Wales over the past five censuses from 1971 to 2011. It illustrates four main features which are common in most European countries:

> The participation rates of prime-age male workers (aged 25 to 54), at around 90%, remain the highest of all groups. The participation rates of men aged 55 to 64 years, which had recorded a steady decline in the past twenty five years, are showing clear signs of a reversal in most countries since the turn of the century, mostly due to pension reforms raising the statutory retirement age or the state pension age; female participation rates have steadily increased over the past twenty five years, largely reflecting societal trends; the participation rates of young people (aged 15 to 24 years) have

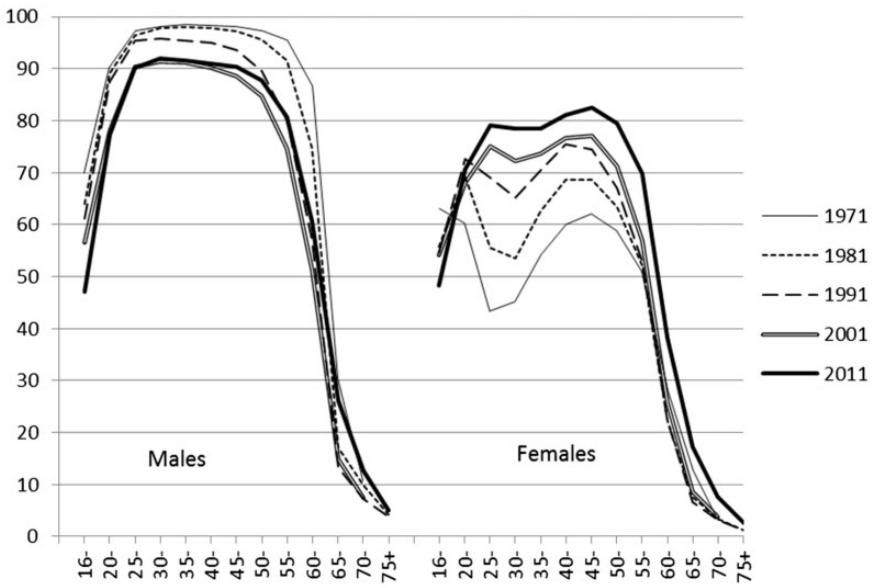

Figure 1. Economic activity 1971-2011, England and Wales. *Notes*: '70-74' refers to 70 and older in 1971; 75+ was not recorded in 2001; school leaving age was raised from 15 to 16 in 1972. *Source*: Population Censuses 1971-2011, compiled by author.

> declined, mostly due to a longer stay in school. (European Commission, 2014: 30)

The observed changes over time make clear that on the one hand, there is room for continuing significant change to economic activity rates, and on the other hand, past change has not been at a steady pace, and therefore, the future is not easily predictable. The key questions for future change involve prediction of the impact of (a) educational and training opportunities for young adults on their participation in the workforce, (b) women's increasing economic activity at all ages above 24 and (c) benefit changes, particularly the delayed age of entitlement to a state pension.

Key questions for making local forecasts of economic activity

With the aim of advising on a strategy for projecting local economic activity that is pertinent for every local district, three key questions arise which this paper aims to answer. The questions have been prompted by consideration of the existing official forecasts of fertility, mortality and household headship rates already referred to (labelled 'sub-national projections' by their producers). Each of these official forecasts assumes that future local trends will parallel a national trajectory. For example, a projection of age-specific fertility rates is carried out using national data, and recent local data provides the starting point for the local projection. Past local data are not used to establish a specific local trajectory. The first question is therefore whether it is better to directly model past local economic activity and continue those past local changes into the future, or to relate the recent local level of economic activity to a national projection. This is answered below from a study of local economic activity in 1991, 2001 and 2011, including the tests of alternative forecasts of 2011 activity from data for earlier years.

The second and third questions refer to the most suitable data available for implementing a strategy. If a national forecast is useful, which is the most suitable in existence for the UK or countries within it? Finally, which data source should measure the local level of economic activity? The choice is between the most recent census and the more regular but less reliable annual surveys.

Methods for projecting economic activity

Accepted ground rules for collecting information about the labour market have been produced by the International Labour Organisation (ILO, 1982, last updated in ILO, 2013), which ask that ''indicators should be computed for the population as a whole and disaggregated by sex, specified age groups (including separate categories for youth), level of educational attainment, geographic region, urban and rural areas, and other relevant characteristics'' (ILO, 2013: 14). Forecasts of the labour force are almost always undertaken by aggregating separate forecasts of males and females in five-year age groups, each derived by multiplying a population forecast by a forecast of the economic activity rate for each age-sex group.

The method of achieving a forecast of economic activity for each age-sex group varies, as described for example in the reviews by the ILO (2011), Burniaux et al. (2004) and Carone (2005). Each review distinguishes the methods slightly differently but four categories may be usefully identified following the ILO:

Qualitative or judgemental approaches are often used, even when time series of past activity rates are available. Most Local Plans in Britain use scenarios of plausible qualitative changes in economic activity or no change at all. The European Central Bank has also employed such qualitative scenarios, such as country rates moving towards other countries with more activity, or moving towards the experience of the USA (for example, Genre and Gomez-Salvador 2002). Experian in the UK assume a steady economic activity rate when averaged over all ages, and calculate the rise in older economic activity which that assumption requires, given the ageing population.

Time extrapolation of activity rates includes logistic or other means of dampening the rates of past change. These approaches have been most common, certainly until the past decade, and were used, for example, in the latest official projections in the UK (Madouros, 2006), are used in the United States (BLS, 2014) and are used by the ILO for forecasts made for all countries (ILO, 2011).

Regression models are based on correlations of activity rates with economic, cultural, or demographic factors. Although unusual outside academic projects because of the need to project the correlated factors, regression models are implicitly used by Statistics Canada in a micro-simulation model from which projections are derived (Caron-Malenfant and Coulombe, 2015; Martel et al., 2011). In the UK, a regression approach to forecasting economic activity is used in the Working Futures project, developed by Cambridge Econometrics and the Institute for Employment Research at the University of Warwick. This embeds labour supply within an economic forecast (Wilson et al., 2014). Labour market participation rates are modelled as a function of unemployment and other variables including house prices relative to wages. Future changes in labour market participation rates are not specific to age and sex but follow an overall level of economic activity and assumptions about the future values of other input variables.

Some Local Plans adopt a similar demand-led approach, but have difficulty making consistent age-specific assumptions for labour supply calculations, as critically observed by Peter Brett Associates (2014).

Cohort approaches are based on analyses of net entry and exit rates from the labour force at each age, for males and females separately. The approach conveniently captures how the activity and inactivity of an age group in year t changes as the cohort becomes one year older in year t+1. It is an approach developed by the OECD (Burniaux et al., 2004) and taken up by the European Commission (EC) (2014), the European Central Bank (Balleer et al., 2009) and the Office for Budget Responsibility (OBR, 2015a). Since this is the approach taken by the two main current projections for the UK by the EC and OBR, it is defined more precisely here.

> *Entry rate = 1 – (Inactivity rate for age a+1 time t+1 / Inactivity rate for age a time t)*, calculated only when activity is increasing as it is for most ages up to around age 50.

For example, the entry rate would show that a tenth of 25-year-old inactive males become active at age 26, if inactivity declines from 20% to 18%, since 1-(18/20) = 0.1. Although called an 'entry rate' in all the documentation cited, it is best described as a net attrition rate among the inactive. These are not true demographic rates since the numerator is not a subset of the denominator: there is movement into activity and out of it and the 'rate' indicates a net flow. It is calculated from past data and applied to those inactive at future time t. The resulting decrease in inactivity is added to the activity projected for age a at time t, to compute the activity rate for age a+1 at time t+1.

> *Exit rate = (Activity rate a+1 time t+1 / Activity rate age a time t)*, calculated only when activity is decreasing.

For example, the exit rate would show that the 60-year-old activity was 90% of 59-year-old activity, if activity decreased to 54% from 60%, since 54/60 = 0.9. It is a net attrition rate rather than a true demographic rate. It is calculated from past data for ages a and a+1 and applied to the forecast activity rate for age a at future time t, to compute the activity rate for age a+1 at time t+1.

The cohort approach was developed particularly to model the activity of each cohort of women in recent decades. In Figure 1, for example, the apparent dip in economic activity rates observed for women in their early thirties is partly a result of lower economic activity among earlier cohorts. For example, although in 2011 a greater percentage of women aged 20–24 are economically active than those aged 30–34 in the same year, the latter cohort is more active at age 30–34 than it was 10 years before, in 2001 when it was aged 20–24. The cohort approach ensures that the observed increases in activity will continue, but starting from the higher level of younger women's activity seen in recent years. By assuming constant entry and exit rates, the cohort approach is not as 'conservative' as assuming constant activity rates. However, it is

> more restrictive than assuming the catching-up of female participation rates towards male levels, or female levels in countries where women's participation is higher. Indeed, the cohort approach implies no further modification of women's/men's individual characteristics and thus behaviour (in terms of probability of entry and exit) beyond those of the latest generations. (Carone, 2005: 15)

All the UK projections using a cohort approach do assume constant entry and exit rates at prime ages 25–54, but make different assumptions for young and older ages as described in the next section.

Economic activity forecasts for the UK

National forecasts of economic activity are more likely to be robust than local

forecasts, due to long-time series of past data, the large samples from national surveys and the greater steadiness of national trends. UK government projections of economic activity were last produced based on data up to 2004, by the Office for National Statistics (Madouros, 2006), providing projections up to 2020. The ILO's forecasts (2011) for the UK, also to 2020, were published based on data up to 2010. Neither is up to date and neither reaches far enough into the future for current use. Since then, the UK government has funded three institutions to produce economic forecasting models that include economic activity (EC, 2014; OBR, 2015a, 2015b; Wilson et al. 2014). The outsourcing has led to a reduction in documentation, data release and relevance to a wider set of potential uses. Only the EC provides detailed methodology as part of its regular report on ageing, from which data are available on request for research purposes.

As mentioned above, Wilson et al. (2014) report to the UK Commission for Employment and Skills but do not attempt to forecast each age-sex group's activity rate sensitively to past and predictable trends. The other two forecasts of the UK's economic activity, by the OBR and the EC, both use a cohort approach with single years of age. Table 1 summarises their assumptions, although the lack of detailed documentation makes it difficult to be precise. Although both have considerable official status, Table 1 and its discussion provide the first published comparison. While using the same method, their detailed approach differs across the entire age range of assumptions – their treatment of young adults and older people and their choice of past years used to calculate cohort rates.

The EC projection is not concerned with young ages, and keeps their activity rates under 25 constant. The OBR assumes that in the UK activity, rates at ages 16–19 will reduce in response to greater participation in education and training, and that the entry rate for age 20–24 will increase in order to compensate.

For ages 25–54, both EC and OBR assume constant cohort entry and exit

Table 1. Assumptions made for UK labour force forecasts by OBR and EC.

	EC (2014) 2015 ageing report	OBR (2015) fiscal sustainability report
Age 16–24	Constant at 2013 values	Reducing participation rate 16–19, compensated by accelerated entry rates age 20–24. Judgemental, undocumented.
Age 25–54	Constant entry and exit rates, based on the Labour Force Survey 2003–2013	Constant entry and exit rates, based on the Labour Force Survey 1997–2008.
Age 55–74	Exit rates are shifted upwards to reflect pension changes, using an analysis of average retirement age and judgement, country by country.	Female exit rates near retirement age are reduced to be equal to male exit rates. To reflect a rise in State Pension Age of one year, exit rates are shifted to equal those aged one year younger.
Age 75+	Zero activity	Not specified

Note: EC: European Commission; OBR: Office for Budget Responsibility. Sources: European Commission (2014), OBR (2011: 18–20, 2015a, 2015b) and personal emails.

rates based on past experience as measured by the Labour Force Survey, but the EC uses the most recent decade as its benchmark while the OBR uses the decade prior to the global financial crisis on the assumption that this reflects a more buoyant period which the future will come to resemble.

For older ages, the assumptions attempt to foresee the impact of changes to the State Pension Age which are assumed to encourage more activity, but the assumptions are developed in different ways which are summarised in Table 1, but are not well documented.

A technical approximation concerning communal establishments affects both EC and OBR forecasts and should be borne in mind for local applications. Both forecasts calculate their activity rates from the Labour Force Survey which excludes those living in communal establishments, other than students. But both apply their forecast activity rates to official forecasts of the entire population including all those in communal establishments. The impact is small nationally, because only a little over 0.5% of the population under 65 are excluded from the Labour Force Survey for this reason. However, the economic activity of non-student residents of communal establishments aged between 25 and 64 is 39%, less than half the activity of those of the same age in the population as a whole (calculated from Census 2011 table DC1602EWla for England and Wales). In sub-national areas with significant communal establishments, this is an issue which should be taken into consideration even if it has not been an issue at national scale.

Figure 2 shows the EC and OBR forecasts together with the time series of previous economic activity, for a selected age group within the young, prime and elderly age groups. Both forecasts for young adults are not plausible. A constant activity rate for those aged under 20 is unlikely in the UK, due to government legislation insisting on continued formal learning up to and including age 18. This legislation is expected to increase the proportion staying full time at school and therefore continue the reduction in economic activity of young adults. The OBR documented reduction in projected activity rates at age 16-19 (2011: 19) is not apparent in their released data used in Figure 2.

The economic activity forecast for most prime ages is quite stable except for increases in females, a result of the constant *cohort* rates as described above. For males and females at each prime age, exemplified by age 50–54 in Figure 2, the OBR forecast economic activity rates are lower than those by the EC.

Economic activity for those aged over 55, represented in Figure 2 by age 65–69, is almost constant for males in the EC projection. This is unlikely given the rise in the past 20 years and the raising of the State Pension Age from 65 to 67 by 2028 for both men and women. The OBR forecast is very different from the EC forecast in its steady increase for elderly activity rates, which may be more plausible. However, both forecasts assume a convergence of women's activity towards that of men's, something that has not been seen in the past decade.

While the EC forecast of economic activity is implausible for youngest and oldest ages in ways that make it unsuitable for general use, the plausibility of the OBR forecast is also open to question. The OBR projected activity rates were released 18 months after the report they were first used in, as a result of persistent requests for this review. The reticence was partly due to the projection not being designed for general use outside national economic forecasts: "there are shortcomings to these projections, particularly in the medium-term where actual participation rates have been higher than the ones implied by the cohort model" (OBR, 22 October 2015, personal communication). Young adult participation rates forecast by the OBR are unrealistically flat. At older ages, the OBR rates are

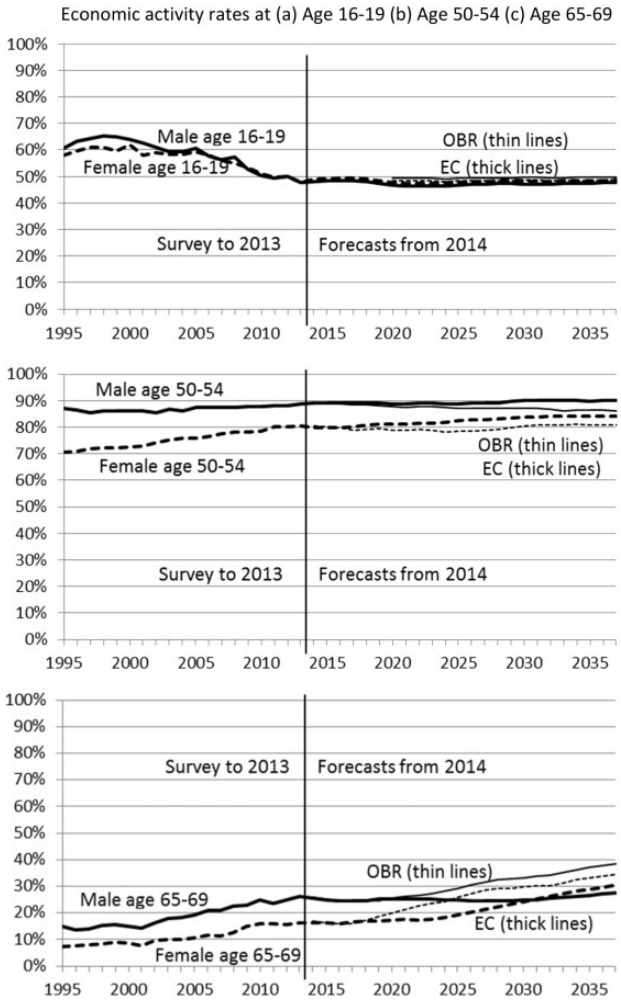

Figure 2. Past economic activity for selected age groups and forecasts by European Commission and Office for Budget Responsibility. Economic activity rates at (a) Age 16-19 (b) Age 50-54 (c) Age 65-69. *Notes*: Selected age groups. Males (continuous line), Females (dashed line), forecasts by EC (thick lines) and OBR (thin lines). *Sources*: Eurostat (2015) for 1995-2013; European Commission (2014) and OBR (2015b) for forecasts 2014-37.

increasing more realistically than the EC. At prime ages, the OBR forecast rates are consistently lower than those of the EC.

Sub-national economic activity: Variation and trends

The economic activity from a national projection cannot be used for each local district in Britain because differences between local areas' economic activity are significant and persistent. This section examines the stability over time of differences between local authorities, and of changes in economic activity between census years. Evidence on these aspects of stability is helpful when choosing methods for forecasting future local economic activity rates.

There are two main sources of data for local economic activity, the decennial Census and the Labour Force Survey (APS). The latter is extended by other surveys and termed the Annual Population Survey for the analyses released for local authority districts in the UK. It has a relatively small sample size when restricted to individual areas. Figure 3 shows its annual estimates and 95% confidence intervals for two areas for all people and for two selected age-sex groups, together with the Census result for 2011 which in each case is very close to the APS sample estimate for that year. To be able to reliably identify a local change, several years would need to be aggregated, so that no advantage is gained over the Census data. There are statistical estimation methods which could help to provide estimates of local trends, but at present they are not developed sufficiently to apply in a standard way in local demographic studies (ONS, 2011; Skinner, 1991). Since results later in this and the following section also suggest that local trends are not the best basis for forecasting, the APS is not considered further in this paper.

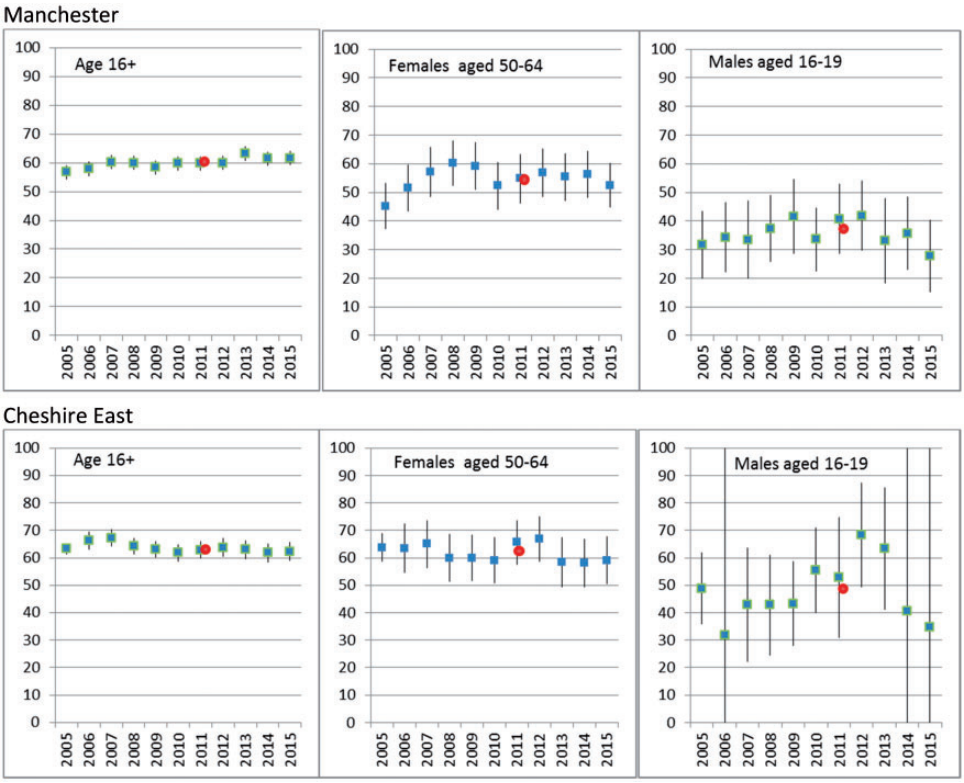

Figure 3. Estimates of economic activity from the Annual Population Survey, selected age-sex groups and local districts. *Note*: Vertical bars show the 95% confidence interval for each survey estimate (and extend from 0 to 100 when the sample size was very small). The survey estimates are shown for each year ending in March, from 2005 to 2015. The circular mark at 2011 is in each case the economic activity measured from the 2011 Census. *Sources*: NOMIS for the APS estimates and 95% confidence intervals; Census 2011.

For the analyses of this and the following section, the decennial census has been used in a database for the 348 Districts of England and Wales reported in the 2011 Census, together with data from 1991 and 2001 aggregated to District boundaries of 2011, made straightforward because all significant boundary changes involved amalgamation of whole districts. The age groups used are those published consistently from the three censuses for males and females, namely 16–19 and five year age groups from 20–24 to 60–64. An older age group is not consistently available, nor are data for consistent boundaries available for districts in Scotland or Northern Ireland.

While Figure 1 above gave the national values of economic activity at each age and sex, Table 2 summarises the variation of economic activity between local authorities and over time. Table 2 yields results that are immediately useful, indicating potential

Table 2. Stability of local economic activity 1991–2001–2011.

	Standard deviation of local economic activity each year			Correlation of local economic activity from one census to the next		Correlation of local change 91 to 01 with change 01 to 11	
Sex and age	1991	2001	2011	r91,01	r01,11	r	Significance
Persons							
16–64	3.2	4.6	3.7	0.88	0.94	−0.26	0.000
Males							
16–19	6.0	8.0	8.1	0.63	0.90	−0.07	0.194
20–24	4.3	10.0	10.6	0.69	0.97	0.04	0.506
25–29	2.0	3.4	3.2	0.82	0.86	−0.34	0.000
30–34	1.8	3.2	2.6	0.85	0.85	−0.43	0.000
35–39	2.0	3.4	2.8	0.91	0.89	−0.50	0.000
40–44	2.4	3.9	3.2	0.91	0.94	−0.59	0.000
45–49	3.2	4.7	3.5	0.93	0.95	−0.58	0.000
50–54	5.0	5.6	4.1	0.93	0.94	−0.15	0.006
55–59	7.9	7.7	5.0	0.90	0.94	−0.03	0.600
60–64	9.6	9.3	6.4	0.93	0.96	−0.01	0.794
Females							
16–19	5.2	8.0	8.0	0.60	0.90	−0.09	0.080
20–24	4.2	8.9	8.4	0.71	0.93	−0.14	0.008
25–29	4.6	5.1	4.2	0.77	0.85	−0.02	0.672
30–34	3.7	4.0	4.1	0.76	0.80	0.05	0.391
35–39	3.7	4.0	3.9	0.85	0.85	−0.02	0.745
40–44	3.9	4.7	4.0	0.84	0.91	−0.07	0.192
45–49	4.1	5.2	3.9	0.80	0.91	−0.26	0.000
50–54	5.1	5.7	4.5	0.85	0.89	0.08	0.125
55–59	6.2	6.4	5.1	0.84	0.89	0.15	0.006
60–64	5.2	5.2	5.5	0.89	0.94	−0.31	0.000

Note. Correlation from one census to the next – all values are significantly different from 0 at $p < 0.01\%$. Source: 1991, 2001 and 2011 Censuses, 348 local authority districts of England and Wales with boundaries at 2011 Census.

strategies for forecasting local economic activity.

First, the standard deviation of local authority economic activity shows no general pattern of reduction over time: there is no evidence of convergence between areas towards a national value. For the young age groups, the standard deviation increases, probably due to the counting of students as resident at their term-time address after the 1991 Census, creating more low-activity areas. But in no age group is there a clear trend towards less variation between areas, except perhaps among men over 50 where the variation is considerably less in 2011 than in either 1991 or 2001. This coincides with the recovery of older men's activity noted in Figure 1. The recovery was greatest among economically depressed areas that had been affected most by de-industrialisation of the 1970s. There may also be greater variation between areas at times of economic recession which coincided with both the 1991 and 2011 censuses.

Second, the correlation of local economic activity from one census to the next is high, for each age-sex group. The minimum correlation between 2001 and 2011 for any age-sex group is 0.80, and most are 0.9 or greater. This means that areas tend to maintain their position relative to the average, a stability that can be utilised in forecasting. For example, the lowest activity for men is found in ex-industrial areas and for women in areas with large Muslim populations. However, this stability does not mean that localities never change their relative economic fortunes. Changes may be predictable in particular local cases.

Third, local change from one period has not continued into the next period. Continuity of change would have been useful to guide local projections, but the correlations between change during 1991–2001 and change during 2001–2011 are low for all age-sex groups, the highest being 0.15. The strongest correlations are negative, for males aged between 25 and 49, where a decrease in the 1990s was followed by an increase in the 2000s.

In summary, it seems that local areas follow national fortunes to a large extent, but deviate from the trend in ways that were unpredictable from past performance, at least in the past two decades. Changes in the second decade tended instead to compensate the changes in the first period.

Tests of strategies for a standard sub-national projection of economic activity

The previous section's review of the past patterns of local economic activity suggests that a strategy for forecasting local economic activity should accept a steady ranking of areas relative to the national condition, but use a national projection to lift or depress the age and sex-specific activity rates by the same amount in each area. As mentioned earlier, this is the strategy employed for demographic rates in population and household projections.

In this section, we test out four variations of this strategy to hold local differences constant with respect to a national projection, and five further alternatives, each projecting the local economic activity rate from 2001 to 2011 by age and sex. The strategies are listed in Table 3, and the distinctions between them now clarified.

In strategies A and B, the national change is assumed to have been predicted correctly from 2001 to 2011, separately for each age and sex. In strategies C and D, the national change is projected as continuation of the change that occurred nationally between 1991 and 2001, separately for each age and sex.

The distinction between additive and multiplicative refers to the way in which a change in the percentage economically active from time 1 to time 2 is applied locally: either addition of the difference in

Table 3. Strategies to project the local economic activity rate from 2001 to 2011.

A	In line with national change 01-11 – additive
B	In line with national change 01-11 – multiplicative
C	In line with national change 91-01 – additive
D	In line with national change 91-01 – multiplicative
E	Continuing local change 91-01 – additive
F	Continuing local change 91-01 – multiplicative
G	Continuing local cohort change 91-01 – additive
H	Continuing local cohort change91-01 – multiplicative
I	No change.

percentages or multiplication by the ratio of percentages. For example, if the national rate for an age-sex group has changed from 50% to 55%, and the local rate was 25%, local rates are either increased by 5% points (additive, becoming 30%) or multiplied by 55/50 (multiplicative, becoming 27.5%).

Strategies E and F ignore the national change and continue the local change from 1991 to 2001, separately for each age and sex. Strategies G and H are also driven by the local change from 1991 to 2001, but applied to cohorts. For example, the increase in economic activity for 20–24 year old males in 1991 as they became 30–34 in 2001 is applied to the 20–24 year olds in 2001. This is only possible for five-year age groups that appear in the data 10 years younger in 1991. The younger age groups 16–19, 20–24 and 25–29 are projected by period change as in strategies E and F.

Finally, strategy I is a benchmark projection which assumes that the economic activity rate in 2011 will be unchanged from 2001, for each age and sex group.

In each case, the projected economic activity rate is constrained to remain within limits of 0% and 100%. For example, if the application of an upward national or local trend brings the rate above 100%, it is reset to equal 100%.

Accuracy averaged across all age-sex groups

Figure 4 shows the results of each strategy applied to the 2001–2011 period. Each projection is compared to the 2011 values and the absolute difference in percentage points summarised by its median across the 348 Districts. The Median Absolute Error (MedAE) is commonly used in the evaluation of local demographic estimates and projections to indicate the 'typical' error, not influenced by outliers (Smith et al., 2013). In Figure 4, the mean of the MedAE is taken across the 20 age-sex groups, while the MedAE for individual age groups is shown in Figure 5.

The first conclusion from Figure 4 is that an accurate national projection is the key to success. Strategies A and B, which assumed the 2011 national change was known, achieve an average local accuracy across all areas and age-sex groups well under two percentage points, while all other strategies' average accuracy are in the range 4.8% to 6%.

The additive or multiplicative options make little difference to the results. Where an increase is being applied as with women's activity rates, a multiplicative application to an area with already high rates will increase it more than other areas, which is counter-intuitive, as there is a smaller capacity for increase. On the other hand, the muliplicative application of a decrease would make more intuitive sense than the same percentage reduction in all areas, which would be unexpected in areas with already low economic activity. The logic would lead to a hybrid application of past change that

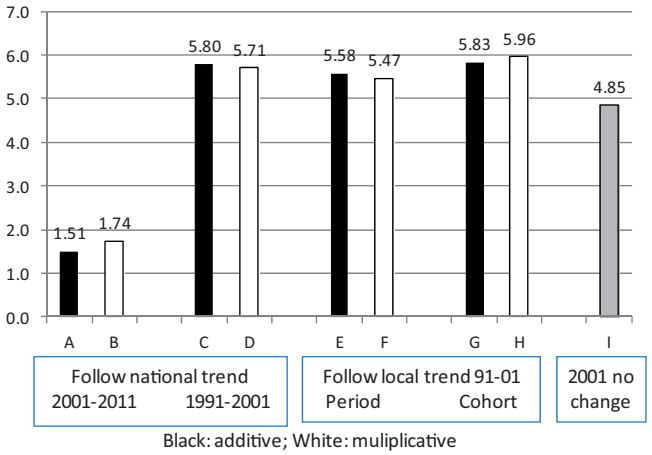

Figure 4. Median absolute error in 2011 economic activity rate across 348 Districts, for nine forecasting strategies. *Notes*: Median Absolute Error of the percentage economically active in each of 348 local authority districts of England and Wales, averaged across 20 age-sex groups. The forecasting strategies A to I are further explained in Table 3 and the text. *Source*: Author's calculations from Census data from 1991, 2001, 2011.

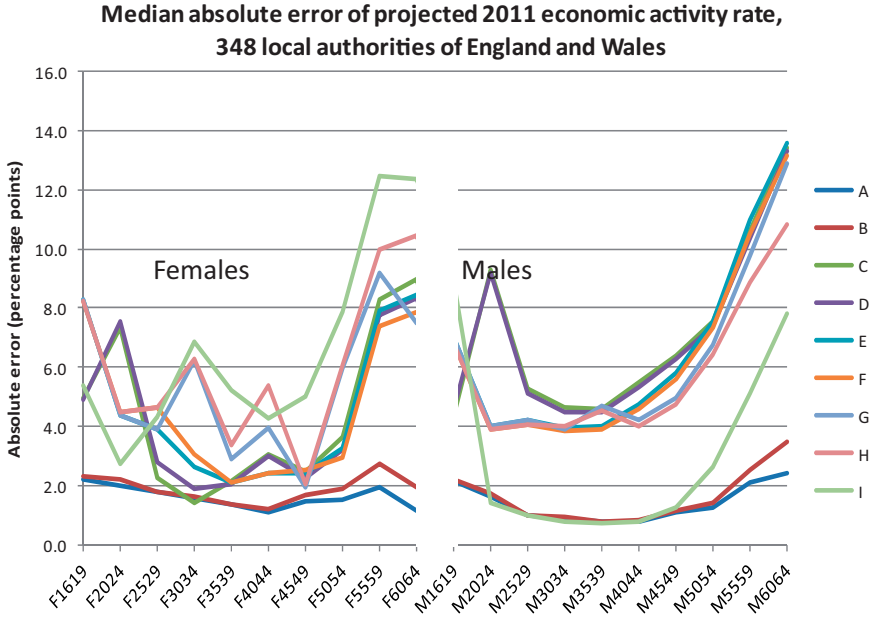

Figure 5. Accuracy of nine projections of 2011 economic activity rate by age and sex. *Notes*: Median absolute error of percentage economic activity across 348 local authority districtsof England and Wales. *Source*: Author's calculations from Census data from 1991, 2001, 2011.

recognises limits in a sensitive manner. However, the evaluation here of the two options suggests that there is not much practical difference in the accuracy of results.

Repeating the change of the decade 1991–2001 gave similar levels of accuracy for 2011 whether national change was applied to all areas or local change was implemented for each age group or each cohort. The six strategies C to H all achieved an accuracy of between 5.5% and 6.0% when averaged across areas and age-sex groups. There was a slight improvement of 0.2 to 0.3 percentage points when applying local change (strategies E and F) rather than the national change (C and D).

A sobering result is that all six strategies using the experience of 1991–2001 were less accurate than assuming no change at all in economic activity rates after 2001. This was above all because the substantial decrease in male economic activity in the 1990s was halted and reversed in the 2000s. One might argue that in 2001 the reversal could not have been confidently predicted. One can also acknowledge that as the reversal became clear from national data during the early 2000s, a local projection could have taken it on board in updates during the decade.

Accuracy varying by age and sex

Figure 5 shows the accuracy of each strategy separately for each age-sex category. The accuracy of the 'no change' strategy I is a fortuitous result of its low error for males aged between 20 and 49. But that strategy performs particularly badly for women aged 30 and older whose economic activity increased substantially in the 2000s. The slight advantage of the additive approach over the multiplicative in the first two strategies A and B is clear throughout the age range, where the applied changes were generally increases. However, there is no hard and fast rule, as for example, the multiplicative approach was more accurate for women over 50 when strategies C and D are compared, even though the changes being applied from the 1990s were also increases.

The local cohort approach (strategies G and H) is only different from the local period approach for ages 35 and above. In this comparison, the cohort outperforms the period for men but not for women.

Accuracy of aggregate economic activity for all persons

A further question of interest is the advantage gained by forecasting each five-year age group separately. From our data, we can apply each strategy (except the cohort approach) to the population aged 16–64 as a whole, for example, applying the national change for persons aged 16–64 as a whole, to each local area's economic activity for that whole age group. Table 4 compares

Table 4. Accuracy of projected 2011 economic activity rate for persons aged 16–64.

Median absolute error, percentage points	Projected directly	Aggregate of projections for 6 age-sex groups	Aggregate of projections for 20 age-sex groups
A: In line with national change 01-11	0.92	0.99	0.94
E: Continuing local change 91-01	2.46	2.30	3.50

Note: Median absolute accuracy of percentage economic activity across 348 LADs of England and Wales. Two selected strategies A and E (see text for further description).

the accuracy of this aggregate projection with the result of adding the 20 age-sex groups projected separately, and also a projection of just three age groups for each of males and females that capture the young ages 16–24, prime age groups 25–49 and older groups 50–64. Projection strategies A and E are shown in the table; the other strategies give similar conclusions.

If the economic activity of the population as a whole were the only indicator of importance, Table 4 suggests that there is no gain in accuracy from aggregating separate projections of each age-sex group. The accuracy of projections made directly of those aged 16–64 equalled or slightly exceeded the aggregate of age-sex specific projections, when an accurate national projection was assumed (strategy A). The lower accuracy of continuing past change (strategy E, with similar results for all strategies C to I) was also not greatly improved, if at all, by working with age-sex groups. In spite of the changing age structure of the population, and the different trends observed for economic activity for males and females of different ages, it seems that their aggregate impact on economic activity is all that is needed to reasonably project future economic activity, in the aggregate.

In practice, the age-sex disaggregation is important to major applications, for example, to consider numbers of older and younger workers and to allow modelling of household needs. It is unlikely that a strategy will be acceptable without an age-sex breakdown.

Combining strategies

Since an accurate national projection is clearly an important element of accuracy, but past local information is intuitively important and slightly improves performance compared to a past national trend (see discussion of Figure 4 above), a strategy that combines the two approaches may be more accurate than either. Combining strategies is a well-tested refinement that sometimes produces positive results (Armstrong, 2001; Wilson, 2015). It is a more complex strategy to implement, involving first applying local change and then scaling all results to meet the national projection:

> J Continuing local change 91-01 (additive, strategy E), then all local results scaled by the same factor to give a national result consistent with the national projection of 2011.

This hybrid strategy was implemented for each age-sex group and constrained to remain within the range 0% to 100% in the same way as strategies A to I. Its MedAE across all areas, averaged across age-sex groups is 3.6, midway between the accuracy of strategies A and E (Figure 4 above). The hybrid strategy worsened the accuracy in some age groups due to the adverse impact of scaling, and in no age group did the hybrid strategy gain a better average performance than Strategy A.

Implementation with software, scenarios and sensitivity testing

In summary, the empirical results above indicate a range of strategies for local projections of economic activity, in which a good national forecast is a strong advantage because local change tends to follow national fortunes. If local data are to improve a local forecast beyond giving it a starting point relative to national economic activity, evidence and argument would need to demonstrate why past local trends would continue, as they have not historically tended to, or why local conditions are changing in ways likely to affect economic activity differently from the national trend.

The calculation of a projection is a straightforward multiplication of the forecast age-sex composition of the population by the

forecast age-sex specific economic activity rates, which can be achieved in spreadsheet applications or statistical software. In the UK, the standard software used in local planning is the Derived Forecasts module of POPGROUP cited in the introduction, developed in collaboration with local authorities and now owned by the Local Government Association. It allows flexible definition of age-sex groups for economic activity, the specification of a reference projection of activity rates to be applied to evidence for recent local rates, in either additive or multiplicative modes, and provides comparisons of different scenarios based on varying assumptions about the development of either economic activity or population change.

The POPGROUP software integrates population, household and labour force projections, and implements the more complex calculation of the impact of jobs or housing targets on population, appropriately combining assumptions for demographic rates or accounts, economic activity, household formation, commuting, unemployment, occupancy of housing and the institutional population (Simpson, 2016). It provides basic graphical and tabular analysis and the decomposition of change in the labour force due to population change and to changing economic activity, while its Excel platform allows generic research skills to be used for further tailored analyses. POPGROUP is used for some sub-national projections (but not yet of the labour force) by the statistical agencies of Wales, Scotland and Northern Ireland.

Plausible scenarios and sensitivity testing

Plausible scenarios (Ramirez and Selin, 2014) are important in settling on a most suitable forecast and a range of possible futures around it. In general, the scenarios test the sensitivity of a labour force forecast to alternative assumptions. The alternatives serve two purposes – first to illustrate uncertainty about current trends so that planners can acknowledge and cater for the range of labour supply that may occur, and second to consider the impact of new factors that would alter the current trends, including specific policy changes and possible external economic and other 'shocks' to the system. The distinction between these two purposes is sometimes termed 'policy off' and 'policy on', but inappropriately, since current trends include the impact of recent policies. The distinction is better thought of as 'business as usual' and 'new policy'.

The first set of scenarios, that illustrate uncertainty about current trends, is likely to include:

- A range of national economic activity forecasts based on logical extrapolation of the impact of existing national trends and the impact of current national policy on education and state pension age.
- Variations based on the study of local evidence of how economic activity has been changing relative to the national experience.
- A range of population forecast outcomes to reflect uncertainty in the population forecaster's assumptions about fertility, mortality and migration. These will affect the size and age-structure of the population which in turn is a major impact on the future size of the labour force.

The second set of scenarios, responding to new factors, is likely to include:

- Policy aspirations to restrict or to expand the number of jobs in the locality, which are usually known as 'jobs-led' forecasts. They might be led by the local number of jobs indicated by an economic forecast which itself includes national or sub-national policy targets.
- 'Housing-led' forecasts, where a target level of house-building determines the migration to a locality and therefore affects the size of the labour force.

- Understanding of local educational and social changes which would impact on the economic activity of particular age-sex groups differently from the past and from national expectations.

The many possible scenarios that a forecaster can implement have to be reduced to be useful to policy discussions. Identification of common features among scenarios may be helpful. In the UK, current population growth is sufficient in most localities to drive the growth of the labour supply to a greater extent than variations in levels of economic activity. Nonetheless, consideration of the impact of alternative policy targets may have marginal effects with major implications for housing requirements. Experience also suggests that policy aspirations are generally under-achieved, so that planners do well to build in contingencies, a practice which demands a range of scenarios.

Discussion and further research

This review of methods of forecasting the labour force and their application to sub-national areas has answered major questions. A robust national projection available for use in sub-national planning and research is an essential ingredient because local economic activity tends to follow national trends. These trends at present include the later entry of young adults into the labour market, a continuing increase in women's economic activity and a later exit from the labour market partly as a result of changes to the State Pension Age. The analyses of this paper show that local census and survey data are sufficient to provide a starting point of local characteristics of economic activity, but insufficient to usefully project forward past trends in a deterministic manner.

This review has also laid a platform for further research and identified a large number of areas where that research is likely to be fruitful. The empirical results based on the censuses of 1991, 2001 and 2011 for local authority districts in England and Wales could usefully be extended using data from other countries and for smaller and larger areas.

The current EC and OBR national forecasts of economic activity have been show in this paper not to be fit to guide local planning. There is a clear need for the development of an evidence-based, documented national projection for the UK or its countries, disseminated by an established public research centre or statistical agency. Attention to the role of student economic activity and the impact of changing eligibility to the state pension should be major themes of that research. Attention to methods should develop the cohort approach and combine it with other time series analysis, as have, for example, Bermudez et al. (2013).

Local studies can more rigorously explore the potential and limits of forecasting economic activity based on local characteristics in addition to age and sex. Ethnic composition is one reasonably predictable factor associated with economic activity particularly for women of Muslim background, for which local demographic projections are in development (Owen et al., 2015; Rees et al., 2015). Further research may indicate other characteristics such as industrial structure that could help local forecasts, when those characteristics are changing in a foreseeable way. Although correlates of economic activity are not necessarily capable of improving forecasts because they are too unpredictable, their study may indicate groups of local areas which could be profitably forecast together.

Other topics for research include the further exploitation of national surveys using small area estimation techniques, the study of forecast accuracy including the performance of different forecasting strategies and combinations of them, the influence in planning of assumptions seldom tested such as the exclusion of communal establishments from

survey estimates, and the impact of commuting and unemployment when relating labour supply to labour demand in local planning. These call for statistical, planning and econometric research skills combined with a careful dialogue with practitioners. There is a strong case for improved research from several disciplinary perspectives to support the forecasting needs of local planning.

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