

Hutchison, Owen et al.

**Working Paper**

## The uncertainty of revenue costings in the medium term

Treasury Working Paper, No. 2019-01

**Provided in Cooperation with:**

The Treasury, The Australian Government

*Suggested Citation:* Hutchison, Owen et al. (2019) : The uncertainty of revenue costings in the medium term, Treasury Working Paper, No. 2019-01, The Australian Government, The Treasury, Canberra

This Version is available at:

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# THE UNCERTAINTY OF REVENUE COSTINGS IN THE MEDIUM TERM

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## Treasury Paper

**2019-01**

Date created: January 2019

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## EXECUTIVE SUMMARY

There is significant interest in the medium-term financial impact of tax policy changes, in part because the financial impact of tax policies can be very different at maturity. There is also a perception that medium-term analysis is of similar reliability as shorter-term analysis. In this context, it is important to understand the sources and magnitude of uncertainty in medium-term costings, and the ability of different types of models to deal with that uncertainty.

Medium-term costings are usually associated with a greater level of uncertainty compared with the forward estimates for several reasons. First, costings models are underpinned by a range of economic parameters, such as nominal GDP, wages, employment, population and inflation. There is inherent uncertainty in the forecasting of these parameters. Forecast errors — the difference between forecasts and their realised outcomes — increase as the projection period increases. Second, it is difficult to predict the behavioural responses of individuals and businesses affected by the costing and the timeframe over which they occur. Third, some models include simplifying assumptions that can ignore important changes in the target population.

Since the short term effects of policy changes do not tend to significantly alter economic structures and projections of economic parameters are subject to less compounding of the forecast error, static microsimulation modelling is a commonly adopted approach for costing tax and transfer policy options within the forward estimates. This approach is less robust over the medium term due to increased forecast errors and changes in the behaviour and characteristics of the affected population over longer time horizons.

In contrast, dynamic microsimulation modelling allows for the characteristics of cohorts impacted by the policy change to vary over time. This feature generally means dynamic models are better suited to estimating longer term impacts. However, this modelling approach is much more resource intensive to develop and requires simplifying modelling assumptions to make the model tractable (compared to static modelling), making dynamic models comparably less well suited to estimating impacts over the forward estimates.

Like any effort to evaluate the future impact of policy, there will always be uncertainty with costings. As the level of uncertainty over the medium term can be significantly greater, it is important to ensure that this is properly reflected in the communication of the costing results. Depending on the characteristics of the costing in question, this may involve presenting results with appropriate caveats, rounding estimates and/or smoothing year by year volatility by aggregating across time periods.

# 1. INTRODUCTION

Modelling of the revenue and, as appropriate, distributional impacts of policy options — known as ‘costings’ — is an important input to policy decision making and provides a valuable evidence base for public debate. Providing estimates of revenue and distributional impacts allows for an explicit consideration of the relative costs and benefits of competing policy ideas. The costings process can also reveal possible unanticipated effects of policy proposals.

Costings are also used to update the budget estimates to reflect the impact of the Government’s proposed policies. They help the Government compare or select an overall policy position consistent with its fiscal strategy and determine whether a particular policy is affordable within the broader fiscal context. The variety of costings processes reflects the wide range of policies and potential policy changes. Data to support each costing is selected with regard to the policy itself, and while many policy developments can draw on models and data that are well established, some policy developments depend upon new or less robust data. The characteristics of the data itself, the models built using the data and the time span of the costing largely determine the level of confidence that can be placed in the costings.

The *Charter of Budget Honesty Act 1998* (Cth) requires that fiscal estimates be provided for the financial year leading up to the budget, budget year and the three subsequent years. Recently, and increasingly so, costings have also been sought over the medium term — the seven years beyond the forward estimates — particularly for policies that start or mature during this period.<sup>2</sup>

Revenue costings beyond the forward estimates are subject to greater uncertainty. Presenting these estimates on the same basis as the forward estimates would be misleading, so these estimates are always accompanied by appropriate caveats. The static microsimulation models that Treasury uses to generate costings are not designed to accurately produce detailed year-by-year costings beyond the forward estimates.

This paper discusses the sources of greater uncertainty in medium-term costings and implications for their communication and use.

We begin with an overview of the costing process and the types of data utilised for costings. In this context, we consider the static microsimulation models that underpin most Treasury costings over the forward estimates and consider their shortcomings over the medium term, resulting in greater uncertainty in results. We also consider the potential for dynamic microsimulation to address some of these issues and conclude with a discussion of the implications for the communication of costings results.

Consistent with the *Charter of Budget Honesty Policy Costing Guidelines* (Australian Government, 2018), Treasury costings typically capture only direct effects or first-round effects of policy change. These include the impact that the policy has on the individuals, businesses or organisations that are directly affected by the policy, including changes in their behaviour as well as the impacts on closely related industries where relevant.

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2 In the 2018-19 Budget, the forward estimates covered 2019-20 to 2021-22 and the medium term covered the period 2022-23 to 2028-29.

Policies often have flow-on effects to the broader economy. These indirect or second-round effects can also affect the budget through changes in prices, wages, employment levels or growth flowing on from the introduction of a new policy. Indirect effects are generally omitted because the magnitude of those impacts on the budget tends to be smaller and/or more uncertain than the direct impacts of policy proposals and can take considerable time to materialise.<sup>3</sup> Sometimes there is also uncertainty surrounding the direction of indirect effects which depend on interactions between individuals, firms and sectors of the economy.

## 2. TYPES OF REVENUE COSTINGS AND DATA

Treasury performs a wide range of revenue costings, which are estimates of the change to tax revenue arising from new policy proposals. These may include changes to personal income tax, company tax, superannuation, GST, excise, and others.

All costings are based on a combination of data and assumptions, which are subject to varying degrees of reliability. Typically, data is available for the tax base at some time in the recent past, while various assumptions must be made about how that tax base will change in the future, both in response to the policy change, and in response to other changes that will happen regardless of the policy, such as economic or population growth. The costing is then the difference between estimated revenue with and without the policy change, over a relevant time period.

Uncertainty will enter this process at multiple points. Administrative data on the existing tax base, such as ATO tax returns, are usually highly reliable. However, if the policy change will alter the tax base significantly, less reliable data sources, such as surveys, may be required to estimate the effects. Forecasts and projections of the economy into the future are intrinsically uncertain, and more so as the time horizon lengthens. Finally, estimates of how people's behaviour will change in response to policy are also uncertain, and may themselves be based on data of greater or lesser quality.

The further into the future the costing goes, the less reliable it will be, since it is further removed from the source data on actual revenue, giving more time for individuals to change their behaviour or for the economy to evolve in unexpected ways. The following sections explore these issues as they specifically apply to the microsimulation models used by Treasury.

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3 Over the past 25 years, there have been several instances where costings have incorporated broader economic effects of policy proposals. For further information, see Parliamentary Budget Office 2017, *Including broader economic effects in policy costings*, available at: <[www.aph.gov.au/About\\_Parliament/Parliamentary\\_Departments/Parliamentary\\_Budget\\_Office/Publications/Information\\_papers](http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Budget_Office/Publications/Information_papers)>.

### 3. STATIC MICROSIMULATION MODELS

Static microsimulation models are generally used by the Treasury to cost tax and transfer policy options by taking a snapshot of the population at a particular point in time and simulating short run (or ‘morning after’) impacts of changes in policy. These models are similar to models used by other Government departments, the Parliamentary Budget Office and international peers.<sup>4</sup>

Microsimulation models carry out calculations on a collection of unit records — for example, individual or company tax filers — and can aggregate the outcomes to estimate policy impacts for particular groups or the whole population. They are especially useful for analysing the effects of proposals where policies interact with each other and a diverse range of outcomes are experienced by units in differing circumstances. To evaluate the impact of policy change, outcomes calculated under the current system are compared with those under an alternative system.

The models are static with respect to how they estimate impacts on the population in future years or ‘age’ observations. With a static approach, the characteristics of the individual observations, such as labour force status, are held constant over time.<sup>5</sup> The weights assigned to the observations — which quantify how many people each observations represents — are then adjusted so that the population matches broad demographic trends. Economic data, such as incomes, are updated using an appropriate factor.

### MODELLING WITHIN THE FORWARD ESTIMATES

Static microsimulation models provide what are generally perceived as reasonably robust costings over the forward estimates. The models estimate impacts over this term on the basis of detailed information from a representative sample of Australian individuals or businesses. It is reasonable to expect that actual outcomes in population and economic projections will differ to the forecasts that are used to adjust the model, and that characteristics of the population cohorts in the models will change over the forward estimates period. However, the impact of this in terms of costings is expected to be relatively minor because of the shorter time period. As a result, static models provide a reasonably accurate estimate of short run effects of policy changes that do not fundamentally change economic structures, including distributional impacts across the tax and transfer system.

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4 The Australian Treasury has a number of key static microsimulation models, including: the personal income and superannuation policy costing model, TAXMOD; the tax-and-transfer model, CAPITA (Stevenson et al, 2017); and the Company Tax Model. There are also several international examples. In the United Kingdom, Her Majesty’s Treasury uses the Intra-Governmental Tax and Benefit Model (IGOTM) (Office of National Statistics, 2018) and the Department of Pensions and Work uses the Policy Simulation Model (PSM) (Department of Pensions and Work, 2018). The New Zealand Treasury uses TaxWell (Creedy & Mok, 2015), Statistics Canada publishes their Social Policy Simulation Database/Model (Statistics Canada, 2013), and EUROMOD (Sutherland & Figaro, 2013), a multi-country microsimulation model, is used by policy makers and researchers across Europe.

5 This is in contrast to dynamic microsimulation models which simulate changes in the characteristics of each individual iteratively, based on their characteristics in previous periods.



## SHORTCOMINGS OF MICROSIMULATION OVER THE MEDIUM TERM

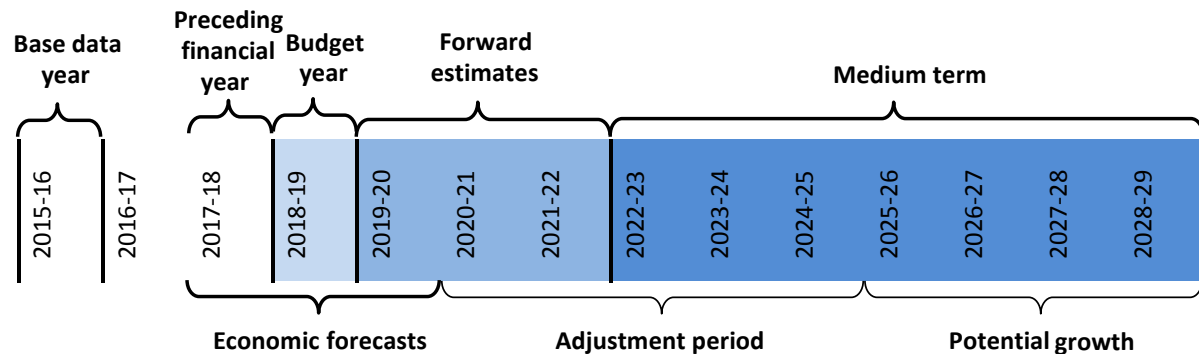
Static microsimulation models ‘usually illustrate the impact of policy change only for today’s world’ (Harding, 2007). There is a greater degree of uncertainty in the medium term than in the forward estimates because these projections are further from a known starting point. This section describes sources of uncertainty that increase as the projection period increases, including economic parameters and behavioural assumptions.

### Economic parameters

Costings models are underpinned by a range of economic parameters, the most prominent of which are nominal GDP, wages, employment, population and inflation. Forecasts and projections of these macroeconomic variables inform the size and structure of the future tax base on which revenue is expected to be collected. They are also often used to proxy future movements in key revenue variables. Working age population growth, for instance, may be used to estimate the future number of tax filers while growth in average weekly wages may be used to uprate their incomes.

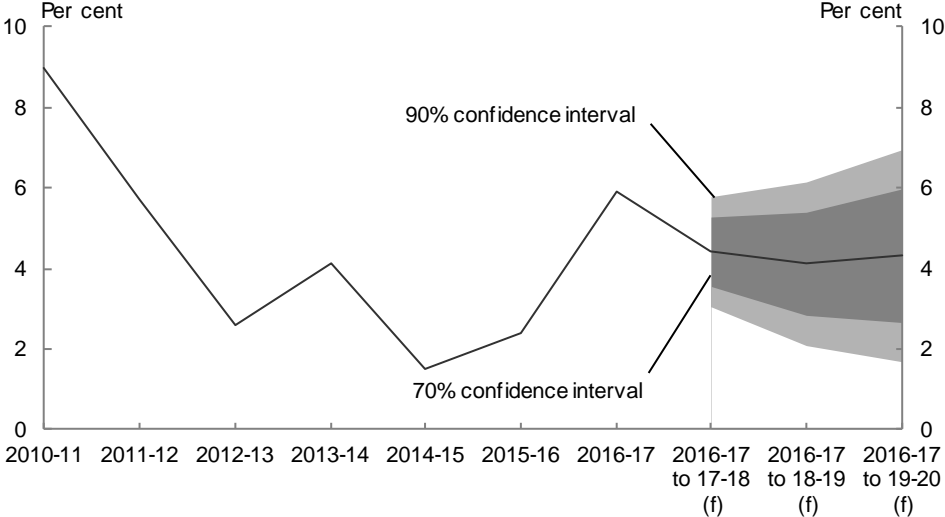
As illustrated in Figure 1, using the 2018-19 Budget as an example, these economic parameters are based on short-term forecasts of the financial year leading up to the budget (2017-18), budget year (2018-19) and subsequent year (2019-20). Given the uncertainty of detailed forecasting after this period, economic parameters are then projected by returning economic activity to its potential level (closing the output gap) over an adjustment period (2020-21 to 2024-25). Economic activity is then assumed to remain at this potential level over the remainder of the medium term (2025-26 to 2028-29).

**FIGURE 1: MEDIUM-TERM COSTING PERIOD (TOP) AND ECONOMIC FORECASTING PERIOD (BOTTOM)**



As with any projection, there is inherent uncertainty in the forecasting of economic parameters. Forecast errors — the difference between forecasts and their realised outcomes — generally increase as the projection period increases (see Figure 2). Uncertainty in macroeconomic forecasts may themselves reflect forecast errors of relevant inputs; higher or lower commodity prices, for example, will flow through to forecasts of nominal GDP. Changes in the relationships between different parts of the economy over time and unanticipated events such as natural disasters or significant events in key trading partners are common sources of uncertainty in the economic parameters.

**FIGURE 2: CONFIDENCE INTERVALS AROUND NOMINAL GDP GROWTH RATE FORECASTS**



Note: The central line shows the outcomes and the 2018-19 Budget forecasts. Annual growth rates are reported for the outcomes. Average annualised growth rates from 2016-17 are reported for 2017-18 onwards. (f) are forecasts. Confidence intervals are based on the root mean squared errors (RMSEs) of budget forecasts from 1998-99 onwards, with outcomes based on December quarter 2017 National Accounts data.

Source: Treasury Budget Paper No.1 Budget Statement 8: Forecasting Performance and Scenario Analysis.

It follows that forecasting errors of these macroeconomic variables flow through to the revenue costings. A large error in forecasting the size of the national wage bill, for instance, will naturally flow through to estimates of the future personal income tax take.

For a more comprehensive discussion on uncertainty of economic parameters, along with estimates of confidence intervals and sensitivity analysis, refer to *Budget Statement 8: Forecasting Performance and Scenario Analysis* (Commonwealth of Australia, 2018).

### Behavioural assumptions

Policy changes create incentives and disincentives that affect the choices of individuals and businesses, and this response is not always predictable. This means that costing and distributional models may incorporate assumptions that account for the impact of a change in policy on the behaviour of certain groups, particularly where this may impact the cost (Australian Government, 2018). For example, a new taxation concession will advantage an activity receiving the concession over those which do not. This is likely to result in resources (capital and labour) moving to activities which receive the concession from those which do not. The more that resources move into the concessionally taxed activity, the higher the costs of the policy.

Assumptions about behavioural responses, including the timing of these responses, are informed by a variety of methods, including experience with previous policy changes, academic studies or consultation. However, the uncertainty around behavioural assumptions can compound over time as the set of choices available to individuals or businesses affected increases. For instance, some individuals who may wish to take advantage of a new tax concession may not be able to restructure their affairs in time for a policy announced at Budget and legislated in the same year, but they will be able to plan ahead for subsequent years. This means that the longer the modelling horizon, the more uncertain behavioural assumptions can become.

## Cohort effects and incoming populations

Further limitations of static models over longer time horizons are caused by assumptions inherent in the static approach. In particular, static models hold the characteristics of records in the base data constant for future years. This leads to the inherent assumption that the population in the base year is a good representation of the population in the future year that is being modelled. The static approach does not take account of cohort effects nor does it capture incoming populations.

Cohort effects are characteristics specific to those born around the same time. For example, a model that uses static ageing assumes that 65 year old Australians in the future have the same characteristics as 65 year olds in the base year. Yet this may be contrary to expectations that future 65 year old cohorts will have higher superannuation balances on average as Australia's superannuation system matures. As the length of time between the model year and base data year increases, cohort effects become more important and the assumption that the base data population remains representative becomes increasingly tenuous.

Future incoming cohorts, such as low-income individuals entering the workforce, will also not be captured. For example, a static microsimulation model that simply grows wages by some parameter will have fewer observations at very low wage levels over time. While this may not have an impact on the results when modelling within a few years of the base data, it is likely to have a significant impact when modelling 10 years into the future.

The box below provides a stylised example of how projections of key variables and constant cohort assumptions under a static microsimulation model can differ from actual outcomes.

## BOX EXAMPLE: BENCHMARKING INCREASES INACCURACY OVER TIME

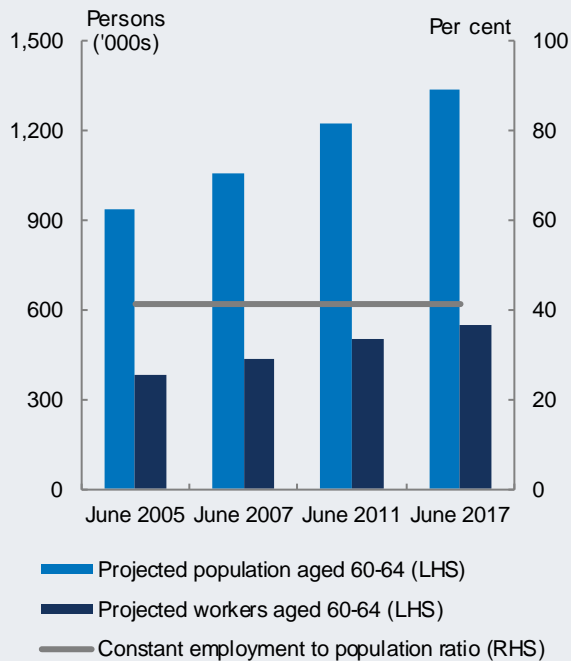
To illustrate how the base data can skew the projections using a simplified example, consider the following stylised projection for employment of people aged 60 to 64. This is an important variable to consider as employment rates determine the amount and source of income and the extent to which behavioural changes are possible in employment. In the example, this is done as if it were at the 2006-07 Budget — at which point the most recent tax system outcomes available would be for the 2004-05 tax year, the end of the forward estimates would be in 2010-11 and the last year of the medium term would be 2016-17.

The first step, as illustrated in Figure 2, is to project the population. For the purposes of this exercise, this is assumed to be known with perfect foresight. In reality, it is not, but errors in population forecasting tend to be smaller as the factors affecting population growth (births, deaths and net overseas migration) tend to be relatively stable.

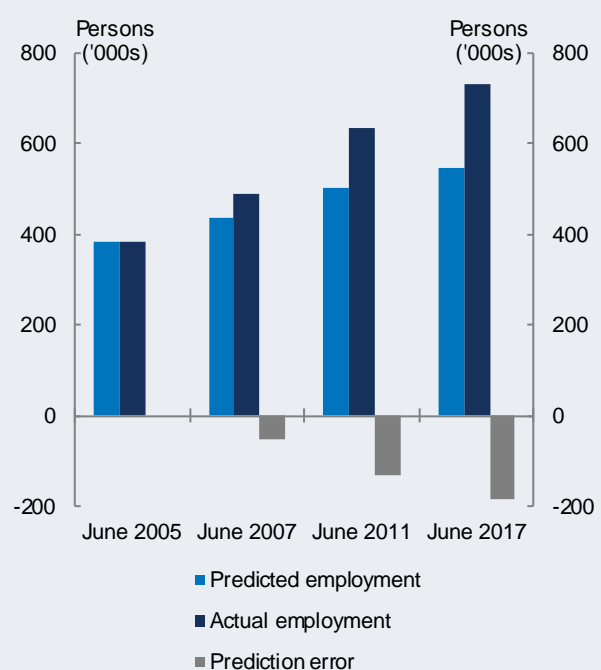
In order to get to the variable of interest, employment of people aged 60 to 64, we need to adjust the base data. In June 2005, 41.1 per cent of 60-64 year olds are employed. Under the usual static microsimulation approach, this ratio will be applied to re-benchmark the population to the future years.

In Figure 3, we compare projections to the actual outcomes to see the size of the errors. Initially, the error is small, but it grows over the forward estimates. By the end of the medium-term period, the estimate is wrong by over 30 per cent as the employment patterns of those over 60 change. This illustrates how projections of key variables and constant cohort assumptions can lead to divergences in projections and actuals in static microsimulation models.

**FIGURE 2: POPULATION PROJECTIONS**



**FIGURE 3: PROJECTIONS VERSUS ACTUALS**



Source: ABS Labour Force Statistics, Australia.

## 4. DYNAMIC MICROSIMULATION MODELS

Dynamic microsimulation models are another tool used by Governments to analyse the effects of policy and are typically better suited to modelling over longer time horizons.<sup>6</sup> Dynamic models differ from their static counterparts in how they ‘age’ records. These models simulate the characteristics of each individual every year based on their characteristics in the previous year. That is, instead of reweighting records aged 40 to represent the number 40 year olds in future years, 40 year olds in a dynamic model become 41 year olds in the subsequent year. This approach means dynamic models are much better able to capture characteristics and outcomes that are cumulative in nature.

A dynamic approach can overcome some of the issues specific to static models when modelling over longer time horizons. Cohort effects are better captured in dynamic models because the cohorts are aged through the model. Characteristics of sixty-five year olds modelled in, say, 2050 are shaped by their simulated experience over the intervening period. As such, this younger cohort may look quite different to 65 year olds in the base year. Incoming populations are also more easily captured. For example, the minimum age modelled in Treasury’s dynamic Model of Australian Retirement Income and Assets (MARIA)<sup>7</sup> is 25 years. Each year new cohorts of 25 year old residents and migrants aged 25 years or over are introduced to the model with differing characteristics to those already in the model.

There are trade-offs between the benefits and added difficulties of dynamic microsimulation. Dynamic microsimulation models are generally more complicated and computationally demanding than static models, and are subsequently more difficult and costly to build and maintain (Zaida & Rake, 2001). This complexity means that more simplifications are often required compared to what may be included in a static model. Rather than model the personal income tax system in great detail, for example, it may only be possible to include marginal rates and thresholds. This simplification results in a model that is less accurate in the short term, and as a result, static models are generally more appropriate for estimating impacts over the forward estimates, while dynamic models are more suited to estimating longer term impacts.

There is also added uncertainty around the transition paths of individual records over time. Whether an individual working part-time this year will work full-time next year is based on probabilities observed among similar individuals in longitudinal studies and a stochastic component. These probabilities are informed by regression models that can be rigorously tested, but uncertainty of the base data from which they are derived and the parameters produced still remains. Further, dynamic models implicitly assume the behaviours that simulations are based upon will continue to hold in future years. This introduces an uncertainty similar to the cohort effect issue of static models.

Due to the added complexity involved in dynamic microsimulation, the additional investment required for the development and maintenance of these models only tends to be made in policy areas where dynamics play out over longer horizons such as the retirement and pensions system, educational financing, health, demographic behaviours and intergenerational wealth.

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6 Li & O’Donoghue (2013) provide a survey of dynamic microsimulation models. Notable examples include: Pensim2 in the UK (Emmerson et al, 2004; Department of Work and Pensions, 2012) and CBOLT in the US (CBO, 2018).

7 For more information on this model, see: <<https://treasury.gov.au/publication/development-of-treasurys-new-model-of-australian-retirement-incomes-and-assets/>>

## **5. PRESENTING RESULTS BEYOND THE FORWARD ESTIMATES**

Beyond the question of uncertainty, there are other considerations that must be taken into account when deciding to provide medium-term costings and this can lead to trade-offs. This includes the profile of a costing — when it begins and the change in cost over time — and the magnitude of its estimated impact.

When medium-term costings are required, caution should be exercised in producing these costings as well as communicating and using the results. Results need to be accompanied with appropriate caveats and considered in the context of the inherently lower confidence associated with forecasting over longer time horizons.

There are a number of options for how greater uncertainty in medium-term costings can be communicated to better inform public debate and decision making. While a detailed evaluation of each is beyond the scope of this paper, options for presenting results that have been used include using less precise rounding than is used in the forward estimates, aggregating results across years and providing estimates as a percent of gross domestic product. The method for communicating these estimates depends on the nature of the uncertainty in the model. For example, aggregation across years captures the estimated magnitude and direction of an impact, and smooths the year by year volatility that occurs due to short term variations in economic parameters, behavioural responses to policy and data issues such as lags and outliers. Regardless of the method, it should be clearly communicated that the estimates are only a broad indication of the costs involved.

## **6. CONCLUSION**

Revenue costings beyond the forward estimates are subject to greater uncertainty and, as such, must be accompanied by appropriate caveats to avoid misrepresenting confidence in those estimates. The static microsimulation models that Treasury uses are similar to those used by domestic and international agencies and are not designed to provide detailed disaggregated year-by-year costings beyond the forward estimates. Dynamic microsimulation models are better suited to medium-term costings. But these also have limits and complexities and it is important that uncertainty around the projections produced from these models is clearly communicated and understood.

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