NSW Intergenerational Report

2016-17

Technical Note

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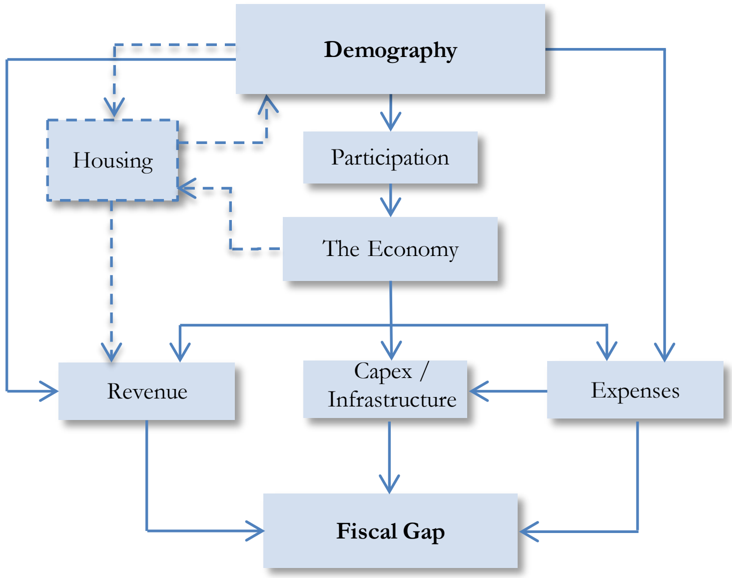
This Technical Note details selected aspects of the modelling underlying the 2016 NSW Intergenerational Report. It is not a comprehensive summary of all technical aspects of the model, nor is it a 'modelling manual'. Rather, it offers additional detail on certain aspects of the modelling which are either new to this year's Report (e.g. the interaction between the housing market and migration flows), or where further material may be of interest but space constraints have prevented its inclusion in the main body of the Report.

1. The Long-Term Fiscal Pressures Model

Underpinning the 2016 NSW Intergenerational Report is the Long-Term Fiscal Pressures Model (LTFPM). Developed by Treasury, this demographic-economic model is designed to project trends in population, the economy, expenses, revenue and capital expenditure over the next 40 years. This model is not an attempt to forecast what the budget will look like in 2055-56 but rather to project what might happen should there be no change in current policy.

Figure 1: The Long-Term Fiscal Pressures Model



The model comprises eight major modules outlined above in Figure 1. The demographic module is shown at the top because the population estimates are the key driver of the economic and fiscal projections. Built into the demography module is a no-ageing scenario that allows the model to capture the economic impacts of the ageing of the population and its influence on revenues and expenses over time.

Flowing from demography is the participation module, which has been updated to project trends in full-time and part-time participation for males and female by five year age cohort. Participation modelling forms the basis of the long-term projections for employment and hours worked and combined with productivity generates gross state product (GSP).

A new addition in the 2016 LTFPM is an underlying housing demand model – with inputs from the economic module and feedback with the demographic model. The inclusion of an endogenous housing model linked to demography has allowed the analysis and assessment of the demographic, economic and fiscal impacts of housing supply.

The final stage of the model is the fiscal component, which comprises the revenue, expenses and capital expenditure modules. Together, these modules form the basis of the projection of the State's primary balance and fiscal gap calculations. These modules have been constructed to model specific items of government revenue and expenditure and thereby allow an analysis of the fiscal pressures that New South Wales is expected to face.

2. Demographic Modelling

2.1 Modelling mortality

Death rates lend themselves well to projection through extrapolation, so this has become the basis of most mortality forecasting methods (Booth and Tickle, 2008).[1] The particular approach adopted for the modelling is the Lee-Carter method, which models age- and sex-specific mortality rates in terms of a time-dependent unobserved intensity index of mortality.

In more detail, the model obtains age- and sex-specific probabilities of dying in each year, $q_{x,s,t}$, both over history and through the projection period, from corresponding historical and projected mortality rates, $m_{x,s,t}$. Here x denotes age, *s* denotes sex and *t* denotes the particular year. Note that henceforth we drop the subscript *s* for simplicity, noting that the same approach is adopted and separately applied for men and for women.

For a given year, the concept of mortality rate used here for a given age cohort is defined by:

$$m_x = \frac{Number\ of\ deaths\ in\ the\ cohort\ between\ ages\ x\ and\ x+1}{Number\ of\ person\ years\ lived\ in\ the\ age\ range\ x\ to\ x+1}$$

These mortality rates can then be mapped across to probabilities of dying (and thence in turn to life expectancy) by age by sex, based purely on one additional set of available data, namely the average number of person years lived during the given year by those (men or women respectively) dying in that year (Preston *et al.*, 2001). For most age groups it is intuitive that this parameter should approximately be equal to 0.5. This is because although some people live out most of the year and others die early in the year, there is generally a continuous uniform distribution of deaths throughout the year. The empirical evidence confirms that this is generally the case for most single year age groups. However, it is certainly not true for infants (aged 0) and it is also unlikely to hold for the oldest age groups such as those aged 100+. Infants face the greatest risk of death as newborns and so this parameter is much less than 0.5 for them (that is, those infants who die often do so within the first few weeks after birth). Similarly, it is intuitive that at older ages, the probability of death rises rapidly with age and so people in these age groups are more likely to die earlier in the interval, rather than later.

Given the existence of a mapping from mortality rates to probabilities of dying, it is sufficient to focus on the process for obtaining projected mortality rates by age and sex in each of the next 40 years.

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1 An alternative approach of projecting mortality based on the opinion of experts has generally been found to underestimate reductions in mortality. This has been attributed to the tendency of expectations to lag rather than lead actual experience (Ahlburg & Vaupel, 1990). Also, explanatory projection methods, which are mortality models based on lagged risk factors, are often used in conjunction with expectation methods – but their usefulness is limited to short time lags and they are not generally helpful for long term projections (Booth and Tickle, 2008).

Historical mortality rates data

We obtained customised historical mortality rates from the Australian Bureau of Statistics. These annual 'age-specific death rates' (ASDRs) span from 1971 to 2013 (forty-three observations per cohort) for males and females (as well as all persons). The data were further divided into NSW series and Rest-of-Australia (RoA), and were mostly provided in five-year cohorts with the exception of the first two groups and the last group. Specifically, twenty-two cohorts were obtained: 0, 1-4, 5-9, 10-14 … 95-99, 100+. To obtain series for single-year age groups, interpolation was carried out by a cubic spline method.

Modelling historical mortality rates in terms of an unobserved factor

Rather than seeking to establish a relationship between mortality rates and specific variables such as health risk factors, we next applied a form of unobserved components analysis to model the age patterns of mortality from the data in terms of an unknown, time-varying factor. Specifically, we estimated the following underlying Lee-Carter model:

$$\ln(\mathbf{m}) = \boldsymbol{\alpha} + \boldsymbol{\beta}\mathbf{k} + \boldsymbol{\varepsilon}$$

where $\ln(\mathbf{m})$ is an $\mathrm{X} \times \mathrm{T}$ matrix of the observed historical log-mortality rates; $\boldsymbol{\alpha}$ is an $\mathrm{X} \times 1$ vector; $\boldsymbol{\beta}$ is an $\mathrm{X} \times 1$ vector; $\mathbf{k}$ is $1 \times \mathrm{T}$; and $\boldsymbol{\varepsilon}$ is an $\mathrm{X} \times \mathrm{T}$ matrix of residuals. Here β_{x} measures the response at age x to a change in the time-varying index $\mathrm{k_t}$ representing the intensity of mortality in year t (Booth and Tickle, 2008), while α_{x} is the average log-mortality at age x over time.

With regard to the use of log-mortality rather than mortality in the modelling, logarithmic transformations of time series data are common and are particularly useful for series that display exponential trends. In the case of mortality rates, a logarithmic transformation results in a roughly linear decline over time – so the picture is one of approximately linear log-mortality rates being modelled by the average log-mortality over time for each age together with a time-varying index $\boldsymbol{k}$ which applies to all ages. How this overall change in mortality over time translates to the mortality rate of each age group is determined by the vector $\boldsymbol{\beta}$, which contains a different parameter for every age.

Estimation of this model was then undertaken via a Singular Value Decomposition approach, yielding values of $\beta_{\mathrm{x}}, \mathrm{k_t}$, and the average mortality rate α_{x} (and hence also fitted values for log-mortality rates for each age x observed in each year t over history).[2]

2 Lee and Miller (2001) suggest several other modifications designed to: adjust k_t to push the fitted life expectancies closer to the observed ones; use only data from the latter half of the twentieth century to minimise structural shifts (which our data set automatically adheres to since it begins in 1975); and eliminate 'jump-off error' in forecasting by doing so from the most recent observed mortality rates rather than the fitted values.

Modelling the time-varying index *k* and obtaining mortality rate projections

Finally, to obtain *projected* values for age- and sex-specific mortality rates (and hence probabilities of dying), it remained to carry forward the time-varying index k_t over the projection period. To do this, our prior was to model it as a random walk with drift:

$$k_t = k_{t-1} + \delta + \epsilon_t \, .$$

This was the functional form used by Lee and Carter in their original 1992 paper, and has been found to be a suitable one in almost all applications (Booth and Tickle, 2008). Under this approach, k_t is equal to its value last year plus some (mean zero) error and a constant which, given declining mortality rates, has a negative value.

To test whether this was a suitable functional form for our NSW data we estimated the following regression using our k_t data:

$$k_t = \gamma k_{t-1} + \delta + e_t \, .$$

This confirmed that γ, the coefficient on k_{t-1}, was not statistically different from one, and that the constant 'drift' term δ was statistically significant. Overall, a random walk with a drift thus seems to fit the NSW data as well, and so was used to extrapolate k_t forward over the next 40 years – hence in turn yielding projected log-mortality rates by age and sex for each year (and thence also age- and sex-specific probabilities of dying).

2.2 Fertility Rates

The projected total fertility rate (TFR) is the sum of age-specific fertility rates live births at each age of mother of the estimated resident population of that age. It represents the number of live births a female would bear during her lifetime if she experienced current age-specific fertility rates at each age of her reproductive life.

The NSW TFR long-run assumption of 1.95 is consistent with the average of the last ten years. This is slightly higher than the national 10 year average of 1.91 and is broadly in line with Australian fertility rate of 1.9 in the Commonwealth Government's 2015 Intergenerational Report.

The profile of the total fertility rate is calculated using custom age-specific birth rates for New South Wales from the Australian Bureau of Statistics based on the Births (cat no 3301.0) release. The age-specific fertility rates are converted into a probability distribution for each year in the time series (1975-2014).

Richards curves were used to project the mean and standard deviation of the age of mothers to 2056. These projected means and standard deviations were applied to a standard normal distribution curve, which was distorted to be consistent with the 2010 distribution of births by age of mother. This provides a probability distribution of the mother's age at the time of childbirth over the projection period. This distribution is combined with the total fertility assumption to yield age-specific birth rates, which when applied to the overall female population provide an estimate of the number of births each year.

3. Economic Modelling – Participation Rate Projections

3.1 Participation

The participation rate projections published in the 2011-12 LTFP report were developed using a methodology consistent with that used by the Productivity Commission in 2005 for its report on the *Economic Impacts of an Ageing Australia*. The 2016 projections use the same methodology.

The 2016 participation rate projections were required as actual participation rates have varied from the 2011-12 projections due to unforeseen trends and the availability of new data. The key development since the 2011-12 Report is that the downturn in participation post-GFC has become a more long-lasting feature than was projected five-years ago.

The other key factor affecting the new projections is the Australian Bureau of Statistics (ABS) making available both full-time and part-time participation rates by age and sex at the state level, allowing the projection of participation on both a full-time and a part-time basis by gender. These factors have resulted in lower participation rates for younger age groups, higher for prime working age groups and lower for older age groups, compared to the 2011-12 Report.

Participation rate modelling

The ABS Labour Force data provide headcount labour force participation by single year of age as well as by full-time or part-time employment status. Full-time employment is defined as working greater than 35 hours per week. The labour force participation rate is measured by both full-time and part-time participation and for unemployed, full-time or part-time work sought. The part-time definition for unemployed does not specify how many hours under 35 hours per week are sought.

Previously, a person was assumed to either participate in the labour force or not participate. As the ABS now publishes both full-time and part-time participation by age, sex and state, the analysis has now been extended to project both full-time and part-time participation rates by age and sex for New South Wales and the rest of Australia. The projection of trends in full-time and part-time work allows more detailed analysis of future work trends and enables the estimation of future hours worked.

Changes in hours worked arising from changes in the share of full-time and part-time work can now be projected, although changes in hours worked due to changes in the average hours worked within full-time and part-time classifications remain outside the scope of the model.

Methodology

The new participation rate projections were modelled using the dynamic cohort approach adopted by the Productivity Commission,[3] the Australian Treasury for the Commonwealth 2015 Intergenerational Report and the NSW Treasury for the 2011-12 Report.

In brief, the steps involved in applying the methodology are:

1. **Averaging ABS Labour force Participation data.** The model used data from the ABS Labour Force survey.[4] Monthly full-time and part-time participation rates for males and females by 5-year cohorts in New South Wales and Rest of Australia (RoA) were averaged over fiscal years. (For example: The average of the monthly full-time participation rates for July 2006 through to June 2007 = a figure for the 2006-07 fiscal year)

2. **Trending participation rate data.** The resulting annual participation rates were trended using a Hodrick-Prescott filter to eliminate volatility associated with short-run business cycles and any sampling error.
3. **Entry and exit rates.** So-called 'entry' and 'exit' rates were derived for each five year age cohort, with respect to their labour force status five years earlier.

The entry rate is defined at time *t* as 'the net addition to the labour force relative to the initial number of people who were not in the labour force five years previously'. The exit rate is defined as 'the net reduction in the labour force relative to the number of people who were initially in the labour force in that cohort'. For example: the entry rate for 45-49 year olds in 2008 is the rate at which 40-44 year olds, who were not in the in the labour force in 2003, had entered the labour force by 2008; similarly the exit rate for 45-49 year olds in 2008 is the rate at which 40-44 year olds, who were in the labour force in 2003, exited the labour force by 2008.

4. **Entry and Exit rates were modelled as Richards curves.** The Richards curves were fitted to the known data using non-linear least squares.
5. **Extract future participation rates from projected entry and exit rates.** Having projected the future path of entry or exit rates, projected participation rates were then recovered.

3 Productivity Commission, (2005), Cohort Analysis Technical Paper 3, Economic Implications of an Ageing Australia, April. Pg 12-13.
4 ABS Labour Force (6291.0.55.001), Detailed Electronic Monthly, July, Data Cube LM2

4. Fiscal Modelling

4.1 Expenses

Other Growth Factors (OGFs)

OGFs are calculated using historical trends in expenses and are designed to reflect cost pressures in different functional areas that are not captured in the model through demographic and economic drivers.

OGFs may also reflect unidentified policy changes which remain embedded to some extent within the expenses. These are referred to as 'policy drift' as they reflect expense trends that occur in the absence of identified policy decisions, but cannot be attributed to economic and/or demographic factors.

The OGFs were calculated using historic expense data from the ABS Government Finance Statistics (GFS) Government Purpose Classification (GPC) for a 36 year period from 1978-79 to 2013-14.[5] The data from 1978-79 to 1997-98 is a derived accrual version of cash-based GFS data, while the data from 1998-99 reflects accrual-based government finance statistics.

Using historic expense growth for each functional area, the OGF is the residual after accounting for real GSP per capita growth, population, consumer price inflation, demographic composition and identified policy changes. For each functional area, the OGF is obtained by constructing an index based on the residual component of expense growth that is not explained by these known drivers. Mathematically, historic recurrent expense growth can be expressed as:

$$\frac{E^i_{t+1}}{E^i_t} = \frac{GSP_{t+1}}{GSP_t} \cdot \frac{POP^i_{t+1}}{POP^i_t} \cdot \frac{CPI_{t+1}}{CPI_t} \cdot \frac{OGFI^i_{t+1}}{OGFI^i_t} \cdot \left(1 + PolicyGrowth^i_{t+1}\right) \quad (1)$$

where: E^i is government expenditure for expense category 'i'; GSP is real gross state product per capita; POP^i is the state estimated resident population weighted by the age-cost index for expense category 'i'; CPI is the capital city consumer price index; $OGFI^i$ is an OGF index for expense category 'i'; and '$PolicyGrowth^i_{t+1}$' is the growth in expenditure in expense category 'i' between years 't' and 't+1' due to changes in government policy. The population term in equation (1) is weighted to take account of the expenditure impacts of demographic change for each policy area, so that both the effects of total population growth and demographic compositional change are captured by this term (see further discussion of age-cost indices below).

The "*PolicyGrowth*" term represents the growth in expenditure arising from explicit government policy decisions. Some care is needed to distinguish between additional funding to accommodate growing demographic demand and additional funding to improve the standard of a service. Only the latter is considered a genuine policy change. For example, in education, a decision to

[5] Government Finance Statistics, Australia (2013-14) ABS Cat No 5512.0 and unpublished ABS data

decrease class sizes would be a policy change, whereas the opening of a new school to meet population growth would not.

Equation (1) is used to extract the values of the OGFI terms using historic data, as the other terms may be calculated by other means. The (gross) growth rate of the OGFI is applied to an index arbitrarily starting at 100 and is fitted to a constant growth curve of the form described by equation (2):

$$OGFI_t^i = e^{\alpha + OGF^i \cdot t} \tag{2}$$

Taking the natural log of (2) gives:

$$\ln(OGFI_t^i) = \alpha + OGF^i \cdot t \tag{3}$$

Linear regression is applied to equation (3) to extract the best fit for the OGF for each expenditure category. The OGF can therefore be understood to be the historic best fit constant expense growth rate for each expenditure category once the effects due to growth in GSP, population (growth and compositional), prices and policy are taken into account.

An alternative approach would be to compute the average growth of the OGF index rather than use the best fit; however, the best fit approach is preferred as all data points contribute to the result using this method, whereas the averaging approach can yield a biased result if either of the two endpoints is anomalous.

In line with the 2011-12 Report, the OGFs for each functional area were calculated separately for two time intervals. In this report the time periods are from 1978-79 to 1997-98 (interval 1) and from 1998-99 to 2013-14 (interval 2). The projections use a weighted average of the OGFs from the two periods. A higher weighting was applied to the OGFs from the second interval as this time period is more representative of likely current and future cost pressures and the more recent data is of better quality.

The OGFs by functional area are presented in Table 3-2 in Chapter Three of the main report. Although they capture the expense pressures in excess of economic growth, inflation, demographic factors and identified policy changes, they may also reflect increases in demand for particular services over time, which are not explained by specific policy changes. Such increases may have been implemented in past budgets as parameter or technical adjustments, or they may reflect larger than expected costs associated with certain policy changes.

The Education OGF has previously been interpreted as representing an inability to achieve the full savings associated with trends away from public schools over the last 36 years. The lower OGF for Education in this report, compared with the 2006-07 Report, reflects a projected slowing in these trends over the next 40 years. In this report the OGF for school education was calculated in line with other functional areas, which is different from the method used to calculate the school education OGF in the 2011-12 report. Given this methodological change, the value for the '2011-12 OGF' reported in Table 3-2 of Chapter Three is the number that would have been computed in that report (i.e. using the data and projections for the 2011-12 Report) using the current method.

Age-Cost indices

An important component of the expense growth rate modelling is to identify and categorise functional areas as 'age sensitive' or 'not age sensitive'. For a functional area to be considered age sensitive, two main criteria must be met:

- Usage and/or cost of usage varies according to age cohort – for example, Health expenses may be higher for infants and the elderly than for other cohorts; and
- Expenses for the functional area are demand driven. A demand-driven area of government service delivery is one where the standard of service is set at a defined level and is universal. Service levels must therefore endogenously expand to reflect increases in demand.

Examples of demand driven functional areas include health and education. In contrast, transport services are considered supply driven as usage increases to reflect transport and infrastructure availability. However, in practice, functional areas are neither completely demand nor supply driven. As such, judgement must be applied when attributing expenses to age-cost factors.

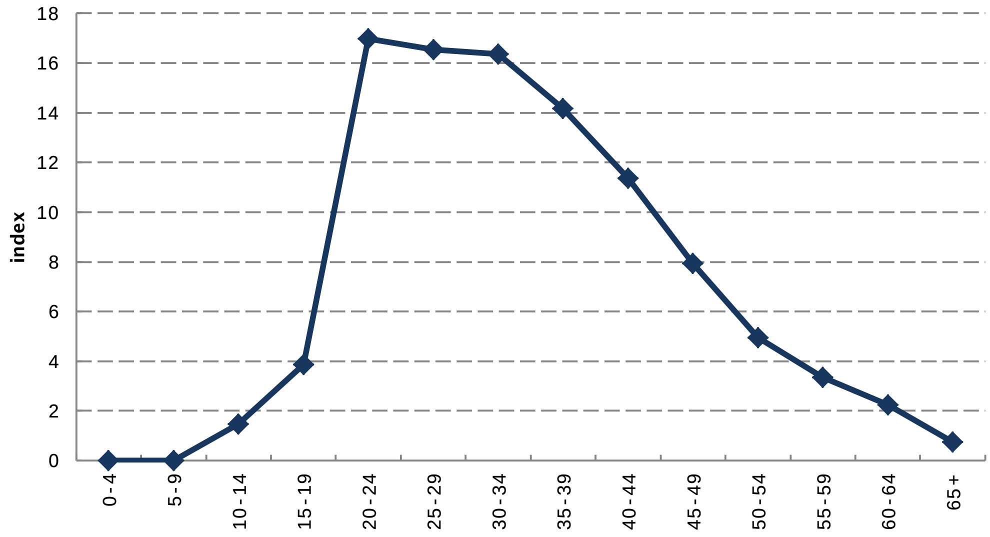
Age-cost indices were constructed using five-year age cohorts for the nine functional areas that meet the 'age-sensitive' criteria – namely: prisons and corrective services (including juvenile justice); primary and secondary education; tertiary education; transport of school students; patients of acute care institutions; community health services; family and child welfare services; welfare services for the aged and disabled; and other welfare services. The age-cost indices used in the model are set out and discussed briefly below, and the data sources used in their development are in Table A1 at the end of this section.

The age-cost indices are used to identify the annual increase in expenses from demographic compositional change. This is done by taking the weighted sum of the population by age cohorts, using the age-cost index values as the weighting factors. The growth rate of this weighted population is equivalent to the growth rate of expenses due to demographic factors, both compositional and population growth. The compositional effect is isolated by subtracting the growth rate of the total (unweighted) population from the growth rate of the weighted population.

Although considerable effort was made to establish that the age-cost indices are representative of all expenses and are stable over time, the data used to create them are not available for all expense components over the whole historical period. Hence, some aspects of their coverage and stability remain based on assumptions, to an extent.

Age-cost indices were developed using usage and cost per usage data for the relevant functional areas, displayed in 5-year age cohorts and normalised so that the total population usage index equals 100. The charts below show age group contributions to the indexes for various functional areas.

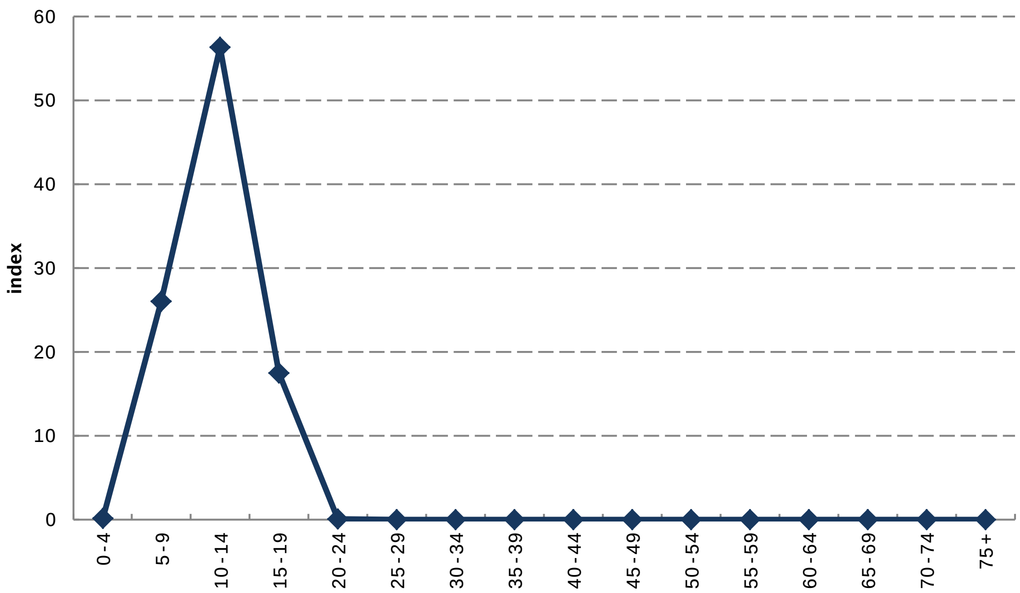
Chart 1: Prisons and Corrective Services (inc. Juvenile Justice)



Source: NSW Treasury

Chart 1 shows the usage index for 'Prisons and Corrective Services', which includes both prison stays and community supervision for both juvenile and legal age offenders. The index is based on data provided by the NSW Departments of Corrective Services and Juvenile Justice and shows that usage is concentrated amongst the 20-24 to 30-34 age cohorts, steadily declining thereafter.

Chart 2: Primary and Secondary Education

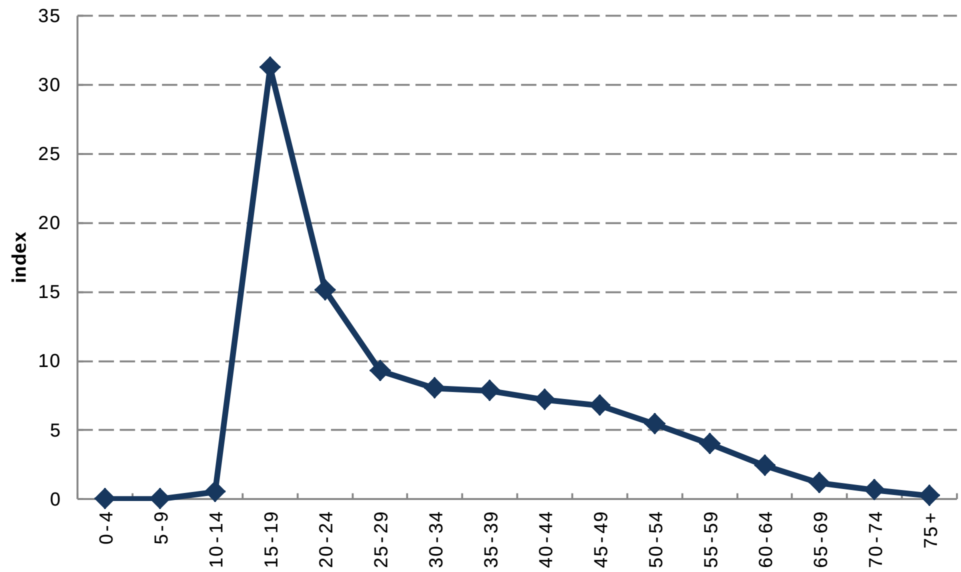


Source: NSW Treasury

The index for primary and secondary education is a combination of usage and cost of use. As expected, the youngest age groups drive education demand. The index declines sharply after the 10-14 age cohort and is zero for the 20-24 cohort and beyond as students move on to tertiary education or the workforce.

This index is derived from ABS age-based school participation data (ABS 4221.0) and NSW Treasury expense data on the cost of educating primary and secondary students.

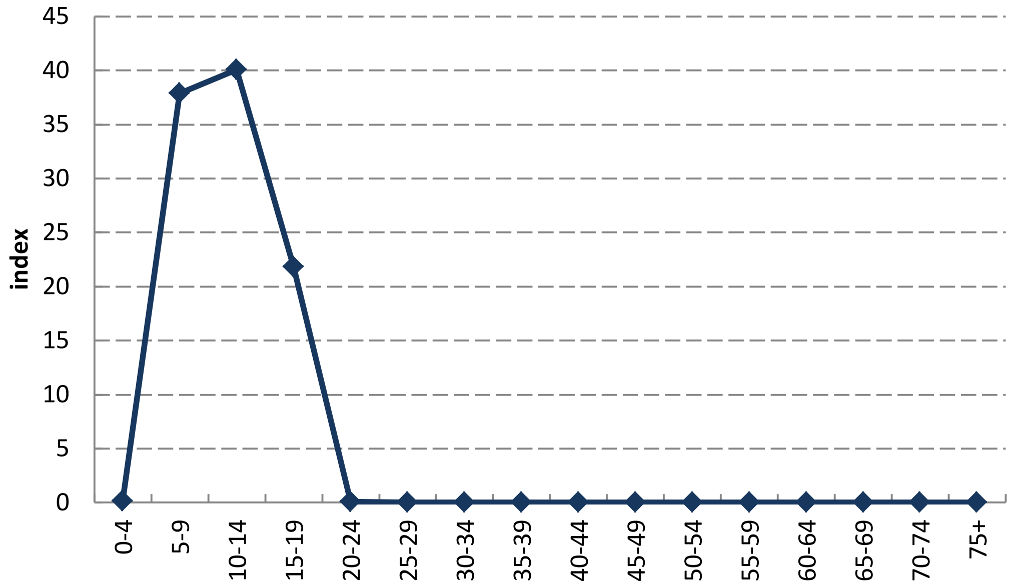
Chart 3: Tertiary Education



Source: NSW Treasury

At the state level, tertiary education incorporates technical and further education through the TAFE and community college system. Expenses are driven primarily by usage, which peaks around the 15-19 age cohort and follows a declining trend thereafter.

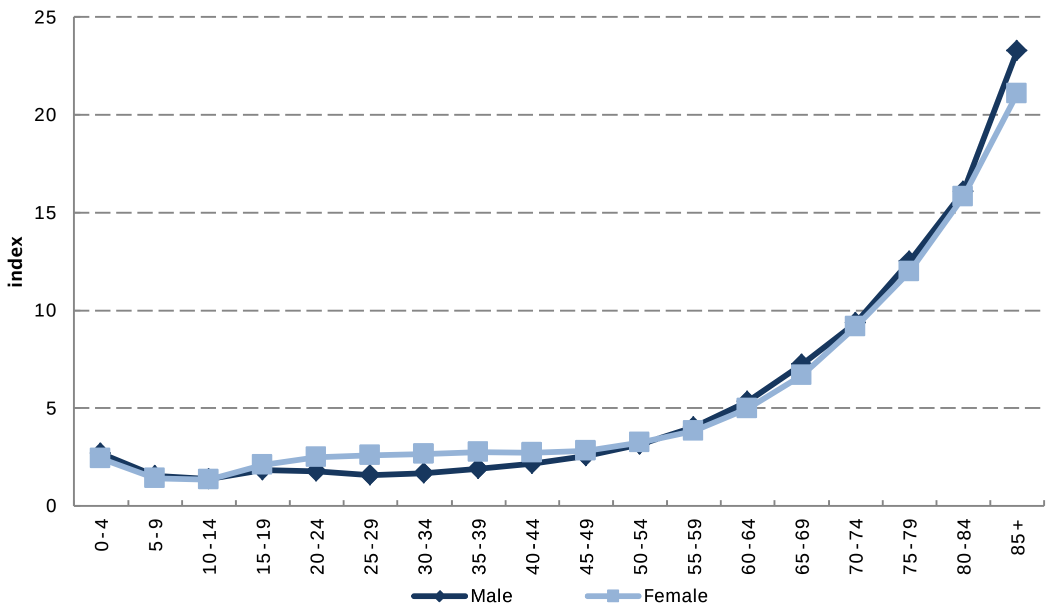
Chart 4: Transport of School Students



Source: NSW Treasury

The usage profile for student transport includes public and private students at the primary and secondary school levels that are eligible for this service. This index is driven by usage as there is no variation in costs associated with age. This index was derived from school student participation data sourced from the ABS (ABS 4221.0).

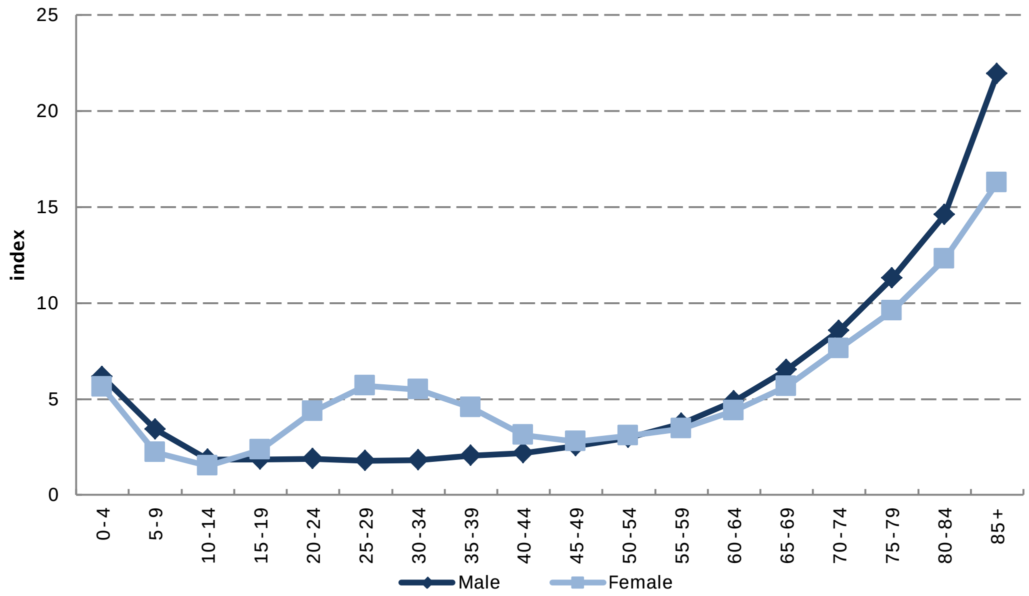
Chart 5: Patients of Acute Care Institutions (Hospitals)



Source: NSW Treasury

The age-cost indices for 'Patients of Acute Care Institutions' reflect cost and frequency of use. The indices were derived using data from the NSW Department of Health. Costs are relatively high in the 0-4 age group as a result of hospital births. The indices for men and women diverge between the 15-19 and 40-44 age groups due to childbirth. The acceleration in the index in the later age cohorts reflects the increase in acute care requirements in older age.

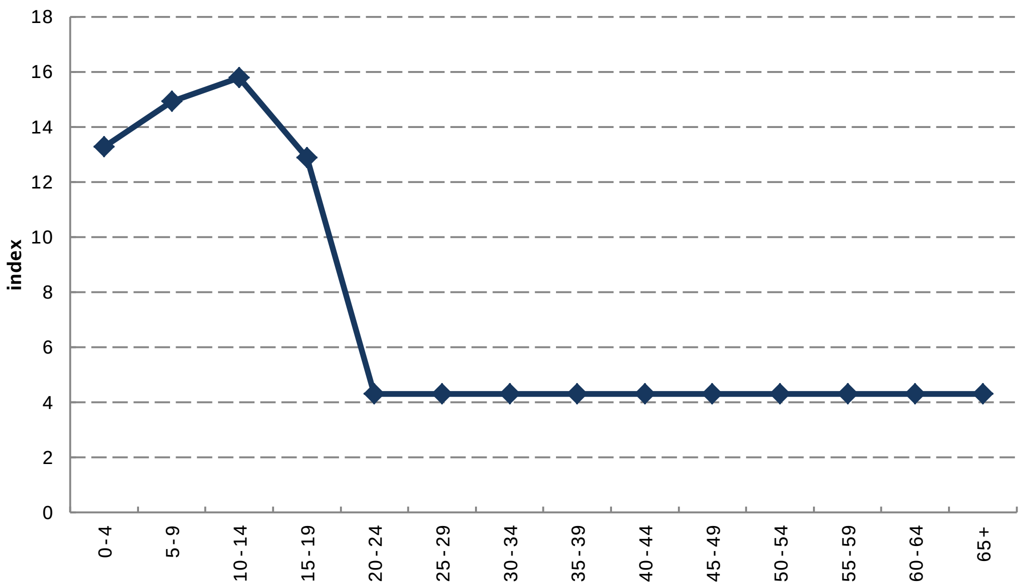
Chart 6: Community Health Services



Source: NSW Treasury

The 'Community Health Services' indices were derived by gender using NSW Department of Health data. Usage is high in the younger age cohorts as a result of child wellbeing and vaccination programs. The female index increases during the childbearing cohorts due to an increase in demand for maternity services. The indices for both men and women follow an increasing trend in the older age cohorts due to an increase in demand for palliative care.

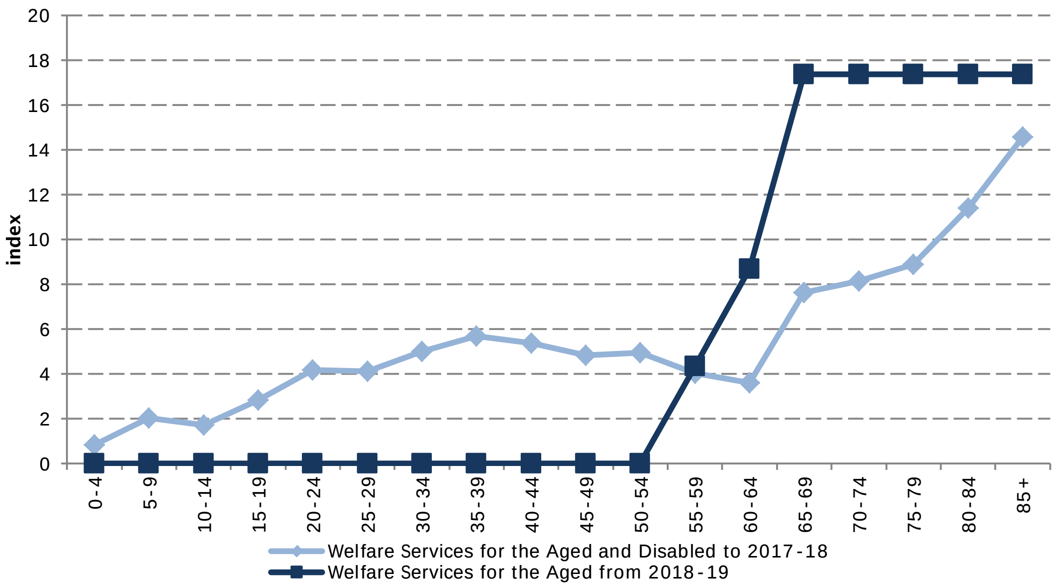
Chart 7: Family and Child Welfare Services



Source: NSW Treasury

The age-cost index for 'Family and Child Welfare Services' primarily reflects the use and cost of providing child protection services. The data used to construct this index were sourced from FACS and the Budget. The increase in the index from the 0-4 to the 10-14 age cohorts reflects the usage of out-of-home care services. The index drops between the 15-19 and 20-24 age cohorts as children enter adulthood and therefore leave the child protection system. The index does not fall to zero as there are programs provided through the Family and Child Welfare Services functional area that are not age-specific.

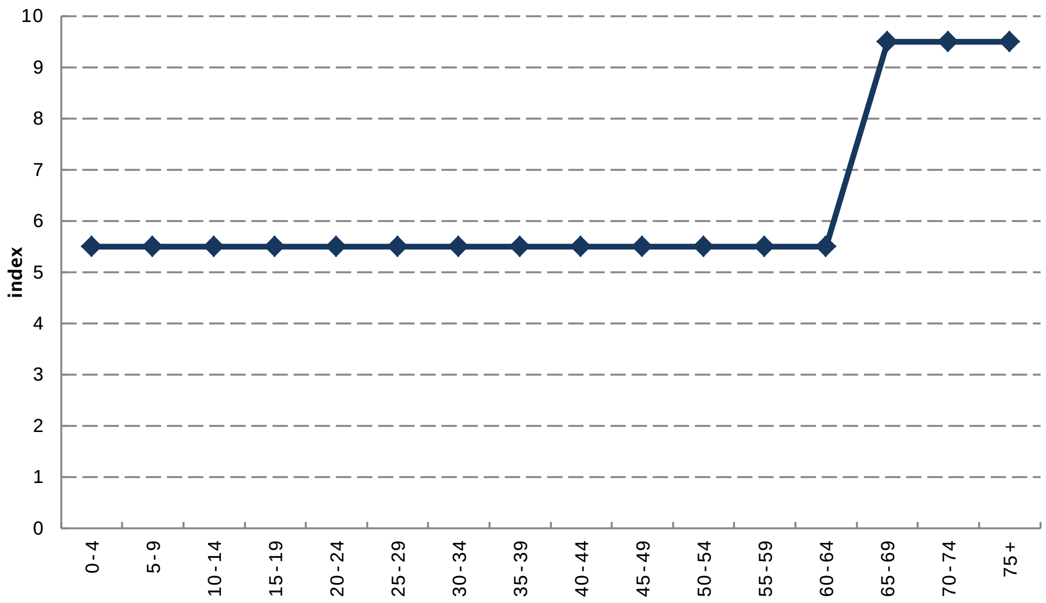
Chart 8: Welfare Services for the Aged and Disabled



Source: NSW Treasury

For 'Welfare services for the aged and disabled', two different age-cost indices are used, one for the period to 2017-18 and another for the period from 2018–19 onwards. This approach is used to allow for the impact of the National Disability Insurance Scheme, which is scheduled to commence in 2018-19. From 2018–19, the age-cost index applied for this functional area reflects services provided for the aged, since services for the disabled will be funded through the NDIS, with the state's contribution of $3.2 billion escalated by 3.5 per cent annually.

Chart 9: Other Welfare Services



Source: NSW Treasury

Finally, the index for 'Other Welfare Services' (Chart 9) reflects both usage and cost of use for various pensioner concessions. These include utilities, transport (the Opal Gold Card) and other services. As the provision of concessions is age-dependent, there is a step-up in the index when the eligibility threshold is reached. There are also some expenses within this category that are not age sensitive. This age-cost index has been developed based on the relative weightings of age-sensitive and non-age sensitive components.

Table 1 sets out the data sources used in developing the age-cost indices described above.

Table 1: Age-Cost indices – Data sources

Expense category	Sub-category	Data source
Public order and safety	Prisons and corrective services	Australian Institute of Health and Welfare publications Corrective Services & NSW Inmate Census NSW Department of Corrective Services
Education	Primary and secondary school education	School Student participation (ABS 4221.0) and unit cost data from DET
	Tertiary education	National Centre for Vocational Education Research VOCSTATS
	Transport of school students	School Student participation (ABS 4221.0)
Health	Patients of acute care institutions	Cost and case mix weighted by age (NSW DoH)
	Community health services	Resource distribution weights (NSW DoH)
Social security and welfare	Family and child welfare services	DOCs and NSW Budget
	Other social security and welfare	Based on proportion of expenditure restricted to over 65s

4.2 Capital expenditure

Consistent with the 2011-12 Report, capital expenditure for the general government sector is modelled using a conventional capital stock-flow model, separated into land capital and non-land capital, and disaggregated by type of government activity using ABS General Purpose Classifications (2-digit).

For the years 2015-16 to 2024-25, total capital expenditure (C_t) is based on agencies' 10-year capital plans and split into its land and non-land components based on historical ratios. The other capital flows – depreciation, sales and disposals, and revaluations and other movements in financial assets – are projected to 2055-56 based on historical relationships (for example, using the average ratio of capital sales and disposals relative to opening capital stock over the past ten years). Using these flows, and applying the following equation to land and non-land capital separately, the capital stock is then modelled via:

$$K_{t+1} = K_t\,(1-\delta) + C_{t+1} - D_{t+1} + R_{t+1}$$

where

K_t = Nominal capital stock at the end of period t

δ = Capital depreciation rate (taken to be zero in the case of land)

C_t = Capital expenditure during period t

D_t = Capital disposals during period t

R_t = Capital revaluations and other movements during period t

Beyond 2024-25, the above approach is then inverted. The aggregate capital stock in each year is first projected, based on assuming (as described in Chapter Four) that real capital intensity for each disaggregated area of government activity remains constant for the remainder of the projection period – with the exception of Transport and Communications, which is modelled differently because it is highly capital intensive and increases in capital stock tend to drive expenses. For Transport and Communications, the nominal capital stock is grown with nominal GSP. Aggregate capital expenditure in each period is then backed out from the above equation.

The transition from the first 10 years to 2024-25 to the long-run projections from 2025-26 is smoothed to minimise year-on-year volatility.

Disaggregation into government activity types

The model is disaggregated by type of government activity using ABS General Purpose Classifications (2 digit): General public services; Public order and safety; Education; Health; Social security and welfare; Housing and community amenities; Recreation and culture; Agriculture, forestry, fishing and hunting; Minerals and mineral resources; Transport and communications; Other economic affairs; and Other purposes. As the ABS Government Finance Statistics do not provide information on capital stock or capital expenditure by General Purpose

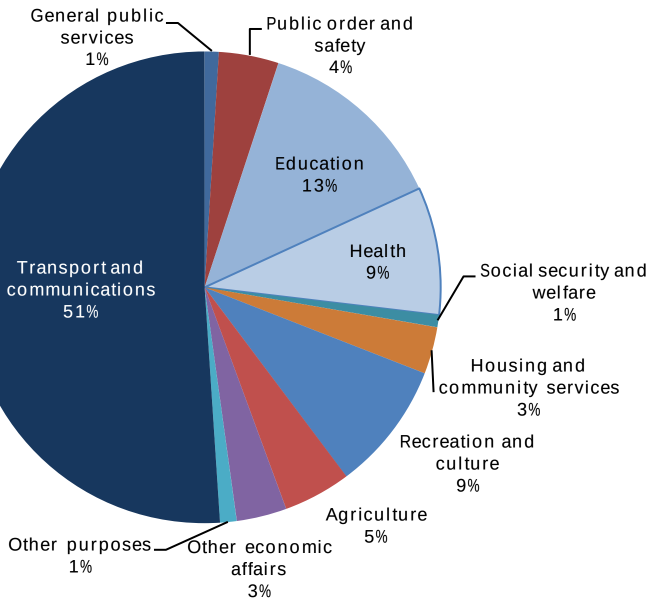
Classification, historical figures were based on NSW Treasury data are mapped to those classifications.

Disaggregation into areas of government activity achieves two purposes. First, the physical capital and land requirements of different areas of government service delivery are heterogeneous, implying different rates of real capital expenditure required to offset depreciation. For example, computer hardware and information systems have relatively short useful lives, whereas capital spending on roads, bridges and railways may have a useful life of many decades.

Second, capital stock is not distributed across functional areas in the same proportions as expenses. For example, 'transport' is a relatively capital-intensive area of government activity, with large components (such as provision and maintenance of roads) that involve substantial capital expenditure but limited direct government provision of services (so associated expenses are relatively small). This contrasts with 'general public services', which is a much less capital-intensive functional area. Such services usually involve sizeable recurrent expenditure relative to their limited capital needs (often mainly for computers or IT systems) and relatively low land intensity (as most government offices are now leased).

Chart 10 shows the distribution of physical and land stock by functional area. Given that the capital stock is concentrated in the less rapidly growing functional areas, the aggregate growth rate of capital expenditure is projected to be slightly lower than the aggregate growth rate of expenses. The disaggregated model thus captures this effect.

Chart 10: Distribution of physical and land capital stock by functional area in 2014-15



Source: NSW Treasury

5.3 Revenue

Revenue figures are based on the 2015-16 Half-Yearly Review from 2015-16 to 2018-19.

For each separate revenue head (subdivided into tax and non-tax), Table A2 summarises the principal factors modelled as driving growth in that revenue head over the remainder of the projection period.

For **taxation revenue** components, where an econometric relationship was established between revenue items and key underlying economic and demographic drivers (listed in Table A2), this was done using policy-adjusted time series. If these series were not available for a revenue item, a simpler growth rate assumption linked to the key drivers was applied.

For **Specific Purpose Payments (SPPs)** from the Commonwealth, economic parameters feed in directly from the demographic and economic sections of the model. In certain cases, other parameters, such as the minimum rates adjustment awarded by Fair Work Australia, have been modelled. It has also been assumed that the current agreed escalation factors will remain in place when national agreements are reviewed. For health, an adjustment has been made for 2015-16 through to 2019-20 to reflect the recent COAG agreement.

Table 2: Key drivers of revenue sources

Revenue Source	Current Drivers (explanators used to model growth)
Transfer Duty	Demographic Index – propensity to purchase by age House Prices Bracket Creep
Payroll Tax	Compensation of Employees NSW
Land tax	House Prices Housing Stock
Motor Vehicles related	Gross State Product (GSP) NSW
Weight tax	GSP NSW
Insurance Duty	House Prices plus Housing Stock Vehicle Fleet Growth plus Consumer Price Index (CPI)
Hotel and Club Gaming	Average Weekly Earnings
Other Gaming	CPI
Health Insurance	Health Insurance Coverage Indexation Rate (WPI and CPI)
Waste and Environment Levy	Revenue projected to grow at 1.0 per cent consistent with EPA figures
Others	Assumed flat or increasing with CPI
Health SPP	2015-16 to 2019-20: As per 2016 COAG agreement From 2020-21: CPI Population Growth
Education SPP	2015-16 to 2018-19: COAG agreed funding From 2019-20: CPI Enrolment Growth
National Partnerships	Modelled Individually
Sales of Goods and Services	Modelled Individually
Mineral Royalties	Coal Tonnage Coal Prices (CPI, Terms of Trade)
GST	Nominal GDP NSW Relativity NSW & ROA population

5. Modelling Housing Prices and Migration Flows

5.1 Underlying Housing Demand

Census data for 1991, 1996, 2001, 2006 and 2011 were used as a basis for modelling propensities for household living arrangements. The model starts with people counted in each Census allocated to their various living arrangement types. These living arrangement types (couples with children; couples without children; lone parent; group households and lone persons, etc.) were split by males and females and five year age cohorts. It is possible to then calculate living arrangement propensities for each age-cohort by sex. For example, in the 2011 Census, 57.3 per cent of all males aged 35-39 lived in a 'couple with children' family household.

For each age cohort by sex, the five-yearly values for each of the household living arrangement propensities categories were interpolated to give annual estimates using a cubic spline approach for the inter-censal years (scaled also to ensure the 'adding up' constraint across all different categories was satisfied). These yearly historical series were then used for fitting growth curves (Richards curves) to obtain sex and age cohort-specific living arrangement propensities projected out to 2055-56. Combining the projected propensities and NSW Treasury's long run population projections, series for expected numbers of persons in different living arrangements were thence produced.

Finally, using household reference person data split between family and multi-family households, conversions were obtained to transform the projected living arrangements to corresponding numbers of households. The aggregate number of households then translates to the total underlying demand for occupied dwellings.

This process was conducted both including and excluding data on propensities from the 2011 Census as part of the basis for projection. This was done because of the unusual shifts in household formation seen between the 2006 and 2011 Censuses, driven in part by the Global Financial Crisis and its subsequent effects. Ultimately the model using data excluding the 2011 Census results was adopted, reflecting a judgement on balance that this would yield more representative projections of underlying demand for household formation going forward, as the direct and indirect effects of the financial crisis recede into history.

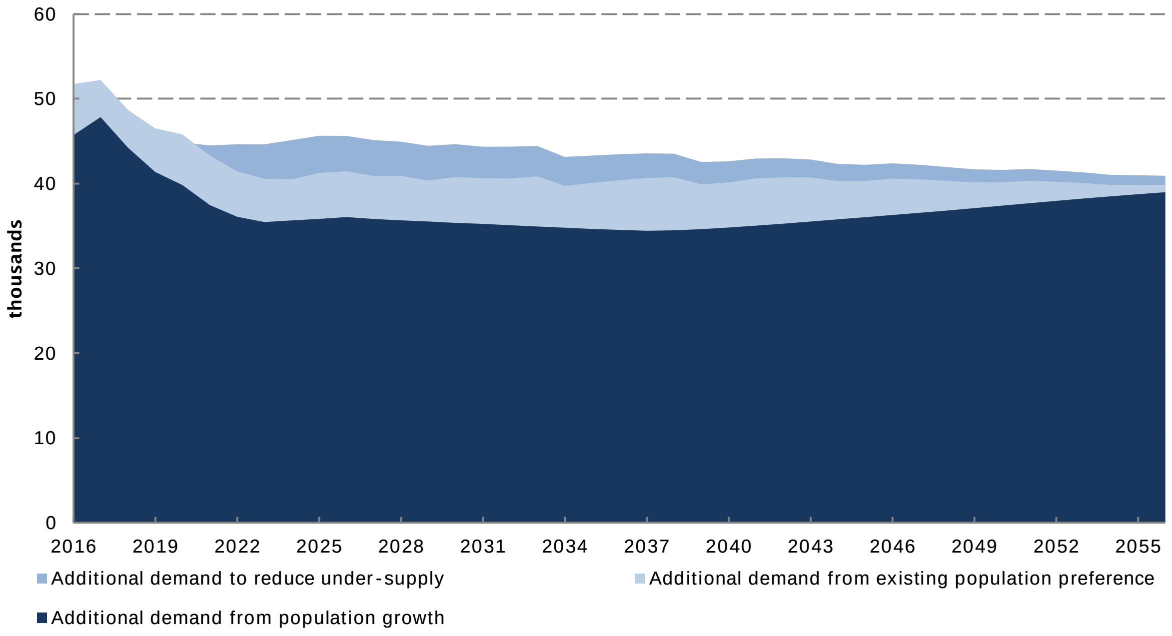
Housing Supply

Historical NSW dwelling stock was constructed using actual counts of dwellings from each Census. Adjustments to the total counts of private structural dwellings were made by removing counts of public dwellings, caravans, cabins, houseboats, improvised homes and tents from the Census data.

Dwelling completions data were then used to interpolate between Censuses to produce a historical yearly housing supply profile. The dwelling completions data in each five year block were scaled to match the total change in dwelling stock data revealed in each Census year. The discrepancy was assumed to be a mixture of over or under counts and demolitions. ABS data (6416.0) on the number of residential dwellings were used to extend the housing supply profile from the 2011 Census to the end of 2015. The same approach was taken to produce a dwelling stock series for Australia.

Over the period to 2031 the average annual construction target of 45,000 per annum was applied consistent with *A Plan for Growing Sydney*[6] scaled up to the whole of New South Wales based on the relative population growth rates between Sydney and the regions. Within this constraint the, the profile of new housing supply was projected based on three distinct factors: population demand; changes to household formation preferences; and a reduction in housing under-supply. Chart 11 shows the impact of these three drivers of the housing supply profile over the projection period. Combined, they imply average NSW dwelling supply growth of around 43,500 dwellings per year over the next 40 years.

Chart 11: Housing Supply Drivers



Source: NSW Treasury

Over time, the additional demand needed to reduce under-supply gradually weakens as the degree of under-supply erodes. Likewise, the number of additional houses demanded each year by the existing NSW population, based on trends in household formation, gradually diminishes over time as the projected rate of decline in the preferred number of people per household slows. This is consistent with Richards Curves projections which tend to continue current trends in living arrangements for a period of time and then flatten out over time. This source of demand averages around 4,500 homes per year over the full projection period. Finally, approximately 37,000 additional houses are required each year on average to accommodate population growth.

[6] NSW Department of Planning and Environment, A Plan for Growing Sydney (2014)

Under-/Over-Supply

The difference in the underlying demand and projected dwelling supply is taken as the new measure of under-/over-supply in the NSW housing market. Chapter Four of the 2016 Intergeneration Report presents that current undersupply estimate of around 100,000.

This new methodology is quite different from that used to generate the housing under-supply estimates published in the 2014-15 Budget. Housing under-supply as published in the 2014-15 Budget assumed the housing market was broadly 'in balance' in 2001 (i.e. underlying demand matched housing stock). This was consistent with the National Housing Supply Council's report on *Housing supply and affordability* which implicitly assessed that 2001 was such a point. Additionally, NSW vacancy rates were at their long run average of around three per cent during that year, which supported the judgement that demand and supply were broadly matched at this time. From this point, underlying demand for dwellings was grown in line with estimated changes in the preferred average number of persons per household. While the level of under/oversupply is different under both approaches, they display quite similar profiles back to 1991.

5.2 Housing Price and Migration Flow Equations

Relative house prices

An OLS approach was adopted to model the ratio of NSW dwelling prices to RoA dwelling prices. The sample period used was 1989 to 2015. Three main explanators were used to explain relative dwelling prices:

- Relative under-/over-supply of housing in NSW vs. RoA, expressed in terms of housing stock per capita (denoted HSPC);
- Annual change in ratio of population of NSW to RoA (denoted POP_TTY); and
- Relative Average Weekly Earnings in NSW vs. RoA (denoted AWE).

In addition to the three main explanators a dummy variable was used to take account of the disruptive effects from the introduction of the GST (taken to be non-zero in the September and December quarters 2000). An AR (1) term was allowed in the estimation, to take into account the persistence observed in the residuals of the estimation.

Overall, this led to the following annual equation for relative house prices (denoted HP) for long term projection purposes (noting the GST dummy is dropped here because it is zero over the projection period):

$$HP_t = -1.012 - 9.756(HSPC_{t-1} + HSPC_{t-3}) + 10.017(POP\_TTY_t + POP\_TTY_{t-1} + POP\_TTY_{t-2} + POP\_TTY_{t-3}) + 0.578\,(AWE_t + AWE_{t-1} + AWE_{t-2} + AWE_{t-3}) + \varepsilon_t$$

$$\varepsilon_t = 0.598\varepsilon_{t-1}$$

The coefficients on the main structural explanators in the annual equation may be interpreted as follows:

- If there were to be a sustained 0.1 percentage point rise in the housing stock per capita in NSW relative to the RoA, then after one year this would be expected to lower the relative price of housing in NSW versus the ROA by approximately 1.0 percentage points, with this impact doubling after a further couple of years;
- If the NSW to RoA population ratio were to permanently increase by 0.1 percentage points then in that year and for the next three years this would be expected to boost relative NSW dwelling prices by approximately 1.0 percentage points, before dissipating; and
- If relative earnings in NSW were to undergo a sustained increase of 1 percentage point then this would be expected to add just under 0.6 percentage points to relative NSW house prices in the current year and each of the next three years, for a total sustained lift of around 2.3 percentage points in the long run.

Share of Net Overseas Migration

The equation was estimated over the sample period 1995 to 2014. The period from 1989 to 1994 was excluded from the sample because NSW's share of NOM experienced extreme volatility during this period, which included the severe recession in the early 1990s. Also, the NSW share of NOM appears to have been structurally affected (downwards) by changes to the focus of Australia's permanent migration program in the second half of the 1990s, away from a predominant focus on the family stream and towards a much more skills-focussed program. To model the NSW share of NOM, four main explanatory variables were used:

- a measure of the unemployment rate differential between NSW and the RoA (denoted UED);
- annual changes in mining investment as a share of GDP, to capture the potential impact of the onset and unwinding of mining booms (denoted MINING_TTY);
- the ratio of dwelling prices in NSW relative to the RoA (HP); and
- relative average weekly earnings in NSW versus the RoA (AWE).

In addition a GFC dummy was used to help model the impact of the global financial crisis in 2008 and 2009.

Overall, this led to the following annual equation for the NSW share of NOM for long-term projection purposes (where the GFC dummy is again dropped since it is zero going forward):

$$NOM_t = -0.228 - 8.986\,UED_t - 2.795\,MINING\_TTY_t - 0.363\,HP_{t-1} + 0.995\,AWE_t + 0.402(AWE\_TTY_{t-1} + AWE\_TTY_{t-2} + AWE\_TTY_{t-3})$$

The coefficients on the main structural explanators in this equation may be interpreted as follows:

- If the unemployment differential between NSW and the ROA were to jump by 0.1 percentage points then, all else equal, this would be expected to reduce NSW's NOM share by around 0.9 percentage points;
- If annual mining investment as a share of GDP were to increase by 1 percentage point compared with the previous year, this would be expected to reduce NSW's NOM share in the current year by approximately 2.8 percentage points;
- If relative house prices in NSW versus the RoA were to rise by 1 per cent, this would be expected to lower NSW's NOM share in the following year by a little under 0.4 ppts, with this lowering then sustained for as long as the relative price rise persisted; and
- If there were to be a sustained 1 percentage point increase in relative earnings in NSW versus the RoA, this would be expected to permanently raise NSW's NOM share by around 1.0 percentage points, starting from that same year, as well as causing an additional temporary lift of 0.4 percentage points in this share during the following three years.

Net Interstate Migration share

This equation was estimated over the sample 1990 to 2014. Net interstate migration was modelled as a share of the NSW population. Over the sample period there was always a net outflow of people from New South Wales to other states.

The same four main variables were considered as explanators for this equation as were used for the NOM share equation (viz. the unemployment rate differential between NSW and the RoA; mining investment as a share of GDP; relative house prices in NSW versus the RoA; and relative average weekly earnings in New South Wales versus the RoA).

During the late 1980s and early 1990s, particularly strong out-migration from New South Wales occurred. Examination of the data for this period shows that this strong out-migration reflected unusually large outflows from New South Wales to Queensland (although there was also stronger net outflow to other states such as Western Australia and, to a lesser degree, Victoria). At the same time there was not a corresponding large net inflow to Queensland from other states during this period. This suggests that this episode – which also coincided with a very large and sustained run-up in relative house prices in New South Wales versus the RoA – was not driven by Queensland-specific factors. Accordingly, we handled this hard-to-model period for the NIM equation by giving the equation scope (via a dummy) to have a more strongly negative coefficient on relative dwelling price developments during these years.

This led to the following final equation specification for long-term projection purposes (where coefficients are shown to four decimal places, all residuals are assumed to be zero going forward, and the dummy term has been omitted since it will be zero throughout the projection period):

$$NIM_t = 0.0079 - 0.0738\, MINING\_TTY_t - 0.202\, UED_t - 0.0081((HP_t + HP_{t-1})/2)$$

The coefficients on the main explanators in this annual equation may be interpreted as follows:

- If annual mining investment as a share of GDP were to increase by 1 percentage point compared with the previous year, this would be expected to lower NIM as a share of the NSW population by around 0.074 percentage points in the current year (currently equivalent to an additional net outflow from NSW of somewhat over 5,000 persons);
- If the unemployment differential between NSW and the RoA were to jump and then remain elevated by 0.1 percentage points, this would be expected to lower NIM as a share of the NSW population by around 0.02 percentage points (currently equivalent to additional annual outflow of just over 1,500 persons), starting contemporaneously; and
- If relative house prices in NSW versus the RoA were to rise by 1 per cent, this would be expected to lower NIM as a share of the NSW population by just over 0.004 ppts in the current year, rising to just over 0.008 ppts in the following year (currently equivalent to additional annual outflow of around 620 persons), with this lowering then sustained for as long as the relative price rise persists.

NSW house prices

Finally, to tie down the projected trajectories for NSW and Australian dwelling prices, a simple long-run levels relationship for the log-level of NSW dwelling prices (NSWHP) was estimated in terms of:

- the degree of under-/over-supply in the NSW housing market, measured in per capita terms (NSWHSPC);
- the log-level of aggregate NSW household disposable income (HHDISY);
- the log of the ratio of working age to total population in NSW (WKAGE_POP_RATIO);
- real mortgage interest rates (RIR); and
- the log of mining investment as a share of GDP, acting once again as a proxy for the existence of mining booms (which would tend to lower equilibrium NSW house prices by drawing activity and population away to more mining-focussed jurisdictions such as WA and Queensland).

With these explanators, a fairly good fit was able to be obtained to the key structural shifts in NSW house prices over the period 1987 to 2015.

The equation captures the sharp rise in dwelling prices in the late 1980s (although with a somewhat more drawn-out pick-up than actually occurred) as well as the extended period of subdued growth that then followed for most of the 1990s. It then broadly matches the further large step-up in prices from the late 1990s to end-2003, somewhat over-predicting the rise prior to the introduction of the GST in mid-2000 but then correspondingly under-predicting the further growth over 2002 and 2003. Finally, it largely captures the period of modest price correction after the end of the early-2000s boom, as well as the boost in prices delivered by the post-GFC reductions in interest rates and, after a further brief pause, the current episode of sharply rising dwelling prices.

The overall estimated equation specification for long-term projection purposes was as follows (where coefficients are shown to three decimal places and all residuals are assumed to be zero going forward):

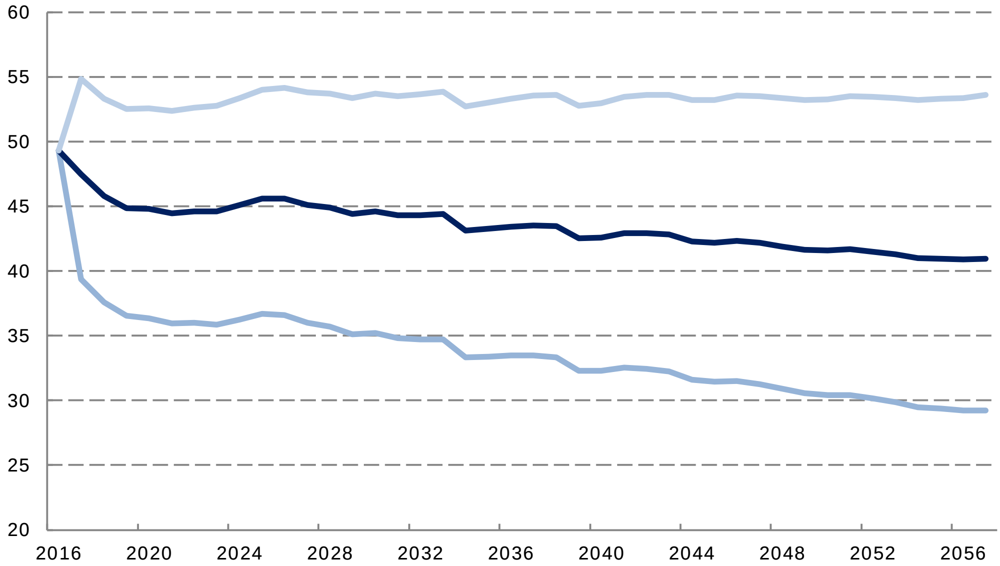
$$\log(NSWHP)_t = -6.116 - 11.098\, NSWHSPC_{t-1} + 1.268\, \log(HHDISY)_{t-1} - 3.599\, RIR_{t-1} - 0.210\, \log(MINING)_t + 3.955\, \log(WKAGE\_POP\_RATIO)_t$$

Importantly, all variables appear with the economically expected signs. Furthermore, the coefficient on NSW household disposable income is close to one but somewhat greater than one, consistent with a plausible prior that, as incomes rise, people will devote a greater proportion of their income to housing.

5.3 Housing Scenarios

Alternative housing scenarios were used to model the sensitivity of economic, demographic and fiscal outcomes to changes in housing supply, relative to the central scenario. For these scenarios, the annual change in NSW housing stock was taken to be +/- 10,000 on average over the projection period.

Chart 13: Alternative annual housing supply scenarios



Source: NSW Treasury

To implement the 'high' scenario, the specific profile for additional annual net housing supply was calibrated against the size of the total dwelling stock over time, rising from just under 8,000 additional dwellings initially to a little over 12,000 additional dwellings in 2055-56. A corresponding calibration was applied in the 'low' scenario.