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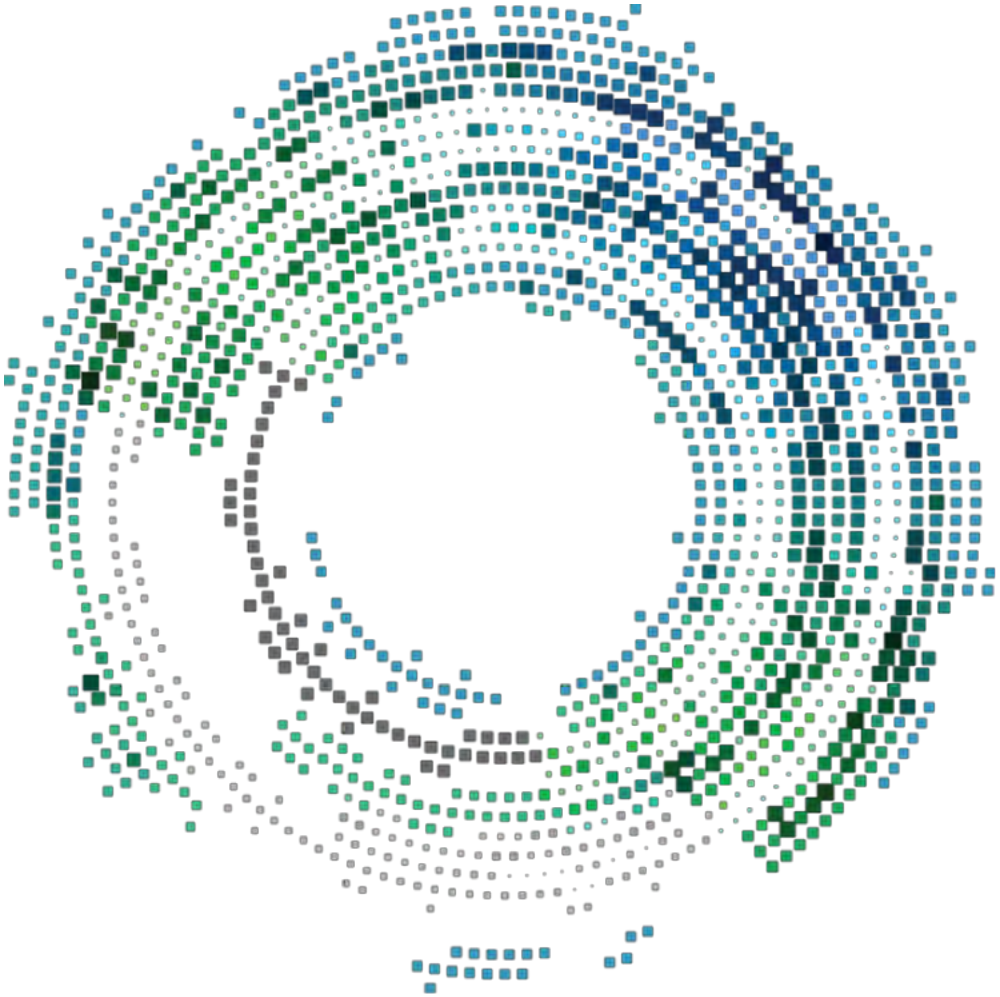

Review of Revenue Forecasting

Prepared for the Government of Western Australia,
Department of Treasury

21 February 2018

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David Christmas
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21 February 2018

Dear David

Review of revenue forecasting – FINAL REPORT

I enclose Deloitte Access Economics' review of revenue forecasting prepared for the Western Australia Department of Treasury. The report has been prepared for the purpose set out in our Offer dated 5 October 2017.

Yours sincerely

Matt Judkins
Partner
Deloitte Access Economics Pty Ltd

Contents

Charts

Tables

Figures

Glossary

Acronym	Full name
ABS	Australian Bureau of Statistics
ACoE	Average Compensation of Employees
ADJ MAPE	Adjusted Mean Absolute Percentage Error
AENA	Average Earnings from the National Accounts
AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
ARMA	Autoregressive Moving Average
AWOTE	Average Weekly Ordinary-Time Earnings
CFR	Cost and Freight
CoE	Compensation of Employees
CPI	Consumer Price Index
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMIRS	Department of Mines, Industry Regulation and Safety
dmt	Dry Metric Tonne
DoI	Department of Industry, Innovation and Science
DSS	Decision Support System
EBA	Enterprise Bargaining Agreements
ERC	Expenditure Review Committee
ERF	Economic and Revenue Forecasting
FHOG	First Home Owner Grant
FOB	Free on Board
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GSP	Gross State Product
GST	Goods and Services Tax
JEFG	Joint Economic Forecasting Group
KPIs	Key Performance Indicators
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MFPS	Mid-year Financial Projections Statement
MRIT	Metropolitan Region Improvement Tax
MYEFO	Mid-Year Economic and Fiscal Outlook
NWS	North West Shelf
OLS	Ordinary Least Squares
OSR	Office of State Revenue
PFPS	Pre-election Financial Projections Statement
PSW	Public Sector Wages

RBA	Reserve Bank of Australia
REIWA	Real Estate Institute of Western Australia
RMSE	Root Mean Squared Error
SGX	Singapore Exchange
SIC	Schwarz Information Criterion
TSI	The Steel Index
VEC	Vector Error Correction
VECM	Vector Error Correction Model
WA	Western Australia
WA Treasury	Western Australia Department of Treasury
wmt	Wet Metric Tonne
WPI	Wage Price Index

Executive Summary

Background

The Western Australia Department of Treasury (WA Treasury) is the primary economic and financial advisory agency for the Western Australian Government. The principal role of WA Treasury's Economic and Revenue Forecasting (ERF) unit is to develop the economic and revenue forecasts that underpin the Western Australian Budget. Budget estimates are used as the basis for policy decisions, and forecasts produced by ERF frame the economic and revenue policy advice provided by WA Treasury.

The purpose of this review is to examine WA Treasury's past forecast performance, current modelling approach, forecasting processes including capability and governance frameworks, and alternative approaches to revenue forecasting. The review covers revenue derived from iron ore royalties, payroll tax, land tax, and transfer duty. Macroeconomic drivers used as inputs to the revenue forecasts have been evaluated to the extent that they affect the performance and quality of revenue forecasts. Based on this review, Deloitte Access Economics proposes a set of 30 recommendations to support the improvement of WA Treasury's revenue forecasting function.

Summary of the review findings

The purpose of this review is to examine the capability, governance and processes employed by WA Treasury, along with the revenue forecasting approach and performance. This examination has been undertaken with respect to the practices adopted by forecasters in other Australian jurisdictions, along with Deloitte Access Economics' considerations of best practice, and with specific regard to the distinctive and relevant challenges of forecasting in a Western Australian context.

This review finds that accurately forecasting Western Australian government revenue is intrinsically difficult, and has become more complex over time. Volatility in Western Australia's economy and revenue base has increased since the turn of the century, largely stemming from growth in the State's resource sector. The forecasting task is more challenging in Western Australia than for other States or Territories that are less vulnerable to movements in economic conditions and government revenue.

With respect to governance and processes, this review finds that, in general, WA Treasury operates within a framework that is consistent with the standards set in other jurisdictions. Within the process of producing revenue forecasts, document management practices are adequate and conducive to consistent model usage by different forecasters. The timeline for regular updates to revenue forecasts is formalised and well documented, and it allows for sufficient time for revenue forecasts to be developed and reviewed. The current approach of modelling underlying revenue and separately adding policy effects is consistent with the approaches used by Treasuries in other jurisdictions.

However, this review has identified a number of findings that, if addressed, would strengthen the governance and processes surrounding the work of the forecasting unit. For example, the three- or four-week gap between the cut-off date for Budget forecasts and the Budget delivery date poses risks for forecast accuracy, given that economic factors may change rapidly during this period of time. This gap is longer than in most other jurisdictions. Also unlike other jurisdictions, WA Treasury does not undertake a regular, rigorous review of forecasting models or revenue forecasts by objective expert parties. Model guides and other instructional documents adopted by WA Treasury are not necessarily consistent or structured in a way that maximises their usefulness.

Staff from the forecasting unit are ideally placed to provide briefings on revenue forecasts and assist with relevant policy questions, but individuals have expressed concern that these and other responsibilities can detract from adequate model development and methodology review outside of the major forecasting rounds.

In other jurisdictions, there is a stronger emphasis on collaborating and testing forecasts with contributors outside of the forecasting team. Responsibility for producing forecasts is more

disaggregated (including, for example, via a unit structure which separates economic and revenue forecasters), providing additional opportunity for forecasts to be sense-checked by other divisions able to apply a fresh perspective.

With respect to capability, this review finds that the WA Treasury forecasting unit is staffed with individuals who possess a diverse mix of economic and quantitative skills, and that the capability of the individuals employed within the unit is adequate to meet core objectives and expectations. The culture within the forecasting team is strong and the work is seen to be both substantive and important, providing a positive factor for staff retention. However, the team is under-resourced with respect to the number of staff relative to other jurisdictions. Indeed, the revenue forecasting teams in all other State Treasuries consulted as part of this review were larger than the WA Treasury team in terms of the number of staff. Importantly, the number of staff in other State Treasuries is adequate for the busiest points in the year (primarily the lead up to the Budget and mid-year update), creating capacity for staff to focus on model development outside of major forecasting rounds.

The review also finds that the revenue forecasting function of WA Treasury is under-resourced, to some extent, with respect to access to and technical capability in utilising analytical tools. Other jurisdictions employ larger teams to undertake, arguably, a less complex forecasting task and also, in general, separate the economic and revenue forecasting functions to allow for greater specialisation of staff.

WA Treasury would be well placed to prioritise strong econometric and quantitative analytical skills when recruiting new staff into the forecasting unit, and should improve analysts' capability in using the database and analytical software package SAS (including acquiring an appropriate number of SAS licences for staff) given the growing role of unit record data in the examination of tax revenue.

Deloitte Access Economics has also found that a perceived lack of opportunities for advancement in the team risks discouraging staff from remaining in the forecasting unit in the long term. The lack of a Level 5 position poses a real threat to the team's ability to maintain staff at Levels 3 and 4 (with individuals effectively forced to leave the team if they seek promotion). If unaddressed, the general level of under-resourcing – compounded by frequent staff movements, uncertainty over promotion processes and timelines, and the growing importance of accurate forecasts in the context of highly volatile economic conditions – poses a threat to WA Treasury's ability to meet its objectives in the future.

With respect to forecast approach and performance, this review finds that, in general, the modelling approach employed by WA Treasury is comparable with other jurisdictions. Deloitte Access Economics does not find that there is a need for wholesale or fundamental change to the forecasting models or approaches utilised by WA Treasury. However, the review has suggested a number of potential improvements, most notably to the transfer duty forecast models, for the consideration of WA Treasury.

While particular attention in recent years has focused on WA Treasury's forecast performance with respect to the price of iron ore, and those forecasts were generally inaccurate in an absolute sense, Deloitte Access Economics notes that very few, if any, other forecasters successfully predicted the volatility in that series over the last decade. WA Treasury's performance in forecasting the iron ore price has been respectable relative to the performance of other forecasters. Further, once the greater volatility in historical revenue data in Western Australia compared to other jurisdictions (and therefore the greater difficulty in forecasting future revenue) is taken into account, WA Treasury's revenue forecasts for payroll tax, transfer duty and land tax have been among the most accurate across all other jurisdictions examined.

The measurement of WA Treasury's forecast performance has been limited by changes in model methodology over time. That is, the historical forecast performance may not be reflective of the performance of current models. That said, this change in model methodology over time is an indication of a culture of continuous improvement and a desire to continually strive for forecasts that are more accurate.

The remainder of this Executive Summary provides further detail on Deloitte Access Economics' analysis of WA Treasury's capability, governance, and forecast approach and performance, before summarising the recommendations stemming from the review.

Summary of the review of capability and governance

Process

ERF develops the economic and revenue forecasts that underpin the State Budget, usually released in May of each year. Forecasts are also published in the Mid-year Financial Projections Statement (MFPS), generally released in December halfway through the Budget year; and the Pre-election Financial Projections Statement (PFPS), released before the March state election once every four years.

ERF updates revenue forecasts on a continuous basis, guided by data releases and the availability of year-to-date actual revenue data from the Office of State Revenue (OSR). The process for regular forecast updates is formalised, consistent, and well documented. However, ERF is required to submit its final forecasts for publication in the Budget some three or four weeks before the Budget delivery date, which poses significant risk for forecast accuracy given how rapidly economic factors may change over this period.

ERF produces a series of regular notes and publications to monitor and communicate important changes gradually over time. However, not all outputs are consistent in format or content, either across revenue heads or between points in time.

Beyond their core responsibilities, ERF analysts have a number of additional demands on their time, such as providing briefings to other parts of Treasury or ministers' offices. While ERF staff are ideally placed to provide advice on forecasts and assist with relevant policy questions, at times current resourcing arrangements mean that these additional responsibilities can detract from adequate model development and methodology review outside of the Budget and MFPS periods.

Capability

It is important that ERF forecasters have a mix of deep economic knowledge, quantitative and analytical ability, and strong communication and teamwork skills. The current ERF team possesses adequate skills to meet the core objective of producing accurate revenue forecasts. There is an internal desire to build the prevalence of econometric ability within the team, but this is not a critical gap in ERF's collective skill base. However, ERF would be well placed to prioritise strong econometric and quantitative skills when recruiting staff in the future.

ERF currently consists of a director, two managers, four principal economists, and three (2.4 FTE) analysts. There are a number of vacancies in the team structure. The senior end of the team structure is highly stable, with many senior staff having built deep expertise over many years' service. However, there are a number of issues affecting the pipeline of staff at junior levels. There is no Level 5 role in the team, meaning that staff at Level 4 seeking promotion are forced to transfer to another team. Likewise, limited turnover among senior economists (Level 7) limits promotion opportunities within ERF for staff at Level 6. Meanwhile, additional strain is placed on senior staff due to high turnover and related vacancies at junior levels.

The culture within ERF is strong and staff are attracted to, and encouraged to stay in, the team due to interest in and passion for its substantive work. However, ERF has a limited profile in the wider economics community in Western Australia and this poses a potential risk for its ability to recruit staff at all levels in the future.

Governance

Analysts continuously review revenue forecasts as they are developed, including both technical checks of the forecasting models and qualitative checks of forecasts against relevant economic trends. WA Treasury's existing Budget processes rely heavily on internal review and analysis. There is presently no rigorous, regular review of forecasts by objective expert parties outside of WA Treasury.

A second level of judgement is applied to forecasts by the Under Treasurer and Treasury Executive when they are briefed on updates. Judgement depends on the relative maturity and breadth of the forecasting models, and on the perceived level of impact of nuanced real-world factors that the models may not capture. Judgement is often not documented formally or consistently over time and across revenue heads.

In the process of producing forecasts, document management practices are adequate and broadly consistent. However, there is scope to improve the consistency and usefulness of model guides and instructional documents, as well as notes and briefings circulated by ERF.

Summary of the review of forecasting approach and performance

Iron ore royalties

At various points in time over the last decade, WA Treasury has both under- and over-estimated iron ore royalty receipts. In common with other forecasters, WA Treasury has faced difficulties in accurately forecasting iron ore prices, and this has been the primary driver of errors in forecasts of iron ore royalty receipts. Forecasts for the other drivers of iron ore royalties, namely volumes and the exchange rate, have been more accurate than WA Treasury's iron ore price forecasts.

Where data is available across the two periods analysed, from 2008-09 and from 2014-15, WA Treasury's iron ore price forecast accuracy has been comparable to that of the Department of Industry, Innovation and Science (DoI); better than some individual Consensus Economics contributors; and below that of the iron ore price assumptions used by Commonwealth Treasury.

WA Treasury has refined its price forecast methodology over time reflecting changes in the global iron ore market. In particular, the move from an annual setting of contract prices to short-term contracts and spot prices has added significant volatility to the iron ore price outlook. The current methodology achieves transparency and alignment to market forecasters. WA Treasury's iron ore price forecasts use derivatives prices in the short-run followed by an interpolation to medium-term projections taken from Consensus Economics and a private sector commodities specialist engaged by WA Treasury. Aspects of this approach, including the use of futures and Consensus Economics, are similar to some other government forecasters. The move from using historical average spot prices to derivatives prices for the short-run attempts to pick up short-term expectations. However, there are questions around the predictive power of futures prices given the limited liquidity in these markets.

Some other government organisations also adopt forecasting approaches based on fundamentals analysis as well as a 'no-change' approach. It is noted that WA Treasury regularly forms a view on supply and demand to derive a set of price projections. While this method is not used to directly inform forecasts, it serves to increase WA Treasury's understanding of the industry.

Deloitte Access Economics compared the forecast accuracy of WA Treasury's current approach with a 'no-change' assumption that uses a short-term spot price average over a one-year forecast horizon. The accuracy of the two approaches has been similar over the period analysed. However a no-change assumption is more easily explained and less open to questions when compared with the futures approach.

All methodologies are subject to forecast errors and fail to adequately predict events that impact prices. For example, the forecasters examined in this report failed to anticipate the turning point and/or the pace of the decline in benchmark prices from 2014. WA Treasury currently seeks opinions on commodity price and volume forecasts from industry, Department of Mines, Industry Regulation and Safety (DMIRS), and Department of Jobs, Tourism, Science and Innovation (DJTSI). However, other government departments benefit from a more formal government consultation process. This includes the sharing of preliminary forecasts and analysis for quality assurance and sense checking purposes.

WA Treasury has invested in building the capabilities of staff responsible for forecasting iron ore royalties as well as other related work. The forecast approach has been supported by extensive supplementary analysis into market conditions, available data and research, and best practice methods. There is some risk that the expertise and experience in commodity forecasting is

concentrated in two key team members. Treasury should continue to train junior staff in this area and prioritise knowledge sharing, for example via greater use of technical documentation and user guides.

Payroll tax

Deloitte Access Economics' analysis of WA Treasury's payroll tax models and forecast performance show that, for the period of 2002-03 onwards, Budget year forecasts were under-estimated initially, and then over-estimated more recently. These two distinct periods of over- and under-estimating highlight the difficulty in forecasting payroll tax revenue during periods of changing economic conditions, with the forecast errors reflecting movements in the overall economic performance of Western Australia over the past 15 years. Given that the errors reflected the prevailing economic conditions of the time, along with analysis of Budget year forecast error distributions, Deloitte Access Economics concludes that WA Treasury's payroll tax forecasts have been, in general, unbiased over time.

WA Treasury's budget year forecast accuracy has lagged the performance of State Treasuries in larger States such as New South Wales, Victoria and Queensland, even after adjusting for the greater volatility in historical payroll tax receipts in Western Australia (and therefore the greater difficulty in forecasting future revenue). However, after adjusting for volatility, the budget year forecasts have been more accurate on average than forecasts for South Australia, Tasmania and the Northern Territory. Since 2012-13, and after adjusting for volatility, WA Treasury's payroll tax forecast accuracy for forecast years beyond the Budget year has been better than or comparable to those of New South Wales, Victoria and Queensland.

A significant challenge with forecasting payroll tax in Western Australia is that the tax base is unevenly skewed towards the mining and related industries, so changes in payroll tax are highly sensitive to conditions in this sector. For example, in 2016-17, the mining industry accounted for around 22% of the State's payroll tax compared to around 7% of the State's employment. As such, the relatively simple, linear approach of linking payroll tax revenue to growth in wages and employment, which may be appropriate in large States with broad payroll tax bases, is not appropriate in Western Australia.

As such, WA Treasury employs a more sophisticated econometric model to forecast payroll tax (as do a number of other State Treasuries). A second econometric model, which includes an additional term capturing 'new entrants and bracket creep' is also run. In general, the concurrent use of two models with different specifications can remove some credibility and rigour in the modelling process. However, Deloitte Access Economics is comfortable that WA Treasury does not intend to regularly switch between the models. In time, as more historical data becomes available, WA Treasury may determine that the model that includes the new entrants and bracket creep term can be estimated robustly and should be used as the 'standard' model. Provided that this decision is made following a thorough review of forecast performance and econometric specification, this progression to a model which includes additional information is logical.

A detailed analysis of the econometric specification of the payroll tax model (along with the labour market model used to develop key independent variables), while resulting in some relatively minor suggestions for WA Treasury to consider, provides Deloitte Access Economics with confidence that the models are sound and are based on appropriate econometric fundamentals. The functional form of the model and the explanatory variables used by WA Treasury differ from the approaches used by some other State Treasuries. However the differences are not material. The supplementary analysis used to inform judgemental adjustments to the model forecasts is appropriate.

Deloitte Access Economics recommends that, in time, WA Treasury move to estimating and running only one econometric model to forecast payroll tax. There may also be merit in having different employees undertake the labour market and payroll tax analysis, which would add an additional level of oversight to the forecasting process. Additional resources devoted to forecasting the labour market and payroll tax would reduce the risk that expertise and experience is concentrated in one team member.

Transfer duty

Deloitte Access Economics' analysis of WA Treasury's transfer duty models and forecast performance show that, since 2002-03, the average Budget year forecast error has been 21%. While, at first glance, the forecast performance in Western Australia has been well below that in other jurisdictions over the same period, the relative performance improves considerably once the greater volatility of the historical transfer duty series in Western Australia (and therefore the greater difficulty in forecasting future revenue) is taken into account. Indeed, in the Budget year and in other years over the forward estimates period, WA Treasury's forecasts have been among the most accurate across all other jurisdictions examined.

As is the case in other jurisdictions, and consistent with transaction values (a combination of volume and price) being the key driver of transfer duty, WA Treasury's forecast approach is reliant on the accuracy and approach of forecasts for transaction volumes and prices. In Western Australia, volumes and prices are modelled for residential transactions, while in some other jurisdictions, specific models for non-residential transactions have also been developed.

A review of the house price forecast model has suggested some improvements. Acknowledging that the model is a work in progress, Deloitte Access Economics notes that the house price forecast model only considers the demand side of the housing market. Rather than demand or supply in isolation, the demand-supply balance affects house prices in a given jurisdiction.

Deloitte Access Economics also considers that WA Treasury should consider some amendments to its transaction volume forecasting model. The model currently incorporates iron ore prices as a measure of economic activity. Given the difficulties in accurately forecasting iron ore prices, WA Treasury should investigate whether an alternative variable could be used (for example, business investment could be used to track the domestic business cycle, and would be available as part of WA Treasury's suite of economic forecasts).

Large or 'specials' transfer duty is volatile. WA Treasury uses a historical average supplemented with advice from OSR over the forward estimates. This is consistent with the methodology used in most other jurisdictions and, in Deloitte Access Economics' view, is the most logical forecast approach. WA Treasury should continue to communicate with OSR to incorporate any information available in near-term forecasts.

Deloitte Access Economics also recommends that additional resources be directed toward transfer duty modelling given (a) the model development task that is required and (b) the existing workload of the staff member who is currently tasked with preparing the transfer duty forecasts.

Land tax

Deloitte Access Economics' analysis of the land tax modelling and forecast performance of WA Treasury has been limited by the current lack of a formal model for this revenue head. WA Treasury is currently in the process of developing a model for forecasting land tax in the later years of the forward estimates period, and intends to continue to rely on analysis and advice of the OSR for Budget year forecasts.

The Budget year forecasts for land tax revenue display a relatively high degree of accuracy. When considering the forward estimates period more generally, a pattern of under-estimation is observed prior to 2012-13, while WA Treasury has, on average, over-estimated land tax revenue since 2012-13. As has been the case for other revenue heads, these errors are reflective of general economic conditions in Western Australia over the same period.

After adjusting for historical volatility, WA Treasury's forecasts of land tax in the Budget year have performed comparatively well relative to those of other States examined since 2002-03. When considering the forward estimates period more generally since 2012-13, and after adjusting for State-specific volatility, WA Treasury's forecasts of land tax have on average performed better than those of New South Wales, and have been close to the performance recorded in Victoria, South Australia and Tasmania.

WA Treasury is in the process of developing a model for the forecasts beyond the Budget year. During this process, WA Treasury should explore the relationship between (lagged) property prices and land values, in line with the methodology used by some other State Treasuries.

Given the accuracy of forecasts for the Budget year, Deloitte Access Economics' view is that the current process for producing those forecasts should be maintained. However, there is the potential for WA Treasury to expand its analysis of OSR data by gaining access to additional information showing trends in aggregation, land holdings, type of land, and taxed land values (as opposed to general land values). Access to this OSR data would provide WA Treasury with greater clarity on the impact of trends that are otherwise difficult to understand and predict.

Deloitte Access Economics also recommends that additional resources be directed toward land tax modelling given (a) the model development task that is required and (b) the existing workload of the staff member who is currently tasked with preparing the land tax forecasts.

Recommendations

This review makes a number of recommendations aimed at improving WA Treasury's revenue forecasting function.

Process

1. **Extension of cut-off date for final forecasts** – While acknowledging that this is not in the direct control of WA Treasury, the cut-off date for submitting final forecasts for the Budget and MFPS should be reviewed and, if possible, set closer to Budget release date. Emphasis should be placed on published forecasts being as accurate as possible as at the date of publication. This is particularly relevant for volatile revenue heads like iron ore royalties that can change rapidly. In all other jurisdictions consulted, the cut-off date for both revenue and expenditure information was significantly closer to the Budget delivery date than is presently the case in Western Australia.

2. **Review briefing material and communication** – Content and format of briefing material relating to forecast updates should be reviewed in consultation with the WA Treasury Executive. ERF should prioritise communicating updates to forecasts that clearly and consistently articulate the information required by WA Treasury Executive and other recipients. Improving the consistency between different outputs and over time would assist recipients in understanding key messages and changes that have occurred in the intervening period. This would also improve record keeping practices.

3. **Consider separation of macroeconomic and revenue forecasting responsibilities** – The revenue heads examined in this study are highly sensitive to macroeconomic drivers, so there is some merit in having analysts responsible for both revenue and the relevant macroeconomic variables. However, ERF should consider separation of the economic and revenue forecasting functions to allow for greater specialisation. This recommendation is particularly relevant for labour market and payroll tax forecasts where there may be merit in having different employees undertake the two forecasts. This would add an additional level of oversight and may reduce potential bias in the forecasting process. This type of structure would likely require additional resources and would be consistent with other State Treasuries.

4. **Establish a forecasting working group** – WA Treasury's existing Budget processes rely heavily on internal review and analysis. It is recommended that WA Treasury establish an external forecasting working group, consisting of an expert group of government representatives. The aim of this group would be to review, debate, test and challenge WA Treasury's preliminary macroeconomic and revenue forecasts. Discussions should be a formalised and scheduled part of the forecasting process, and should cover all revenue heads. The precise composition of the group should be determined in consultation with the WA Treasury Executive, based on an assessment of the relative capabilities of other agencies and the value they could reasonably be anticipated to add to the forecast review process. WA Treasury should consider including both State and Commonwealth agencies within the working group.

Capability

5. **Devote additional resources to economic and revenue forecasting** – WA Treasury should devote additional resources to ERF given the breadth and significance of the work undertaken by the team. During consultations, concern was raised that senior staff juggle too many areas of responsibility. Staff at all levels face difficulties in meeting competing priorities, particularly during busy periods. Generally speaking, economic and revenue forecasting teams in other jurisdictions are larger than ERF in terms of staff resourcing. In the case of property related forecasts, one team member is responsible for forecasting transfer duty and land tax. This workload presents risks to model development plans and continuity.

6. **Fill vacant positions in team structure** – It is recommended that WA Treasury prioritise finding staff to fill the vacant positions within the team structure. Current resourcing arrangements mean that any vacancies are felt particularly acutely.

7. **Embed career progression opportunities** – ERF's team structure should be amended to create a clear pathway for career progression of forecasters especially at junior levels. The lack of a Level 5 position is a disincentive for junior analysts to remain in the team. Staff at Level 6 need to be provided with other opportunities for advancement, such as through secondments, in circumstances where positions at Level 7 have very slow rates of turnover.

8. **Boost the profile of economic and revenue forecasting** – ERF should actively contribute to boosting the profile of WA Treasury's economic and revenue forecasting. This could be achieved via further collaboration with local academic institutions through joint projects, conferences, and other initiatives. This would help to build the reputation of ERF, assist recruitment of high quality staff, and facilitate knowledge sharing beyond WA Treasury.

Governance

9. **Conduct regular reviews** – WA Treasury has prepared various products in-house to measure its forecasting performance. Separately, two holistic reviews of revenue forecasting have been commissioned since 2005. It is recommended that WA Treasury commissions or conducts more regular external reviews of revenue forecasting, including both forecast outputs and technical forecasting models. WA Treasury could also seek to engage other forecasters to provide a peer review of models on an individual basis. These initiatives would relieve some of the pressure on ERF's internal assessments and expose the models, parameters, and judgement to objective critique. More regular, independent evaluation may provide improved insight, accountability and rigour to the existing evaluation process, including the embedding of lessons-learned into the future forecasting process. Deloitte Access Economics is not of the view that the outcomes of these reviews should necessarily be made public.

10. **Formalise systems of internal review** – WA Treasury should prepare a detailed forecast performance report following the release of final collections data each year. The report should compare forecasts with actual collections data, outline reasons for forecast errors, and emphasise any lessons learned. The report should be consistent across all revenue heads and over time.

11. **Refine performance targets** – WA Treasury currently publishes performance against targets in its annual report and in the Budget papers. While this is a somewhat reasonable approach to measuring and reporting on forecast accuracy, the use of flat targets does not account for varying degrees of difficulty across different revenue heads, and does not seek to tighten error bands over time. Deloitte Access Economics suggests the following:

    - Disaggregate targets by individual revenue heads. WA Treasury may consider this more appropriate for internal release only;
    - Expand discussion of reasons for error; and
    - Update targets at each forecast round for the absolute percentage error to be set equal to the Mean Absolute Percentage Error (MAPE) of the relevant revenue head (or macroeconomic input) over the last five years.

12. **Better documentation of forecasts and judgement** – WA Treasury should develop a framework to consistently document forecasts over time. This should include quantifying changes to forecasts and the reason for change, including changes due to i) parameters ii) policy iii) actual revenue data iv) methodology v) judgement. Understanding the role of judgement is critical to transparent evaluation of forecasts and models.

13. **Improve model guides and other instructional documentation** – These documents should be of such a standard that new staff or staff unfamiliar with certain models could pick up precisely where a previous staff member left off. This is particularly important given the large number of responsibilities spread across ERF, and would improve continuity as staff leave and join the team.

Methods

The following recommendations relate to forecasts of all revenue heads, while recommendations that are specific to individual revenue heads within the scope of this review are listed thereafter.

14. **Internally consistent forecasts** – WA Treasury should enhance the integration of forecasting models, both within the suite of revenue forecast models, and between the revenue and economic models. Greater integration between the models would also enhance WA Treasury's ability to conduct sensitivity and scenario analyses that are consistent across revenue and macroeconomic forecasts.

15. **Prioritise consistency through time** – Recognising the inherent difficulties in forecasting revenue, WA Treasury should prioritise consistency of approach through time. This would enhance confidence in the process from the WA Treasury Executive, the Treasurer and Government, and the public. WA Treasury has continued to refine its revenue forecast models over time and has further development plans for a number of revenue heads. Once ERF has developed a full suite of reliable forecast models, greater consistency of approach would reduce potential criticism and would allow for flexibility when required.

16. **Greater focus on economic risks at the margin** – It is recommended that greater emphasis is placed on analysis and communication of low probability-high impact macroeconomic risks at the margin of Treasury's central expectations. This could be achieved through a periodic review of key economic risks that incorporates scenario analysis (discussed below) as well as views gathered via external consultation.

17. **Enhanced scenario analysis** – Given the volatility in the State's economic base and the impact this has on the State's revenue, WA Treasury should expand the scenario analysis it undertakes. WA Treasury should give formal, structured consideration to macroeconomic risks using upside and downside scenarios across all years of the forward estimates, for example using possible lower and upper band trajectories in the iron ore price. Scenarios should be run across all revenue heads and should therefore be consistent with macroeconomic forecasts. Scenario analysis should be communicated within WA Treasury and with the Expenditure Review Committee (ERC) as part of the Budget and MFPS process. These scenarios (ideally published in Budget papers) would improve the communication and understanding of volatility and risks relevant the revenue forecasts.

18. **Structured model sensitivity tests** – In addition to enhanced scenario analysis, WA Treasury should bolster the current sensitivity analysis it undertakes by "vanilla testing" models, whereby economic inputs to revenue models are held constant at previous values and then changes to each input since the previous forecast are added one at a time. The resultant changes should make intuitive sense at each step. This test would serve as a useful sense check of the models and would improve the understanding of important drivers of revenue variation. Results of these tests should be updated on a periodic basis and become a regular part of the revenue forecasting process.

Iron ore royalties

19. **Update Visual Decision Support System (DSS) royalty forecasting database** – Based on the demonstration of the Visual DSS royalty forecasting database during consultations, the

programme appeared to be overly complex, disconnected from other data sources, and cumbersome to update. This would likely create inefficiencies during forecast rounds. The database was not intuitive or easy to use, which would likely create barriers for knowledge sharing and staff training. WA Treasury should consider creating a new model to simplify calculations and eliminate redundant code. An alternative software could be used that would allow for a more streamlined, efficient and transparent approach. Such a task would require additional funding to cover capital costs and staff time.

20. **Continued review of forecast performance and approach** – WA Treasury should continue to regularly monitor its forecasting performance with a focus on assessments of forecast error and these should be communicated to the WA Treasury Executive. Given the dynamic nature of the global iron ore market, it is important to continually consider the appropriateness of the forecasting approach and adjust the forecasting approach as warranted.

21. **Greater government liaison** – While it is acknowledged that WA Treasury currently seeks opinions on commodity price and volume forecasts from industry, DMIRS, and DJTSI, WA Treasury should expand and formalise its consultation process. If appropriate, consultation should include discussions with Australian government organisations including the Commonwealth Treasury, DoI, the RBA, the WA Government trade office in China and the Australian Trade and Investment Commission (Austrade) China Offices. This could include the sharing of preliminary forecasts and analysis for quality assurance and sense checking purposes. Consultation should be a regular and scheduled part of the forecasting process.

22. **Enhance private sector liaison** – Notwithstanding WA Treasury's liaison with mining companies and information gathering from commodities consultants, there is value in expanding liaison to include commodity analysts within investment and trading banks. It is recommended that WA Treasury establishes relationships with private sector contacts and engages with contacts in the lead up to forecasting rounds. There are a number of private sector organisations that conduct commodity analysis, including Goldman Sachs, UBS, Citi, Macquarie, CBA, ANZ, and Westpac.

23. **Expand iron ore royalty scenario analysis** – WA Treasury should extend its scenario capability to better understand how alternate outlooks for the global economy would affect iron ore royalty revenue raised. This could be done in conjunction with a broader framework across all sources of revenue, for example by quantifying a downside scenario across all revenue heads over the forward estimates period.

24. **Mitigate against key person risk** – While acknowledging the investment that WA Treasury has made in expanding the capabilities of its commodity forecasters, there is some risk that the expertise and experience in commodity forecasting is concentrated in two team members. WA Treasury should continue to train junior staff in this area and prioritise knowledge sharing, for example via greater use of technical documentation and user guides.

25. **Maintain resourcing requirements** – With Western Australian LNG projects continuing to ramp-up and come on line, LNG will make up a greater share of the State's export basket. WA Treasury may need to devote additional resources to monitor the LNG industry. This should not come at the expense of current coverage of the iron ore industry.

Payroll tax

26. **Move to the use of a single model when possible** – In time, as more historical data becomes available, WA Treasury could determine that the model that includes the new entrants and bracket creep term can be estimated robustly. At this point, WA Treasury should determine which model should be used as the 'standard' model following a thorough review of forecast performance and econometric specification.

Transfer duty

27. **Review of transaction volume forecasts** – WA Treasury is in the process of redeveloping its current approach to forecasting transfer duty. As part of this redevelopment, WA Treasury should consider some amendments to its transaction volume forecasting model. Given the

difficulties in accurately forecasting iron ore prices, WA Treasury should investigate whether an alternative variable could be used (for example, business investment could be used to track the domestic business cycle, and would be available as part of WA Treasury's suite of economic forecasts). Additionally, WA Treasury should consider using forecasts of households in place of population forecasts, as the number of households is more relevant for housing demand than population. That said, the relatively slow-moving relationship between population and households means that population is a useful proxy for housing demand if forecasts of the number of households cannot be produced.

28. **Review of house price forecasts** – WA Treasury is currently considering amendments to its house price model. As part of this review, consideration should be given to the supply-demand balance in the housing market.

Land tax

29. **Expand analysis of OSR data** – Historically, forecasts of land tax revenue in the Budget year have been relatively accurate. The current approach for producing land tax revenue estimates in the Budget year should be maintained, including liaising with OSR for land tax revenue estimates and advice. However, there is potential for WA Treasury to expand its analysis of OSR data by gaining access to additional information showing trends in aggregation, land holdings, type of land, and taxed land values (as opposed to general land values). Access to this OSR data would provide WA Treasury with greater clarity on the impact of trends that are otherwise difficult to understand and predict.

30. **Further explore the relationship between house prices and land values for forecasts beyond the Budget year** – WA Treasury is planning to develop a model to forecast land tax. During this development process, WA Treasury should explore the relationship between property prices and land values, in line with the methodologies adopted by some other State Treasuries.

Key Performance Indicators

The following Key Performance Indicators (KPIs) have been developed to assess the performance of the revenue forecasting function based on the recommendations formulated as part of this review.

- Hold a forecasting working group meeting at least twice per year, during the Budget and MFPS processes.
- Fill vacant positions in the team structure within three months of vacancy.
- Conduct or commission a review of forecast methods and processes at least once every four years. Refer to recommendation 9.
- Achieve forecast accuracy within set targets for MAPE across all revenue heads and macroeconomic inputs. Refer to recommendation 11.
- Ensure that at least two staff members are able to produce forecasts for each revenue head at any point in time.
- Implement accepted recommendations according to the timeframe detailed in Figure i.

Figure i: Suggested implementation schedule

	Suggested implementation dates		
	Budget 2018-19	MFPS 2018-19	Budget 2019-20
Process			
Extension of cut-off date for final forecasts			◆
Review briefing material and communication	◆		
Consider separation of macroeconomic and revenue forecasting responsibilities			◆
Establish forecasting working group	◆		
Capabilities			
Devote additional resources to economic and revenue forecasting		◆	
Fill vacant positions in team structure	◆		
Embed career progression opportunities		◆	
Boost the profile of economic and revenue forecasting		◆	
Governance			
Conduct regular external reviews			◆
Formalise systems of internal review		◆	
Refine performance targets	◆		
Better documentation of forecasts and judgement	◆		
Improve model guides and other instructional documentation			◆
Methods			
Internally consistent forecasts			◆
Prioritise consistency through time			◆
Greater focus on economic risks at the margin			◆
Enhanced scenario analysis			◆
Structured model sensitivity tests			◆
Iron ore royalties			
Update Visual DSS royalty forecasting database			◆
Continued review of forecast performance and approach	◆		
Greater government liaison		◆	
Enhance private sector liaison		◆	
Expand iron ore royalty scenario analysis			◆
Mitigate against key person risk	◆		
Maintain resourcing requirements	◆		
Payroll tax			
Move to the use of a single model when possible			◆
Transfer duty			
Review of transaction volume forecasts		◆	
Review of house price forecasts		◆	
Land tax			
Expand analysis of OSR data		◆	
Explore the relationship between house prices and land values for forecasts beyond the Budget year	◆		

1 Background

Deloitte Access Economics has been engaged by the Western Australia Department of Treasury (WA Treasury) to conduct an external review of revenue forecasting. This review examines current revenue forecast methods and processes, and recommends measures to address identified areas of improvement.

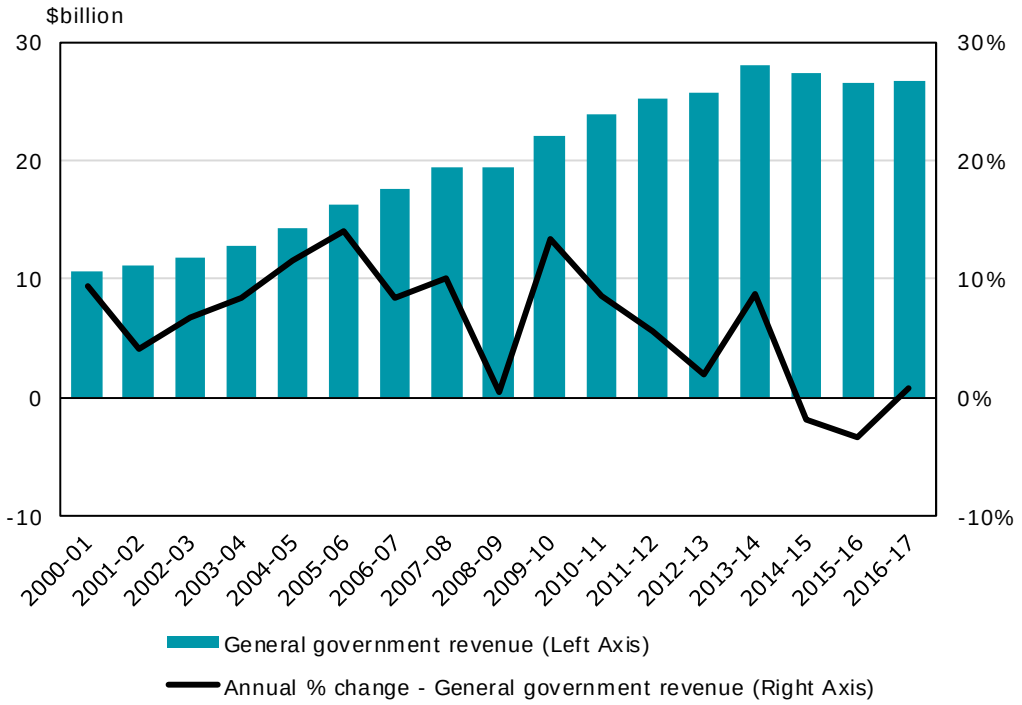
1.1 Context of the review

1.1.1 Western Australia government revenue

Western Australian general government revenue has grown by an average of 3.8% per annum since 2008-09. General government revenue peaked in 2013-14 at almost $28bn. This reflected the strong domestic and global economic conditions that prevailed during that period.

The period from 2008-09 was also characterised by significant volatility, with revenue growth peaking at 13.4% in 2009-10 before decelerating. General government revenue contracted in 2014-15 and 2015-16. The volatility is reflective of both the nature of the Western Australian economy as well as the structure of the State's revenue base.

Chart 1.1: Western Australia general government revenue



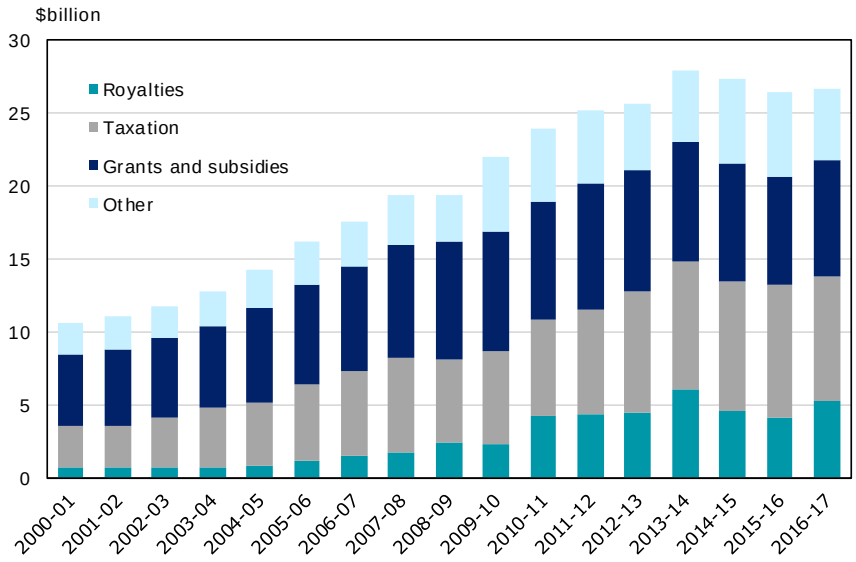
Source: WA Budget Papers

Chart 1.2 illustrates the items that make up Western Australia government revenue. Grants and subsidies (which are not in scope for this review) have been the largest contributors to State revenue since 2000-01, comprising 36% on average over the period.

Taxation has been the second largest contributor to State revenue since 2000-01, comprising 31% on average. Taxation revenue includes payroll tax and property taxes that are within the scope of this review.

Royalty income has increased from around 6% of total revenue in 2000-01 to a peak of 22% in 2013-14. This coincided with increases in the volume and value of the State's mineral output in response to rising commodity prices. Meanwhile, goods and services tax (GST) grants fell from 24% to 9% of total revenue over the same period. Greater reliance on royalty revenue has had a lagged effect on GST revenue through the Commonwealth Grants Commission process.

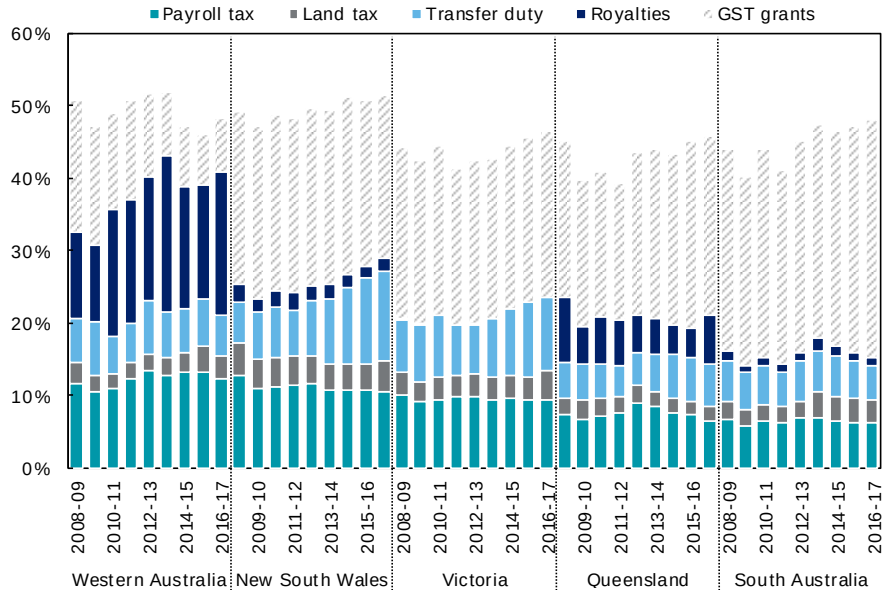
Chart 1.2: Western Australia general government revenue by source



Source: WA Budget Papers

Western Australia relies heavily on royalties relative to other jurisdictions. Chart 1.3 illustrates that the share of revenue made up by royalties is much higher in Western Australia than in New South Wales, Victoria, Queensland and South Australia, while the share of revenue made up by more stable revenue sources is much lower. The heavy reliance on a volatile revenue source such as iron ore royalties increases Western Australia's vulnerability to sharp changes in government revenue more generally.

Chart 1.3: General government revenue by source



Source: State Budget Papers

KEY FINDING: Volatility in Western Australia's general government revenue is reflective of both the nature of the Western Australian economy as well as the structure of the State's revenue base. The State's revenue relies heavily on royalties and less on more stable revenue sources compared to most other jurisdictions. This increases the vulnerability of Western Australia's revenue base to sharp – and unpredictable – movements.

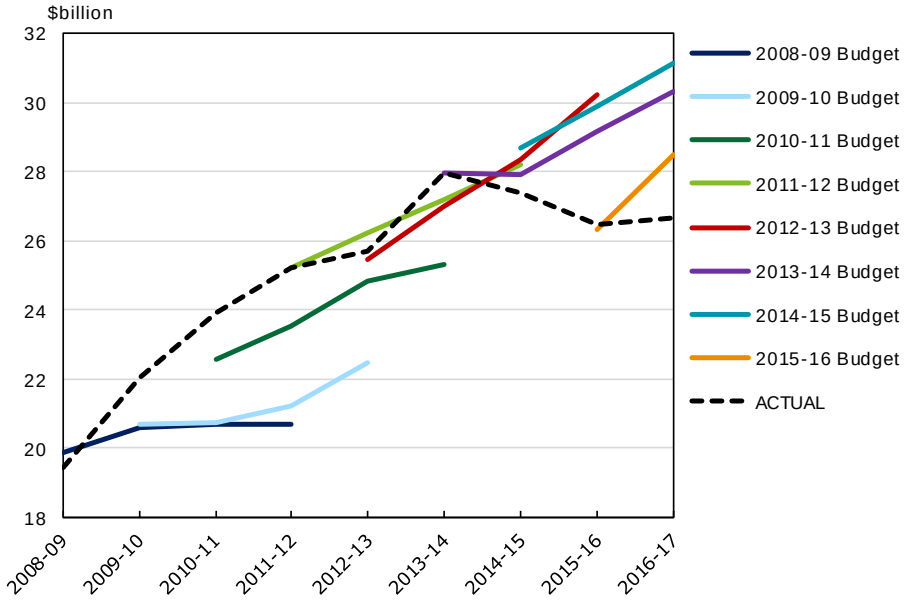
1.1.2 Western Australian government revenue forecasts

Revenue forecasting is a core function of WA Treasury and it is a key component of the economic and financial advice provided to the State Government. WA Treasury prepares forecasts of the State Government's revenue streams each year as part of the State Budget and Mid-year Financial Projections Statement (MFPS). The accuracy of revenue forecasts is critical to planning around the State Budget as the projections inform future expenditure decisions by the State Government.

Chart 1.4 illustrates WA Treasury's Budget forecasts of general government revenue over successive forward estimates periods relative to actual revenue over the same periods. The accuracy of the revenue forecasts largely reflects the accuracy of forecasts of key macroeconomic parameters. Volatility in economic conditions has made accurately forecasting revenue growth increasingly difficult in Western Australia.

Forecasts at the beginning of the mining boom were consistently lower than actual revenues as royalties increased sharply due to rising commodity prices, lifting headline revenue growth. Since global commodity prices softened and economic activity in Western Australia weakened, forecasts of royalty and taxation receipts have been too optimistic and have over-estimated income flows. The decline in revenue that occurred in 2014-15 and 2015-16 was unforeseen.

Chart 1.4: Successive forecasts of Western Australia general government revenue



Source: WA Budget Papers

Accurately forecasting Western Australian government revenue is a difficult task, and one that has become more complex over time. In undertaking this review, Deloitte Access Economics has identified the following challenges inherent in forecasting Western Australian government revenue:

- Forecasting tax revenues is more challenging than forecasting macroeconomic parameters. Any errors in forecasts of macroeconomic parameters will have implications for the accuracy of tax forecasting.

- Economic and revenue forecasting for any State or Territory is more difficult than forecasting at the national level. State and Territory economies are less diverse, the historical data is less reliable, there is a greater reliance on property and transaction taxes which are inherently difficult to forecast, and there is a reduced likelihood of offsetting errors.
- Volatility inherent in the Western Australian economy and in the revenue base makes the forecasting task more difficult than for other States or Territories that are less vulnerable to sharp movements in economic conditions and government revenue.
- The rise of China and other emerging economies has been associated with increased volatility in national income, with much of that increased volatility generated by commodity prices. As Australia's leading commodity producer, Western Australia's economy and its tax take have become more volatile and harder to forecast since the turn of the century.
- Forecasting errors can be correlated, leading to the amplification of errors. For example, if forecasts of Chinese activity are inaccurate, this would lead to inaccurate forecasts for commodity prices and exchange rates, and in turn, iron ore revenues. This would have flow-on effects for expectations of employment and population growth as well as housing market conditions, affecting forecasts of payroll tax and transfer duties respectively.

While China's economy has been growing rapidly since the 1980s, 2003 is generally considered the start of Australia's recent mining boom. At this time, Australia enjoyed large increases in demand for its key export commodities. The charts that follow consider measures of volatility in key macroeconomic drivers of government revenue across two periods: 1990 to 2003, and 2003 to 2017. Comparisons are drawn over time, between different States and Territories, and in reference to the national level.

Chart 1.5 and Chart 1.6 consider nominal State income, the most fundamental driver of a State's revenue receipts. Chart 1.5 illustrates that nominal gross state product (GSP) has been more volatile in Western Australia than in any other State since 2003. Chart 1.6 shows that income flows, and hence tax receipts, have become more volatile since 2003, particularly in Queensland and Western Australia.

Chart 1.5: Post-2003 volatility of nominal GSP (GDP)

Source: Deloitte Access Economics analysis of Australian Bureau of Statistics data. Average standard deviation of year-to data for the period 2003 to 2017.

For Western Australia, the change in volatility has been evident even among typically stable macroeconomic variables. Since 2003, global economic activity has been dominated by the rise of

emerging economies, which saw sustained increases in commodity prices. For New South Wales and Victoria, the resultant positives for Australia (such as higher nominal incomes, company profits, and business investment) were, in part, offset by higher interest rates and exchange rates. This is an example of 'automatic stabilisers' working to reduce the resultant variations for some States.

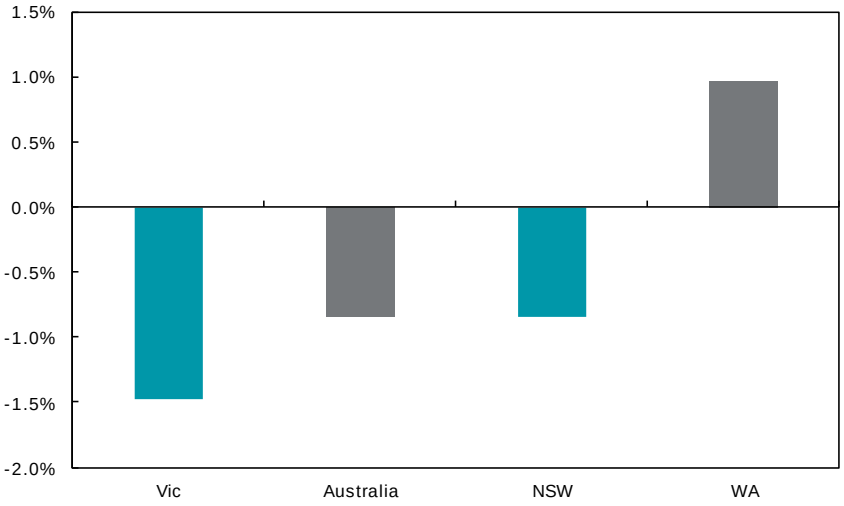
However, for Western Australia, the implications of changes in global conditions were magnified at the State level. The post-2003 period saw the volatility of variables such as wage and employment growth increase for Western Australia at the same time as they fell for New South Wales, Victoria and for Australia as a whole.

Chart 1.6: Percentage point difference in volatility of nominal GSP (GDP) for two periods: 1990 to 2003, and 2003 to 2017

Source: Deloitte Access Economics analysis of Australian Bureau of Statistics data. Difference in year-to average standard deviations of year-to data for two periods: 1990 to 2003, and 2003 to 2017.

The basic drivers of payroll tax became more volatile in Western Australia across a period in which they became less volatile for Australia and for other major States, as shown in Chart 1.7.

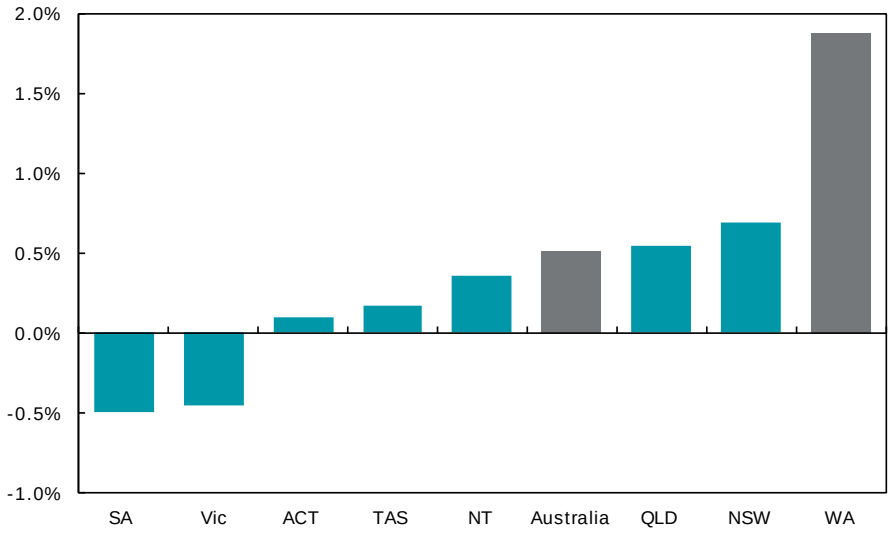
Chart 1.7: Percentage point difference in volatility of the wage bill for two periods: 1990 to 2003, and 2003 to 2017



Source: Deloitte Access Economics analysis of Australian Bureau of Statistics data. Difference in average standard deviations of year-to data for two periods: 1990 to 2003, and 2003 to 2017.

A similar pattern is evident across other key revenue heads, such as housing prices that underlie transfer duty, as is shown in Chart 1.8.[1]

Chart 1.8: Percentage point difference in volatility of house prices for two periods: 1990 to 2003, and 2003 to 2017

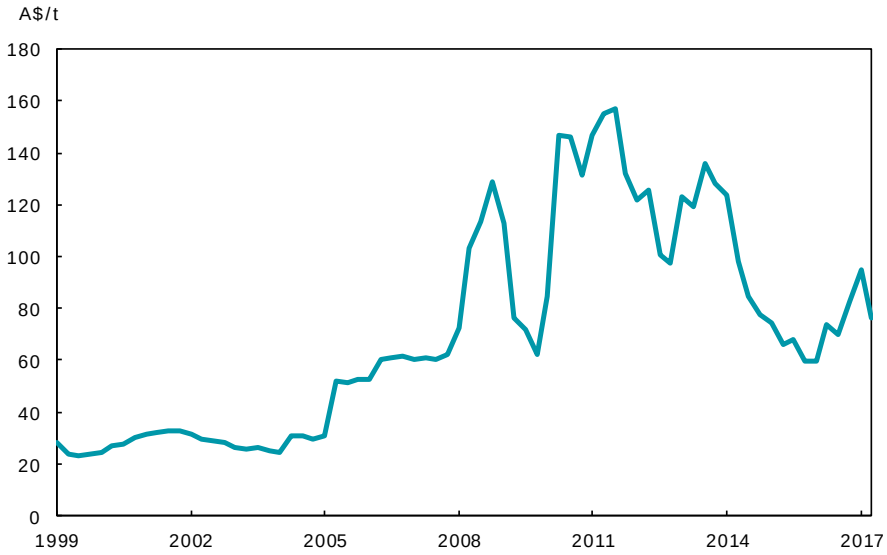


Source: Deloitte Access Economics analysis of Australian Bureau of Statistics data. Difference in average standard deviations of year-to data for two periods: 1990 to 2003, and 2003 to 2017.

Finally, volatility has been most pronounced in iron ore royalties owing to sharp movements in iron ore prices. The standard deviation of quarterly growth increased from 14% for the period 2000 to 2007 to 20% since the beginning of 2008. This has been a key contributor to forecast errors for WA Treasury and is discussed in further detail in Chapter 4 of this review. It is worth noting that iron ore prices in the first period were determined under the annual benchmark process, this process began to breakdown at the beginning of the second period.

[1] The discussion here is in terms of tax bases rather than tax revenues. As a generalisation, the thresholds applying to payroll tax, the progressivity of the transfer duty schedule, and the specifics around some royalty arrangements will tend to further exacerbate the change in volatility noted in this section of the report.

Chart 1.9 Iron ore export prices per tonne, A$



Source: WA Department of Mines, Industry Regulation and Safety.

Uncertainty is intrinsic to forecasting the future level of Western Australia's government revenue. Certain measures can be adopted to improve forecasts rather than eliminating errors entirely. Understanding the sources of uncertainty assists in mitigating against risks.

Regular reviews are critical to ensuring WA Treasury has in place the processes, capabilities and frameworks to generate consistently reliable forecasts. The last holistic review of revenue forecasting in Western Australia was conducted in 2005-06. Since then the Western Australian economy has navigated Australia's largest mining boom and the subsequent decline, resulting in significant structural changes. With the end of the mining decline in sight, and in the context of the current inquiry into State Government Programs and Projects, it is timely to reassess WA Treasury's process for revenue forecasting.

KEY FINDING: Revenue forecasting is a core function of WA Treasury; it is a key component of the economic and financial advice provided to the State Government. The accuracy of revenue forecasts is critical to planning around the State Budget as the projections inform future expenditure decisions by the State Government.

Accurately forecasting Western Australian government revenue is a difficult task, and one that has become more complex over time. Uncertainty is intrinsic to forecasting the future path of Western Australia's government revenue. Certain measures can be adopted to improve forecasts rather than eliminating errors entirely.

1.2 Terms of reference

The scope of this review covers the following elements WA Treasury's revenue forecasting process:

- Past forecast performance;
- Current modelling approach;
- Current processes including capabilities and governance frameworks; and
- Alternative approaches to revenue forecasting.

The revenue streams covered as part of the review are:

- Iron ore royalties;
- Payroll tax;
- Transfer duty; and
- Land tax.

This report focuses on forecasting methods and processes for the revenue streams listed above. Macroeconomic variables that are used as inputs to the revenue forecasts have been evaluated to the extent that they affect the performance and quality of revenue forecasts.

This review of forecasting is limited to the Budget year and forward estimates period, and does not evaluate longer-term forecasts.

An important component of this review process has been consultations with the revenue and macroeconomic forecasting teams of Commonwealth Treasury, New South Wales Treasury, Victorian Department of Treasury and Finance, Queensland Treasury, and the Commonwealth Department of Industry, Innovation and Science (DoI).

In addition to assessing the soundness of current methods and processes of the revenue forecasts, as well as the adequacy, suitability, and sustainability of capabilities and resourcing of the forecasting functions, this report:

- Identifies Key Performance Indicators (KPIs) to assess the performance of the revenue forecasting function;
- Identifies potential areas for improvement in forecasting methods and capabilities; and
- Suggests approaches and measures to address identified improvement opportunities.

1.3 Structure of the review

The remainder of this report is structured as follows:

Part A – Process, capabilities and governance

- **Chapter 2: Process review** – examines the process adopted by WA Treasury to produce revenue forecasts. Each stage of the forecasting round is discussed, as well as core outputs and competing responsibilities.
- **Chapter 3: Capability and governance review** – outlines the current capabilities and resourcing necessary for producing revenue forecasts, including skills and experience of staff. It also examines the forecasting function's structure and opportunities for career progression. This section also covers the governance arrangements that presently apply to the production and review of forecasts, and examines the role of judgement in complementing model outputs.

Part B - Individual heads of revenue

- **Chapters 4 – 7: Iron ore royalties, payroll tax, transfer duty, land tax** – each of these reviews in detail one of the revenue heads within the scope of this study. Each chapter evaluates forecast performance as well as current models, analytical approaches, tools and datasets used by WA Treasury in developing revenue forecasts. Each chapter summarises the recommendations that address identified improvement opportunities for the revenue forecasting function.

Appendices

- **Appendix A**: **Performance of Treasury's revenue forecasts** – describes the methodology and criteria used to assess the performance of WA Treasury's forecasts.
- **Appendix B**: **Model evaluation** – presents a review of the econometrics models considered, with a focus on methodology and model validation.

Part A – Process, capabilities and governance

2 Process review

WA Treasury is the primary economic and financial advisory agency for the Western Australian Government. The principal role of WA Treasury's Economic and Revenue Forecasting (ERF) unit is to develop the economic and revenue forecasts that underpin the Western Australian Budget. The Budget estimates are used as the basis for policy decisions, and forecasts produced by ERF frame the economic and revenue policy advice provided by WA Treasury.

Core responsibilities of ERF include monitoring relevant data releases, updating economic and revenue models, and writing the narrative included in Budget documents. The team also undertakes continuous model development, contributes to briefing material for the Treasury Executive, and advises on relevant policy matters.

This chapter examines the process adopted by WA Treasury to produce revenue forecasts. Each stage of the forecasting round is discussed, as well as core outputs and competing responsibilities.

2.1 Forecast process and timeline

ERF updates revenue forecasts on a continuous basis throughout the year, guided by macroeconomic data, actual revenue received to date, and policy announcements with revenue implications.

Forecasts are published biannually: in the State Budget generally released in May, six to eight weeks before the start of the Budget year; and in the MFPS, generally released in December halfway through the Budget year.

In Western Australia's fixed electoral cycle, the State election occurs on the second Saturday of March every four years; in election years, the Budget is generally delivered later – for example, on 8 August 2013 and 7 September 2017. However, in an election year, ERF is required to produce an additional set of published forecasts for the Pre-election Financial Projections Statement (PFPS), released in the February immediately preceding a March election.

ERF maintains a centrally accessible timetable that lists Australian Bureau of Statistics (ABS) and other data releases, scheduled dates for forecast runs, deadlines for notes and publications, and a parallel timeline for external consultations with industry, agencies, and other stakeholders.

2.1.1 Budget and MFPS periods

In a non-election year, the Budget process begins in early February with the commencement of regular meetings of the Expenditure Review Committee[2] (ERC) of Cabinet, at which WA Treasury Officials provide updates of revenue forecasts. Generally, these updates are given by the Under Treasurer or Deputy Under Treasurer. This timeline, February commencement for May Budget delivery, is broadly consistent with other Treasury departments in Australia.

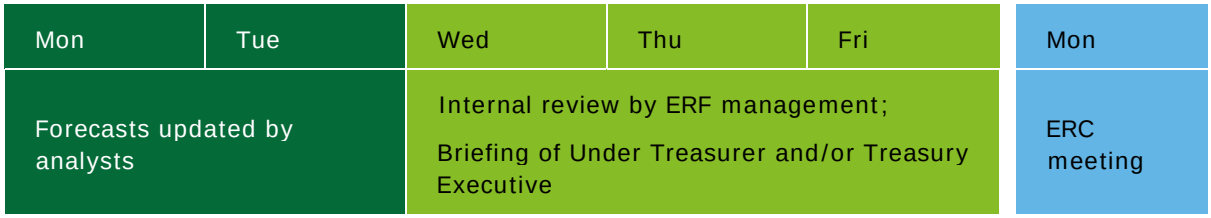
ERF forecast runs are conducted in line with the cycle of ERC meetings at which forecasts are presented. With notice of an ERC meeting for the Monday of a given week, analysts will update model outputs by the previous Tuesday, which are then reviewed internally by ERF. Briefings of the Under Treasurer and other members of Treasury Executive who may be involved in the ERC

[2] As of May 2017, ERC is chaired by the Treasurer and includes the Premier, Minister for Regional Development, Minister for Planning, Minister for Mines and Petroleum, and Minister for Finance.

presentation take place by the end of the preceding week, for presentation on the subsequent Monday (see Figure 2.1). This cycle repeats three to four times on a fortnightly basis during the standard Budget process, and two to three times during the MFPS process.

The internal ERF review process occurs on a regular basis during the Budget and MFPS periods, with team meetings to discuss high-level factors that may impact particular revenue heads. These also provide an opportunity to informally apply judgemental adjustments to model outputs before they are finalised and provided to Treasury Executive.

Figure 2.1: Timeline of forecast updates for ERC during Budget and MFPS periods



Generally, forecasts updates provided to ERC reflect policy and parametric changes only, such as updated economic indicators or details of actual revenue received. ERF is instead encouraged to undertake model development and reviews of forecasting methodology outside of the Budget and MFPS periods. This is consistent with practice in other jurisdictions, where updates to ERC (or equivalent) are driven chiefly by releases of new data and other changes to macroeconomic conditions.

The Budget cut-off date occurs in mid to early April, the deadline beyond which ERF is no longer able to adjust revenue forecasts. This deadline is occasionally pushed out by up to one week. Final revenue and expenditure forecasts approved by ERC are presented to the full Cabinet just before the cut-off date, at which point these figures become final and ready for publication.

There is a gap of approximately three weeks between the cut-off date and the date on which the Treasurer delivers the Budget and revenue forecasts are made public. The length of this period is determined by ERC to conform to the Budget timeline as a whole, but poses significant risks for the forecasts especially during times of considerable economic volatility. Given, for example, that iron ore royalties are forecast to account for more than 16% of general government revenue in 2017-18, sharp price movements over this three week period could significantly alter the outlook. In 2017, the Budget cut-off was 8 August and the Budget was delivered on 7 September, a gap of more than four weeks.

The gap between cut-off and Budget delivery is generally longer than in other jurisdictions. In some jurisdictions, forecasts are finalised within the final fortnight and the cut-off for changes to revenue forecasts is less than a week before Budget delivery. Greater flexibility allows Budget estimates to incorporate more timely information.

Table 2.1: Comparative Budget cut-off dates for revenue forecasts

Agency	Cut off date	Note
WA Treasury	Three to five weeks before Budget	Usually less than four, but greater than four for the 2017-18 Budget.
Treasury A	Less than one week before Budget	Cut-off is the Thursday preceding Budget delivery on Tuesday.
Treasury B	One week before Budget	Some flexibility in extending this until the deadline for printing.
Treasury C	One to two weeks before Budget	Varies; latest Budget cut-off was eleven days before delivery.
Treasury D	One to two weeks before Budget	Varies; latest Budget cut-off was eight days before delivery.

The MFPS process mirrors the Budget process in most respects, but with fewer forecast rounds and on a condensed timeline. While governments tend to use the Budget to announce major policy changes, the MFPS is predominately intended to reflect parametric changes and update the forecasts based on year-to-date actual economic and revenue data.

KEY FINDING: The timeline for regular updates to revenue forecasts is formalised, consistent and well documented. The timeline allows for sufficient time for revenue forecasts to be developed and reviewed.

The three- or four-week gap between the cut-off date for Budget forecasts and the Budget delivery date poses risks for forecast accuracy, given that economic factors may change rapidly during this period. This gap is also longer than in most other jurisdictions. Greater flexibility would allow Budget estimates to incorporate more timely information.

2.1.2 Regular outputs

ERF produces a set of regular notes, updates, and internal publications reflecting changes to forecasts. Individual analysts are responsible for producing these regular outputs for respective revenue heads. These outputs include:

- A 'heads up' note following a significant data release;
- 'Tax Monitor' publication to track actual receipts against forecasts;
- 'Iron Ore Monitor' publication to track developments in the iron ore market;
- Internal rationalisation meeting notes to justify proposed changes to forecasts;
- Central revenue tables to document differences between published forecasts;
- 'Economic and Revenue Update' to document the justification of final economic and revenue estimates; and
- Material to support presentations by the Under Treasurer.

When a new data release occurs prompting the update of a particular revenue forecast, the responsible analyst will produce a 'heads up' note to provide an overview of the update, key drivers for any significant change, and implications for revenue. Once finalised by ERF, these notes are circulated to the Treasury Executive and the Treasurer's Office.

On a monthly basis, ERF produces a 'Tax Monitor' publication for the Treasury Executive. The document compares published forecasts to latest actuals across multiple revenue heads, providing an indication of whether estimated revenue for that year will exceed or fall below forecast levels.

In advance of the Budget and MFPS periods, ERF produces the 'Iron Ore Monitor' to track recent developments and refine the outlook for the iron ore market. This in-depth publication also examines the steel supply chain, especially in China, and detailed information on unit costs and shipped volumes on a company level. This standalone publication reflects the increasing significance of iron ore royalties as a share of total revenue.

In the lead-up to the Budget or MFPS periods, ERF conducts internal rationalisation meetings. These meetings feature detailed discussion and analysis of economic trends and consequent changes to revenue forecasts. The notes from the rationalisation meetings track incremental changes from published figures to recent internal updates from past forecast runs, and propose adjustments. These notes are circulated to the Treasury Executive, at which point proposed adjustments are either adopted as the latest forecast figures, or adjusted further through the application of judgement.

Adjustments made between published forecasts are documented in the form of central revenue tables, provided to Treasury Executive and curated for presentation at ERC meetings. For example, mining revenue for 2017-18 was forecasted to be $6,080 million in the February 2017 PFPS, revised down to $5,878 million in the September 2017 Budget. The central revenue table contains ERF's decomposition of this $202 million write-down, explaining what proportion of the change is caused by production volumes, policy changes, exchange rate movements, freight assumptions, and commodity prices. Variations derived from the final central revenue tables are published in the Budget Papers or MFPS. The central revenue tables are supported by the 'Economic and Revenue Update' document that presents justification of final economic and revenue estimates.

In addition to updating forecast model outputs on a regular basis, ERF also prepares appropriate material for the Under Treasurer's presentations at ERC meetings as and when required. The process for the intermittent updates described above is essentially consistent across revenue heads, with key differences resulting from variation in the timing of data releases or availability of year-to-date actuals. For example, most land tax is paid in the first quarter of a given calendar year, so there is limited additional information that arises in other parts of the year requiring significant adjustments to forecasts.

There is scope to improve the consistency of format and content across ERF's set of regular outputs. For example, some other Treasuries produce standard forecast briefing notes for each revenue head or sector to both communicate forecasts internally and for record-keeping purposes. The notes explain reasons for changes in forecasts since the last time forecasts were presented. Changes are quantified and categorised, for example changes due to i) economic parameter changes ii) policy changes iii) data iv) methodology changes and v) judgement. WA Treasury uses the 'Economic and Revenue Update', central revenue tables, and material prepared for the internal rationalisation meeting for this purpose. While these documents are informative, improving consistency between different outputs and over time would assist recipients in understanding key messages and changes that have occurred in the intervening period. For example, charts and analysis included in the internal rationalisation meeting notes provided to Deloitte Access Economics were not always consistent across revenue heads. Format, such as branding, font, and chart colours, also varies across WA Treasury's publications.

KEY FINDING: Regular outputs produced by ERF analysts demonstrate the practice of continuously updating revenue forecasts and undertaking analysis throughout the year. Regular outputs allow ERF to monitor and communicate important changes gradually over time, including outside of the Budget and MFPS periods.

However, not all outputs are consistent in format or content, either across revenue heads or between points in time. Improving the consistency between different outputs and over time would assist recipients in understanding key messages and changes that have occurred in the intervening period. This is particularly important for briefing material relating to forecast updates.

2.1.3 Capturing policy effects

Policy impacts are modelled by the Revenue and Intergovernmental Relations unit within WA Treasury, which sits separate to ERF. One-off changes to revenue collections that occur as a result of policy are added to ERF's forecasts of 'underlying' revenue to produce final forecasts. Permanent changes are captured in the underlying revenue forecast model. For example, ERF will amend its model to reflect a permanent change in the payroll tax schedule, while a one-off increase in payroll tax revenue resulting from an audit of taxpayers is considered a policy change and accounted for separately. In many cases, these one-off impacts are marginal in size relative to the underlying base.

KEY FINDING: The current approach of modelling underlying revenue and separately adding policy effects is broadly consistent with the approaches used by Treasuries in other jurisdictions.

2.2 Additional responsibilities

Individual analysts within ERF are responsible for monitoring relevant data releases, retrieving updated information, processing changes through the respective revenue model, and reporting on these changes through the means described in section 2.1.2. These are considered core elements of producing revenue forecasts. Competing priorities are discussed in this section.

2.2.1 Model development

ERF staff review and continuously develop forecast models to improve the accuracy of outputs. This is a critical aspect of ensuring the integrity of forecasts, but is not a priority during forecast rounds in the Budget or MFPS periods. Model development is also deprioritised relative to the reporting and other support services that ERF provides.

ERF management allocates additional time for model development on an as-needs basis, for example by relieving a particular analyst of one element of their regular responsibilities to allow for greater emphasis on model development. However, given limited staff resources, this can only occur for one analyst at a time and requires other team members to temporarily take on additional responsibilities. Staff indicated that, in total, more time is necessary for model development and improvement than is presently available to them.

2.2.2 Policy advice and briefings

From time to time, ERF analysts are required to provide advice indirectly to the Treasurer to support answers to Parliamentary questions, which are turned around on short timeframes. ERF also provides a range of briefing notes on economic and revenue conditions to other business units within WA Treasury, other agencies, and other ministers' offices. While costing of policy measures may in theory sit outside ERF's purview, analysts may be required to assist in the policy modelling process because they possess the expertise or access to software necessary to do so.

ERF analysts also support the development of regular Treasury economic notes, submissions to the State and National Wage Cases, investor prospectuses for the WA Treasury Corporation, presentations for investor visits domestically and overseas, submissions to credit rating agencies, and other presentations.

2.2.3 Balancing resources and responsibilities

Competing demands on forecasters' time are a common feature across other jurisdictions, with staff required to support drafting Treasury publications and briefing material on a regular basis. As with ERF, other forecasters prioritise model development outside of the busy Budget and mid-year review processes.

ERF previously took on responsibility for the Public Sector Wages (PSW) Policy function, which traditionally sat outside of the purview of the team; at the time, this additional responsibility came with additional resources. Recently, the PSW Policy function was transferred to a different team, but ERF was able to retain part FTE of one manager and one Level 3 analyst previously working on PSW Policy. However, due to staff losses, the analyst has been allocated to other responsibilities, resulting in no net gain for ERF resourcing. Additional manager-level resources increases capability for challenging and sense-checking forecasts, but adds to an already top-heavy team structure lacking in analyst-level resources.

While new staff resources can be leveraged to assist with core ERF tasks, this creates risk; if the responsibilities are returned to other parts of Treasury, and the staff transition out with them, ERF stands to lose both resources and expertise in forecasting.

KEY FINDING: ERF staff are ideally placed to provide briefings on revenue forecasts and assist with relevant policy questions. However, staff have expressed concern that these and other responsibilities can detract from adequate model development and methodology review outside of the Budget and MFPS periods.

2.3 Alternative approaches to preparing forecasts

In other jurisdictions there is a stronger emphasis on collaborating and testing forecasts with contributors outside of the forecasting team. For example, revenue forecasts are tested in regular conferences with representatives from the agencies responsible for collecting revenue. At the Commonwealth level, economic forecasts used as inputs for revenue forecasts are subject to rigorous review by the Joint Economic Forecasting Group (JEFG), which consists of staff from Treasury, Australian Government central agencies, and the ABS[3].

Reporting to ERC (or the equivalent body) varies widely across jurisdictions. In some cases, the ERC equivalent does not review revenue forecasts on a fixed regular basis, instead doing so based on interest (for example because of a significant change in macroeconomic conditions).

[3] Commonwealth Treasury, 2013.

Economic and revenue forecasts are produced by different teams within most of the departments consulted as part of this review. In one State, forecasts are reviewed by a forecasting committee, consisting of representatives from OSR, the State Treasury's revenue forecasting and policy team, and the economic forecasting team. In another State Treasury, the previously combined macroeconomic and revenue forecasting teams were recently split; the revenue function was combined with the tax policy team, and the economic forecasting function was combined with the macroeconomic strategy team, resulting in less disconnect between the policy costings and forecast models. In another State Treasury, economic and revenue forecasts are produced by a single division but with dedicated internal branches for each area.

In each case, responsibility for producing forecasts is more disaggregated, providing additional opportunity for economic forecasts to be sense-checked by revenue forecasters able to apply a fresh perspective, and vice versa.

There are costs and benefits to separating economic and revenue forecasting functions. The revenue heads that ERF is responsible for forecasting are sensitive to macroeconomic drivers and developments in the global economy. There is hence significant merit to the current structure, in which analysts develop expertise in both a particular revenue head (such as payroll tax) and the relevant economic indicators upon which that revenue head relies (such as wage conditions, labour market composition, and so on). This is especially significant for WA Treasury, given the large share of revenue accounted for by iron ore royalties and the resources invested in building iron ore price and volume forecasting capability.

In some other jurisdictions, the revenue forecasting function tends to sit with the equivalent of WA Treasury's Revenue and Intergovernmental Relations unit, noting the synergies between revenue forecasting and revenue policy work. The functionally separate revenue forecasting team then has the opportunity to review the economic forecasts, adding an arms-length perspective that would otherwise be unavailable.

However, there would be a significant upfront cost to separating the two functions as analysts relinquish some existing areas of responsibility and acquire new, potentially unfamiliar ones. Further, with 15 to 19 full-time equivalents (FTE) in total for revenue and economic forecasting functions in other State Treasuries, separated teams in other jurisdictions have approximately 8 to 9 FTE each, only slightly less than the total current FTE resources available to ERF. Splitting ERF into two teams of 4 to 5 FTE may introduce additional resourcing risks in an environment of regular staff promotions and movements to other parts of Treasury, or where staff become unavailable at short notice due to illness. Team sizes are discussed in further detail in 3.1.3.

KEY FINDING: In other jurisdictions, there is a stronger emphasis on collaborating and testing forecasts with contributors outside of the forecasting team. Further, in the other jurisdictions, responsibility for producing forecasts is more disaggregated, providing additional opportunity for forecasts to be sense-checked by other divisions able to apply a fresh perspective.

2.4 Key findings and recommendations

2.4.1 Key findings

- The timeline for regular updates to revenue forecasts is formalised, consistent and well documented. The timeline allows for sufficient time for revenue forecasts to be developed and reviewed. However, the three- or four-week gap between the cut-off date for Budget forecasts and the Budget delivery date poses significant risks for forecast accuracy, given that economic factors may change rapidly during this gap. This gap is also longer than in most other jurisdictions. Greater flexibility would allow Budget estimates to incorporate more timely information.

- Regular outputs produced by ERF analysts demonstrate the practice of continuously updating revenue forecasts and undertaking analysis throughout the year. Regular outputs allow ERF to monitor and communicate important changes gradually over time, including outside of the Budget and MFPS periods. However, not all outputs are consistent in format or content,

either across revenue heads or between points in time. Improving the consistency between different outputs and over time would assist recipients in understanding key messages and changes that have occurred in the intervening period. This is particularly important for briefing material relating to forecast updates.

- The current approach of modelling underlying revenue and separately adding policy effects is consistent with the approaches used by Treasuries in other jurisdictions.
- ERF staff are ideally placed to provide briefings on revenue forecasts and assist with relevant policy questions. However, staff have expressed concern that these and other responsibilities can detract from adequate model development and methodology review outside of the Budget and MFPS periods.
- In other jurisdictions, there is a stronger emphasis on collaborating and testing forecasts with contributors outside of the forecasting team. Further, in the other jurisdictions, responsibility for producing forecasts is more disaggregated, providing additional opportunity for forecasts to be sense-checked by other divisions able to apply a fresh perspective.

2.4.2 Recommendations

The following recommendations are based on the findings above:

- **Extension of cut-off date for final forecasts** – While acknowledging that this is not in the direct control of WA Treasury, the cut-off date for submitting final forecasts for the Budget or MFPS should be reviewed and, if possible, set closer to Budget release date. Emphasis should be placed on published forecasts being as accurate as possible as at the date of publication. This is particularly relevant for volatile revenue heads like iron ore royalties that can change rapidly. In all other jurisdictions consulted, the cut-off date for both revenue and expenditure information was significantly closer to the Budget delivery date than is presently the case in Western Australia.
- **Review briefing material and communication** – Content and format of briefing material relating to forecast updates should be reviewed in consultation with the Treasury Executive. ERF should prioritise communicating updates to forecasts that clearly and consistently articulate the information required by Treasury Executive and other recipients. Improving the consistency between different outputs and over time would assist recipients in understanding key messages and changes that have occurred in the intervening period. This would also improve record keeping practices.
- **Consider separation of macroeconomic and revenue forecasting responsibilities** – The revenue heads examined in this study are highly sensitive to macroeconomic drivers, so there is some merit in having analysts responsible for both revenue and the relevant macroeconomic variables. However, ERF should consider separation of the economic and revenue forecasting functions to allow for greater specialisation. This recommendation is particularly relevant for labour market and payroll tax forecasts where there may be merit in having different employees undertake the two forecasts. This would add an additional level of oversight and may reduce potential bias in the forecasting process. This type of structure would likely require additional resources and would be consistent with other State Treasuries.
- **Establish a forecasting working group** – WA Treasury's existing Budget processes rely heavily on internal review and analysis. It is recommended that WA Treasury establish an external forecasting working group, consisting of an expert group of government representatives. The aim of this group would be to review, debate, test and challenge WA Treasury's preliminary macroeconomic and revenue forecasts. Discussions should be a formalised and scheduled part of the forecasting process, and should cover all revenue heads. The precise composition of the group should be determined in consultation with the Treasury Executive, based on an assessment of the relative capabilities of other agencies and the value they could reasonably be anticipated to add to the forecast review process. WA Treasury should consider including both State and Commonwealth agencies within the working group.

3 Capability and governance review

This section outlines the core skills and qualifications necessary for producing revenue forecasts, and assesses the current status of ERF staff capabilities. It also examines ERF's structure and opportunities for career progression for forecasters. Finally, this section covers the governance arrangements that presently apply to the production and review of forecasts, and examines the role of judgement in complementing model outputs.

3.1 Capabilities

3.1.1 Relevant skills and qualifications

The bulk of the WA Government's own-source revenue comes from the revenue heads covered in this study: land tax, payroll tax, transfer duty, and iron ore royalties. Each of these revenue heads are sensitive to broader economic variables, such as land prices, wage growth, and iron ore prices and production volumes. It is therefore necessary for analysts producing revenue forecasts to have a strong background in economics and quantitative analysis, enabling them to understand the relationships between revenue and other variables and to curate, update, and sense-check the forecasting models. Further, revenue forecasters in WA Treasury are responsible for forecasts of underlying economic drivers.

Econometric methods are used to forecast some revenue heads, and so econometric skills are important for ERF analysts to possess. Even in cases where forecasts are produced through other means, statistical methods may be necessary for retrospective reviews of forecast performance. Economists with experience in quantitative analysis are ideally suited to revenue forecasting work.

It is equally necessary for forecasters to possess strong communication skills, as analysts take responsibility not only for updating forecasts for particular revenue heads, but also for deriving a narrative from the figures and determining the best way to communicate this. Analysts are involved in the chain of reporting forecasts that go to the Treasury Executive, Treasurer's Office, and eventually released to the public. The ability to explain outputs in a clear and concise manner is critical.

While analysts are given responsibility for particular revenue heads, the volume of work required to finalise forecasts for the Budget and MFPS demands a collaborative effort. Multiple team members participate in internal rationalisation meetings to discuss trends and economic drivers that may affect forecasts, and so strong communication and teamwork abilities are important.

Finally, published forecasts are the result of applying judgement to model outputs. All models are limited, to varying degrees, in their ability to capture nuanced or unobservable factors. In this respect, pragmatism is a key skill necessary for ERF forecasters to possess.

This is consistent with forecasting teams from other jurisdictions, in which emphasis is placed on capability to understand and communicate analysis, in addition to operating the forecasting models.

KEY FINDING: Analysts are responsible for the end-to-end process of producing forecasts for given revenue heads, including retrieving data, operating the forecasting models, analysing model outputs, and communicating key messages in a clear and concise narrative. Therefore, revenue forecasters require a mix of deep economic knowledge, quantitative and analytical ability, and strong communication and teamwork skills.

3.1.2 Current skills and experience

The forecasting team consists of capable economists with varying degrees of experience, most of whom have qualifications in economics at Honours or Masters level. The team has one PhD graduate with specialist knowledge in financial econometrics at manager level and one other analyst has a

technical econometric background. Across the broader team, the level of technical modelling and econometric skills is mixed.

Senior staff, many of whom have been in ERF for a number of years, have developed capability through experience but concerns were raised about the rate at which new staff with strong quantitative skills are being recruited. This issue surfaced during a period in which the econometrician at manager level was on extended leave, exposing a shortfall in econometric knowledge across the rest of the team. While econometric models are not used for forecasting all revenue heads, statistical methods for measuring past forecasts against actuals are central to the task of continuously improving forecast models.

WA Treasury raised concern that the scarcity of candidates with the required technical skills has meant that it can be difficult to fill vacancies, particularly when there is a need to temporarily backfill senior team members on long period of leave.

There is a desire from ERF management to improve the econometric capabilities of analysts. In early 2017, taking advantage of the late election-year Budget process, staff were given the opportunity to enrol in the IMF/edX Macroeconometric Forecasting course. This nine-week course provides an introduction to forecasting, evaluating macroeconometric models, and using vector autoregression and vector error correction models. Though useful to an extent, a nine-week online course is no substitute for years of econometric training in a university setting. ERF would therefore be well-placed to prioritise strong econometric capability when recruiting new staff, especially those with specific econometric and quantitative training at university. On-the-job training should continue to be a priority, given the importance of applied learning for econometrics.

The structure of certain revenue heads can be complex and some have idiosyncratic features. Further, revenue policy is ultimately subject to changes made by the government of the day, and can change intermittently. There is hence a premium on forecasters' experience and time spent with the team; long-serving staff develop familiarity with systems and processes that is difficult to teach.

Some of the datasets used by ERF are large and complex, requiring significant cleaning and matching work before the data can be used in the forecasting models. This is necessary to make use of large volumes of unit record data, which has the potential to improve land tax and other forecasts in the future. This work requires the use of the statistical analysis software SAS, however ERF currently only has three licenses for this software, each limited to a single user. The process is still developing and the complexity of the work can make it difficult for other analysts to pick up if more experienced staff are absent, posing a risk for continuity.

KEY FINDING: ERF staff have a diverse mix of deep economic knowledge and quantitative ability. The current team possesses adequate skills to meet the core objective of producing accurate revenue forecasts. While some concern exists about the relatively low prevalence of econometric ability, this is not a critical gap in ERF's collective skill set; however, ERF would be well-placed to prioritise strong econometric and quantitative skills when recruiting new staff.

WA Treasury should invest in improving analysts' capability with SAS to manage unit record data, including acquiring an appropriate number of software licenses for staff.

3.1.3 Team structure and resourcing

At the time of reporting, ERF consists of a director, two managers at Level 8, four principal economists at Level 7, and three analysts (2.4 FTE) ranging from Levels 3 to 6. There are presently a number of vacancies within ERF: one at Level 3, one at Level 4, and two at Level 6; one Level 3 analyst is presently acting in the vacant Level 4 role (see Figure 3.1).

The team is top-heavy, with seven of ten staff at Level 7 or above and all four vacancies at Level 6 or below. Concerns were raised about the long-term sustainability of the level of resourcing, with an insufficient pipeline of new staff coming in at lower levels, developing skills, and remaining part of the team for a long period of time.

Current resourcing levels present threats to succession planning, workload management, and risk mitigation.

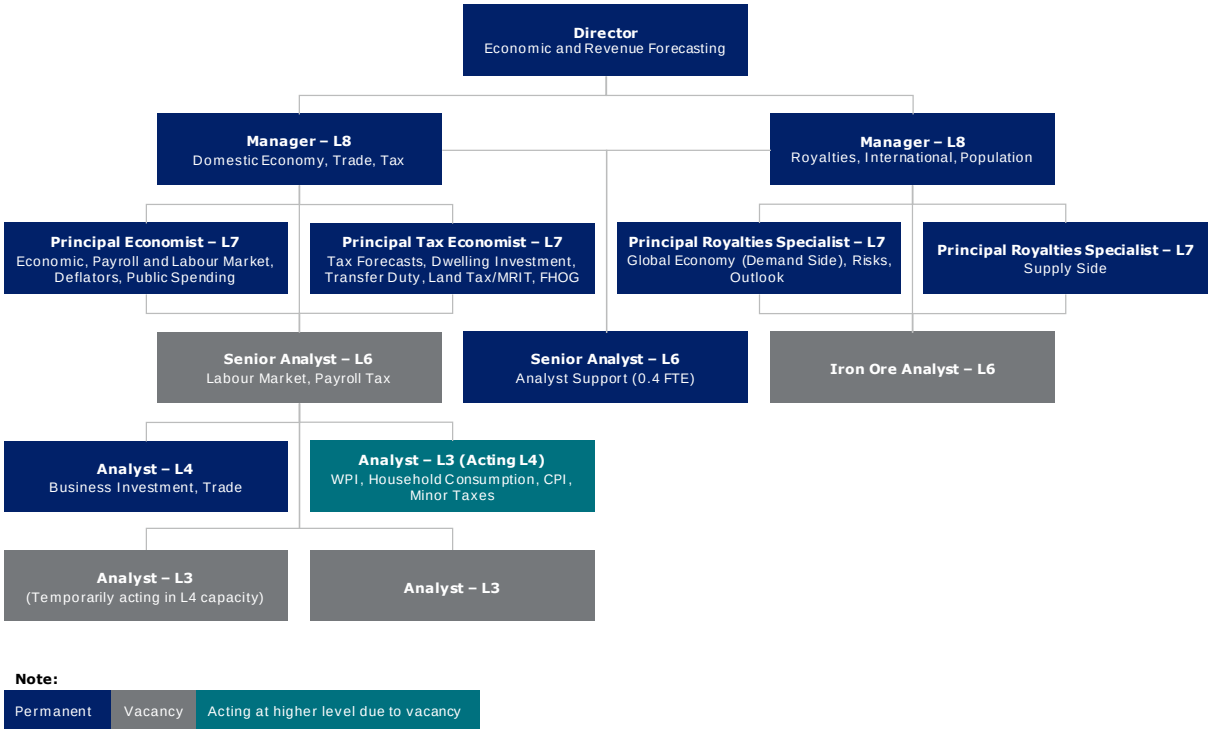
Career progression and succession planning

The senior end of the team structure is relatively stable, with many staff having developed strong familiarity and expertise with both the technical and process elements of revenue forecasting over many years. In contrast, the junior end of the structure is relatively unstable. Staff at Level 3 and Level 4 tend to move in and out of the team at a faster than desirable pace. Most staff at Level 4 and below moved into the team in the last 18 months, and historically tend to stay for 2-3 years.

Concerns were raised about junior analysts' prospects for promotion; seeing a stable management group, junior staff may get the impression that long-term career progression within the team is not possible and seek opportunities elsewhere.

This problem is more explicit at some levels. There is no Level 5 position in ERF, meaning that staff at Level 4 who aspire to be promoted are compelled to leave the team to do so. ERF staff raised this as an issue requiring immediate redress, in reference to a recent case in which a Level 4 staff member left the team to seek promotion, despite indicating a strong preference to remain, because of the lack of Level 5 opportunities. On previous occasions, it was possible to 'upgrade' the same role within the team, achieving the individual's desire for promotion without affecting team capability, but a tighter budget in recent years has made this more difficult.

Figure 3.1: Structure of Economic and Revenue Forecasting team



The pipeline of junior staff has been further restricted in recent years due to the freezing of Treasury's graduate recruitment program. ERF has historically hosted a graduate officer and the team's resourcing was impacted by the program freeze in 2016 and 2017. ERF staff consider graduates as highly valuable resources, however the rotational nature of the program means that they lack direct control over movements in and out of the team. Graduates' decisions may also be affected by the same perceived lack of progression opportunities facing staff at Levels 3 and 4.

Generally, many staff are seen as 'flight risks' because of the perceived rate at which opportunities for career progression arise outside of the team, more often than they do within ERF.

KEY FINDING: The senior end of the team structure is relatively stable, with many staff having developed strong familiarity and expertise in revenue forecasting over many years. In contrast, the junior end of the structure is more unstable with a number of vacant positions and higher rates of turnover. Perceived and real shortages of opportunities for advancement pose a threat to attracting and retaining junior staff.

There is a relationship between the level of investment in staff resources and improvements in forecasting outputs. Staff responsible for forecasting iron ore royalty and payroll tax revenue, for example, have been given significant space to work on model development relative to other revenue heads. This has resulted in methodological changes and the overall improvement in forecasts of these two revenue heads.

The idiosyncratic nature of certain revenue heads is such that forecasting capability requires time to be developed. Internal promotions within ERF are a key means for retaining and growing capability while meeting individual staff members' aspirations for advancement. ERF has some success stories in this regard, with three internal promotions in the last six months; further, all current Level 7 staff joined ERF at more junior levels and were subsequently promoted internally.

Tacit knowledge, acquired by junior analysts through mentoring and experience, is an important component of the team's skillset and succession planning. There is a need for senior staff to have sufficient time to train and mentor junior analysts both to ensure a future capability pipeline and to mitigate risks that may arise from illness, leave, or departures. At present, the top-heavy nature of the team and general under-resourcing means that senior staff are taking on more primary substantive analysis, diminishing time available for training and mentoring their junior colleagues.

In order to manage risks to ERF meeting its objectives, management makes dynamic and pragmatic decisions regarding promotions and temporary assignment of different or additional responsibilities. However, if the total level of resourcing is insufficient, this limits the extent to which these risks can be managed in the short term. For example, one Level 7 staff member is presently responsible for coordinating the domestic economy forecasts, but due to a vacancy at Level 6, is also conducting payroll tax and labour market analysis. Were this one staff member to fall ill or otherwise be absent at short notice, it would compromise ERF's capability because of the lack of other staff resources to act in these roles.

If unaddressed, the general level of under-resourcing – compounded by frequent staff movements, uncertainty over promotion processes and timelines, and the growing importance of accurate forecasts in the context of highly volatile economic conditions – poses a threat to ERF's ability to meet its objectives in the future.

KEY FINDING: Current resourcing levels offer senior staff limited time to mentor junior staff, and junior staff have limited time for skill development. This presents a risk to succession planning. If unaddressed, the level of under-resourcing – compounded by frequent staff movements, uncertainty over promotion processes, and the growing importance of accurate forecasts in the context of highly volatile economic conditions – poses a threat to ERF's ability to meet its objectives in the future.

Workload management and risk mitigation

ERF adequately delivers on its core responsibilities under current resourcing arrangements, as described in the previous chapter. However, staff have limited capacity for critical additional tasks including model development and training. Further, concentration of responsibilities the team is vulnerable to key-person risk and strain during peak periods or staff absences.

Managers within ERF are supported by staff at Level 7, who perform coordinating roles for various groups of revenue heads and reporting processes. Concern was raised that senior staff juggle too many areas of responsibility, leaving them with too little time to devote to model development and methodology changes. Staff also lack the level of administrative support they had historically enjoyed, with administration taking up a larger share of their time than is desired. This puts

considerable strain on staff particularly in busy Budget and MFPS periods. By contrast, in other jurisdictions, resourcing levels are such that deliverables can be met comfortably during peak periods.

Staff absences and losses present risks to ERF meeting current responsibilities. Staff tend to have high leave balances, especially at senior levels; staff are required during Budget and MFPS periods and tend to avoid taking leave at these times, but are then expected to devote time in the intervening periods to model development and methodology improvement. ERF should have sufficient staff levels to be able to manage periods of change without affecting sustainability.

The concentration of responsibilities (for example, for a particular revenue heard) among more senior staff adds to risks around succession planning, generation of new ideas, and an inability to rotate to different roles. Ideally, there should be a 'back-up' analyst for all roles, so that staff losses and absences can be managed without risk to achieving deliverables.

KEY FINDING: ERF adequately delivers on its core responsibilities under current resourcing arrangements. However, staff have limited capacity for critical additional tasks (including model development and training) and face strain in peak periods. Concentration of responsibilities means the team is vulnerable to staff absences and losses. Ideally, ERF should have sufficient staff levels to manage periods of change without affecting sustainability.

Culture and reputation

The team displays a strong culture, and it was clear that staff are attracted to work in ERF by the nature of the work content. While this promotes longevity, there is also a risk of the team becoming closed to fresh ideas and external contributions, compounded by the lack of a pipeline of junior staff moving up through the team.

Staff acknowledge the need to promote their work and responsibilities in the wider economics community to attract the highest-quality recruits. ERF's presence is currently limited, with narrow exposure to academic and industry economists. There are a number of options, from running school competitions to promote a career in economic forecasting to publishing a working paper series, all of which would require additional financial and staff resources.

KEY FINDING: The culture within the ERF team is strong and the substantive work is a positive factor encouraging staff to stay. However, the team's relatively low profile in the wider economics community creates the potential risk of a limited pipeline of future staff at all levels.

Resourcing in other jurisdictions

In most other jurisdictions, economic and revenue forecasts are produced by separate teams, allowing analysts to specialise in forecasting particular indicators or revenue heads.

Revenue forecasting teams in all other State Treasuries consulted with as part of this review were larger than ERF in terms of staff resourcing. Resources are adequate for the busiest points in the year, creating capacity for staff to focus on model development outside of major forecasting rounds. Additionally, this allows for one analyst to shadow the primary analyst responsible for a particular revenue head, bringing multiple perspectives and improving model checks while diminishing the risk of 'checking fatigue'.

New starters in other forecasting teams are generally assigned to simpler forecasting models, and advance to more complex models as their skills develop. Teams place emphasis on new starters commencing with a sufficient lead time before Budget or Mid-year Review periods, thereby allowing time to settle in and develop familiarity with models and processes.

At the Commonwealth level, both the Treasury and Reserve Bank are investing more heavily in staff resources with a view to expanding model development in their macroeconomic modelling. This follows acknowledgement, internally and from external reviews, that forecasting models require dynamic updating to take account of contemporary factors especially in an environment of volatile

economic conditions. This is particularly critical for WA Treasury, noting the large share of State revenue derived from volatile mineral royalties.

The total level of resourcing in revenue forecasting in other States has increased in recent years. For one State Treasury, this was particularly driven by the separating of the economic and revenue forecasting functions into distinct teams, with subsequent additional investment in staff specialisation.

Table 3.1: Comparative levels of revenue forecasting resourcing

Agency	Revenue forecasting, FTE	Economic forecasting, FTE	Total FTE
WA Treasury – Economic and Revenue Forecasting	9.4 FTE Both economic and revenue forecasting.		**9.4 FTE**
Treasury A	9 – 10 FTE	Economic forecasts are the responsibility of a separate division, FTE not available.	**N/A**
Treasury B	7 FTE	8 – 10 FTE	**15 – 17 FTE**
Treasury C	8 FTE	8 FTE	**16 FTE**
Treasury D	10 FTE	9 FTE	**19 FTE**

3.2 Governance

This section addresses the governance arrangements currently in place to ensure the consistency and transparency of revenue forecasts. It also describes the role that judgement plays in augmenting model outputs to produce final forecasts.

3.2.1 Judgement and forecast review

WA Treasury's existing Budget processes rely heavily on internal review. Analysts responsible for individual revenue heads continuously review models and outputs as data is updated and forecasts refreshed. Staff acknowledge the considerable risk of publishing erroneous information and hence devote a considerable amount of time to performing checks of models and outputs. However, this creates its own risk – of 'checking fatigue' – and speaks to the importance of having forecasts reviewed externally from time to time.

Presently, there is limited external review of forecasts on a recurrent basis. Preliminary forecasts of some revenue heads are communicated externally. For example iron ore forecasts are shared with the Department of Mines, Industry Regulation and Safety (DMIRS). However, external review is limited for other revenue heads within the scope of this review.

Staff expressed a desire to establish such a practice, for example with university econometricians with the capability to check the technical models, although regular external reviews would require additional resources. In other jurisdictions, Treasury department forecasters hold regular conferences during forecast rounds with representatives from other agencies who independently prepare forecasts and report on to-date actuals. These forums provide an opportunity for forecasts to be rigorously tested and reviewed if necessary.

KEY FINDING: There is presently no regular, rigorous review of revenue forecasts or forecasting models by objective expert parties outside of WA Treasury.

Judgement is applied to forecasts in the first instance by ERF analysts and management as they are produced. Regular rationalisation meetings provide the opportunity for changes to forecasts to be explained and, where necessary, challenged and revised. The WA Treasury Executive and Under Treasurer may apply a second level of judgement when they are briefed on updated forecasts. Generally, judgement is applied more heavily where the perceived level of uncertainty is greater. These applications of judgement are important for guiding the choice of a specific number within the range of feasible forecasts produced by the models.

Analysts and senior staff will undertake external consultations to complement internal judgement. This includes discussions with relevant industry bodies (for example, with the Real Estate Institute of Western Australia [REIWA] regarding housing market drivers), other State and Commonwealth Treasuries, and other agencies.

Judgement is applied to varying degrees across different revenue heads, depending on the perceived strength (or weakness) of the technical models at capturing nuanced real-world factors. For example, there is no model used to forecast land tax receipts beyond just the Budget year, and so judgement is applied especially heavily. Judgement may also be driven by different factors; in some cases, leading market indicators provide a clearer idea of variation against forecasts than pro-rated estimates of year-to-date receipts, while in other cases the opposite is true. Staff showed strong familiarity with the shortfalls of particular models, and hence an understanding of where judgement was more important. However, the process of applying judgement, and the quantification of the impacts of judgement, is largely informal and not systematically recorded. Deloitte Access Economics notes that judgemental adjustments to forecasts, by definition, are subjective in nature and are difficult to quantify. Indeed, a formal model represents the quantification of relationships between dependent and independent variables, while judgemental adjustments should be used to account for additional information that is not (or can not) be captured within the model. For this reason, it is very difficult to quantify the magnitude of judgemental adjustments.

KEY FINDING: Judgement is applied to varying degrees across different revenue heads, depending on the perceived strength (or weakness) of the technical models at capturing nuanced real-world factors. However, the process of applying judgement, and the quantification of the impacts of judgement, is not systematically recorded.

Models based on a growth profile added to an underlying base can tend toward long-term behaviour and hence may struggle to identify turning points. In such cases, judgement is critical for informing more accurate short-term forecasts. However, awareness of this reality also means that forecasting short-term turning points carries some additional risk. In an attempt to mitigate this risk, emphasis is placed on producing forecasts that conform to a smooth profile, rather than predicting sharp or sudden changes.

However, applying judgement to forecasts to smooth the profile carries its own risk. In cases where short-term fluctuations are predicted by analysts but reported in a subdued or diminished fashion, and subsequently occur, the compounded change in the next period can be even more severe.

Staff raised the example of land tax forecasts, which prior to the 2015-16 Budget had used a uniform growth rate of approximately 10.0% for the forecast years beyond the Budget year. From 2015-16 onward, these out-year forecasts were revised down to 7.7%, 5.0%, and in the most recent Budget ranged from 0.0% to 2.5%. Staff indicated that while the future impact of the economic downturn on land tax receipts was apparent, it was seen as necessary to revise the out-year forecasts down gradually over multiple Budgets, rather than in a sudden revision, in part so that the figures conformed to a smoother profile. The decision to adopt a gradual step down also partly reflected consideration for volatility in land prices and the risk that land values could rebound strongly.

Emphasis on the 'presentational' aspects of the forecast growth profile of revenue could potentially leave the Government unprepared for sudden shortfalls in actual revenue, in turn impacting its ability to responsibly plan expenditure over the same period.

KEY FINDING: A lack of consistent external review, combined with a lack of rigorous recording of the impact of judgement over time, presents risks that judgement is applied for 'presentational' reasons rather than to improve the accuracy of the forecasts.

3.2.2 Measures of forecast accuracy

WA Treasury currently publishes performance against targets in its Annual Report and in the Budget Papers. This is a somewhat reasonable approach to measuring and reporting on forecast accuracy. However, the KPIs and supporting analysis could be more informative if further detail were provided.

Targets could also be refined to be more appropriate for individual revenue heads. For example, in the 2016-17 Annual Report, the 2016-17 target for mining revenue is set at +/-5.0%. This is significantly lower than past actual forecast errors and is not necessarily appropriate in the context of inherent volatility in this revenue base.

The ultimate aim in forecasting is to achieve a zero forecast error across all revenue heads. However, this is not possible in practise. As such, targets should be set which aim to tighten error bands over time. Deloitte Access Economics suggests updating targets at each forecast round, with the absolute percentage error to be set equal to the mean absolute percentage error (MAPE) of the relevant head of revenue (or macroeconomic variable) over the last five years.

A rolling average target seeks to improve forecast errors over time. This framework also accounts for the fact that different revenue heads have varying degrees of forecasting difficulty, for example due to varying volatility among different revenue streams. For this reason, it is hard to achieve a flat forecast error across all revenue heads, as suggested by a flat target of +/-5.0%.

Performance of forecasts are discussed in further detail in this report in the sections that follow and in Appendix A.

3.2.3 Document management

ERF's document management processes for conducting and recording revenue forecasts are robust. Staff share access to a common drive, subdivided into folders for economic, tax, and royalty forecasts, which is appropriate given royalty forecasts are updated more frequently than others. Analysts responsible for particular revenue heads manage the appropriate subfolders. They take individual responsibility for retrieving updated data, populating the relevant workbooks, and producing and circulating the 'heads up' note within the relevant subfolder.

The structure and format of model workbooks are broadly consistent. Master workbooks are linked to original data sources retrieved by the relevant analyst, and there are no double inputs of original data. Data sources are organised and labelled by catalogue number for consistency. The layout within a standard workbook is formatted consistently, for example with dates as rows and item headers as columns, values on the left and percentage changes on the right hand side, actual numbers in black and forecasts in blue, and so on. These are consistent across workbooks in all but a few cases, for example date structures and format differ between workbooks with monthly versus quarterly data.

There is some scope to reduce the risk resulting from manually entering data. For example, on a monthly basis, analysts acquire actual unit record payroll tax data from OSR and enter this into the pro-rata workbook by copying and pasting values. These values replace estimates from the previous forecasting round. This process could be improved by centrally maintaining one sheet of actual values, and having formulas in other workbooks automatically update using conditional statements, which would switch based on whether actual data for a particular month was available.

Analysts organise outputs for particular revenue heads within workbooks, and then copy and paste this information into Word documents for briefing notes, ERC updates, and other publications. Outputs from forecast runs and associated documents are saved and organised by run date, enabling them to be retrieved when required, for example to analyse period-to-period changes. During the Budget and MFPS processes, revenue forecast runs are conducted on the same dates as State Finance estimates, so that both sets of figures are directly comparable.

While robust document management processes are in place for producing forecasts, there is scope for improving the extent to which the application of judgement is documented. This is critical from an accountability perspective; in circumstances where forecasts may change sharply or where actuals differ from forecasts significantly, it is important to know the degree to which judgement affected the final forecasts so as to know whether the models or parameter require improvement.

Likewise, there is scope for improving the consistency of notes and publications such that they document and quantify reasons for changes to forecasts. For example, the material used during the internal rationalisation meetings appeared to be inconsistent across revenue heads and over time.

New staff are introduced to the structure and format of models largely by performing checks. While this builds familiarity over time, there is scope for improving documented model guides for new or temporary personnel to cover cases where, for example, an analyst falls sick during the Budget period and someone else has to step in with limited time and preparation.

Generally speaking, document management processes were similar across other jurisdictions, with model workbook and other formats strictly adhered to. However, other forecasters place stronger importance on quantifying and recording the impacts of judgement, for example by requiring analysts to explain the reason for changes to model outputs when a new version of the model is archived. Changes driven by judgement are quantified and transparent in the same way as changes driven by policy, parametric, or methodological change. There is greater emphasis on having forecasts reviewed externally in other jurisdictions, in some cases on a fixed annual basis.

KEY FINDING: Within the process of producing revenue forecasts, document management practices are adequate and conducive to models being handled consistently by different forecasters. However, model guides and other instructional documents, as well as notes and briefings circulated beyond ERF, are not necessarily consistent or structured in a way that maximises their usefulness.

3.3 Key findings and recommendations

3.3.1 Key findings

Capability

- Analysts are responsible for the end-to-end process for producing forecasts for given revenue heads, including retrieving data, operating the forecasting models, analysing model outputs, and communicating key messages in a clear and concise narrative. Therefore, revenue forecasters require a mix of deep economic knowledge, quantitative and analytical ability, and strong communication and teamwork skills.
- ERF staff have a diverse mix of deep economic knowledge and quantitative ability. The current team possesses adequate skills to meet the core objective of producing accurate revenue forecasts. While some concern exists about the relatively low prevalence of econometric ability, this is not a critical gap in ERF's collective skill set. However, ERF would be well-placed to prioritise strong econometric and quantitative skills when recruiting new staff. WA Treasury should invest in improving analysts' capability with SAS to manage unit record data, including acquiring an appropriate number of software licenses for staff.
- The senior end of the team structure is relatively stable, with many staff having developed strong familiarity and expertise in revenue forecasting over many years. In contrast, the junior end of the structure is more unstable with a number of vacant positions and higher rates of turnover. Perceived and real shortages of opportunities for advancement pose a threat to attracting and retaining junior staff.
- Current resource levels offer senior staff limited time to mentor junior staff, and junior staff have limited time for skill development. This presents a risk to succession planning. If unaddressed, the level of under-resourcing – compounded by frequent staff movements, uncertainty over promotion processes, and the growing importance of accurate forecasts in the context of highly volatile economic conditions – poses a threat to ERF's ability to meet its objectives in the future.
- ERF adequately delivers on its core responsibilities under current resourcing arrangements. However, staff have limited capacity for critical additional tasks (including model development and training) and face strain in peak periods. Concentration of responsibilities means the team is vulnerable to staff absences and losses. Ideally, ERF should have sufficient staff levels to manage periods of change without affecting sustainability.

- The culture within the ERF team is strong and the substantive work is a positive factor encouraging staff to stay. However, the team's relatively low profile in the wider economics community creates the potential risk of a limited pipeline of future staff at all levels.

Governance

- There is presently no regular, rigorous review of revenue forecasts or forecasting models by objective expert parties outside of WA Treasury.
- Judgement is applied to varying degrees across different revenue heads, depending on the perceived strength (or weakness) of the technical models at capturing nuanced real-world factors. However, the process of applying judgement, and the quantification of the impacts of judgement, is not systematically recorded.
- A lack of consistent external review, combined with a lack of rigorous recording of the impact of judgement over time, presents risks that judgement is applied for 'presentational' reasons rather than to improve the accuracy of the forecasts.
- Within the process of producing revenue forecasts, document management practices are adequate and conducive to models being handled consistently by different forecasters. However, model guides and other instructional documents, as well as notes and briefings circulated beyond ERF, are not necessarily consistent or structured in a way that maximises their usefulness.

3.3.2 Recommendations

The following recommendations are based on the findings above:

Capability

- **Devote additional resources to economic and revenue forecasting** – WA Treasury should devote additional resources to ERF given the breadth and significance of the work undertaken by the team. During consultations, concern was raised that senior staff juggle too many areas of responsibility. Staff at all levels face difficulties in meeting competing priorities, particularly during busy periods. By way of an example, one team member is responsible for forecasting transfer duty and land tax. This workload presents risks to model development plans and continuity. Generally speaking, economic and revenue forecasting teams in other jurisdictions are larger than ERF in terms of staff resourcing.
- **Fill vacant positions in team structure** – It is recommended that WA Treasury prioritise finding staff to fill the vacant positions within the team structure. Current resourcing arrangements mean that any vacancies are felt particularly acutely.
- **Embed career progression opportunities** – ERF's team structure should be amended to create a clear pathway for career progression of forecasters especially at junior levels. The lack of a Level 5 position is a disincentive for junior analysts to remain in the team. Staff at Level 6 need to be provided with other opportunities for advancement, such as through secondments, in circumstances where positions at Level 7 have very slow rates of turnover.
- **Boost the profile of economic and revenue forecasting** – ERF should actively contribute to boosting the profile of WA Treasury's economic and revenue forecasting. This could be achieved via further collaboration with local academic institutions through joint projects, conferences, and other initiatives. This would help to build the reputation of ERF, assist recruitment of high quality staff, and facilitate knowledge sharing beyond WA Treasury.

Governance

- **Conduct regular external reviews** – WA Treasury has prepared various products in-house to measure its forecasting performance. Separately, two holistic reviews of revenue forecasting have been commissioned since 2005. It is recommended that WA Treasury commissions or conducts more regular external reviews of revenue forecasting, including both forecast outputs and technical forecasting models. WA Treasury could also seek to

engage other forecasters to provide a peer review of models on an individual basis. These initiatives would relieve some of the pressure on ERF's internal assessments and expose the models, parameters, and judgement to objective critique. More regular, independent evaluation may provide improved insight, accountability and rigour to the existing evaluation process, including the embedding of lessons-learned into the future forecasting process. Deloitte Access Economics is not of the view that the outcomes of these reviews should necessarily be made public.

- **Formalise systems of internal review** – WA Treasury should prepare a detailed forecast performance report following the release of final collections data each year. The report should compare forecasts with actual collections data, outline reasons for forecast errors, and emphasise any lessons learned. The report should be consistent across all revenue heads and over time.
- **Refine performance targets** – WA Treasury currently publishes performance against targets in its annual report and in the Budget papers. While this is a somewhat reasonable approach to measuring and reporting on forecast accuracy, the use of flat targets does not account for varying degrees of difficulty across different revenue heads, and does not seek to tighten error bands over time. Deloitte Access Economics suggests the following:
    - Disaggregate targets by individual revenue heads. WA Treasury may consider this more appropriate for internal release only;
    - Expand discussion of reasons for error; and
    - Update targets at each forecast round for the absolute percentage error to be set equal to the MAPE of the relevant revenue head (or macroeconomic input) over the last five years.
- **Better documentation of forecasts and judgement** – WA Treasury should develop a framework to consistently document forecasts over time. This should include quantifying changes to forecasts and the reason for change, including changes due to i) parameters ii) policy iii) collections iv) methodology v) judgement. Understanding the role of judgement is critical to transparent evaluation of forecasts and models.
- **Improve model guides and other instructional documentation** – These documents should be of such a standard that new staff or staff unfamiliar with certain models could pick up precisely where a previous staff member left off. This is particularly important given the large number of responsibilities spread across ERF, and would improve continuity as staff leave and join the team.

Part B – Individual heads of revenue

4 Iron ore royalties

Chapter summary

At various points in time over the last decade, WA Treasury has both under- and over-estimated iron ore royalty receipts. In common with other forecasters, WA Treasury has faced difficulties in accurately forecasting iron ore prices, and this has been the primary driver of errors in forecasts of iron ore royalty receipts. Forecasts for the other drivers of iron ore royalties, namely volumes and the exchange rate, have been more accurate than WA Treasury's iron ore price forecasts.

Where data is available across the two periods analysed, from 2008-09 and from 2014-15, WA Treasury's iron ore price forecast accuracy has been comparable to that of DoI; better than some individual Consensus Economics contributors; and below that of the iron ore price assumptions used by the Commonwealth Treasury.

WA Treasury has refined its price forecast methodology over time reflecting changes in the global iron ore market. In particular, the move from an annual setting of contract prices to short-term contracts and spot prices has added significant volatility to the iron ore price outlook. The current methodology achieves transparency and alignment to market forecasters. WA Treasury's iron ore price forecasts use derivatives prices in the short-run followed by an interpolation to medium-term projections taken from Consensus Economics and a private sector commodities specialist engaged by WA Treasury. Aspects of this approach, including the use of futures and Consensus Economics, are similar to some other government forecasters. The move from using historical average spot prices to derivatives prices for the short run attempts to pick up short-term expectations. However, there are questions around the predictive power of futures prices given the limited liquidity in these markets.

Some other government organisations also adopt forecasting approaches based on fundamentals analysis as well as a 'no-change' approach. It is noted that WA Treasury regularly forms a view on supply and demand to derive a set of price projections. While this method is not used to directly inform forecasts, it serves to increase WA Treasury's understanding of the industry.

Deloitte Access Economics compared the forecast accuracy of WA Treasury's current approach with a 'no-change' assumption that uses a short-term spot price average over a one-year forecast horizon. The accuracy of the two methods is similar over the period analysed. However, a no change assumption is more easily explained and may be less open to question amongst forecasters when compared with the futures approach.

All methodologies are subject to forecast errors and fail to adequately predict events that impact prices. For example, forecasts from various organisations examined in this report failed to anticipate the turning point and/or the pace of the decline in benchmark prices from 2014. WA Treasury currently seeks opinions on commodity price and volume forecasts from industry, DMIRS, and the Department of Jobs, Tourism, Science and Innovation (DJTSI). However, other government departments benefit from a more formal government consultation process. This includes sharing preliminary forecasts and analysis for quality assurance and sense checking purposes.

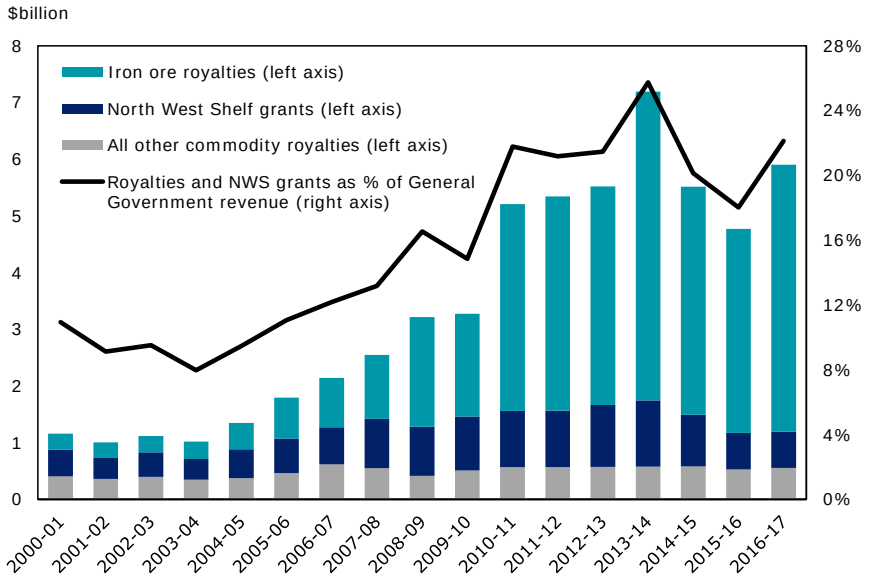
WA Treasury has invested in building the capabilities of staff responsible for forecasting iron ore royalties as well as other related work. The forecast approach has been supported by extensive supplementary analysis into market conditions, available data and research, and best practice approaches. There is some risk that the expertise and experience in commodity forecasting is concentrated in two key team members.

4.1 Background on iron ore royalties

Mineral and petroleum royalties are levied on the basis that resources are owned by the Western Australian community. A royalty is a purchase price for the resource, reflecting the fact that the community should earn a fair return for the loss of its non-renewable mineral resources.[4]

Royalties comprised less than 5% of Western Australia's general government revenue in the late 1990s. Its importance as a revenue source for the State increased significantly as global commodity prices and domestic extraction both increased through the 2000s. By 2008-09, royalties accounted for over 12% of total revenue and reached a peak share of 22% in 2013-14. Royalties accounted for almost 20% of revenue in 2016-17.

Chart 4.1: WA government royalty receipts by commodity type and as a share of total revenue



Source: WA Budget Papers and WA Treasury

Chart 4.1 confirms that the increase in the importance of royalties to general government revenue is largely explained by iron ore royalties. On average, iron ore royalties accounted for 86% of total mineral and petroleum royalties, and 14% of total general government revenue over the period from 2008-09 to 2016-17.

The Western Australian Government collects the majority of iron ore royalties as a percentage of the Australian dollar assessable value of the commodity sold.[5] A small amount is also raised on a volumetric basis at a rate of $0.25 per tonne from mining tenements that have been operating for at least 15 years.

The growth in iron ore royalty receipts reflects the State's vast wealth of iron ore deposits, which were developed in earnest as the global iron ore price rose sharply through the mid-2000s. This

[4] WA Department of Mines and Petroleum, 2017a.

[5] The royalty rate on lump and fines is currently 7.5%, for beneficiated products it is 5.0% (Western Australian Government 2016).

delivered higher royalty income to the State. Accurate forecasts of short- to medium-term iron ore prices and domestic production volumes became critical for State Budget planning.

North West Shelf grants further increase the State's exposure to changes in commodity prices. The State receives around two thirds of the royalties levied on gas extracted from a defined area at the North West Shelf project as part of a revenue sharing agreement with the Commonwealth. On average over the period from 2008-09 to 2016-17, commodity royalties including North West Shelf grants accounted for 20% of general government revenue.

It is worth noting that over time, changes in iron ore royalty revenue have a lagged and offsetting effect on GST grants. The State produces virtually all of the nation's iron ore, which means that an increase in the value of iron ore sales increases the capacity of Western Australia to raise revenue relative to other States. Therefore, the Commonwealth Grants Commission redistributes GST grants to offset this relative increase in revenue raising capacity – albeit, with a lag of 2-4 years.

KEY FINDING: Mineral and petroleum royalties comprised less than 5% of total general government revenue in the late 1990s. This share had risen to over 12% by 2008-09 and to 22% by 2013-14. The growth in importance of royalties is explained by iron ore royalties that, on average, accounted for 86% of total royalties and 14% of total general government revenue over the period from 2008-09 to 2016-17. Accurate forecasts of short to medium term iron ore price movements and domestic production volumes became critical for State Budget planning.

4.2 Performance of Treasury's revenue forecasts

This section examines WA Treasury's forecast performance of iron ore royalties. The methodology and criteria used to assess the performance of the forecasts are described in detail in Appendix A. WA Treasury's forecast approach has been refined over time; the discussion that follows is not wholly reflective of WA Treasury's current forecast method.

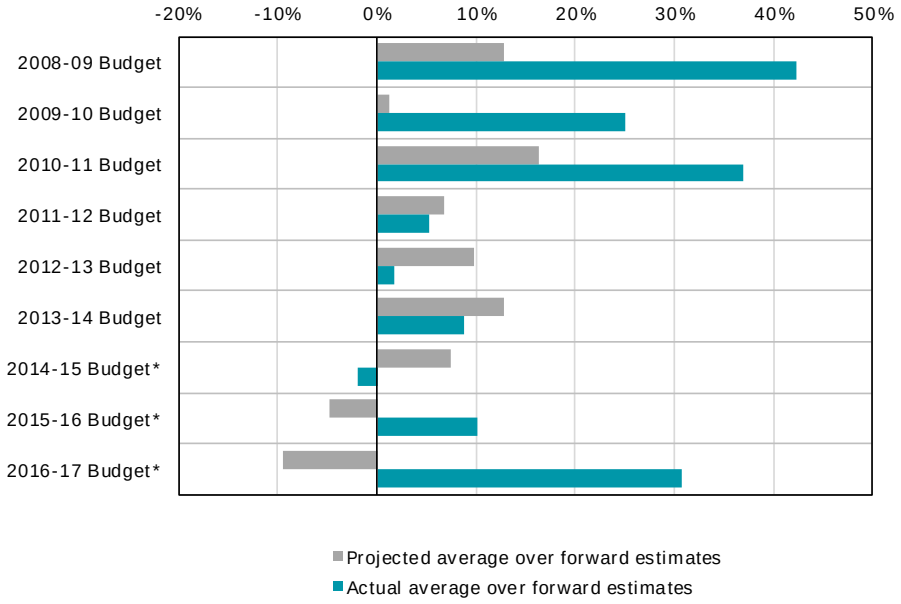
Projected growth in iron ore royalty revenues was under-estimated over the forward estimates in each of the 2008-09, 2009-10 and 2010-11 Budgets. This delivered significant and unexpected revenue windfalls to the State Government. Over the respective forward estimates periods of these three Budgets, the State Government earned $3.4bn, $4.3bn and $5.1bn more than it had forecast. This occurred during a period in which the traditional contract based determination of prices was breaking down. WA Treasury, and other forecasters alike, underestimated growth in commodity prices over this period. A large part of the misses during the upswing of the terms of trade came down to an underappreciation of how much demand for commodities would grow, and how long it would take for new supply to come to market[6].

While forecasts contained in the 2011-12 Budget were relatively accurate, projections between the 2012-13 and 2014-15 Budgets were optimistic, culminating in the 2014-15 Budget which expected average yearly growth in iron ore royalty revenue over the forward estimates, against an actual average decrease. Optimism in the 2012-13 and 2013-14 Budgets saw actual iron ore royalties come in $3.7bn and $5.1bn below forecasts over the respective forward estimates periods of each Budget. Forecasts made at the 2014-15 Budget were $6.1bn above actual royalties for the three years to 2016-17.

Projections of iron ore royalty revenue over the forward estimates were revised down sharply in the 2015-16 and 2016-17 Budgets. However, actual iron ore royalty receipts increased by over 30% in 2016-17 against a projected 10% decline.

[6] RBA, 2015.

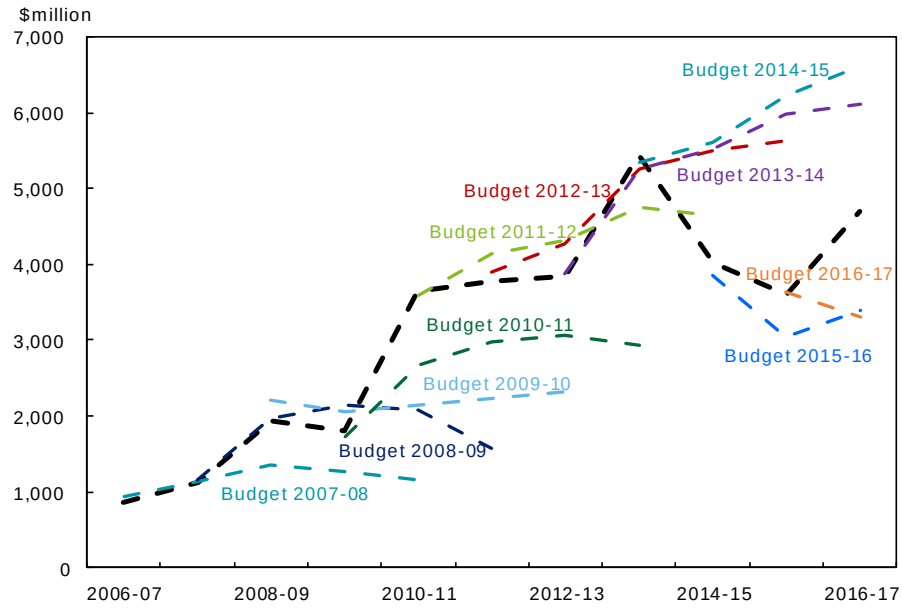
Chart 4.2: Iron ore royalty receipts and WA Treasury Budget forecasts



Source: WA Budget papers; *forward estimates in these years are only compared to years in which actual data is available.

Chart 4.3 shows forecast iron ore royalties from successive Budgets compared to actuals. The chart illustrates that WA Treasury has had difficulty in picking turning points and the pace of growth in the trajectory of iron ore royalties.

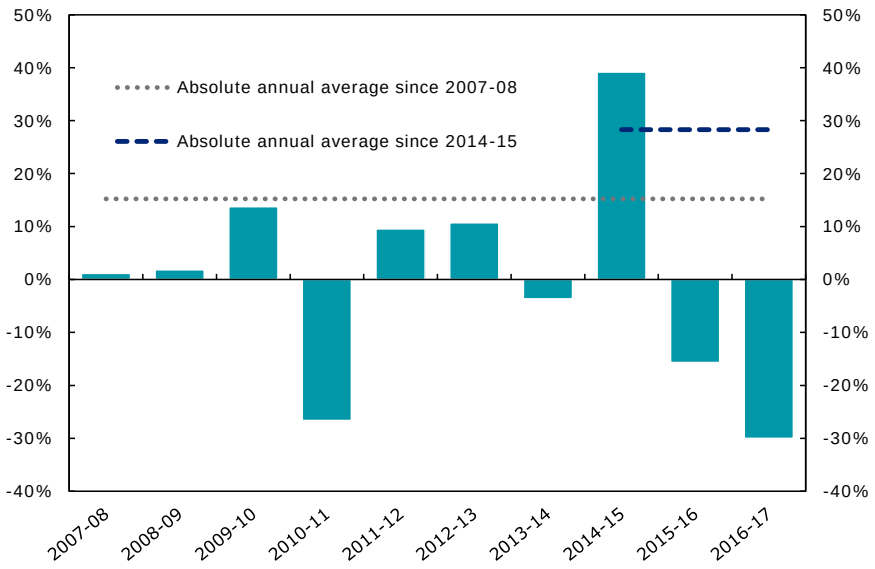
Chart 4.3: Iron ore royalty receipts and WA Treasury Budget forecasts



Source: WA Budget Papers

Looking specifically at the first year of the forecast period, WA Treasury has had some difficulty in forecasting iron ore royalties in the near-term. Chart 4.4 shows forecast errors for iron ore royalties for the Budget year. Since the 2007-08 Budget, the forecast for the Budget year has varied from the actual figure by 15% on average each year. In recent years, increased volatility in global iron ore markets has resulted in larger forecast errors, with an average Budget year forecast error of 28% from 2014-15 to 2016-17.

Chart 4.4: Budget year relative forecast errors for iron ore royalties



Note: Based on WA Budget Papers and estimates provided by WA Treasury

WA Treasury's forecasts of iron ore royalties incorporate projections of iron ore prices, the US$/A$ exchange rate, and production volumes. Table 4.1 illustrates that WA Treasury's iron ore price forecasts have varied significantly more from the actual values than either of the volume or exchange rate forecasts over time. The table also shows that WA Treasury's exchange rate and volume forecasts have become more accurate in recent years in contrast to the accuracy of iron ore price forecasts.

WA Treasury's forecasts for both price and volumes have also been more accurate in the WA MFPS compared to Budget. This is to be expected given that the forecasts are undertaken halfway through the Budget year so the forecast period is significantly reduced.

Table 4.1: Performance of iron ore royalty component forecasts in the Budget year, MAPE

Budget year	2007-08 to 2016-17	2014-15 to 2016-17
Budget		
Price (CFR)[(a)(b)]	N/A	36.5%
Price (FOB)[(a)(c)]	22.7%	38.2%
Volume[(d)(e)]	5.6%	4.3%
Exchange rate	9.1%	4.3%
Mid-year Review		
Price (FOB)[(f)]	N/A	6.7%
Volume[(d)(g)]	N/A	2.0%

Note: (a) Measured in US$ per tonne. CFR refers to 'Cost and Freight'. FOB refers to 'Free on Board'. Based on published Budget figures. (b) Series begins in 2013-14. (c) Series begins in 2007-08. (d) Volume measured in million tonnes. Based on published Budget figures. (e) Series begins 2007-08. (f) Series begins in 2012-13. (g) Series begins 2014-15.

KEY FINDING: Over the last decade, WA Treasury has both under- and over-estimated iron ore royalties and, as a result, government revenue. In common with other forecasters, WA Treasury has faced difficulties in accurately forecasting iron ore prices, and this has been the primary driver of errors in forecasting iron ore royalty receipts.

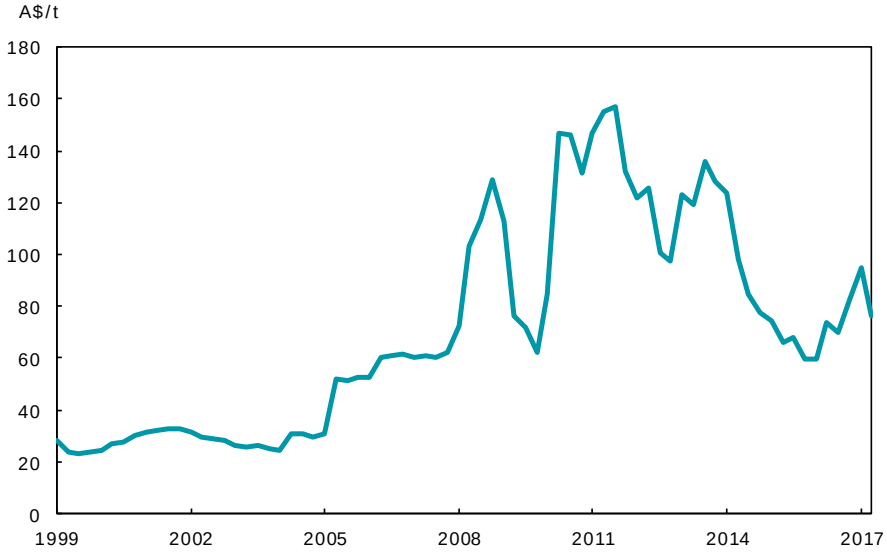
4.2.2 Performance of iron ore price forecasts

Over the last decade, the prices received by iron ore producers have become more responsive to short-term market developments, making forecasting more difficult.

Chart 4.5 shows that volatility in the iron ore price has increased significantly since 2008. Prior to the mid-2000s, the majority or iron ore was traded in reference to annual contracts. Average export prices over this period were correspondingly stable.

As China's demand for iron ore increased over the 2000s, more and more iron ore began to be traded in reference to shorter-term contracts and spot prices. The prices received by Australia's iron ore producers became more responsive to global short-term supply and demand dynamics and the shift to spot price sales gathered pace at the end of 2011.[7]

Chart 4.5 Iron ore export prices per tonne, A$



Source: WA Department of Mines, Industry Regulation and Safety.

Chart 4.6 shows the forecast price of iron ore in successive Budgets compared to the actual price. Both the benchmark 'free on board' (FOB) and 'cost and freight' (CFR) prices of iron ore are shown. From the 2010-11 Budget, iron ore price assumptions were reported on an FOB basis, while price assumptions were reported on a CFR basis from the 2013-14 Budget. The 2015-16 and 2016-17 Budgets only reported CFR prices.

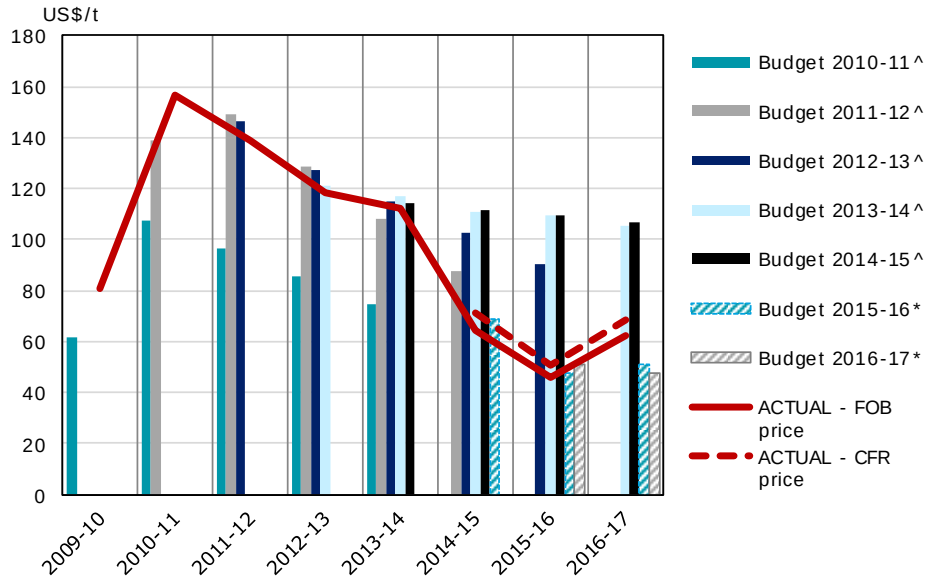
It is evident from Chart 4.6 that price forecasts formulated across the 2011-12 Budget and much of the 2012-13 Budget forward estimates proved relatively accurate. However, 2014-15 marked a critical turning point in the global iron ore market. Benchmark prices decreased substantially in that year, by -43% on a FOB basis and -42% on a CFR basis. However, like many other forecasters, WA Treasury did not predict the turning point and the pace of the decline in benchmark prices from 2014-15.

Across the forward estimates of the 2014-15 Budget itself, the actual iron ore price was on average 47% lower than forecast prices. With the collapse in price observed in 2014-15, the 2015-16 Budget saw WA Treasury apply downward revisions to projections of the iron ore price for that year and over the forward estimates.

KEY FINDING: Over the last decade, the prices received by iron ore producers have become more responsive to short-term market developments making forecasting more difficult. Iron ore price forecasts formed across various Budgets for 2011-12 and 2012-13 proved relatively accurate. However, in common with other forecasters, WA Treasury did not predict the turning point and pace of the decline in benchmark prices from 2014-15.

[7] RBA, 2012

Chart 4.6: Successive WA Treasury projections of the global iron ore price relative to actual (US$ per tonne)

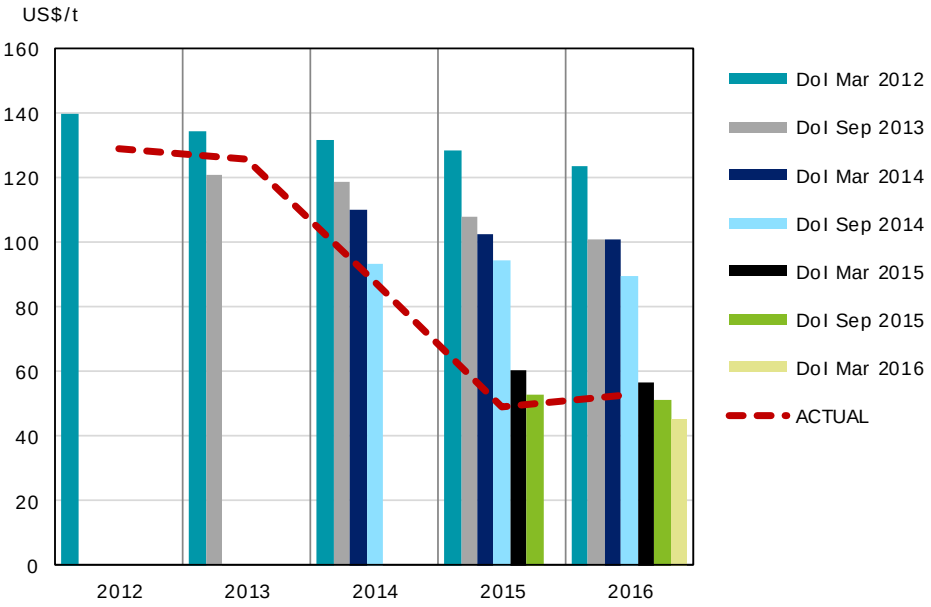


Source: WA Budget Papers; ^FOB price, *CFR price

Other commodity forecasters also failed to predict the magnitude of the decline in 2014-15. Chart 4.7 shows successive forecasts of the global iron price prepared by the Department of Industry, Innovation and Science (DoI, previously Bureau of Resource and Energy Economics). DoI's commodity forecasts are prepared every quarter on a calendar year basis.

Chart 4.7 confirms that while DoI correctly expected the iron price to trend downwards over time, it did not correctly forecast the scale of the downturn in the global iron ore price in 2014, 2015 and 2016. In the March quarter 2014, DoI's iron ore price forecasts for 2014, 2015 and 2016 were on average 40% higher each year than actual prevailing prices. Like WA Treasury, DoI also revised down its price projections in 2015 following the sharp falls in 2014.

Chart 4.7: Department of Industry, Innovation and Science, successive projections of the global iron ore price relative to actual (US$ per tonne; spot price, 62% iron content basis)



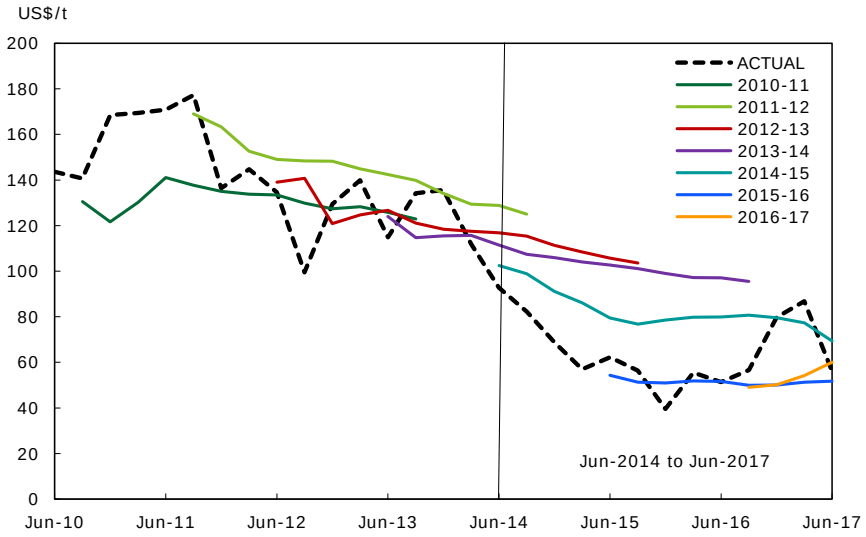
Source: Department of Industry, Innovation and Science

Chart 4.8 shows the average of Consensus Economics[8] market forecasts of the iron price. Like WA Treasury and DoI, market forecasters did not predict the severity of the decline in the iron ore price from June 2014. Forecasts made in 2011-12, 2012-13 and 2013-14 did not foresee the price decrease, although it is clear that a downward trend in the iron ore price was expected for some time.

Forecasts made in 2013-14 for 2014-15 and 2015-16 were on average 36% and 48% higher than actual respectively. Even market forecasts prepared throughout 2014-15 for 2015-16 were on average 35% higher than the actual prevailing price.

This period marked a time when iron ore producers were able to achieve larger cuts to input costs than the market forecast. This made it especially difficult to predict the extent of price falls.

Chart 4.8: Consensus Economics, average of successive market projections of the global iron ore price relative to actual (US$ per tonne)



Source: Consensus Economics. Note: FOB price projections were provided until Q2 2014 after which time CFR price forecasts were provided. Actual CFR price shown is price at the end of each quarter.

KEY FINDING: The difficulties in accurately forecasting global iron prices during this period were not limited to WA Treasury. This followed a structural change in the iron ore market that occurred in the late 2000s, marking the beginning of higher volatility.

WA Treasury's Budget year iron ore price forecast performance is shown against those of other government forecasters and Consensus Economics contributors in Table 4.2. The comparison is limited by the years and timing when forecasters have published data. Consensus Economics Budget year forecasts are estimated taking forecasts as at April of each year for the following financial year. DoI price forecasts are analysed on a calendar year basis, given data availability for the period of analysis. On average since 2008-09, WA Treasury's Budget year FOB iron ore price forecast has been more accurate than those produced by Consensus Economics contributors. Over the last three years, while outperforming some individual contributors, WA Treasury's forecasts performance has been below the Consensus Economics mean. WA Treasury's forecast performance has been comparable to that of DoI, but below that of the iron ore price assumptions used by Commonwealth Treasury.

[8] Consensus Economics prepares monthly compilations of mineral and energy forecasts published by a range of different forecasters around the world.

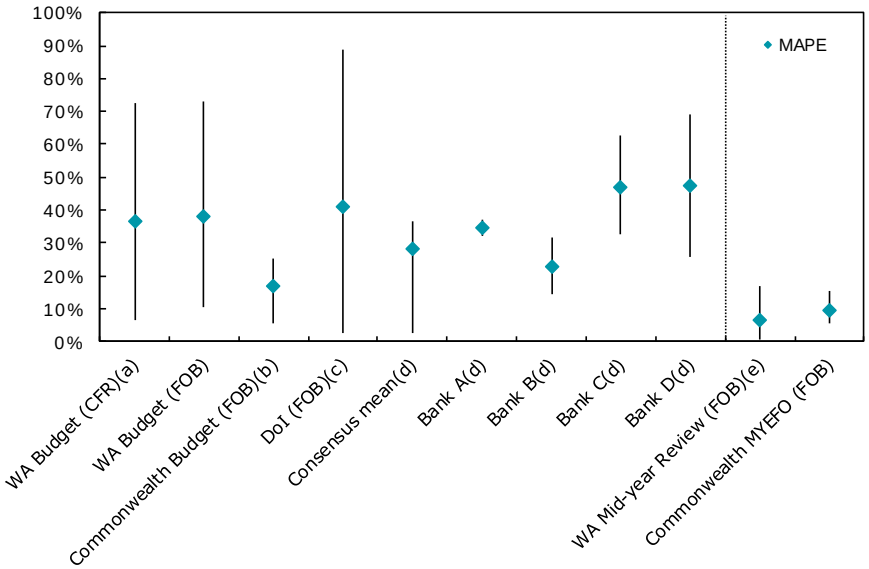
Table 4.2: Performance of iron ore price forecasts and assumptions in Budget year, MAPE

Budget year	2008-09 to 2016-17	2014-15 to 2016-17
WA Budget (CFR)[a]	N/A	36.5%
WA Budget (FOB)	22.2%	38.2%
Commonwealth Budget (FOB)[b]	N/A	16.7%
DoI (FOB)[c]	N/A	40.8%
Consensus mean[d]	33.1%	28.2%
Bank A[d]	44.1%	34.4%
Bank B[d]	32.0%	22.9%
Bank C[d]	44.1%	46.8%
Bank D[d]	39.7%	47.5%
WA Mid-year Review (FOB)[e]	N/A	6.7%
Commonwealth MYEFO (FOB)	N/A	9.3%

Note: Measured in US$ per tonne. CFR refers to 'Cost and Freight'. FOB refers to 'Free on Board'. Based on Budget papers, Consensus Economics publications, WA Treasury data. (a) Series begins in 2013-14. (b) Series begins in 2014-15. (c) Series begins in 2012, March estimates used. DoI price forecasts are analysed on a calendar year basis, given data availability for the period of analysis. (d) MAPE for Consensus participants are estimates using financial year forecasts as at April 2014, June 2015 and April 2016. Prices for individual Consensus participants are quoted as FOB to 2014-15 and CFR thereafter. Not all participants make contributions in each year. (e) Series begins in 2012-13.

Chart 4.9 extends the comparison across forecasters by showing the maximum and minimum forecast error over the period from 2014-15 to 2016-17. WA Treasury's maximum forecast error over this period is larger than that of DoI and considerably larger than that of the Commonwealth Treasury.

Chart 4.9: Comparison of performance of iron ore price forecasts and assumptions in Budget year (or equivalent), 2014-15 to 2016-17, MAPE and distribution of absolute percentage errors



Note: Measured in US$ per tonne. CFR refers to 'Cost and Freight'. FOB refers to 'Free on Board'. Based on Budget papers, Consensus Economics publications, WA Treasury data. (a) Series begins in 2013-14. (b) Series begins in 2014-15. (c) Series begins in 2012, September estimates used. DoI price forecasts are analysed on a calendar year basis, given data availability for the period of analysis. (d) MAPE for Consensus participants are estimates using financial year forecasts as at April 2014, June 2015 and April 2016. Prices for individual Consensus participants are quoted as FOB to 2014-15 and CFR thereafter. Not all participants make contributions in each year. (e) Series begins in 2012-13.

KEY FINDING: Since 2014-15, while outperforming some individual contributors, WA Treasury's Budget year forecast performance has been below the Consensus Economics mean. WA Treasury's forecast performance has been comparable to that of DoI, but below that of the iron ore price assumptions adopted by the Commonwealth Treasury.

4.3 Modelling methodology review

This section evaluates the methodology used by WA Treasury to forecast iron ore royalties.

WA Treasury's forecasts of iron ore royalties rely on forecasts of iron ore prices, the US$/A$ exchange rate, production volumes, and allowable deductions (for example, shipping costs). Forecasts of these components are inputs to the Visual DSS royalty forecasting database, which calculates projections of royalty revenue. WA Treasury and DMIRS maintain the Visual DSS database. Inputs are updated each time revenue is forecast and Treasury and DMIRS liaise on input assumptions.

4.3.1 Volumes

WA Treasury estimates iron ore volumes on a mine-by-mine basis drawing on a number of information sources, including:

- An annual survey of miners' anticipated production levels conducted by DMIRS;
- Quarterly production reports published by listed companies;
- An off-the-shelf iron ore market outlook by a private sector commodities specialist engaged by WA Treasury;
- WA Treasury's industry liaison program; and
- Discussions with DMIRS and DJTSI (formerly State Development).[9]

Volume assumptions are typically updated annually based on DMIRS' annual survey of miners. Assumptions may be updated during the year when new information becomes available. WA Treasury supplements the annual survey information by undertaking its own analysis at the project level. WA Treasury draws on published information from listed companies and independent analysis provided by a private sector commodities specialist engaged by Treasury. WA Treasury has regular industry consultations with large and small miners. In developing volume assumptions, WA Treasury considers the likelihood of projects proceeding. For example, WA Treasury will consider the viability of the smaller miners as part of their analysis.

Our consultations have found that this approach is broadly consistent with those of other Australian government forecasters. WA Treasury's approach has performed relatively well in anticipating the pace of production increases from Western Australian mines over the course of the mining investment boom.

KEY FINDING: WA Treasury estimates the volume of iron ore production on a mine-by-mine basis based on a survey of miners in Western Australia. WA Treasury's volume forecasts benefit from extensive industry research and external consultations.

This approach is broadly consistent with those of other government departments and agencies that forecast iron ore volumes in Australia.

4.3.2 Prices

WA Treasury's price forecasting method has drawn considerable attention, given its significance for the Budget. The approach to forecasting has evolved over time as price movements and market circumstances have changed.

[9] WA Treasury consultation, 2 and 3 November 2017

WA Treasury has adopted a mechanical method for some time. The current approach relies on futures prices and consensus forecasts of private sector forecasters. With this approach, WA Treasury aims to enhance transparency and alignment with private sector forecasters.

Since the 2013-14 Budget, WA Treasury has forecast iron ore prices on a US$/dmt CFR basis. WA Treasury's short-run (first six to twelve months) iron ore price forecast is derived from the Singapore Exchange (SGX) iron ore futures price curve. Medium-term forecasts are an average of private sector forecasts from Consensus Economics and a private sector commodities specialist engaged by WA Treasury. Forecast prices move from the short-run to the medium-term consensus price using a linear interpolation.

The US$/dmt CFR price is converted to an A$/dmt FOB price as this is the basis on which iron ore royalties are levied. The FOB price excludes the cost of shipping and other fees related to exporting the iron ore from the mine to its destination port. This conversion is based on WA Treasury's assumptions for the cost of shipping and US$/A$ exchange rate.

Consultations with other government departments and agencies revealed that most forecasters estimate the FOB price directly. Forecasting the FOB price directly removes the need to make assumptions around the cost of shipping. However, nearly all iron ore sales from Western Australia are priced relative to a CFR benchmark. Derivatives prices are also quoted on a CFR basis.

KEY FINDING: WA Treasury's price forecasting method has drawn considerable attention, given its significance for the Budget. WA Treasury has implemented a mechanical approach aimed at enhancing transparency and alignment with private sector forecasters. Iron ore price forecasts use derivatives prices in the short-run followed by an interpolation to medium-term projections taken from Consensus Economics and a private sector commodities specialist engaged by WA Treasury.

Since the 2013-14 Budget, WA Treasury has forecast a CFR price, which is converted to a FOB price using a forecast for shipping costs. Consultations with other government departments and agencies revealed that most forecasters estimate the FOB price directly. Forecasting the FOB price directly removes the need to make assumptions around the cost of shipping. However, nearly all iron ore sales from Western Australia are priced relative to a CFR benchmark. Derivatives prices are also quoted on a CFR basis.

4.3.3 Supplementary analysis and capabilities

WA Treasury has invested in building the capabilities of staff responsible for forecasting iron ore royalties as well as other related work.

The current price methodology has been informed by a review of relevant academic literature and best practice approaches, as well as increased understanding of market dynamics. This research not only underpinned the selection of the current method, but was important in communicating the methodology change to the WA Treasury Executive.

The mechanical forecast approach is supported by extensive supplementary analysis into market conditions. Staff responsible for iron ore forecasts regularly update the Iron Ore Monitor publication, which provides a detailed overview of the supply and demand dynamics in the iron ore market. The publication informs the narrative for Budget updates and the communication of forecasts to WA Treasury's Executive and the WA Treasurer's Office. The research done to produce the Iron Ore Monitor supports WA Treasury's ability to check underlying assumptions and make judgement-based adjustments where appropriate.

DMIRS previously maintained the Visual DSS royalty forecasting database, with WA Treasury taking joint responsibility for the database in the last four years. WA Treasury has also taken on increased responsibilities for developing volumes forecasts over this period.

WA Treasury regularly forms a view on supply and demand to derive a set of price projections. While this method does not directly inform forecasts, it serves to increase WA Treasury's understanding of the industry, in particular trends in industry costs and global demand.

Two team members take primary responsibility for iron ore forecasts, with one junior member in training. The two key staff members have extensive experience and expertise in this field, having both been in their respective roles for four to five years. There is some risk that the knowledge and expertise is concentrated and the forecasting task could not easily be performed by other team members. WA Treasury should continue to train junior staff in this area and prioritise knowledge sharing, for example via greater use of technical documentation and user guides.

WA Treasury publishes a sensitivity in the Budget that estimates the impact of a change in the price of iron ore on the iron ore royalty estimates. The 2017-18 Budget estimated that a US$1 increase (decrease) in the iron ore price in 2017-18 would increase (decrease) royalty receipts by A$74 million or in that year. This is standard practice across other Treasury departments in Australia. Some Treasury departments have further invested in scenario capacity to understand how revenue collections would differ under different outlooks for the global and domestic economy. This includes downside scenarios assessed across total government revenue. Deloitte Access Economics considers that the presentation in the Budget of scenarios and the impact of various possible trajectories for the iron ore price would be helpful in quantifying risks to the revenue estimates. This could be undertaken using plausible 'high case' and 'low case' paths for the iron ore price and determining the impact on royalty revenue.

KEY FINDING: WA Treasury has invested in building the capabilities of staff responsible for forecasting iron ore royalties as well as other related work. The forecast approach has been supported by extensive supplementary analysis into market conditions and best practice approaches. There is some risk that the expertise and experience in commodity forecasting is concentrated in two key team members.

Some Treasuries in other jurisdictions undertake more extensive sensitivity and scenario analysis than WA Treasury. This includes understanding how revenue conditions would differ under different outlooks for the global and domestic economy.

Visual DSS

All mining revenue including royalties, lease rentals and North West Shelf grants are calculated in a software programme developed by True Blue using Visual DSS code. In forecasting iron ore royalties, assumptions relating to prices, shipping deductions and the exchange rate are updated at each revenue update. Other assumptions, for example volume assumptions, are updated either annually or on an ad-hoc basis, such as when new information requires a change in assumption.

The software has been in use for many years and has become larger overtime. Some calculations are now duplicated while some code has become redundant.

Based on the demonstration of the Visual DSS royalty forecasting database during consultations, the programme appeared to be overly complex, disconnected from other data sources, and cumbersome to update. This would likely create inefficiencies during forecast rounds. The database was not intuitive or easy to use, which would likely create barriers for knowledge sharing and staff training.

4.3.4 Price forecast methodology changes and alternate approaches

The evolution of WA Treasury's forecast methodology is outlined in Table 4.3.

Table 4.3: Evolution of forecasting methodology

Budget	Starting point	End point	Rationale^
2010-11	Average spot price of previous quarter.	Linear interpolation to long-run price in final month of forecast period in line with private sector forecasts.	Breakdown of annual contract prices to short-term contracts and spot prices.
2012-13 MFPS	Average spot price of previous quarter lagged by one month.	Linear interpolation to Consensus Economics forecasts over an 8-10 year period.	Reversion over a longer time horizon deemed more consistent with expected time for supply and demand to balance.
2013-14	Average price over a 12-month period comprising historical spot prices for year-to-date and derivative prices for the remainder of the year.	Linear interpolation to Consensus Economics forecasts over an 8-10 year period.	Mitigated short-term factors thought to be overly influencing medium term price assumptions.
2015-16	6-12 months of derivative prices.	Consensus Economics forecasts over an 8-10 year period.	Using 12 months of derivative prices better leveraged the market's assessment of the near-term outlook for prices.
2017-18	6-12 months of derivatives prices.	Consensus Economics medium-term assumptions.	Reduce sensitivity of medium-term projections to short-term fluctuations of derivative contracts.

^Rationale has been drawn from WA Budget papers.

WA Treasury has refined its price forecast methodology over time reflecting changes in the global iron ore market. In particular, the move from an annual setting of contract prices to short-term contracts and spot prices has added significant volatility to the iron ore price outlook. Given the impact of movements in prices on government revenues, there has been increased scrutiny on forecasts for iron ore.

Like other forecasters, WA Treasury has failed to accurately predict the future path of iron ore prices. It is clear that WA Treasury has actively attempted to improve its forecast method, with shortcomings and merits in each approach.

The forecast method used by WA Treasury over the period 2013-14 and 2014-15 generated price projections which were heavily influenced by historical prices and therefore vulnerable to structural changes. This period marked a time when China's demand for iron ore slowed and iron ore producers were able to achieve larger cuts to input costs than the market thought possible. The nature of these structural changes meant that backward-looking and even forward-looking approaches failed to pick the speed and size of the price falls. All methodologies regularly exhibit substantial forecast errors, largely because no methodology can anticipate the news which impacts prices[10].

The current methodology emphasises transparency and alignment to market forecasters. Aspects of this approach, including the use of futures and Consensus Economics, is similar to some other government forecasters. The move from using historical average spot prices to derivatives prices for the short-run attempts to pick up short-term expectations. However, there are questions around the predictive power of futures prices given the limited liquidity in these markets.

The key challenge is to see through short-term volatility while at the same time being responsive to turning points. An additional challenge is the need for the method to be consistent and easily explainable in order to instil confidence in the process from WA Treasury Executive and the public.

[10] WA Treasury, 2017b.

KEY FINDING: WA Treasury has actively attempted to improve its iron ore price forecast method, with shortcomings and merits in each approach. Weight should be given to an approach that aims for transparency, consistency through time, and accuracy.

4.3.5 Alternative approaches for price forecasting

This section considers different approaches used by other government forecasters to predict future iron ore and other commodity prices.

The majority of iron ore mined in Australia is in Western Australia, which means that iron ore royalties are not a significant source of revenue for other State governments. However, other public sector organisations develop iron ore price and volume forecasts or assumptions as part of their analysis of the Australian economy. These include the Commonwealth Treasury, RBA and DoI. Deloitte Access Economics has also examined commodity price forecast approaches taken by Standard & Poor's, international government organisations, and Queensland Treasury – including for commodities other than iron ore. A summary of the forecast approaches taken by these organisations is presented in Table 4.4.

As has been the case for WA Treasury, the methodology used to forecast iron ore prices has changed over time across different organisations.

Table 4.4: Alternative approaches for commodity price forecasts and assumptions

	Short run	Long run
Organisation 1	Recent average spot price held flat for two year forecast period.	Long-term forecast framework using demand and supply modelling.
Organisation 2	Forecasts are informed by other government forecasts, futures, analysis of supply (informed by industry liaison), and monitoring of demand drivers.	N/A
Organisation 3	'Fundamentals-based' approach using cost curves and estimates of global demand.	
Organisation 4	Forward curves determine starting point for prices assumptions. Price assumptions for the remainder of the current year and following two years derived from forward curve and analysis of supply/demand and production costs.	N/A
Organisation 5*	Futures	Long-run anchor informed by supply and demand indicators, and other government and private sector forecasts including Consensus Economics forecasts.
Organisation 6*^	Average of surveyed private sector forecasts.	N/A
Organisation 7*^	Futures for first two years.	Price held flat in real terms using a price index based on major countries' CPI.

Note: All forecasters listed above are government forecasters or ratings agencies. *indicates forecasts of commodity prices other than iron ore including coal and oil. ^indicates international government organisation.

A 'fundamentals-based' approach

Some government organisations use a 'fundamentals-based' approach, which involves forecasting iron ore supply and demand to derive a global iron ore price. Supply is determined via cost curves that are either estimated by the organisations or taken from third party providers such as AME Group

and Wood Mackenzie. Demand is estimated as a function of global output and industrial production. The prevailing global price and volume is where the demand and supply curves meet. In general, Australian iron ore production is some of the most competitive production in the world and sits at the bottom end of the global cost curve.

Commonwealth Treasury uses a technical assumption for forecasting short-term iron ore prices, and also uses a fundamentals-based approach that feeds into its long run terms of trade framework. While not directly informing short run assumptions, this modelling exercise adds to staff capability, understanding and analysis.

In terms of deriving price forecasts, fundamentals analysis poses a practical challenge in that government forecasts are often required to update forecasts at short notice, whereas fundamentals may not change frequently. There may be an expectation amongst stakeholders that the short-run assumptions will reflect very recent price movements which may not be explained by identifiable changes to fundamentals. As such, fundamentals based approaches tend to be less useful in forecasts of short-run prices, but can be used in forecasting medium term prices.

Another challenge in using a fundamentals based approach is that key variables which underpin forecasts of supply and demand are often difficult to forecast and availability of historical data can be limited.

Futures

A number of government forecasters, in addition to WA Treasury, use futures either directly or indirectly to aid short-term forecasts for iron ore prices. However, there is no general consensus on the usefulness of iron ore futures for forecasting.

There are two main futures platforms for iron ore: the SGX and the Dalian Commodity Exchange (DCE). This is distinct from other commodities where each commodity has only one type of exchange market. SGX is a location market used predominantly by institutional investors, whereas the Dalian is a warehouse market and is used primarily by retail investors.

There are mixed views around the predictive power of these derivatives, in part due to limited liquidity in these markets. In 2016, daily trading volumes on all iron ore futures markets were around 20% of NYMEX WTI daily trading volumes. SGX futures were launched in 2013 and are considered to have more pricing power than the DCE despite lower trading volumes.

There are aspects of the iron ore futures market that remain not well understood despite increased trading volumes in recent years.[11] For example, the historically persistent backwardation (where spot prices are higher than futures prices) in iron ore futures markets does not always conform to conventions in other markets, such as oil. Difficulties in understanding aspects of the iron ore market add to the complexity in using and interpreting iron ore futures.

The mixed views among market participants, commentators and forecasters around the predictive power of iron ore futures, expose a futures-based forecasting framework to prejudices (whether warranted or not).

Historical average

Commonwealth Treasury uses iron ore price and volume assumptions as inputs into the outlook for the Australian economy. Since the 2015-16 Budget, the Commonwealth Treasury has used a technical assumption to determine its iron ore spot price assumption. Treasury uses a recent average of the spot price held flat over the two-year forecast period.

In the 2016-17 MYEFO and 2017-18 Budget, Treasury incorporated some flexibility into its methodology. Noting significant price volatility at the time, Treasury applied what it termed "prudent" judgement to its technical assumption, and used a step-down to a consensus price.[12]

[11] Goldman Sachs, 2016.
[12] Commonwealth Treasury, 2016-17 MYEFO and 2017-18 Budget.

Commonwealth Treasury draws attention in the Budget papers to the uncertainty surrounding the iron ore assumptions and the effect that different outcomes would have on the Budget aggregates. Commonwealth Treasury has also increased the amount and prominence of analysis in the Budget papers related to the sensitivity of economic and Budget aggregates to movements in the iron ore price. Commonwealth Treasury reports what a US$10 per tonne movement in the iron ore price assumption would mean for nominal GDP and revenue receipts. It also incorporated sensitivity analysis around a faster or slower step-down.

Deloitte Access Economics analysed monthly SGX iron ore futures data to compare the performance of forecasts based on futures data with forecasts based on a monthly historical average (a 'no-change' approach). The performance of the 'futures approach' was measured each month from the beginning of 2009-10 to the end of 2015-16[13] over a 12 month forecast horizon using the ten day average futures price at the end of each month. This is in line with the approach currently adopted by WA Treasury.

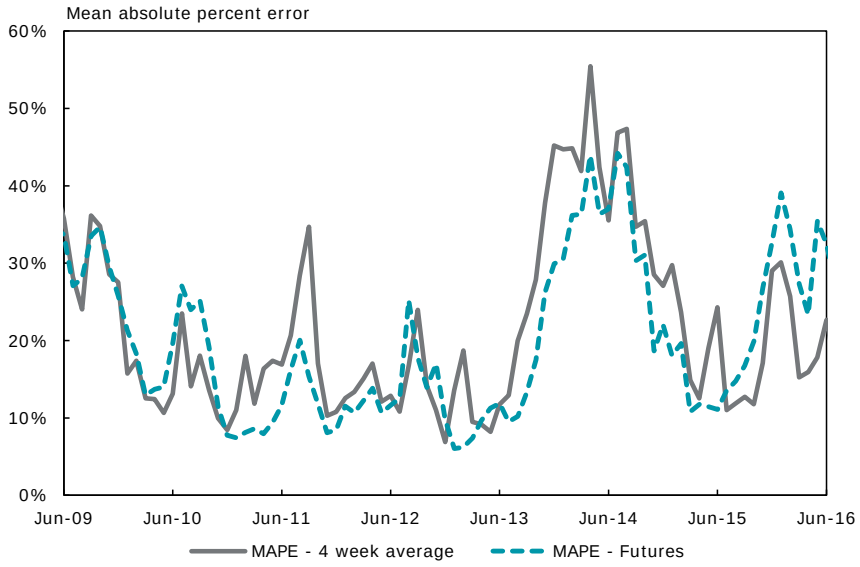
The forecast performance of the two approaches was close over the period analysed. The no-change approach and the futures approach recorded a MAPE of 21% and 20% respectively.

Chart 4.10 shows the MAPE of both forecast approaches at monthly intervals. The chart shows that from 2013-14 to 2014-15 the futures approach outperformed the no change approach, with a MAPE of 25% and 32% respectively. However, the futures approach performed worse than the no-change in 2015-16 with a MAPE of 26% and 18% respectively.

These findings are consistent with research conducted by the RBA. The Bank states that, "analysis at the Bank suggests that there is relatively little value in using something more sophisticated than the no-change assumption for many commodity prices. In other cases futures prices appear to provide information about near-term price movements."[14]

The accuracy of the two approaches has been similar over the period analysed, however a no-change approach is more easily explained and less polarising when compared with the futures approach.

Chart 4.10 Iron ore price forecast performance, futures vs short-term average



Source: SGX, WA Treasury, Thomson Reuters

[13] Using actual data to June 2017.
[14] RBA, 2015.

Consensus Economics

Consensus Economics prepares monthly compilations of mineral and energy forecasts published by a range of different forecasters around the world. Most government forecasters subscribe to this publication. This publication provides a useful comparison of market expectations and benchmark forecasts. It is generally accepted that an average of independent forecasts perform better than individual forecasts. There are, however, practical limitations associated with using Consensus Economics forecasts directly. While the forecasts are now updated monthly, potential delays in contributors updating and providing forecasts to Consensus Economics may mean that the results do not always take into account rapid or substantial historical price movements.

WA Treasury analysis suggested that consensus forecasts perform better than the forward curve over longer time period[15].

External forecast meetings and external engagement

Commonwealth government departments and agencies discuss forecasts as part of the joint economic forecasting group (JEFG) process, consisting of Commonwealth Treasury, RBA, Department of Prime Minister and Cabinet, the Department of Finance, and ABS. As part of this process, there are also sub-JEFG meetings. One of the sub-JEFG meetings is held to discuss commodity prices, with the DoI being a participant at this meeting.

This forum provides an opportunity for knowledge sharing, testing of assumptions, and quality assurance of preliminary forecasts. These discussions help to sense check forecasts and eliminate organisational bias. Importantly, these meetings have become a formalised and scheduled component of the forecasting process. In contrast, WA Treasury's liaison with other government departments is conducted on an ad hoc basis, with the exception of discussions with DMIRS and DJTSI.

Commonwealth forecasters also benefit from information gathered from overseas posts, particularly in China and India.

Other government forecasters also have regular contact with private sector analysts, for example, from investment banks. Liaison with private sector organisations serves as a useful source of information and adds another level of sense checking. Many of the investment banks provide daily commodity commentary (via email distribution) as well as more extensive research pieces on market developments for clients. Government agencies highlighted the usefulness of these market insights particularly when trends in the iron ore market are more uncertain. In the lead up to forecasting rounds, government agencies reported that they call a range of their private sector contacts to discuss market views. There are a number of private sector organisations that conduct commodity analysis, those mentioned during consultations include Goldman Sachs, UBS, Citi, Macquarie, CBA, ANZ, and Westpac. There is scope for WA Treasury to expand consultation with investment banks, especially those with a presence in China.

KEY FINDING: Some other government forecasters adopt similar price forecast methodologies to WA Treasury that incorporate the use of futures and consensus forecasts. Some other forecasters use alternative methods including no-change and fundamentals based approaches. Analysis conducted by Deloitte Access Economics comparing a futures based approach to a no-change approach suggested that the accuracy of the two approaches has been similar over the period analysed. However, a no-change approach is more easily explained and less polarising when compared with the futures approach.

Other government departments undertake more extensive external consultation than WA Treasury and regularly socialise preliminary forecasts and views among themselves as part of the forecasting process.

[15] WA Treasury, 2017b.

4.4 Key findings and recommendations

4.4.1 Key findings

Forecast performance

- Mineral and petroleum royalties comprised less than 5% of total general government revenue in the late 1990s. This share had risen to over 12% by 2008-09 and to 22% by 2013-14. The growth in importance of royalties is explained by iron ore royalties that, on average, accounted for 86% of total royalties and 14% of total general government revenue over the period from 2008-09 to 2016-17. Accurate forecasts of short to medium term iron ore price movements and domestic production volumes became critical for State Budget planning.
- Over the last decade, WA Treasury has both under- and over-estimated iron ore royalties and, as a result, government revenue. In common with other forecasters, WA Treasury has faced difficulties in accurately forecasting iron ore prices, and this has been the primary driver of errors in forecasting iron ore royalty receipts.
- Over the last decade, the prices received by iron ore producers have become more responsive to short-term market developments making forecasting more difficult. Iron ore price forecasts formed across various Budgets for 2011-12 and 2012-13 proved relatively accurate. However, in common with other forecasters, WA Treasury did not predict the turning point and pace of the decline in benchmark prices from 2014-15.
- The difficulties in accurately forecasting global iron prices during this period were not limited to WA Treasury. This followed a structural change in the iron ore market that occurred in the late 2000s, marking the beginning of higher volatility.
- Since 2014-15, while outperforming some individual contributors, WA Treasury's Budget year forecast performance has been below the Consensus Economics mean. WA Treasury's forecast performance has been comparable to that of DoI, but below that of the iron ore price assumptions adopted by the Commonwealth Treasury.

Model methodology

- WA Treasury estimates the volume of iron ore production on a mine-by-mine basis based on a survey of miners in Western Australia. WA Treasury's volume forecasts benefit from extensive industry research and external consultations. This approach is consistent with those of other government departments and agencies that forecast iron ore volumes in Australia.
- WA Treasury's price forecasting method has drawn considerable attention, given its significance for the Budget. WA Treasury has implemented a mechanical approach aimed at enhancing transparency and alignment with private sector forecasters. Iron ore price forecasts use derivatives prices in the short-run followed by an interpolation to medium-term projections taken from Consensus Economics and a private sector commodities specialist engaged by Treasury.
- Since the 2013-14 Budget, WA Treasury has forecast a CFR price, which is converted to a FOB price using a forecast for shipping costs. Consultations with other government departments and agencies revealed that most forecasters estimate the FOB price directly. Forecasting the FOB price directly removes the need to make assumptions around the cost of shipping. However, nearly all iron ore sales from Western Australia are now priced relative to a CFR benchmark. Derivatives prices are also quoted on a CFR basis.
- WA Treasury has invested in building the capabilities of staff responsible for forecasting iron ore royalties as well as other related work. The forecast approach has been supported by extensive supplementary analysis into market conditions and best practice approaches. There is some risk that the expertise and experience in commodity forecasting is concentrated in two key team members.

- Some Treasuries in other jurisdictions undertake more extensive sensitivity and scenario analysis than WA Treasury. This includes understanding how revenue conditions would differ under different outlooks for the global and domestic economy.
- WA Treasury has actively attempted to improve its iron ore price forecast method, with shortcomings and merits in each approach. Weight should be given to an approach that aims for transparency, consistency over time, and accuracy.
- Some other government forecasters adopt similar price forecast methodologies to WA Treasury that incorporate the use of futures and consensus forecasts. Some other forecasters use alternative methods including no-change and fundamentals based approaches. Analysis conducted by Deloitte Access Economics comparing a futures based approach to a no-change approach suggested that the accuracy of the two approaches has been similar over the period analysed. However, a no change approach is more easily explained and less polarising when compared with the futures approach.
- Other government departments undertake more extensive external consultation than WA Treasury and regularly socialise preliminary forecasts and views among themselves as part of the forecasting process.

4.4.2 Recommendations

- **Update Visual DSS royalty forecasting database** – Based on the demonstration of the Visual DSS royalty forecasting database during consultations, the programme appeared to be overly complex, disconnected from other data sources, and cumbersome to update. This would likely create inefficiencies during forecast rounds. The database was not intuitive or easy to use, which would likely create barriers for knowledge sharing and staff training. WA Treasury should consider creating a new model to simplify calculations and eliminate redundant code. An alternative software could be used that would allow for a more streamlined, efficient and transparent approach. Such a task would require additional funding to cover capital costs and staff time.
- **Continued review of forecast performance and approach** – WA Treasury should continue to regularly monitor its forecasting performance with a focus on assessments of forecast error and these should be communicated to the WA Treasury Executive. Given the dynamic nature of the global iron ore market, it is important to continually consider the appropriateness of the forecasting approach and adjust the forecasting approach as warranted.
- **Greater government liaison** – While it is acknowledged that WA Treasury currently seeks opinions on commodity price and volume forecasts from industry, DMIRS, and DJTSI, WA Treasury should expand and formalise its consultation process. Consultation should include discussions with Australian government organisations including the Commonwealth Treasury, the Department of Industry, Innovation and Science (DoI), the RBA, the WA Government trade office in China and the Australian Trade and Investment Commission (Austrade) China Offices. This could include the sharing of preliminary forecasts and analysis for quality assurance and sense checking purposes. Consultation should be a regular and scheduled part of the forecasting process.
- **Enhance private sector liaison** – Notwithstanding WA Treasury's liaison with mining companies and information gathering from commodities consultants, there is value in expanding liaison to include commodity analysts within investment and trading banks. It is recommended that WA Treasury establishes relationships with private sector contacts and engages with contacts in the lead up to forecasting rounds. There are a number of private sector organisations that conduct commodity analysis, those mentioned during consultations include Goldman Sachs, UBS, Citi, Macquarie, CBA, ANZ, and Westpac.
- **Expand iron ore royalty scenario analysis** – WA Treasury should extend its scenario capability to better understand how alternate outlooks for the global economy would affect iron ore royalty revenue raised. This could be done in conjunction with a broader framework

across all sources of revenue, for example by quantifying a downside scenario across all revenue heads over the forward estimates period.

- **Mitigate against key person risk** – While acknowledging the investment that WA Treasury has made in expanding the capabilities of its commodity forecasters, there is some risk that the expertise and experience in commodity forecasting is concentrated in two team members. Treasury should continue to train junior staff in this area and prioritise knowledge sharing, for example via greater use of technical documentation and user guides.
- **Maintain resourcing requirements** – With Western Australian LNG projects continuing to ramp-up and come on line, LNG will make up a greater share of the State's export basket. WA Treasury may need to devote additional resources to monitor the LNG industry. This should not come at the expense of current coverage of the iron ore industry.

5 Payroll tax

Chapter summary

Deloitte Access Economics' analysis of WA Treasury's payroll tax models and forecast performance show that, for the period of 2002-03 onwards, Budget year forecasts were under-estimated initially, and then over-estimated more recently. These two distinct periods of over- and under-estimating highlight the difficulty in forecasting payroll tax revenue during periods of changing economic conditions, with the forecast errors reflecting movements in the overall economic performance of Western Australia over the past 15 years. Given that the errors reflected the prevailing economic conditions of the time, along with analysis of Budget year forecast error distributions, Deloitte Access Economics concludes that WA Treasury's payroll tax forecasts have been, in general, unbiased for the Budget year over time.

WA Treasury's budget year forecast accuracy has lagged the performance of State Treasuries in larger States such as New South Wales, Victoria and Queensland, even after adjusting for the greater volatility in historical payroll tax receipts in Western Australia (and therefore the greater difficulty in forecasting future revenue). However, after adjusting for volatility, the budget year forecasts have been more accurate on average than forecasts for South Australia, Tasmania and the Northern Territory. Since 2012-13, and after adjusting for volatility, WA Treasury's payroll tax forecast accuracy for forecast years beyond the Budget year has been better than or comparable to those of New South Wales, Victoria and Queensland.

A significant challenge with forecasting payroll tax in Western Australia is that the tax base is unevenly skewed towards the mining and related industries, so changes in payroll tax are highly sensitive to conditions in this sector. For example, in 2016-17, the mining industry accounted for around 22% of the State's payroll tax compared to around 7% of the State's employment. As such, the relatively simple, linear approach of linking payroll tax revenue to growth in wages and employment, which may be appropriate in large States with broad payroll tax bases, is not appropriate in Western Australia.

As such, WA Treasury employs a more sophisticated econometric model to forecast payroll tax (as do a number of other State Treasuries). A second econometric model, which includes an additional term capturing 'new entrants and bracket creep' is also run. In general, the concurrent use of two models with different specifications can remove some credibility and rigour in the modelling process. However, Deloitte Access Economics is comfortable that WA Treasury does not intend to regularly switch between the models. In time, as more historical data becomes available, WA Treasury may determine that the model that includes the new entrants and bracket creep term can be estimated robustly and should be used as the 'standard' model. Provided that this decision is made following a thorough review of forecast performance and econometric specification, this progression to a model which includes additional information is logical.

A detailed analysis of the econometric specification of the payroll tax model (along with the labour market model used to develop key independent variables), while resulting in some relatively minor suggestions for WA Treasury to consider, provides Deloitte Access Economics with confidence that the models are sound and are based on appropriate econometric fundamentals. The functional form of the model and the explanatory variables used by WA Treasury differ from the approaches used by some other State Treasuries. However the differences are not material. The supplementary

analysis used to inform judgemental adjustments to the model forecasts is appropriate.

Deloitte Access Economics recommends that, in time, WA Treasury move to estimating and running only one econometric model to forecast payroll tax. There may also be merit in having different employees undertake the labour market and payroll tax analysis, which would add an additional level of oversight to the forecasting process. Additional resources devoted to forecasting the labour market and payroll tax would reduce the risk that expertise and experience is concentrated in one team member.

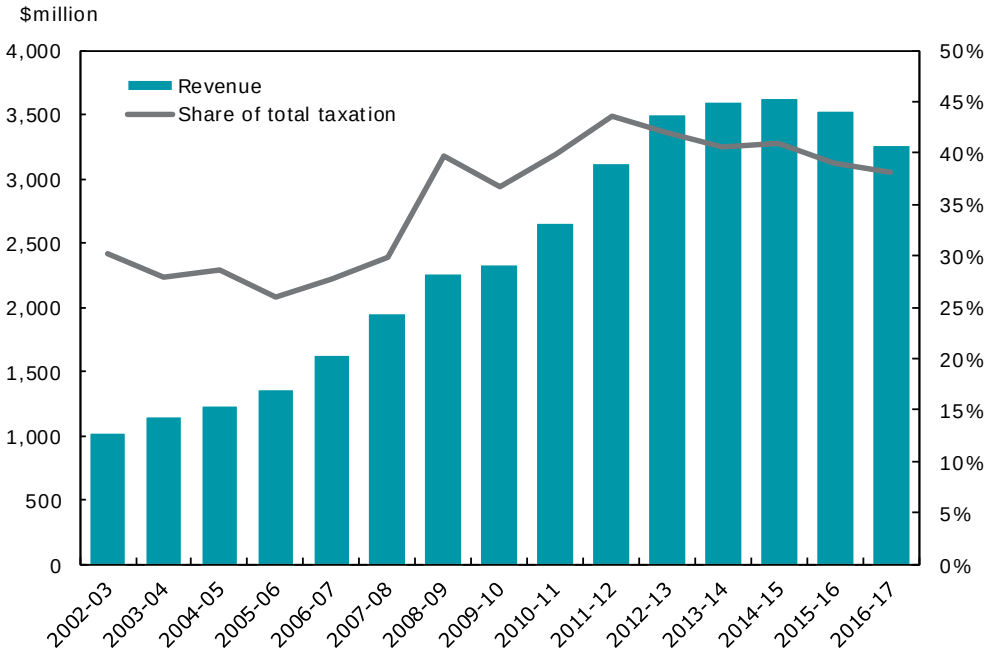
5.1 Background on payroll tax

Payroll tax is a general purpose tax applied to the wages paid by employers. In Western Australia, it is applicable to employers with total Australian wages exceeding a threshold of $850,000 per annum, applied at a rate of 5.5%. There is no threshold available for firms with an annual wage bill greater than $7.5 million (that is, rate of payroll tax is applied to the entire wage bill), and there is a diminishing threshold for firms with an annual wage bill between $850,000 and $7.5 million. A temporary increase in the tax rate for larger taxpayers is also due for implementation from 1 July 2018. Payroll tax revenue is a large contributor to total general government sector revenue, accounting for an average of 12% of revenue between 2008-09 and 2016-17.

Chart 5.1 shows the value of payroll tax revenue increasing over the period to 2014-15, before falling in the subsequent years. As a share of total tax revenue, payroll tax has increased from 26% in 2005-06 to 38% in 2016-17.

Payroll tax revenue is driven by growth in employment and wages. In the early period following the turn of the century, both wages and employment increased strongly, with payroll tax following suit. Since that time, movements in payroll tax collections have largely been reflective of the broader changes in the labour market, though a diminishing threshold was introduced from 1 July 2015.

Chart 5.1: Payroll tax revenue, in dollars and as a share of total taxation revenue



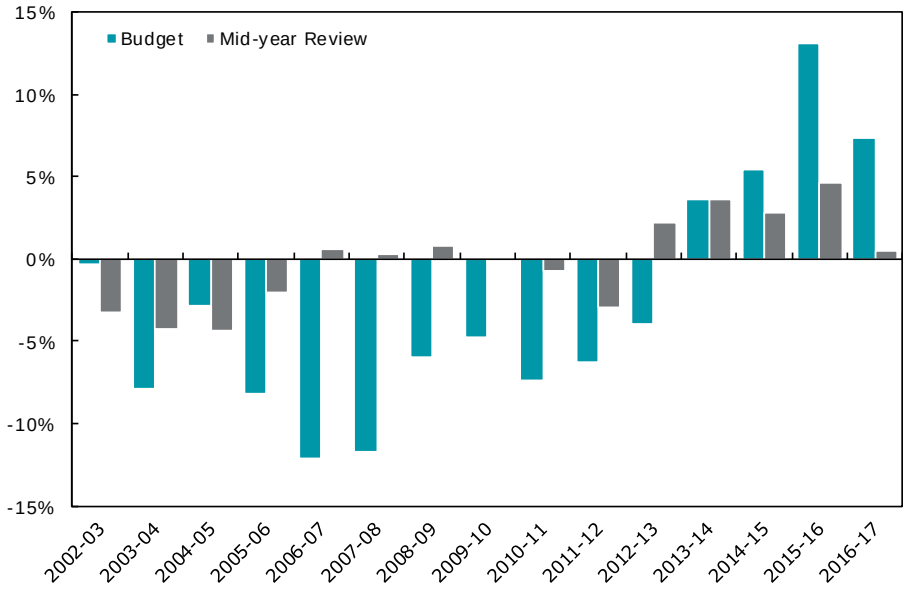
Source: WA Treasury Budget papers and mid-year financial projections statements

5.2 Performance of WA Treasury's revenue forecasts

This section examines WA Treasury's forecast performance of payroll tax. The methodology and criteria used to assess the performance of the forecasts are described in detail in Appendix A.

Chart 5.2 shows the relative forecast error in the Budget year for payroll tax revenue in Western Australia. From 2002-03, WA Treasury's payroll tax forecasts exhibit a MAPE of 6.7%.

Chart 5.2: Budget year relative forecast errors for payroll tax revenue



Source: Based on published Budget figures and estimates provided by WA Treasury

For the period of 2002-03 to 2012-13, Budget year forecasts were consistently under-estimated, ranging from a maximum error of 12.8% in 2006-07 (reflecting a shortfall of $197.7 million) to a minimum of 0.3% in 2002-03 (reflecting a shortfall of only $3.6 million). From 2013-14 onwards, this pattern reverses, with the forecasts consistently higher than the actual figures observed. This was most clear in 2015-16, where the relative forecast error was 13.1%.

These two distinct periods of over- and under-estimating highlight the difficulty in forecasting payroll tax revenue during periods of changing economic conditions. These forecast errors reflect movements in the overall economic performance of Western Australia over the past 15 years. In particular, in the period following the turn of the century, Australia experienced a terms of trade boom, which led to strong growth in the State's mining industry and strong demand for labour and wages growth. Western Australia's mining industry is the largest payroll tax paying industry. A significant challenge with forecasting payroll tax is that the tax base is unevenly skewed towards the mining and related industries, so changes in payroll tax are highly sensitive to conditions in this sector. For example, in 2016-17, the mining industry accounted for around 22% of the State's payroll tax compared to around 7% of the State's employment. When related industries are taken into account, WA Treasury estimates that the sector accounted for around 44% of the State's payroll tax base in that year, well above its 24.4% share of employment.

As expected, WA Treasury's mid-year review (MFPS) forecasts are more accurate on average than those produced at Budget (see Table 5.1). This reflects the time difference between when the forecasts are produced and the beginning of the horizon period.

Since 2002-03, WA Treasury's Budget year forecasts have been less accurate on average than those produced by the Victoria, New South Wales and Queensland Treasuries, measured in MAPE. It should be noted, however, that Western Australia has experienced a greater degree of economic volatility compared to these jurisdictions during this period. As such, the difficulty in producing forecasts is

not necessarily equivalent across States. Over this period, WA Treasury's forecasts have performed better than South Australia and the Northern Territory measured by MAPE.

Two measures of forecast performance that account, in part, for differences in volatility in tax revenue between States are the Mean Absolute Scaled Error (MASE) and Adjusted MAPE (ADJ MAPE). MASE scales the mean absolute error by average growth in the tax over the period. If a scaled error is greater than one, a naïve forecast – where the forecast for the next period is equal to the current period – would have performed better than the forecasts used. ADJ MAPE adjusts MAPE by the standard deviation in annual growth of the relevant tax. A lower ADJ MAPE indicates greater forecast accuracy (see Appendix A). Even after adjusting for the volatility in the historical revenue data, WA Treasury's forecasts were again less accurate on average than those of New South Wales, Victoria and Queensland, but performed better than forecasts for South Australia, Tasmania and the Northern Territory. It is important to note that the results presented in Table 5.1 are not entirely reflective of the performance of the current model, which was implemented from late 2015.

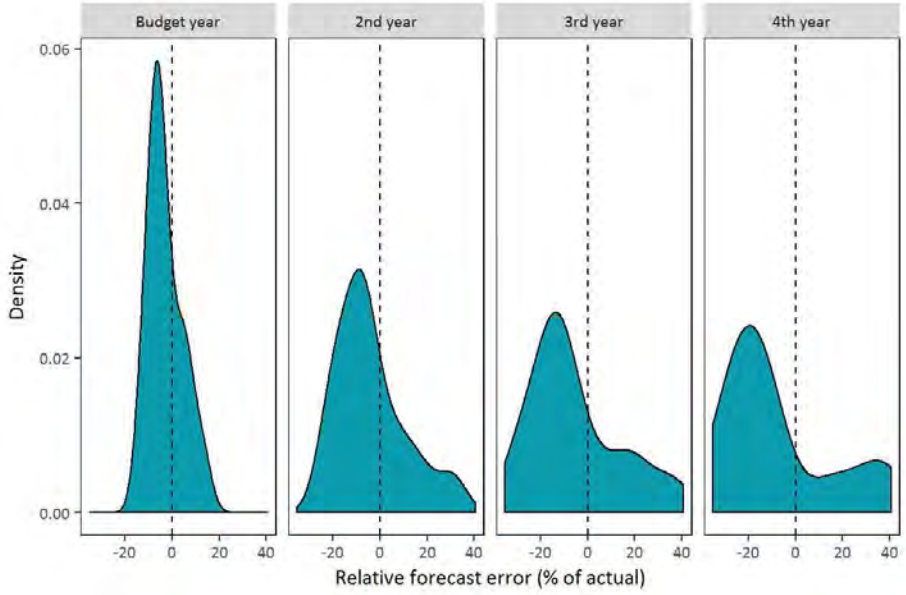
Table 5.1: Performance of payroll tax revenue forecasts in Budget year

Budget year	2002-03 to 2006-07			2007-08 to 2011-12			2012-13 to 2016-17			2002-03 to 2016-17		
	MAPE	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*
WA Budget	6.3%	0.58	1.30	7.2%	0.59	1.08	6.7%	2.00	0.94	6.7%	0.78	0.82
WA Mid-year Review	2.9%	0.23	0.60	1.0%	0.09	0.14	2.8%	0.84	0.39	2.2%	0.25	0.27
NSW Budget	2.4%	0.30	0.72	1.6%	0.42	0.33	1.9%	0.44	1.13	2.0%	0.37	0.55
VIC Budget	3.0%	0.43	0.76	2.1%	0.40	0.60	1.1%	0.24	0.64	2.1%	0.35	0.65
VIC Budget Update	N/A	N/A	N/A	1.1%	0.22	0.32	0.9%	0.19	0.50	N/A	N/A	N/A
QLD Budget	7.4%	0.59	3.13	3.4%	0.37	0.51	4.5%	1.67	0.92	5.1%	0.64	0.74
QLD Mid-year Review	N/A	N/A	N/A	1.3%	0.14	0.19	2.5%	0.91	0.50	N/A	N/A	N/A
SA Budget	12.9%	1.62	1.58	3.2%	0.91	0.87	9.9%	1.69	1.10	8.7%	1.50	1.23
TAS Budget	13.1%	1.32	3.24	4.6%	0.91	1.62	1.3%	0.44	0.53	6.3%	0.99	1.53
NT Budget	14.4%	1.71	1.58	4.2%	0.86	1.09	11.3%	1.00	1.68	10.0%	1.05	1.38

Source: Based on published Budget figures. Figures for Queensland Mid-year Review and Victorian Budget Update available from 2005-06.

Notwithstanding periods of over- and under- estimation, on average since 2002-03 WA Treasury's forecasts show a pattern of under-estimation over the forward estimates (see Figure 5.1). Relative forecast errors for Budget year estimates are reasonably centred on zero, with the initial period of under-estimation being largely offset by a period of over-estimation in the final four years of the analysis. A pattern of positively skewed forecast error densities (indicating a bias towards under-estimation) becomes more pronounced as the forecast horizon is extended. Indeed, this reflects a level of conservatism within WA Treasury's forecast as uncertainty increases.

Figure 5.1: Forecast error distributions for payroll tax revenue, 2002-03 to 2016-17



Source: WA Budget Papers

KEY FINDING: Payroll tax revenue is driven by growth in employment and wages. In the early period following the turn of the century, both wages and employment increased strongly, with payroll tax following suit.

From 2002-03, WA Treasury consistently under-estimated forecasts of payroll tax revenue forecasts, before a period of over-estimating from 2013-14. This largely reflects the economic conditions flowing from the terms of trade boom.

Table 5.2 shows the MAPE, MASE and ADJ MAPE for WA Treasury's Budget and MFPS forecasts compared to other State Treasuries for forecast years beyond the Budget year. Looking at the period from 2012-13 (given data limitations in other periods) WA Treasury's forecasts of payroll tax were among the least accurate, measured by MAPE. After adjusting for volatility, WA Treasury's payroll tax forecast accuracy for forecast years beyond the Budget year has been better than or comparable to that in New South Wales, Victoria and Queensland, as measured by ADJ MAPE.

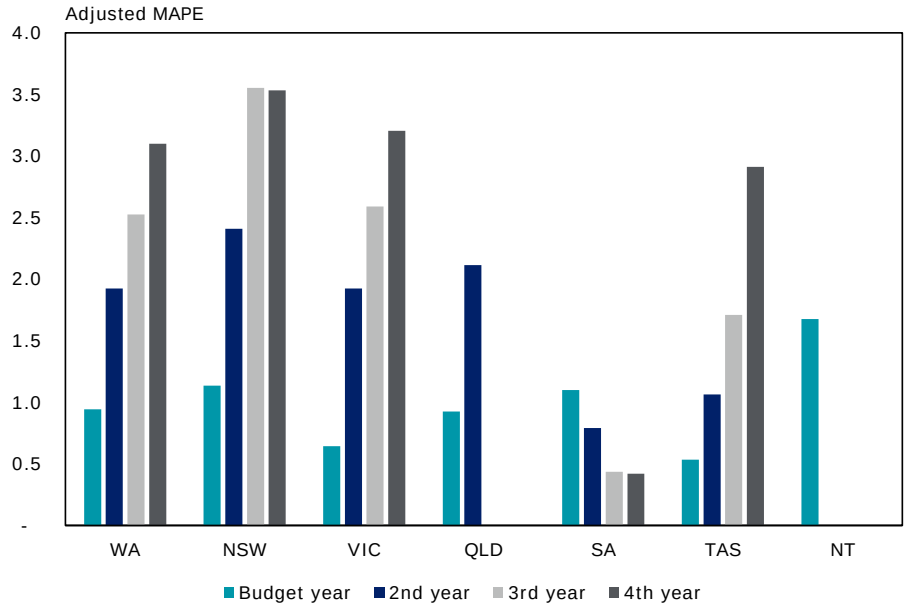
Table 5.2: Performance of payroll tax forecasts in 2nd, 3rd and 4th forecast years

2nd forecast year	2002-03 to 2006-07			2007-08 to 2011-12			2012-13 to 2016-17			2002-03 to 2016-17		
	MAPE	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***
WA Budget	8.5%	0.80	1.76	13.5%	1.11	2.02	13.7%	4.02	1.92	11.9%	1.45	1.44
WA Mid-year Review	8.2%	0.75	1.69	7.2%	0.60	1.07	11.4%	3.40	1.61	8.9%	1.09	1.08
NSW Budget	3.8%	0.47	1.14	2.8%	0.74	0.60	4.1%	0.96	2.41	3.6%	0.68	0.99
VIC Budget	N/A	N/A	N/A	4.7%	0.90	1.35	3.4%	0.72	1.92	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	3.1%	0.58	0.90	2.3%	0.50	1.33	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	10.4%	3.79	2.11	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	7.0%	2.55	1.42	N/A	N/A	N/A
SA Budget	15.1%	1.90	1.85	2.4%	0.67	0.66	7.1%	1.17	0.79	8.2%	1.34	1.17
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	2.6%	0.86	1.06	N/A	N/A	N/A
NT Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3rd forecast year												
	MAPE	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***
WA Budget	9.8%	0.88	2.03	19.2%	1.55	2.87	18.0%	5.29	2.52	15.7%	1.91	1.89
WA Mid-year Review	10.9%	0.98	2.25	11.2%	0.89	1.68	18.1%	5.34	2.55	13.4%	1.64	1.62
NSW Budget	4.0%	0.51	1.21	5.1%	1.33	1.07	6.1%	1.44	3.55	5.0%	1.00	1.40
VIC Budget	N/A	N/A	N/A	5.4%	1.04	1.56	4.6%	1.00	2.59	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	4.2%	0.79	1.20	4.2%	0.91	2.39	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	13.7%	5.00	2.78	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	N/A	N/A	N/A	3.9%	0.62	0.43	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	4.2%	1.41	1.71	N/A	N/A	N/A
NT Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4th forecast year												
	MAPE	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***
WA Budget	N/A	N/A	N/A	24.4%	1.97	3.65	22.1%	6.50	3.10	N/A	N/A	N/A
WA Mid-year Review	N/A	N/A	N/A	17.7%	1.36	2.65	20.9%	6.16	2.94	N/A	N/A	N/A
NSW Budget	2.6%	0.35	0.79	7.1%	1.88	1.50	6.0%	1.44	3.53	5.2%	1.07	1.46
VIC Budget	N/A	N/A	N/A	N/A	N/A	N/A	5.6%	1.27	3.20	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	N/A	N/A	N/A	5.8%	1.27	3.27	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	N/A	N/A	N/A	3.8%	0.60	0.42	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	7.1%	2.41	2.91	N/A	N/A	N/A
NT Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Based on published Budget figures. Relevant Queensland Mid-year Review figures available from 2005-06; Victorian Budget Update from 2005-06; Victorian Budget from 2005-06; Queensland Budget from 2011-12, Queensland Mid-year Review from 2010-11; South Australia Budget from 2004-05; Tasmania Budget from 2008-09.

KEY FINDING: Since 2012-13, after adjusting for State specific volatility, WA Treasury's payroll tax forecast accuracy for forecast years beyond the Budget year has been better than or comparable to those of New South Wales, Victoria and Queensland, as measured by ADJ MAPE.

Chart 5.3: Adjusted MAPE for forecasts of payroll tax revenue from 2012-13 to 2016-17



Source: State Budget Papers

It is also worth considering the source of the forecast error for payroll tax. As is discussed in the following section of the report, the payroll tax model incorporates forecasts from WA Treasury's labour market model. As such, the source of forecast error can be disaggregated between these two models. Deloitte Access Economics has undertaken this analysis by running the payroll tax model under three different model assumptions:

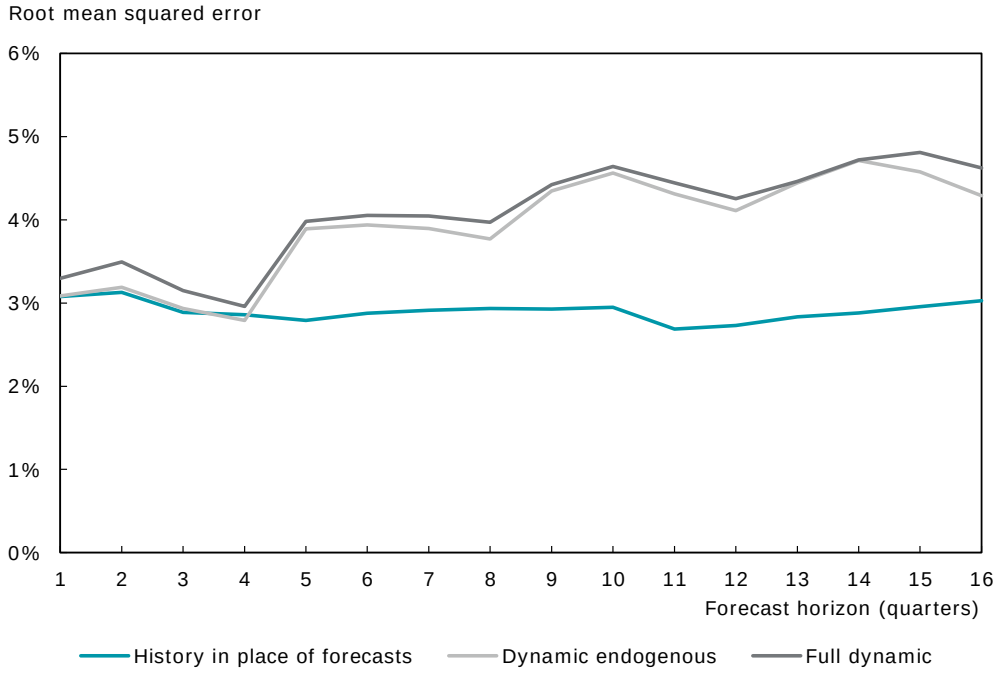
- History in place of forecasts: This model run uses exogenous historical data as the independent variables to isolate the performance of the payroll tax model itself. That is, it represents the forecast error from the payroll tax model assuming that the input data from the labour market model is perfectly accurate.
- Dynamic endogenous: This model run uses lagged dependent variable forecasts but exogenous independent variables.
- Full dynamic: This model run incorporates forecasts from the labour market model for the independent variable (and also uses lagged dependent variable forecasts).[16]

These model runs were completed by restricting the historical data sample to March 2012, estimating the labour and payroll tax models, and forecasting 16 periods ahead to March 2016. The chart below shows a measure of forecast error − the root mean squared error − for payroll tax forecasts under the three different assumptions. Note that one important limitation of this analysis is that it uses the labour market forecasts directly from the labour market model, rather than the final labour market forecasts determined by WA Treasury after judgemental adjustments were applied.

As the chart shows, and as might be expected, the payroll tax model using perfectly accurate historical labour market data records the lowest mean squared error over the forecast period. The error is relatively constant at (or just below) 3% over the 16 quarter forecast horizon. In contrast, when endogenous independent variables are added to the model, the forecast performance deteriorates and the error increases over time (to around 5% by the end of the forecast period).

[16] Note that the current version of WA Treasury's labour market model was only implemented from the 2017-18 Budget. Even so, this exercise is using 'in sample' testing to understand the accuracy of the payroll tax model (and to disaggregate the forecast error between the labour market and payroll tax models). This remains a valid exercise even when using a relatively new version of the labour market model.

Chart 5.4: Payroll tax forecast error under three modelling assumptions



Source: WA Treasury, Deloitte Access Economics

By isolating the error attributable to the payroll tax model itself, this analysis shows that a root mean squared error of around 3% is the lowest error than can be expected from the model. Any forecast error in the labour market forecasts that are used as independent variables in the payroll tax model will increase this error further.

Additional analysis of the models is discussed below and in Appendix B.

5.3 Modelling methodology review

WA Treasury's forecasts for payroll tax revenue are derived from the combination of a statistical model and supplementary labour market analysis. These are detailed separately in in following sections.

5.3.1 Model specification

Theoretically, payroll tax is a function of the price and quantity of labour, along with policy settings such as the rate, threshold and exceptions applied. WA Treasury utilises estimates of the aggregate level of employment as a proxy for the quantity of labour and average compensation of employees (CoE) as a proxy for the price of labour. An Ordinary Least Squares (OLS) multivariate linear model is used in the forecasting process, expressed as a function of employment, average CoE, past trends (lagged values) and seasonal factors (dummy seasonal variables). Employment and average CoE are estimated via WA Treasury's labour market model.

Model variations

WA Treasury utilises two variations of the payroll tax model: one that incorporates a dependent variable to account for new entrants and bracket creep, and one that does not. Given data limitations, the model that includes the additional dependent variable is based on a shorter historical sample, beginning in the early 2000s. The 'new entrants and bracket creep' variable is included within the payroll tax model to account for the extra revenue that flows from the increasing tax base given additional employers meeting the requirements to pay payroll tax. This is derived from unit record data from the OSR to ascertain changes to the number and type of businesses forming the tax base.

The use of two models concurrently is unusual in revenue forecasting. Deloitte Access Economics understands that WA Treasury would prefer to use the model that has greater explanatory power (that is, the model which includes new entrants and bracket creep), but is concerned that because of the shorter sample period, the forecasts may be upwardly biased by the boom period. That is, the purpose of using two models is not to provide a mechanism for 'picking and choosing' between two model outputs.

The latter is a key concern, in general, with respect to using multiple models concurrently. Specifically, forecasting with both models and then selecting the forecasts that give the most subjectively intuitive (or desirable) results removes some credibility and rigour of the forecasting process. In addition, it makes it more difficult to identify the causes of errors, as it may become less clear whether the forecast errors stem from model selection, model performance, or adjustments to the forecasts following the analysis.

Deloitte Access Economics is comfortable that WA Treasury does not intend to switch between the two models on a regular basis. Rather, the model without the new entrants and bracket creep term is used as the 'standard' or 'baseline' model. The model that includes the new entrants and bracket creep term is used as it is seen to be providing valuable, additional information. In that sense, the latter model could be seen as helping to inform judgemental adjustments to the forecasts. In time, as more historical data becomes available, WA Treasury may determine that the model that includes the new entrants and bracket creep term can be estimated robustly and should be used as the 'standard' model. Provided that this decision is made following a thorough review of forecast performance and econometric specification, this progression to a model which includes additional information is logical.

Forecasts for new entrants and bracket creep are produced via an Autoregressive Integrated Moving Average (ARIMA) model with two dummy variables to smooth potential outliers. Previous versions of this model incorporated a commodity price index as a proxy of activity in the Western Australian economy. This variable was recently removed as it was not statistically significant.

ARIMA models use past values and errors to forecast into the future. In this case, 'new entrants and bracket creep' is likely to be driven by future trends in specific industries. As such, using an ARIMA model that uses only past values to forecast may not be optimal. However, the absence of a longer historical dataset means there are few, if any, appropriate alternatives. As more historical data becomes available, WA Treasury may consider if other variables can be used to explain movements in new entrants and bracket creep. State Treasuries in some other jurisdictions have more limited data from their respective OSR, and therefore cannot calculate a variable similar to the 'new entrants and bracket creep' variable created by WA Treasury. Similar concepts (such as accounting for firms moving above and below the wage bill threshold for payroll tax) are attempted to be explained using variables such as the unemployment rate.

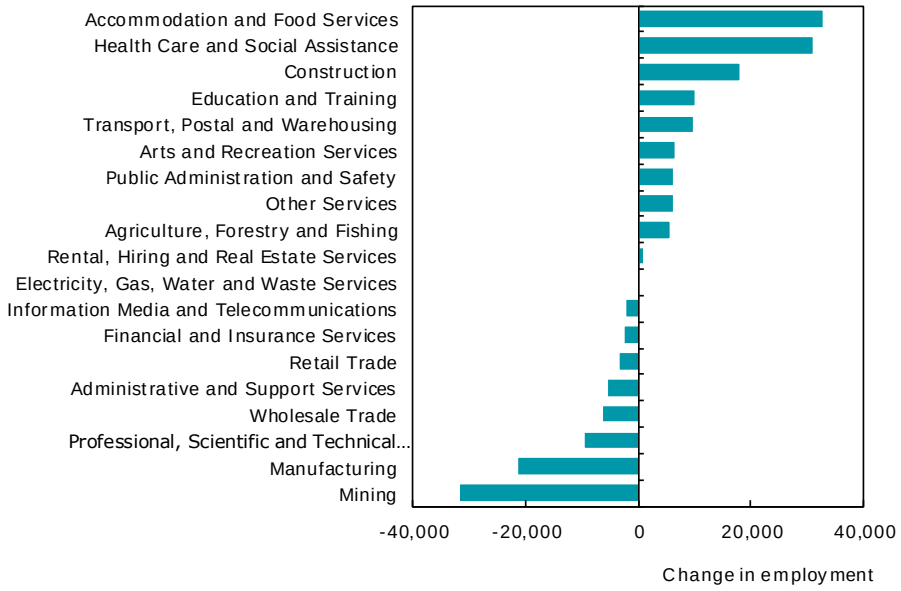
Labour market variables

The payroll tax revenue model uses forecasts from the labour market model (level of employment and average CoE) to capture changes in revenue. Given the recursive nature of the modelling process, potential errors in the forecasts for these variables will have flow-on effects to the estimates of payroll tax revenue. Incorrect assumptions or model specification in the labour market model will adversely affect the performance of the payroll tax model.

This could be exacerbated by the fact that both the payroll tax revenue forecasts and the labour market forecasts are produced by the same person in WA Treasury. While this is not necessarily problematic, it has the potential to lead to bias and a reduced level of oversight in the preparation of the labour market forecasts. If different individuals conducted the modelling there would be an inherent review process of the labour market forecasts that would occur through the payroll tax forecasting process.

The payroll tax model currently includes State-wide measures of employment and wages to capture changes in payroll tax revenue. These aggregate figures may not capture some compositional changes in labour market outcomes that could materially influence payroll tax receipts. For instance, industry employment trends are likely to drive changes in revenue, particularly through movements in the mining industry in Western Australia. Chart 5.5 shows the change in total employment by industry between 2012 and 2017. Over this period, employment in the mining industry fell by over 31,000 individuals, while employment expanded by a similar magnitude in accommodation and food services. Importantly, wage bills of different industries vary significantly, with traditionally stronger wages in the mining industry driving higher payroll tax contributions. Indeed, in 2016-17 the mining industry accounted for around 22% of total payroll tax revenue, while the accommodation and food services sector accounted for just 2.1%. As a result, despite total employment and wages (measured by the wage price index) in the State increasing over this period, payroll tax revenue moderated in 2013-14 and 2014-15, before falling in the subsequent years.

Chart 5.5: Change in WA employment by industry, 2012-2017



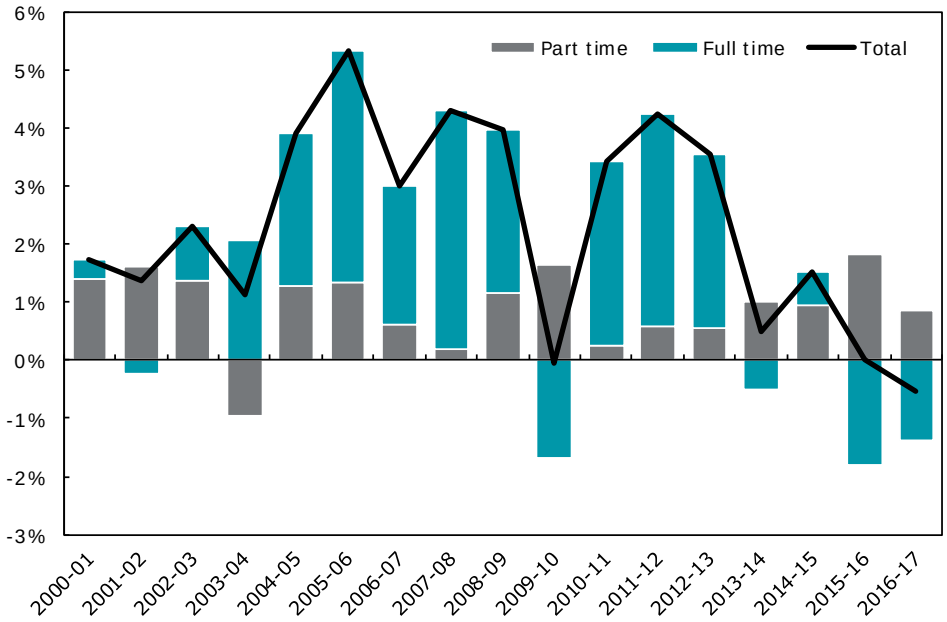
Source: ABS Cat. 6291.0, August quarter of each year

Similarly, as payroll tax is levied on the value of an employer's payroll, a shift towards larger part-time workforces at the expense of full-time roles would have the effect of reducing the payroll tax liabilities of an entity, all else equal. Indeed, the compositional makeup – and changes – in the Western Australian labour market is likely to have influenced the performance of forecasts for this revenue head in recent years.

Specifically, the period from 2000-01 to 2007-08 was characterised by strong growth in both part-time and full-time employment. However, from 2008-09 onwards, jobs growth has been predominantly underpinned by part-time roles. This trend was particularly pronounced between 2012-13 and 2016-17, during which time full-time employment in Western Australia fell in three of the four years (see Chart 5.6). Indeed, in 2016-17 the part-time workforce accounted for 32.0% of the total WA workforce, up from 27.8% in 2007-08.

In the formation of the current model, WA Treasury considered the inclusion of compositional variables that may go some way to capture these trends, such as hours worked. Where this additional analysis cannot be directly incorporated into the forecasting model, WA Treasury uses judgement to adjust the forecasts to take account of this information. This is discussed in section 5.3.2.

Chart 5.6: WA employment, annual change and part-time/full-time contribution



Source: ABS Cat. 6202.0, average over financial year

Lags, dummy variables and statistical tests

The payroll tax model also includes a seasonal dummy variable to account for quarterly differences in payroll receipts – particularly those in the third quarter. To account for periods of instability, dummy variables are added to the model as required. Additionally, a lagged variable of payroll tax revenue is also included.

Statistical tests for autocorrelation, heteroscedasticity and normality of errors are conducted to ensure the appropriate assumptions for the econometric modelling are met.

KEY FINDING: WA Treasury forecasts payroll tax using an econometric model with inputs from WA Treasury's labour market modelling. The recursive nature of using the employment and wage forecasts from the labour market model may lead to additional errors. This is particularly true given that forecasts for both models are produced by the same individual, potentially reducing the level of oversight.

In general, the concurrent use of two models with different specifications can remove some credibility and rigour in the modelling process. However, Deloitte Access Economics is comfortable that WA Treasury does not intend to regularly switch between the models. In time, as more historical data becomes available, WA Treasury may determine that the model that includes the new entrants and bracket creep term can be estimated robustly and should be used as the 'standard' model. Provided that this decision is made following a thorough review of forecast performance and econometric specification, this progression to a model which includes additional information is logical.

Payroll tax collections are affected by industry trends and compositional trends in the labour market. WA Treasury should continue to explore methods to account for these variations.

5.3.2 Supplementary analysis

Forecasts produced by the statistical model are augmented by analysis of a range of available information to ensure the reasonableness and appropriateness of the estimates, particularly in the short-term. Each aspect of this analysis is described below.

Pro-rata projections for current financial year

Pro-rata projections of payroll tax revenue are produced by extrapolating year-to-date collections from the OSR, and escalating them based on the average seasonal patterns from 2012-13. Using data from the OSR is a timely and accurate source of information for changes to payroll tax revenue collections. However, to the extent that additional data can be acquired from OSR, this would further assist in making judgemental adjustments to the forecasts. For example, information on the number (or full-time equivalent number) of employees for each entity paying payroll tax would be beneficial in assisting WA Treasury in understanding the labour market and payroll tax base.

Analysis of compositional trends in labour market

As discussed in Section 5.3.1, the labour force inputs to the payroll tax model are aggregate figures for the total level of employment and average CoE of the State. To account for the industry composition of the Western Australian economy – particularly the large resource sector – WA Treasury undertakes an analysis of particular labour market trends. These include:

- Full-time and part-time employment;
- Employment growth by industry; and
- Wage Price Index (WPI) by industry.

Adjustments to the forecasts produced by the econometric modelling are judgement-based, and predominantly affect the short-term forecasts.

Relationship between key industries and economic indicators

In addition to overall labour force compositional changes, WA Treasury conducts an analysis of particular key industries. These industries have been linked to various economic indicators that are expected to move with the payroll tax revenue of each industry. For instance, expected movements in total non-dwelling construction (ABS Cat 5206) help inform directional movements in payroll tax from the non-residential building construction sector.

Utilising movements in economic variables can be useful to guide expected directional changes in payroll tax revenue for certain industries. However, while the correlations can give insight into the direction of the movements, it is difficult to determine magnitude. This has been noted by WA Treasury. Data from OSR detail the payroll tax liability of each organisation over time, which can be linked to industry classifications. This data could be used to better understand industry trends.

Judgemental adjustments to forecasts, by definition, are subjective in nature and are difficult to quantify. Indeed, a formal model represents the quantification of relationships between dependent and independent variables, while judgemental adjustments should be used to account for additional information that is not (or can not) be captured within the model. For this reason, it is very difficult to quantify the magnitude of judgemental adjustments. As WA Treasury already does, the communication of payroll tax forecasts internally (for example, to the WA Treasury Executive) should clearly detail the information that is being taken into account within the formal model, and the additional information that has been considered in determining a final forecast. To the extent it does not already, WA Treasury should also review the direction and magnitude of judgemental adjustments made to payroll tax forecasts over time, in order to build and reinforce the credibility of analysts' judgement, and therefore the confidence that the WA Treasury Executive have in the adjustments.

KEY FINDING: WA Treasury's payroll tax model is supplemented by in-depth analysis of labour market and industry trends. The detailed approach to understanding trends and compositional labour force changes is likely to aid the basis for adjustments to the model outputs. There is scope for this to play a larger role in the development of payroll tax revenue forecasts. For example, while WA Treasury already uses the data to assess some trends at the sub-industry level, a more systematic analysis of this data – including in conjunction with a view on the forward outlook – could assist in helping to identify and predict turning points. This is particularly relevant in the resources sector where, in some instances, the sub-industry payroll data appears align relatively closely to economic variables such as engineering construction.

5.3.3 Labour market forecast performance

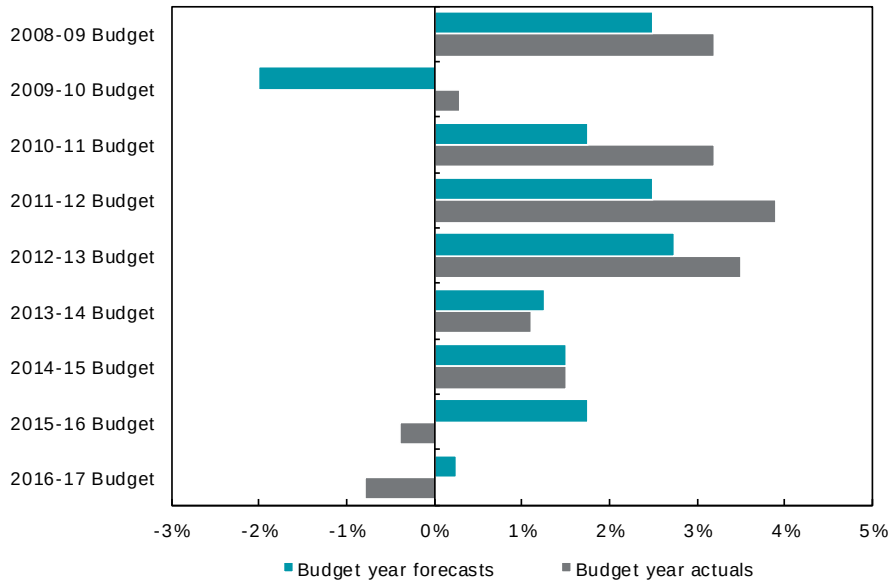
Estimates for the level of employment and average CoE are informed by WA Treasury's Labour Market model through a Vector Error Correction Model (VECM). The VECM comprises the level of employment and average CoE, which are both treated endogenously, as well as State Final Demand (SFD) and the seasonally adjusted unemployment rate treated as exogenous. The performance of the labour market forecasts as it relates to payroll tax revenue forecasts is described in subsequent sections.

Employment

The Western Australian labour market experienced a stark slowing in recent years, with employment growing by 13% between 2008-09 and 2016-17, down from 26% over the previous nine years to 2007-08. This slowing employment growth contributed to the unemployment rate almost doubling between 2007-08 and 2016-17.

Consistent with this wider volatility and uncertainty in key economic parameters and the labour market broadly at the time, State Budget projections of employment growth consistently under-estimated employment growth following the 2008 financial crisis, before over-estimating growth from 2013-14 in each Budget year.

Chart 5.7: Employment growth, Budget year forecasts and actual

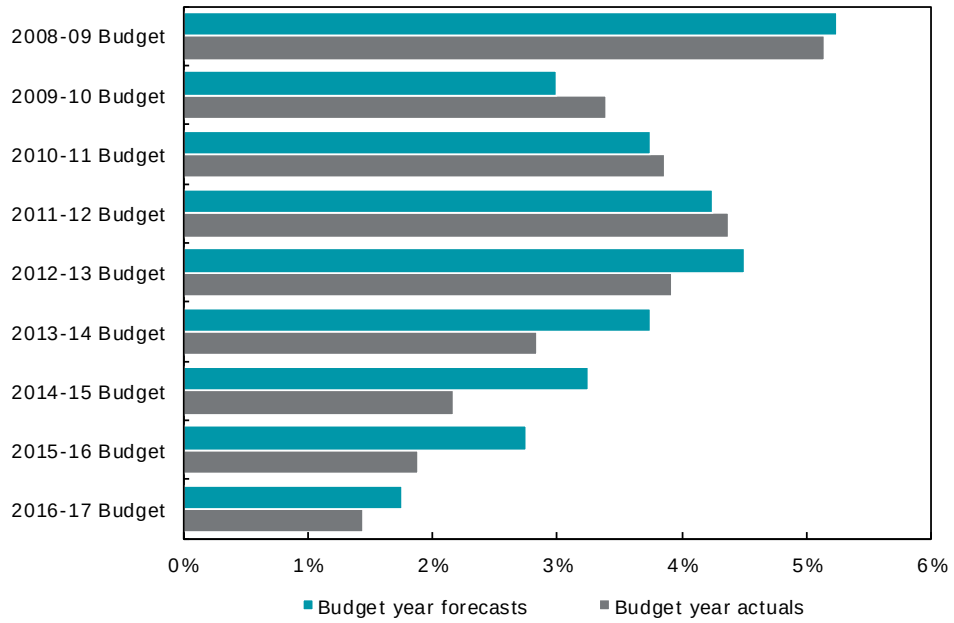


Source: WA Budget papers. Note, Employment actuals for 2015-16 and 2016-17 differ from those published by the ABS as they include WA Treasury's estimate of the impact of the downward revision to Western Australia's population as a result of the 2016 Census. Actual figure for 2016-17 is estimated.

Wages

Wage growth in Western Australia was extremely strong through the peak of the terms of trade boom, however has slowed significantly in recent years – similar to employment. During this period of moderation, wage growth has been consistently over-estimated relative to the actual revenue received. It should be noted that average CoE is used in the payroll tax model rather than WPI. However, given the data limitations, this analysis was conducted using WPI.

Chart 5.8: Wage Price Index growth, Budget year forecasts and actual



Source: ABS Cat. 6345.0

5.4 Alternative approaches to preparing revenue forecasts

Approaches to forecasting payroll tax revenue vary across other government forecasters. In some jurisdictions, econometric methods are used, while in others the focus is on non-econometric techniques. Table 5.3 below provides a summary of the approach to forecasting payroll tax revenue in three other jurisdictions, while a brief overview of the key approaches follows.

Table 5.3: Summary of payroll tax revenue forecasting approach in other jurisdictions

Summary	Approach	Supplementary analysis
State A		
Payroll tax is forecast based on growth in average CoE and growth in employment. While described as a linear equation, the model assumes a coefficient of 1 for each of these variables. A measure of 'bracket creep' is then added.	Gross payroll tax is forecast as the revenue in the previous year, multiplied by the combined growth of average CoE and employment in the State. Coefficients or elasticities for these two variables are set equal to 1. Policy changes are then added, eliminations (government agency payroll tax) are deducted, and an estimate of the impact of bracket creep is added. This methodology used to estimate bracket creep is currently under review, but at present simply grows a historical estimate of tax payable just below the payroll tax threshold by average CoE and employment, and assumes that some of this becomes payable in the current year.	Analysis of labour market data in order to try to determine movements in and out of the tax base. Data from workplace health and safety regulator is used to inform historical data by size of wage bill to inform the analysis of bracket creep.
State B		
A series of error correction equations is used to inform the forecasts, which is also supplemented by industry and sectoral analysis.	Payroll tax is forecast econometrically using a system of error correction models. The variables modelled include the wage price index, employment, hours worked and the part-time/full-time share of labour.	Additional judgement applied to account for industries with/without tax liabilities and general labour market conditions analysis.
State C		
Error correction model	Payroll tax is forecast econometrically using an error correction model. The independent variables used in the model include average COE, employment, unemployment and engineering construction (in logs), as well as a lagged dependent variable. The unemployment and engineering construction variables are included in the model as they are seen as being, to some extent, predictors for entry and exit (that is, predictors of whether firms on the margin of paying payroll tax will have wage bills above or below the threshold).	Analysis of payroll tax collection data from the Office of State Revenue.

Econometric alternatives

Many State Treasuries use econometric methods to forecast payroll tax revenue in their respective States. In these instances, additional variables are included to account for compositional changes in the labour market that may influence payroll receipts. Generally, these include variables that measure changes in the type of work (such as part-time share or hours worked), industry makeup (such as key industry employment or wages growth) or unemployment.

Non-econometric alternatives

In general, the relationship between payroll tax revenue, wages and employment is clear; payroll tax liability is the total Australian wages bill for an organisation (above the threshold) multiplied by the appropriate tax rate. Therefore, if future wages and employment growth can be estimated, the expected receipts of payroll tax revenue can be calculated.

However, movements in and out of the payroll tax base and within the base, as well as industry dynamics, add complexities to this accounting identity. For this reason, the relationship between wages, employment and payroll tax is less clear in Western Australia. Given the relatively high share of payroll tax accounted for by the resources sector, a relatively simple non-econometric approach may not sufficiently explain movements in payroll tax.

In some other jurisdictions, agencies do utilise non-econometric techniques to forecast payroll tax revenue. In these cases, the method relies on the simple relationship between wages and employment. However, while this approach may be suitable for larger States with a relatively broad industrial structure, it is likely to be less appropriate in a Western Australian context where a small number of industries account for an unusually large share of payroll tax.

KEY FINDING: Like WA Treasury, some other government forecasters use econometric methods to forecast payroll tax revenue. In these instances, other variables are typically included to account for compositional changes in the labour market. There are some government forecasters that use non-econometric approaches based on the rationale that the relationship between payroll tax revenue, wages and employment is clear. In Deloitte Access Economics' view, this relationship is less clear in Western Australia and a non-econometric approach may not be suitable.

5.5 Key findings and recommendations

5.5.1 Key findings

Performance of payroll tax revenue forecast

- Payroll tax revenue is driven by growth in employment and wages. In the early period following the turn of the century, both wages and employment increased strongly, with payroll tax following suit.
- From 2002-03, WA Treasury consistently under-estimated forecasts of payroll tax revenue forecasts, before a period of over-estimating from 2013-14. This largely reflects the economic conditions flowing from the terms of trade boom.
- Since 2012-13, after adjusting for State specific volatility, WA Treasury's payroll tax forecast accuracy for forecast years beyond the Budget year has been better than or comparable to those of New South Wales, Victoria and Queensland, as measured by ADJ MAPE.

Methodology

- WA Treasury forecasts payroll tax using an econometric model with inputs from WA Treasury's labour market modelling. The recursive nature of using the employment and wage forecasts from the labour market model may lead to additional errors. This is particularly true given that forecasts for both models are produced by the same individual, potentially reducing the level of oversight.
- In general, the concurrent use of two models with different specifications can remove some credibility and rigour in the modelling process. However, Deloitte Access Economics is comfortable that WA Treasury does not intend to regularly switch between the models. In time, as more historical data becomes available, WA Treasury may determine that the model that includes the new entrants and bracket creep term can be estimated robustly and should be used as the 'standard' model. Provided that this decision is made following a thorough review of forecast performance and econometric specification, this progression to a model which includes additional information is logical.
- Payroll tax collections are affected by industry trends and compositional trends in the labour market. WA Treasury should continue to explore methods to account for these variations.

- WA Treasury's payroll tax model is supplemented by in-depth analysis of labour market and industry trends. The detailed approach to understanding trends and compositional labour force changes is likely to aid the basis for adjustments to the model outputs. There is scope for this to play a larger role in the development of payroll tax revenue forecasts. For example, while WA Treasury already uses the data to assess some trends at the sub-industry level, a more systematic analysis of this data – including in conjunction with a view on the forward outlook – could assist in helping to identify and predict turning points. This is particularly relevant in the resources sector where, in some instances, the sub-industry payroll data appears align relatively closely to economic variables such as engineering construction.

Alternative approaches

- Like WA Treasury, some other government forecasters use econometric methods to forecast payroll tax revenue. In these instances, other variables are typically included to account for compositional changes in the labour market.
- There are some government forecasters that use non-econometric approaches based on the rationale that the relationship between payroll tax revenue, wages and employment is clear. In Deloitte Access Economics' view, this relationship is less clear in Western Australia and a non-econometric approach may not be suitable.

5.5.2 Recommendations

- **Move to the use of a single model when possible** – In time, as more historical data becomes available, WA Treasury could determine that the model that includes the new entrants and bracket creep term can be estimated robustly. At this point, WA Treasury should determine which model should be used as the 'standard' model following a thorough review of forecast performance and econometric specification.

6 Transfer duty

Chapter summary

Deloitte Access Economics' analysis of WA Treasury's transfer duty models and forecast performance show that, since 2002-03, the average Budget year forecast error has been 21%. While, at first glance, the forecast performance in Western Australia has been well below that in other jurisdictions over the same period, the relative performance improves considerably once the greater volatility of the historical transfer duty series in Western Australia (and therefore the greater difficulty in forecasting future revenue) is taken into account. Indeed, in the Budget year and in other years over the forward estimates period, WA Treasury's forecasts have been among the most accurate across all other jurisdictions examined.

As is the case in other jurisdictions, and consistent with transaction values (a combination of volume and price) being the key driver of transfer duty, WA Treasury's forecast approach is reliant on the accuracy and approach of forecasts for transaction volumes and prices. In Western Australia, volumes and prices are modelled for residential transactions, while in some other jurisdictions, specific models for non-residential transactions have also been developed.

A review of the house price forecast model, discussed both in this chapter of the report and in Appendix B, has suggested some improvements. Acknowledging that the model is a work in progress, Deloitte Access Economics notes that the house price forecast model only considers the demand side of the housing market. Rather than demand or supply in isolation, the demand-supply balance affects house prices in a given jurisdiction.

Deloitte Access Economics also considers that WA Treasury should consider some amendments to its transaction volume forecasting model. The model currently incorporates iron ore prices as a measure of economic activity. Given the difficulties in accurately forecasting iron ore prices, WA Treasury should investigate whether an alternative variable could be used (for example, business investment could be used to track the domestic business cycle, and would be available as part of WA Treasury's suite of economic forecasts).

Large or 'specials' transfer duty is volatile. WA Treasury uses a historical average supplemented with advice from OSR. This is consistent with the methodology used in most other jurisdictions and, in Deloitte Access Economics' view, is the most logical forecast approach. WA Treasury should continue to communicate with OSR to incorporate any information available in near-term forecasts.

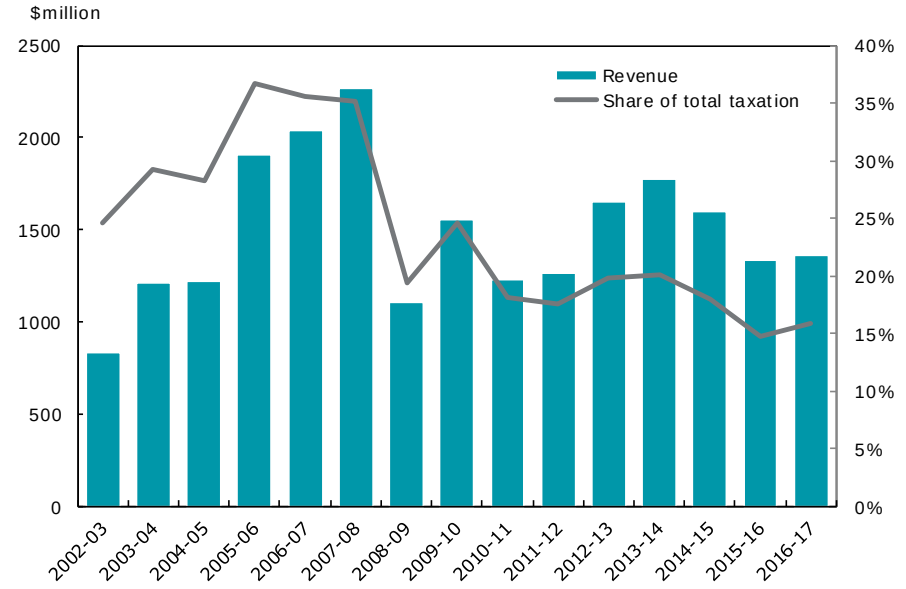
Deloitte Access Economics also recommends that additional resources be directed toward transfer duty modelling given (a) the model development task that is required and (b) the existing workload of the staff member who is currently tasked with preparing the transfer duty forecasts.

6.1 Background on transfer duty

Transfer duty is paid by the purchaser of dutiable property (primarily land, buildings, mining tenements and business assets) on the basis of dutiable value of property transferred. Between 2002-03 and 2016-17, transfer duty revenue accounted for around 24% of Western Australia's government taxation revenue on average. It is currently the State's largest tax after payroll tax, but its share of total taxation has decreased since 2007-08.

Transfer duty is a relatively volatile source of revenue with large movements year on year as evident in Chart 6.1. Large and unpredictable commercial transactions contribute to volatility in this revenue head. In addition, drivers of demand for residential property such as employment, wage and population growth, have been affected by the unwinding of the resources boom in recent years.

Chart 6.1: Transfer duty revenue, in dollars and as a share of total taxation

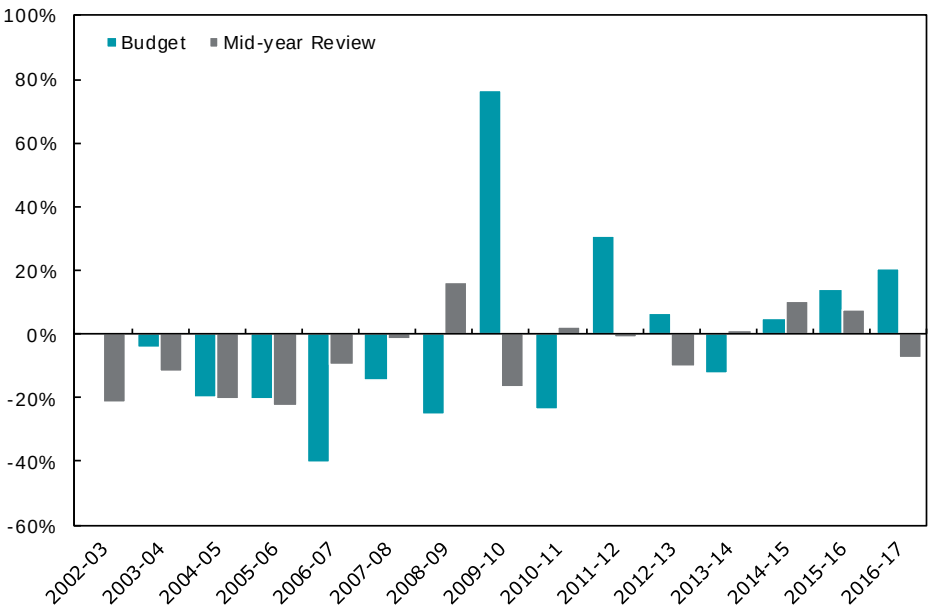


Source: WA Treasury Budget Papers

6.2 Performance of Treasury's revenue forecasts

This section examines WA Treasury's forecast performance of transfer duty. The methodology and criteria used to assess the performance of the forecasts are described in detail in Appendix A.

Chart 6.2: Budget year relative forecast errors for transfer duty revenue (excluding landholder duty)



Source: WA Budget Papers

Chart 6.2 shows the relative forecast error in the Budget year for transfer duty in Western Australia. Since the 2002-03 Budget, the Budget year forecast error has been 21% on average. It is important to note that this result is not entirely reflective of the current method, given that WA Treasury changed its forecasting approach in 2014 and again in 2017.[17]

The largest percentage forecast error was recorded in 2008-09, when transfer duty revenue was over-estimated by approximately 77%. This forecast error is explained by a number of factors related to the global financial crisis of that time and the associated economic downturn. These include a weakening Western Australian property market and a fall in house prices causing household confidence to deteriorate.[18] Additionally, there was a substantial cut in transfer duty on residential properties from 1 July 2008 as a concessional transfer duty scale was introduced.[19] The average error for Budget year forecasts falls to 17% if the 2008-09 error is omitted from the calculation.

Table 6.1 shows the MAPE, MASE and ADJ MAPE for WA Treasury's Budget year forecasts of transfer duty, compared to other State Treasuries.

Since 2002-03, WA Treasury's Budget year forecasts of transfer duty rank among the least accurate across comparable State Treasuries' forecasts, measured by MAPE. In the most recent period examined, from 2012-13 to 2016-17, WA Treasury's MAPE has been in line with the larger States of New South Wales and Victoria and has performed better than the smaller States. After adjusting for varying degrees of volatility in each State, Western Australia's forecast performance is better than all States examined except for the Northern Territory, as measured by ADJ MAPE from 2002-03 to 2016-17.

Table 6.1: Performance of transfer duty revenue forecasts in Budget year

Budget year	2002-03 to 2006-07			2007-08 to 2011-12			2012-13 to 2016-17			2002-03 to 2016-17		
	MAPE	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*
WA Budget	19.7%	1.05	0.83	32.6%	0.91	0.94	10.9%	1.14	0.59	21.0%	0.99	0.75
WA Mid-year Review	17.3%	0.80	0.72	7.6%	0.21	0.22	7.4%	0.78	0.40	10.8%	0.49	0.38
NSW Budget	17.4%	1.39	1.01	15.0%	0.70	0.61	11.5%	0.68	1.41	14.7%	0.86	0.78
VIC Budget	18.8%	1.77	2.31	17.5%	0.88	0.74	10.7%	0.74	0.95	15.7%	1.01	1.03
VIC Budget Update	N/A	N/A	N/A	7.9%	0.40	0.33	6.7%	0.47	0.59	N/A	N/A	N/A
QLD Budget	24.5%	1.28	1.43	22.7%	1.21	1.08	7.3%	0.49	0.45	18.2%	1.01	0.94
QLD Mid-year Review	N/A	N/A	N/A	9.6%	0.57	0.46	4.5%	0.32	0.28	N/A	N/A	N/A
SA Budget	13.5%	0.95	0.94	20.2%	1.73	1.10	6.1%	1.04	0.69	13.3%	1.14	0.89
TAS Budget	26.5%	2.01	1.78	26.5%	1.66	1.02	13.8%	1.19	1.60	22.2%	1.47	1.23
NT Budget	28.3%	0.95	0.82	8.4%	0.74	0.67	19.3%	0.51	0.37	18.7%	0.69	0.52

Note: Based on published Budget figures. Figures for Queensland Mid-year Review and Victorian Budget Update available from 2005-06.

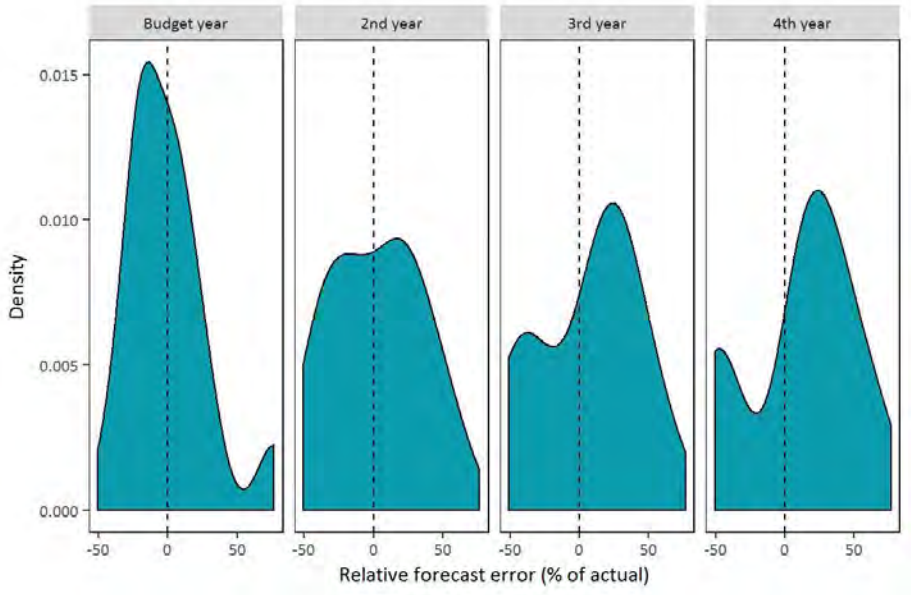
KEY FINDING: Forecasting transfer duty accurately in Western Australia is a difficult task due to the volatile nature of the property market and the economy. After accounting for the historical volatility of transfer duties across different States, WA Treasury's Budget year forecasts rank among the most accurate when compared to those of other State Treasuries.

Between 2002-03 and 2016-17, an examination of the relative forecast errors in Figure 6.1 shows an underestimation of transfer duty revenue in the Budget year. However, since 2013-14, WA Treasury has overestimated this revenue head in the Budget year. In Deloitte Access Economics' view, this profile (from underestimation to overestimation) is consistent with the broader profile of the Western Australian economy, related to the peak and subsequent unwinding of commodity prices and business investment.

In the out-years, a pattern of overestimation of transfer duty has been observed. As expected, the distribution of forecast errors in the out-years is larger relative to the Budget year due to increased uncertainty.

[17] Consultations with WA Treasury, 3 November 2017.
[18] Western Australia Department of Treasury, *Mid-year Financial Projections Statement 2008-09,* p. 8
[19] Western Australia Department of Treasury, *Overview of State Taxes 2008-09*, p. 8.

Figure 6.1: Forecast error distributions for transfer duty revenue



Source: WA Treasury

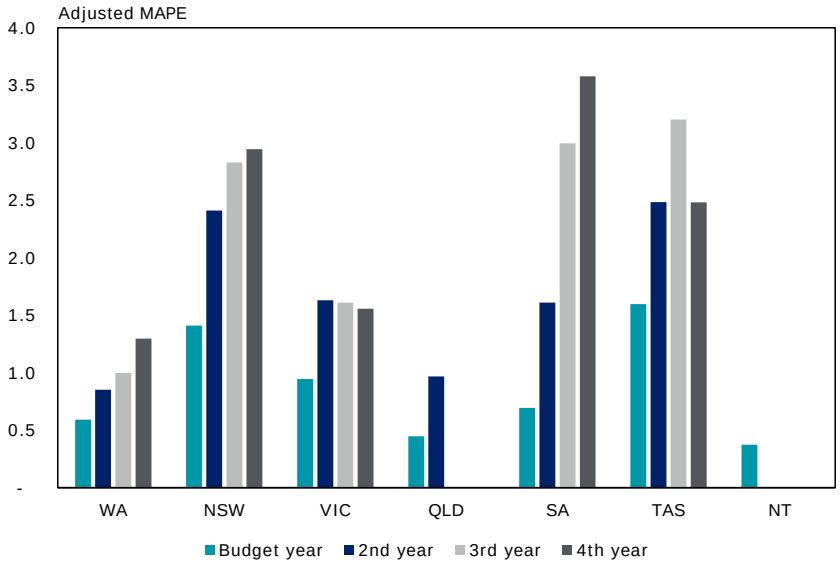
Table 6.2 shows the MAPE, MASE and ADJ MAPE for WA Treasury's Budget and MFPS, compared to other State Treasuries for forecast years beyond the Budget year. Over the period from 2012-13 (given data limitations in other periods) WA Treasury's forecasts of transfer duty for forecast years beyond the Budget year have been among the most accurate relative to other State Treasuries (Chart 6.3).

Table 6.2: Performance of transfer duty forecasts in 2nd, 3rd and 4th forecast years

2nd forecast year	**2002-03 to 2006-07**			**2007-08 to 2011-12**			**2012-13 to 2016-17**			**2002-03 to 2016-17**		
	MAPE	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***
WA Budget	29.6%	1.60	1.24	35.8%	1.04	1.03	15.7%	1.59	0.85	27.0%	1.30	0.96
WA Mid-year Review	33.8%	1.78	1.42	36.9%	1.01	1.06	12.8%	1.33	0.70	27.9%	1.31	0.99
NSW Budget	20.9%	1.65	1.21	17.0%	0.79	0.69	19.7%	1.20	2.41	19.2%	1.23	1.02
VIC Budget	N/A	N/A	N/A	11.6%	0.64	0.49	18.5%	1.26	1.63	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	17.6%	0.91	0.74	16.3%	1.11	1.44	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	15.7%	1.02	0.97	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	10.3%	0.69	0.63	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	19.0%	1.61	1.03	14.3%	2.34	1.61	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	21.5%	1.83	2.48	N/A	N/A	N/A
NT Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3rd forecast year												
	MAPE	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***
WA Budget	35.0%	1.81	1.47	40.0%	1.19	1.15	18.4%	1.83	1.00	31.1%	1.49	1.10
WA Mid-year Review	38.4%	2.01	1.61	40.0%	1.22	1.15	16.6%	1.69	0.90	31.7%	1.55	1.12
NSW Budget	23.5%	1.89	1.35	17.1%	0.82	0.70	23.1%	1.48	2.83	21.2%	1.44	1.13
VIC Budget	N/A	N/A	N/A	16.2%	0.88	0.68	18.3%	1.32	1.61	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	11.0%	0.61	0.46	18.8%	1.32	1.66	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	15.2%	0.97	0.93	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	15.6%	1.39	0.85	26.6%	4.29	2.99	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	27.7%	2.27	3.20	N/A	N/A	N/A
NT Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4th forecast year												
	MAPE	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***	***MAPE***	***MASE***	***ADJ MAPE***
WA Budget	N/A	N/A	N/A	41.0%	1.24	1.18	23.9%	2.41	1.30	N/A	N/A	N/A
WA Mid-year Review	N/A	N/A	N/A	43.6%	1.33	1.26	20.4%	2.02	1.11	N/A	N/A	N/A
NSW Budget	28.4%	2.28	1.64	26.0%	1.23	1.06	24.1%	1.55	2.94	26.2%	1.68	1.39
VIC Budget	N/A	N/A	N/A	N/A	N/A	N/A	17.7%	1.33	1.56	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	N/A	N/A	N/A	17.8%	1.33	1.57	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	21.2%	1.82	1.15	31.8%	5.30	3.58	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	21.4%	1.85	2.48	N/A	N/A	N/A
NT Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: Based on published Budget figures. Relevant Queensland Mid-year Review figures available from 2005-06; Victorian Budget Update from 2005-06; Victorian Budget from 2005-06; Queensland Budget from 2011-12, Queensland Mid-year Review from 2010-11; South Australia Budget from 2005-06; Tasmania Budget from 2008-09.

Chart 6.3: Adjusted MAPE for forecasts of transfer duty from 2012-13 to 2016-17



Source: State Budget Papers

KEY FINDING: For the Budget year forecasts, WA Treasury has under-estimated transfer duty revenue on average between 2002-03 and 2016-17. However, since 2013-14, WA Treasury has more often over-estimated this revenue head. In the forecast years beyond the Budget year, a pattern of overestimation of transfer duty can be observed.

Over the period from 2012-13, WA Treasury's forecasts of transfer duty for forecast years beyond the Budget year have been among the most accurate relative to other State Treasuries after accounting for State specific volatility.

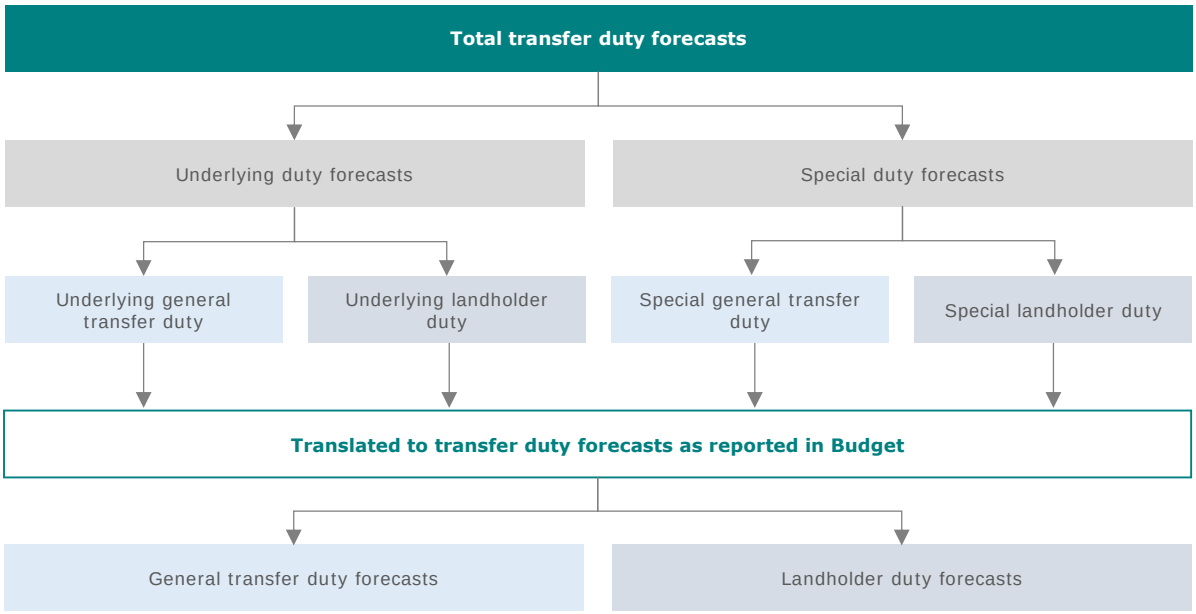
6.3 Modelling methodology review

The Western Australian Budget reports general transfer duty and landholder duty. Total transfer duty forecasts (the sum of general transfer duty and landholder duty) are based on projections of:

- "Underlying" duty forecasts (approximately 80% of total transfer duties): collected on housing transfers and smaller commercial property transactions – transactions where duty is less than $1 million; and
- "Specials" duty forecasts (approximately 20% of total transfer duties): collected on larger property transactions, which are generally non-residential – transactions where duty is equal to or greater than $1 million.

Figure 6.2 below illustrates how total transfer duty forecasts are developed, compared to what is reported in the Budget.

Figure 6.2: Transfer duty splits



Source: WA Treasury

The forecast methodology for this revenue head is analysed in the following sections, with a focus on underlying duty and specials duty.

6.3.2 Underlying Duty on Transfers

Underlying transfer duty forecasts are modelled using forecasts for housing transactions and median house prices. There are three separate models used to forecast underlying duty on transfers:

- Housing transactions model;
- House price model; and
- Underlying transfer duty model.

Deloitte Access Economics' analysis of the models is set out below and at Appendix B at the end of this report.

KEY FINDING: WA Treasury's forecast approach reflects the primary drivers of underlying transfer duty – the number of transactions and transaction prices – and is reliant on the accuracy and approach of forecasts for transaction volumes and median house prices.

Housing transaction volumes

Total finance commitments for owner-occupiers (first home buyers and non-first home buyers) and investors is used as a proxy for housing transaction volumes. This was first used in the 2017-18 Budget. Total finance commitments was chosen as the data is considered to be more timely when compared to actual transaction volumes data, with the latter also typically subject to significant revisions.

The number of finance commitments for owner-occupiers is calculated as the sum of ABS housing finance commitments for first homebuyers and non-first homebuyers. The number of finance commitments by investors is not published by the ABS and is estimated as the value of commercial finance commitments divided by an estimate of the 'investor' loan size.

The requirement to separately estimate the number of finance commitments by investors is a drawback of using finance commitment data rather than actual transaction volume data. However, the approach implemented by WA Treasury is logical and, in Deloitte Access Economics' view, the benefit of using more timely finance commitment data as a proxy for transaction volumes likely outweighs any potential inaccuracies of needing to estimate the investor data.

Housing transaction volume forecasts are developed using a short run OLS regression model in first differences using projections of the following explanatory variables:

- Compensation of employees: an income measure;
- Population of age group 25-39: constitutes demand of new home buyers;
- Population of age group 40-45: constitutes demand of non-first homebuyers trading up;
- Population of age group 55-75: constitutes demand of non-first homebuyers trading down;
- The iron ore price cycle: driver for the domestic business cycle; and
- Dummy variables to account for different trends and structures in the series.

The above variables are demand side drivers of housing transaction volumes. Compensation of employees is an income and affordability measure that represents wage and employment growth. An increase in the compensation of employees translates to a greater level of household income. This improves the affordability and therefore demand of houses leading to transaction volumes rising.

Population by different age groups drives demand for different types of housing transactions. WA Treasury incorporates three different age groups to constitute demand for new homes, and non-first homebuyers trading up and down. This approach assumes population growth drives housing demand, and therefore housing transactions.

Transaction volumes are expected to move in line with the domestic business cycle, given its cyclical nature. The iron ore price cycle is used as a proxy for the domestic business cycle as it has historically been a key driver for growth in the State. This is increasingly deserving of reconsideration given the difficulty in forecasting iron ore prices.

KEY FINDING: Housing transaction volumes are forecast using demand side drivers including population, CoE and the iron ore price cycle. Iron ore prices are a key driver for growth in the State's economy, and transaction volumes increase in light of stronger observed economic growth. As the Western Australian economy undergoes structural change and moves towards a more diversified sector composition, this may need to be re-evaluated. Further, iron ore prices have become increasingly difficult to predict.

The transaction volume model generates baseline projections, which are further informed by analysis of recent trends and seasonality patterns, leading indicators, and consultations with residential building firms, REIWA, and the Housing Industry Authority. For the 2017-18 Budget process, the model generated output that was considered to be an under-estimate given recent sales data from REIWA. Consequently, the model results were adjusted to be slightly higher in 2017-18, with that adjustment phasing out in the forecast years beyond the Budget year.

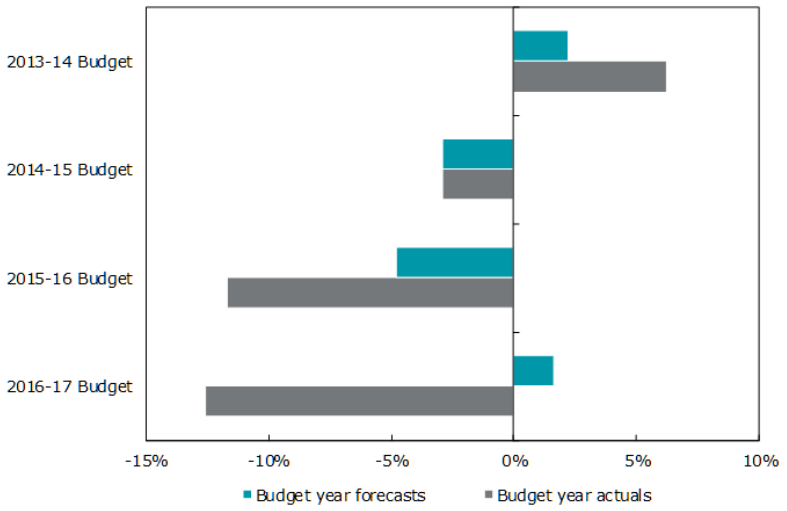
As part of this study, the Budget year forecasts for growth in transaction volumes and the difference from observed growth was provided from 2013-14 to 2016-17. The average percentage point error was calculated as follows:

$$Average\ percentage\ point\ error = \frac{\sum_{t=1}^{T} |ppe_t|}{T}$$

where, the forecast percentage point error in period t is defined as $ppe_t = \hat{g}_t - g_t$ with g_t denoting the observed percentage point growth and $\hat{g}_t$ denoting the forecast percentage point growth in the same period. The forecast error in MAE is calculated using forecast and actual values, whereas the forecast error here uses growth rates.

The average percentage point error of forecasts of transaction volumes in the Budget year 6.3% between 2013-14 and 2016-17. This is broadly in line with the average percentage point error of transfer duty growth overall, of 6.7%. Chart 6.4 below shows the percentage point errors of the transaction volume growth forecasts from 2013-14 to 2016-17.

Chart 6.4: Average percentage point error of transaction volumes growth forecasts in Budget year



Source: WA Treasury

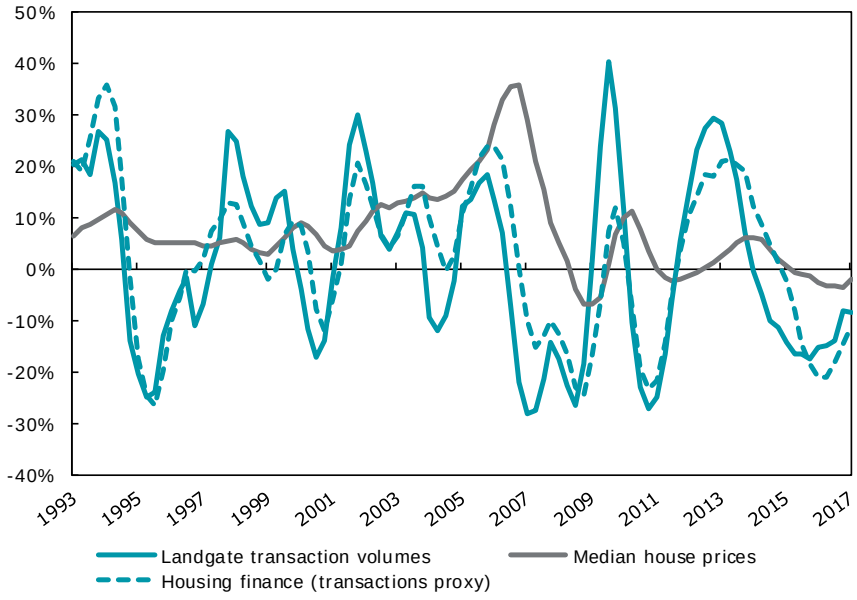
House prices

WA Treasury uses an ARIMA short-run model to forecast median house prices. The forecasts are developed using the following explanatory variables:

- Housing finance (a proxy for transaction volumes) lagged by two quarters;
- Housing prices three and four quarters before the forecast quarter (to account for serial correlation);
- Time trend; and
- Dummy variables.

The inclusion of lagged housing finance (a proxy for transaction volumes) in the house price model corresponds with statistical evidence that transaction volumes have a lagged effect on housing prices in Western Australia (seen in Chart 6.5).

Chart 6.5: Historical Landgate transaction volumes growth, housing finance (transactions proxy) growth and median house price growth



Source: WA Treasury and Landgate data

The house price model output is used to form the baseline projections, which are supplemented by other analysis. Budget year forecasts in particular are informed by actual data and advice from REIWA. Leading indicators of housing supply and demand are gathered from a range of sources including consultations with residential building firms, REIWA and the Housing Industry Authority. However, input variables that represent the supply side of the housing market are not included in the house price model.

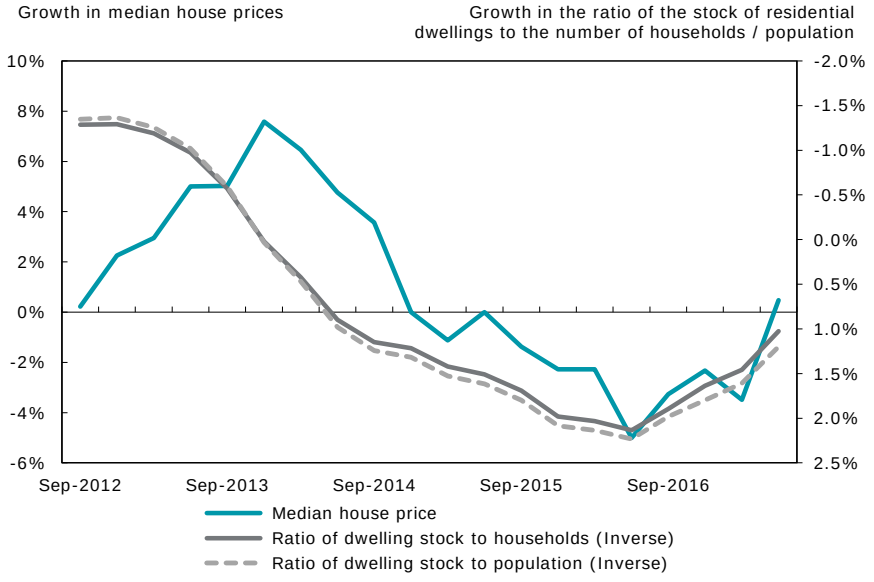
KEY FINDING: Acknowledging that the WA Treasury transfer duty model is a work in progress, and that prior to this review WA Treasury had already commenced testing a variety of supply-side explanatory variables, Deloitte Access Economics notes that the house price forecast model only considers the demand side of the housing market. Rather than demand or supply in isolation, the demand-supply balance affects house prices in a given jurisdiction. A ratio of housing stock (supply) to the number of households should be considered for inclusion in the house price forecast model. An alternative would be to consider the ratio of housing stock to population, given the relatively slow-moving relationship between population and the number of households.

Deloitte Access Economics' own modelling of house prices in other jurisdictions – for example, in relation to the recent land titles office privatisations in New South Wales and South Australia – included both demand and supply considerations. Even a relatively crude examination of the available data suggests that this may also be worth considering in Western Australia.

For example, Chart 6.6 below shows growth in median house prices in Western Australia, along with growth in the ratio of the stock of residential dwellings to the number of households. The historical data for the number of residential dwellings was drawn from the Australian Bureau of Statistics. This information is only available on a consistent basis publicly from 2011. The number of households in Western Australia is drawn from Deloitte Access Economics' in-house demographic model, which uses Census information to map single-year-of-age population data to household types. The ratio of the dwelling stock to the number of households is a measure of the demand-supply balance in the Western Australian housing market. For example, when the ratio increases (that is, the number of dwellings increases relative to the number of households), then supply is increasing relative to demand and downward pressure on prices could be expected.

This inverse relationship is shown in the chart below. As the chart also shows, the ratio of dwelling stock to total population shows a very similar growth rate (given the relatively slow-moving relationship between population and households) and could be used as an alternative if household forecasts cannot be produced by WA Treasury.

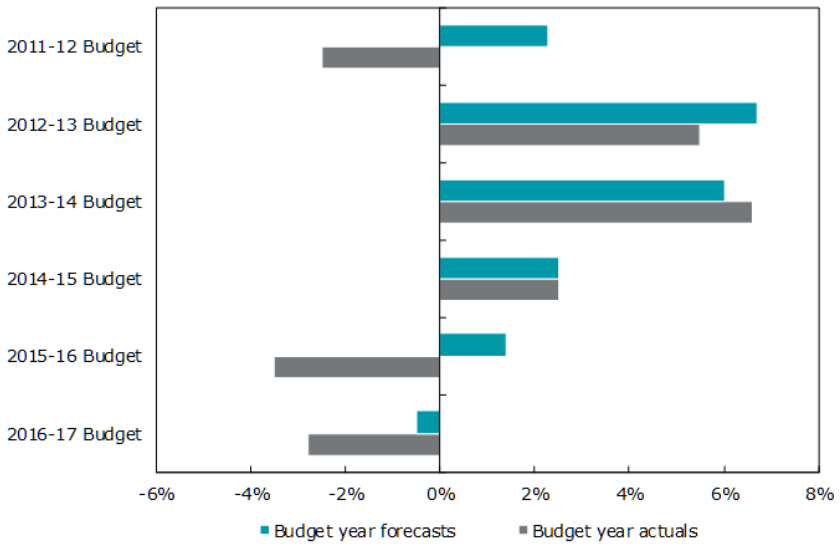
Chart 6.6: Historical Landgate house price growth and growth in the ratio of the residential dwelling stock to the number of households and population in Western Australia (inverted)



Source: Australian Bureau of Statistics, Deloitte Access Economics and Landgate data

Forecasts for growth in house prices were provided from 2011-12 to 2016-17. The average percentage point error of Budget year forecasts was 2.3%. This is lower than the average percentage point error for transaction volumes and total transfer duty overall. Chart 6.7 below shows the percentage point error of the house price growth forecasts from 2011-12 to 2016-17. It should be noted that other forecasters also had difficulty forecasting house price growth in Western Australia over the same period.[20]

Chart 6.7: Average percentage point error of house price growth forecasts in Budget year



Source: WA Treasury

KEY FINDING: The average percentage point error of Budget year forecasts for house price growth is 2.3% from 2011-12 to 2016-17. This is lower than corresponding errors for transaction volume forecasts.

Underlying duty forecast modelling

Using forecasts for house prices and transaction volumes, underlying duty is forecast using an autoregressive distributed lag (ARDL) model, with the following inputs:

- Housing finance (proxy for transaction volumes): current level and previous quarter level;
- Median house prices: current level and lagged level (by three quarters);
- Underlying duty in the previous quarter (that is, a lagged dependent variable); and
- Dummy variable for March quarter 2009 (reflecting the 2008 Financial Crisis).

The calculated underlying duty is split into transfer duty and landholder duty as reported in the Budget papers.

6.3.3 Specials transfer duty

Specials transfer duty collections are forecast based on historical trends in medium sized transactions, and large transactions.[21] The forecast model assumes that the value of 'specials' transactions will be in line with the average over the past 15 years ($255 million per annum over the forecast period – the baseline assumption). However, specials duty is generally very volatile and WA Treasury receives advice from OSR to supplement forecasts. The calculated specials duty is then split into transfer duty and landholder duty as reported in the Budget papers.

[20] See, for example, page 40 of the following presentation: https://www.qbelmi.com/Uploads/Documents/79_ff28b7-9647-4740-a355-44cb6266bb75.pdf

[21] Medium sized transactions are classified as $1-10 million duty liability, or $19.5-195 million transaction value, by WA Treasury. Large sized transactions are classified as greater than $10 million duty liability or greater than $195 million transaction value, by WA Treasury.

This approach is generally consistent with that used by other State Treasuries (including the threshold of $1 million of duty used to define 'specials' or 'large' transactions). Because larger transactions are 'lumpy' and difficult to forecast, a historical average (supplemented with advice from the OSR, particularly for the Budget year) is the most logical forecast approach. Some other State Treasuries also implement a more conservative treatment of very large (typically multi-billion dollar) transactions. The structure of these transactions can mean that the amount of transfer duty paid is different to the amount implied by the sale price and the statutory rate. Combined with the fact that the timing of receipt of transfer duty can also differ, the uncertainty regarding the amount of transfer duty has led some State Treasuries to recognise the duty only once it has been received. This helps to prevent issues associated with recognising the wrong amount of duty in a given year.

KEY FINDING: Given that specials transfer duty is volatile, a historical average (supplemented with advice from OSR) is the most logical forecast approach. WA Treasury should continue to communicate with OSR to incorporate any information available in near-term forecasts.

6.3.4 Capability and resourcing

WA Treasury has one experienced staff member responsible for forecasting transfer duty and land tax. To promote knowledge sharing and reduce the risk of reliance on one employee, it is important that all work is comprehensively documented. The development of user guidelines and explanatory notes, as well as having another staff member shadow the current transfer duty modeller will support the process.

KEY FINDING: There is one experienced staff member responsible for forecasting transfer duty and land tax. This workload presents risks to model development plans and continuity.

6.4 Alternative approaches to preparing revenue forecasts

The approach to forecasting transfer duty varies across other government forecasters. In some jurisdictions, historical averages are used, while other jurisdictions have developed econometric models. Table 6.3 below provides a summary of the approach to forecasting transfer duty in three other jurisdictions, while a brief overview of the key approaches follows.

Table 6.3: Summary of transfer duty forecasting approach in other jurisdictions

Summary	Approach	Supplementary analysis
State A		
Underlying transfer duty is forecast on the basis of property price and transfer forecasts, which are based on judgement	Property prices and transfers are assessed separately across a number of sub-categories, including concessional residential (for example, first home buyers), non-concessional residential, small commercial and large commercial. For each of these categories, transfer duty is grown in line with the value of transactions (that is, the multiple of price and volume). The number of transactions and the average price is determined through judgement after consideration of a number of market indicators (listed in this table under 'supplementary analysis').	OSR provides price and volume data split by residential, non-residential and by price bands. Judgement is informed by property market indicators including auction clearance rates, days on market, stock on market from Australian Property Monitors.
Large transactions are forecast using a historical average	Large transactions (where transfer duty receipts are expected to be greater than $1m) are forecast using a historical average. This is consistent with a number of other States and is logical given the underlying volatility in the data.	Large transactions are treated separately from underlying duty.

State B		
A suite of econometric models is used to inform the forecast for transfer duty, including a vector auto-regressive (VAR) model and a VECM system of equations.	Transfer duty forecasts are informed by a number of econometric models. A VAR model is used to inform near-term forecasts, one to two years ahead. The variables modelled include transaction volumes, average transaction price, national income, variable mortgage interest rates, and a measure of consumer sentiment. A VECM, which models long-run relationships in the data explicitly, is used to inform forecasts at longer-term horizons. Long-run models are estimated for prices and transfers, and for the residential and non-residential sectors. The two residential models and the two non-residential models are estimated simultaneously in a system, under the assumption that prices and quantities are jointly determined. For the residential models, key variables include the number of households, variable mortgage rates, household credit, and a measure of consumer sentiment. For the non-residential models, population, business interest rates and business credit growth are the key variables modelled. Once forecasts for the price and volume of transactions have been determined, the total value of transactions (price multiplied by volume) is used to forecast transfer duty accounting for differences in the timing of transactions and when duty is likely to be paid.	Leading indicator models are also used to nowcast prices and volumes growth. The forecasting team also monitors other property market indicators and State and National macroeconomic indicators before finalising the duty forecast.
Large transfers are not forecast separately	Unlike in other States, large transactions are not forecast separately but are included in the modelling of overall transfer duty. Large transactions have accounted for a broadly constant share of overall duty over time, and the data is considered separately (but not forecast separately) and may inform judgemental adjustments.	n/a
State C		
An econometric equation (Ordinary Least Squares) is used to forecast transfer duty.	Transfer duty is forecast econometrically using OLS. The independent variables included in the forecast are dwelling investment (as a proxy for activity in the residential property market), non-dwelling investment, house prices, the ASX 200 (as a proxy for business conditions), and a dummy variable the implementation of policy changes such as the first home owner grant.	The forecasts are adjusted for timing changes between activity and the receipt of duty, while significant monitoring of announcements of major transactions is undertaken.

Large transactions are forecast using a historical average	Large transactions are forecast using a historical average approach. However, duty from very large (multi-billion dollar) transactions is not recognised until receipt given uncertainty regarding the timing and amount of duty.	n/a

6.4.2 Alternative econometric approaches

Like WA Treasury, some other State Treasuries use econometric-based approaches to forecast transfer duty. When compared to WA Treasury's approach, other State Treasuries have included different or additional input variables in forecast equations for house prices and transactions. These include dwelling investment, non-dwelling investment, measures of business activity, household credit, business credit and housing supply. In some instances, OSR and land title data is used to estimate transaction volumes in the Budget year. A variety different econometric structures are used, including ordinary least squares, vector auto-regressive and vector error correction models.

6.4.3 Historical average

Most other government forecasters use historical averages to grow transfer duty for 'large' or 'special' transactions. This approach involves breaking down the transactions into relevant market groups such as residential, commercial and industrial. Transaction volumes and prices for each market group are estimated based on historical averages, with seasonal adjustments applied. This approach does not consider forward indicators that drive changes in the market.

This is similar to the approach used by WA Treasury for forecasting large transactions, though is more detailed. As noted in 6.3.3, Deloitte Access Economics' view is that this approach is logical and appropriate given the historical volatility in large transactions and the unpredictable nature of the occurrence and timing of large transactions in the future.

6.4.4 Judgement and consultation

Other forecasters apply judgement and engage in consultation to forecast transfer duty. Leading indicators (such as auction clearance rates) are compiled to analyse trends in prices and transfers. Additionally, consultations with macroeconomic advisors and external businesses with in-depth knowledge of the property market take place to inform the price and volume analysis.

In at least one State Treasury, the review of property market information to inform judgement with respect to growth in transfer duty includes analysis of the market by price range. That is, the State Treasury reviews the residential transaction volume and price data, along with the corresponding transfer duty, for the specific price bands across which duty rates are progressively applied. The use only of median price data in Western Australia, without the additional analysis of data by specific price band, means that potentially useful distributional insights cannot be examined. Deloitte Access Economics notes that WA Treasury is already seeking to develop a reliable distributional dataset as part of its ongoing research into transfer duty.

KEY FINDING: Like WA Treasury, many other government forecasters use econometric methods to forecast transfer duty, and apply judgemental adjustments after engaging in industry consultation. 'Large' or 'special' transactions are typically, but not uniformly, forecast using a historical average approach in other jurisdictions.

6.5 Key findings and recommendations

6.5.1 Key findings

Forecast performance

- Forecasting transfer duty accurately in Western Australia is a difficult task due to the volatile nature of the property market and the economy. After accounting for the historical volatility of transfer duties across different States, WA Treasury's Budget year forecasts rank among the most accurate when compared to those of other State Treasuries.
- For the Budget year forecasts, WA Treasury has under-estimated transfer duty revenue on average between 2002-03 and 2016-17. However, since 2013-14, WA Treasury has more often over-estimated this revenue head. In the out-years, a pattern of overestimation of transfer duty can be observed.
- Over the period from 2012-13, WA Treasury's forecasts of transfer duty for forecast years beyond the Budget year have been among the most accurate relative to other State Treasuries after accounting for State specific volatility.

Current methodology

- WA Treasury's forecast approach reflects the primary drivers of underlying transfer duty – the number of transactions and transaction prices – and is reliant on the accuracy and approach of forecasts for transaction volumes and median house prices.
- Housing transaction volumes are forecast using demand side drivers including population, CoE and the iron ore price cycle. Iron ore prices are a key driver for growth in the State's economy, and transaction volumes increase in light of stronger observed economic growth. As the Western Australian economy undergoes structural change and moves towards a more diversified sector composition, this may need to be re-evaluated. Further, iron ore prices have become increasingly difficult to predict.
- Acknowledging that the WA Treasury transfer duty model is a work in progress, and that prior to this review WA Treasury had already commenced testing a variety of supply-side explanatory variables, Deloitte Access Economics notes that the house price forecast model only considers the demand side of the housing market. Rather than demand or supply in isolation, the demand-supply balance affects house prices in a given jurisdiction. A ratio of housing stock (supply) to the number of households should be considered for inclusion in the house price forecast model. An alternative would be to consider the ratio of housing stock to population, given the relatively slow-moving relationship between population and the number of households.
- The average percentage point error of Budget year forecasts for house price growth is 2.3% from 2011-12 to 2016-17. This is lower than corresponding errors for transaction volume forecasts.
- Given that specials transfer duty is volatile, a historical average (supplemented with advice from OSR) is the most logical forecast approach. WA Treasury should continue to communicate with OSR to incorporate any information available in near-term forecasts.
- There is one experienced staff member responsible for forecasting transfer duty and land tax. This workload presents risks to model development plans and continuity.

Alternative approaches

- Like WA Treasury, many other government forecasters use econometric methods to forecast transfer duty, and apply judgemental adjustments after engaging in industry consultation. 'Large' or 'special' transactions are typically, but not uniformly, forecast using a historical average approach in other jurisdictions.

6.5.2 Recommendations

- **Review of transaction volume forecasts** – WA Treasury is in the process of redeveloping its current approach to forecasting transfer duty. As part of this redevelopment, WA Treasury should consider some amendments to its transaction volume forecasting model. Given the difficulties in accurately forecasting iron ore prices, WA Treasury should investigate whether an alternative variable could be used (for example, business investment could be used to track the domestic business cycle, and would be available as part of WA Treasury's suite of economic forecasts). Additionally, WA Treasury should consider using forecasts of households in place of population forecasts, as the number of households is more relevant for housing demand than population. That said, the relatively slow-moving relationship between population and households means that population is a useful proxy for housing demand if forecasts of the number of households cannot be produced.

- **Review of house price forecasts** – WA Treasury is currently considering amendments to its house price model. As part of this review, consideration should be given to the supply-demand balance in the housing market.

7 Land tax

Chapter summary

Deloitte Access Economics' analysis of the land tax modelling and forecast performance of WA Treasury has been limited by the current lack of a formal model for this revenue head. WA Treasury is currently in the process of developing a model for forecasting land tax in the later years of the forward estimates period, and intends to continue to rely on analysis and advice of the OSR for Budget year forecasts.

The Budget year forecasts for land tax revenue display a relatively high degree of accuracy. When considering the forward estimates period more generally, a pattern of under-estimation is observed prior to 2012-13, while WA Treasury has, on average, over-estimated land tax revenue since 2012-13. As has been the case for other revenue heads, these errors are reflective of general economic conditions in Western Australia over the same period.

After adjusting for historical volatility, WA Treasury's forecasts of land tax in the Budget year have performed comparatively well relative to those of other States examined since 2002-03. When considering the forward estimates period more generally since 2012-13, and after adjusting for State-specific volatility, WA Treasury's forecasts of land tax have on average performed better than those of New South Wales, and have been close to the performance recorded in Victoria, South Australia and Tasmania.

WA Treasury is in the process of developing a model for the forecasts beyond the Budget year. During this process, WA Treasury should further explore the relationship between (lagged) property prices and land values, in line with the methodology used by some other State Treasuries. While some State Treasuries use nominal economic growth to forecast land tax revenue beyond the Budget year, Deloitte Access Economics' view is that this would not be an appropriate approach to adopt in Western Australia. A number of the many factors that influence nominal economic growth in Western Australia – including commodity prices – are not sufficiently related to land values to suggest a meaningful or reliable relationship.

Given the accuracy of forecasts for the Budget year, Deloitte Access Economics' view is that the current process for producing those forecasts should be maintained. However, there is the potential for WA Treasury to expand its analysis of OSR data by gaining access to additional information showing trends in aggregation, land holdings, type of land, and taxed land values (as opposed to general land values). Access to this OSR data would provide WA Treasury with greater clarity on the impact of trends that are otherwise difficult to understand and predict.

Deloitte Access Economics also recommends that additional resources be directed toward land tax modelling given (a) the model development task that is required and (b) the existing workload of the staff member who is currently tasked with preparing the land tax forecasts.

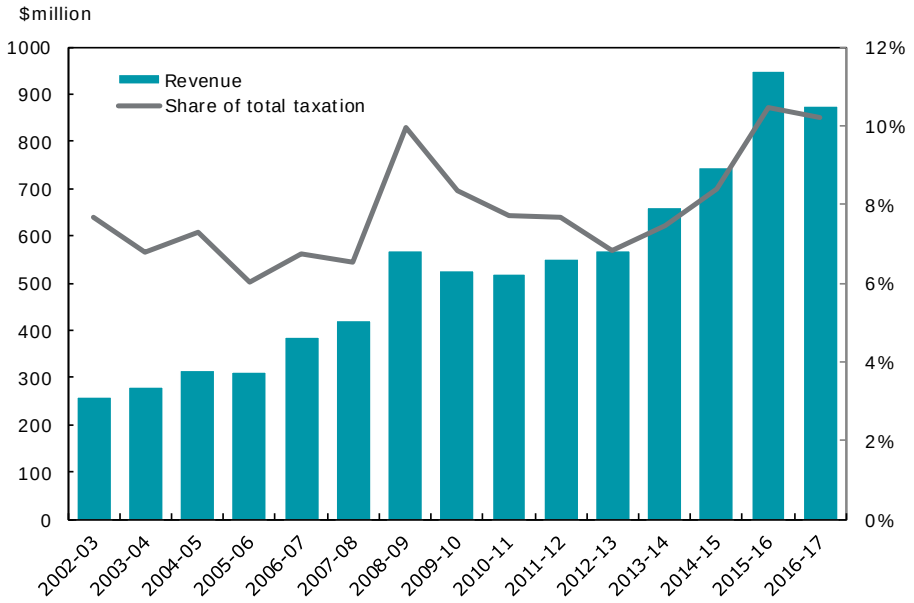
7.1 Background on land tax

Land tax is an annual tax on land owned at 30 June in a given year and is calculated on the unimproved value of the land. The unimproved value of the land is determined by Western Australia's Valuer-General. Land tax is payable by owners of Western Australian land (excluding exempt land[22]) with an aggregated taxable value in excess of $300,000, in accordance to a land tax rate scale. A 50% cap on growth in land values applies for the purpose of assessing land tax to help reduce the volatility and unpredictability of growth in individual land tax. This cap was introduced from 2009-10.

Land tax accounted for 2.4% of total Western Australia general government revenue on average between 2002-03 and 2016-17, and just under 8% of taxation revenue on average over the same period. The share has fluctuated since 2002-03, but has increased as a share of total government taxation over the period from 2002-03 to 2015-16 (see Chart 7.1).

In recent years, much of the growth in land tax has been policy driven, including consecutive increases in land tax rates in the 2013-14 and 2014-15 Budgets and a change to the land tax scale in 2015-16. Land tax revenue declined in 2016-17, primarily due to a fall in taxable land value.[23]

Chart 7.1: Land tax revenue, in dollars and as a share of total taxation revenue



Source: WA Treasury, budget papers and mid-year financial projections statements

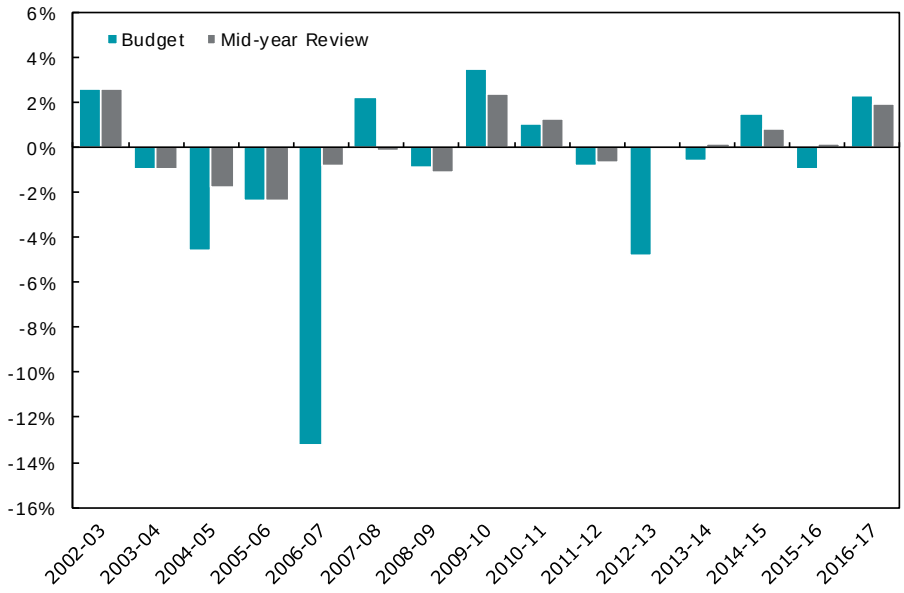
7.2 Performance of WA Treasury's revenue forecasts

This section examines WA Treasury's forecast performance of land tax. The methodology and criteria used to assess the performance of the forecasts are described in detail in Appendix A.

WA Treasury's Budget year forecast performance for land tax has been relatively accurate over the period of analysis (Chart 7.2). Since the 2002-03 Budget, the average forecast error for Budget year forecasts has been just under 3%.

[22] Exemptions cover land that is of primary residence, newly constructed or refurbished private residence that is not yet ready for occupancy, moving from one residence to another, subdivided residential land, land used for primary production, charitable use as well as other exemptions, concessions and rebates.
[23] WA Treasury, *Western Australia State Budget 2017-18, Budget Paper No. 3: Economic and Fiscal Outlook,* http://static.ourstatebudget.wa.gov.au/17-18/2017-18-wa-state-budget-bp3.pdf?, page 83.

Chart 7.2: Budget year relative forecast errors for land tax revenue



Source: Based on published Budget figures and estimates provided by WA Treasury

The largest forecast percent error across this period was in 2006-07, when WA Treasury under-estimated land tax revenue by approximately 13%. This was explained by strong increases in land values well above growth rates in previous years.[24] The average forecast error for Budget year forecasts falls to just over 2% if the 2006-07 error is omitted from the calculation.

Table 7.1 shows the MAPE, MASE and ADJ MAPE for WA Treasury's Budget year forecasts, compared to other State Treasuries. After adjusting for historical volatility, WA Treasury's forecasts of land tax in the Budget year have performed comparatively well relative to those of other States examined since 2002-03. Abstracting from obvious differences in land tax rates and timing differences, land tax in other jurisdictions is assessed in a very similar way to Western Australia. Similar types of land are liable for land tax in other jurisdictions and, in some States such as Victoria and Queensland, land tax is calculated on the total (aggregated) taxable value of an owner's land, as is the case in Western Australia.

Table 7.1: Performance of land tax revenue forecasts in Budget year

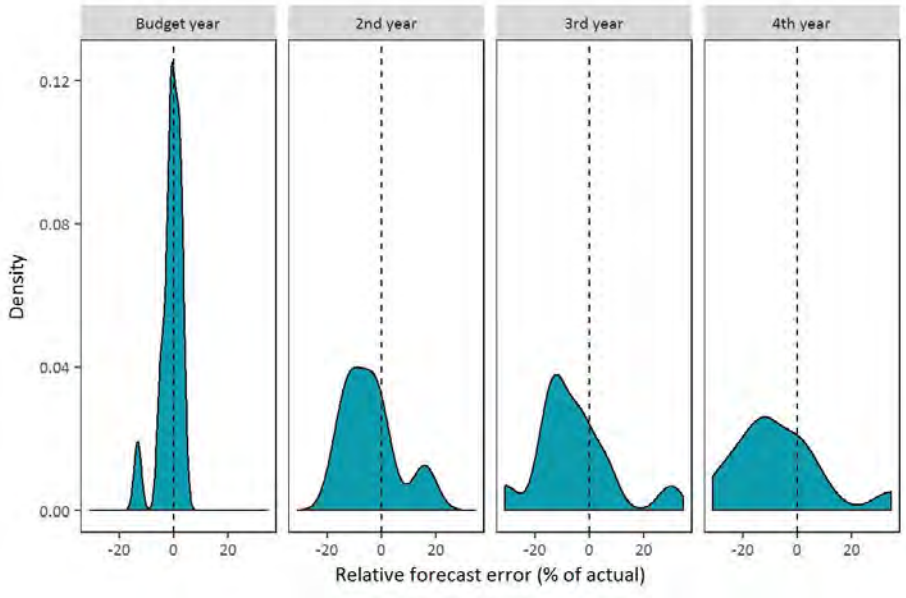
Budget year	2002-03 to 2006-07			2007-08 to 2011-12			2012-13 to 2016-17			2002-03 to 2016-17		
	MAPE	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*
WA Budget	4.8%	0.50	0.74	1.7%	0.15	0.10	2.0%	0.13	0.15	2.8%	0.22	0.24
WA Mid-year Review	1.7%	0.15	0.27	1.1%	0.10	0.07	0.7%	0.05	0.05	1.1%	0.09	0.10
NSW Budget	8.9%	0.64	1.29	6.3%	1.28	0.79	5.1%	0.56	0.65	6.7%	0.81	0.77
VIC Budget	9.5%	0.71	0.66	7.4%	0.51	0.33	5.7%	0.50	0.35	7.5%	0.56	0.45
VIC Budget Update	N/A	N/A	N/A	2.9%	0.22	0.13	2.6%	0.24	0.16	N/A	N/A	N/A
QLD Budget	4.0%	0.29	0.29	4.1%	0.33	0.24	1.8%	0.59	0.46	3.3%	0.35	0.23
QLD Mid-year Review	N/A	N/A	N/A	2.6%	0.20	0.15	1.2%	0.39	0.30	N/A	N/A	N/A
SA Budget	3.9%	0.20	0.31	1.8%	0.18	0.13	6.3%	0.87	0.41	4.0%	0.44	0.29
TAS Budget	10.9%	0.53	0.46	3.3%	0.22	0.22	4.3%	0.68	0.51	6.2%	0.44	0.35

Note: Based on published Budget figures. Figures for Queensland Mid-year Review and Victorian Budget Update available from 2005-06.

As expected, forecast accuracy is lower in the years beyond the Budget year. WA Treasury's forecasts show a pattern of under-estimation in the remaining years of the forward estimates (see Figure 7.1).

[24] WA Treasury, *Mid-year Financial Projections Statement 2007-08,* p. 56

Figure 7.1: Forecast error distributions for land tax revenue



Source: WA Treasury

KEY FINDING: WA Treasury's Budget year forecasts for land tax revenue display a relatively high degree of accuracy. For the Budget year, land tax revenue estimates and advice are provided from OSR. In the remaining years of the forward estimates, forecast errors increase. Prior to 2012-13, patterns of under-estimation are observed. Since 2012-13, WA Treasury has, on average, over-estimated land tax revenue.

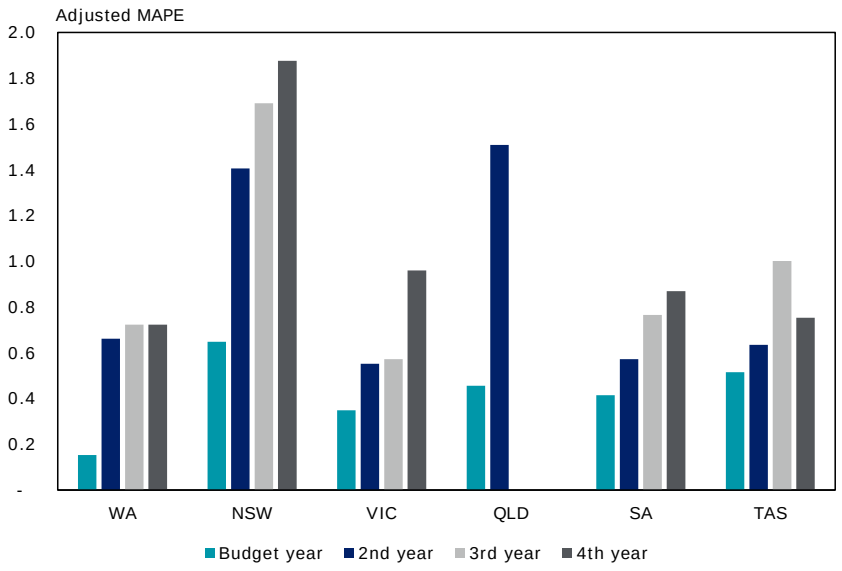
Table 7.2 shows the MAPE, MASE and ADJ MAPE for WA Treasury's Budget and MFPS, compared to other State Treasuries for forecast years beyond the Budget year. Looking at the period from 2012-13 (given data limitations in other periods) WA Treasury's forecasts of land tax have on average performed better than those of New South Wales, after adjusting for State specific volatility. WA Treasury's land tax forecast performance has been closer to those of Victoria, South Australia and Tasmania.

Table 7.2: Performance of land tax revenue forecasts in 2nd, 3rd and 4th forecast years

2nd forecast year	2002-03 to 2006-07			2007-08 to 2011-12			2012-13 to 2016-17			2002-03 to 2016-17		
	MAPE	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*
WA Budget	6.9%	0.66	1.07	11.3%	1.03	0.70	8.8%	0.64	0.66	9.0%	0.83	0.76
WA Mid-year Review	6.5%	0.64	1.02	9.7%	0.93	0.60	7.5%	0.56	0.56	7.9%	0.75	0.67
NSW Budget	16.2%	1.16	2.36	8.5%	1.78	1.08	11.0%	1.26	1.41	11.9%	1.46	1.35
VIC Budget	N/A	N/A	N/A	16.3%	1.21	0.73	9.0%	0.80	0.55	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	8.0%	0.59	0.36	7.9%	0.73	0.48	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	6.0%	1.96	1.51	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	4.4%	1.43	1.09	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	9.6%	0.94	0.71	8.7%	1.11	0.57	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	5.3%	0.82	0.63	N/A	N/A	N/A
3rd forecast year												
	MAPE	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*
WA Budget	7.7%	0.73	1.20	18.3%	1.72	1.13	9.6%	0.67	0.72	11.9%	1.08	1.00
WA Mid-year Review	7.8%	0.76	1.22	15.1%	1.40	0.93	8.5%	0.59	0.64	10.5%	0.94	0.88
NSW Budget	21.8%	1.56	3.17	11.2%	2.33	1.41	13.2%	1.52	1.69	15.4%	1.88	1.75
VIC Budget	N/A	N/A	N/A	22.7%	1.76	1.02	9.3%	0.80	0.57	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	17.1%	1.33	0.77	8.9%	0.79	0.55	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	10.1%	3.26	2.53	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	18.4%	1.78	1.36	11.6%	1.42	0.77	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	8.4%	1.28	1.00	N/A	N/A	N/A
4th forecast year												
	MAPE	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*	*MAPE*	*MASE*	*ADJ MAPE*
WA Budget	N/A	N/A	N/A	21.5%	2.05	1.33	9.6%	0.68	0.72	N/A	N/A	N/A
WA Mid-year Review	N/A	N/A	N/A	16.8%	1.59	1.04	7.9%	0.57	0.59	N/A	N/A	N/A
NSW Budget	28.2%	2.01	4.10	12.5%	2.58	1.59	14.6%	1.65	1.88	18.4%	2.19	2.10
VIC Budget	N/A	N/A	N/A	N/A	N/A	N/A	15.7%	1.30	0.96	N/A	N/A	N/A
VIC Budget Update	N/A	N/A	N/A	N/A	N/A	N/A	14.9%	1.24	0.91	N/A	N/A	N/A
QLD Budget	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
QLD Mid-year Review	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SA Budget	N/A	N/A	N/A	25.2%	2.43	1.86	13.2%	1.58	0.87	N/A	N/A	N/A
TAS Budget	N/A	N/A	N/A	N/A	N/A	N/A	6.3%	0.95	0.75	N/A	N/A	N/A

Note: Based on published Budget figures. Relevant Queensland Mid-year Review figures available from 2005-06; Victorian Budget Update from 2005-06; Victorian Budget from 2005-06; Queensland Budget from 2011-12, Queensland Mid-year Review from 2010-11; South Australia Budget from 2005-06; Tasmania Budget from 2008-09.

Chart 7.3: Adjusted MAPE for forecasts of land tax from 2012-13 to 2016-17



Source: State Budget Papers

KEY FINDING: After adjusting for historical volatility, WA Treasury's forecasts of land tax have performed comparatively well relative to those of other States examined since 2002-03.

7.3 Modelling methodology review

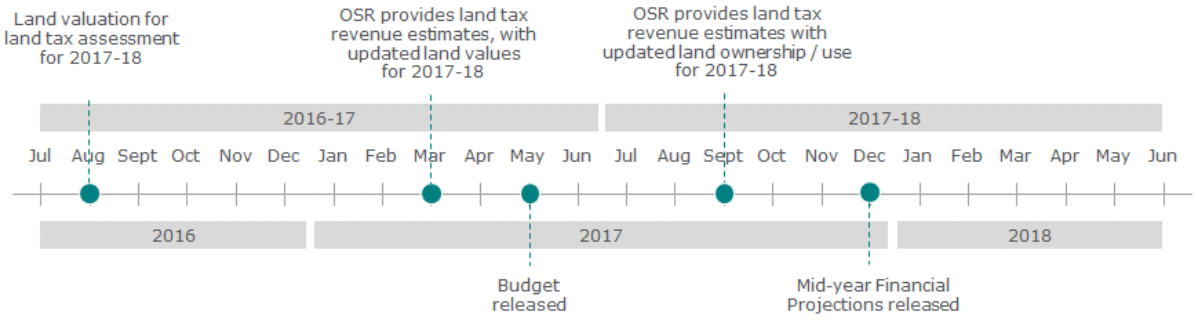
WA Treasury's current forecasts approach for land tax considers:

- Advice from the OSR;
- Leading indicators for land prices; and
- Judgement.

7.3.1 Advice from the Office of State Revenue

The timeline for advice received from OSR is set out in Figure 7.2 below. In March, OSR provides modelled land tax revenue estimates for the Budget year to WA Treasury. The estimated land tax revenue has new land values updated, holding all other variables (such as land use and ownership) constant. The only judgement applied to these estimates by WA Treasury is to adjust for the estimated rates of early and late payment (which are assumed to be the same as in the previous year).

Figure 7.2: Timeline for advice received from the Office of State Revenue, 2017-18 Budget year



Source: WA Treasury

Additionally, OSR provides an updated estimate for Budget year land tax revenue in September, which incorporates updated land ownership and use as well as changes to land values. Again, WA Treasury adjusts these estimates using assumptions for early and late payment.

While the advice and information from the OSR is detailed and informs relatively accurate Budget year forecasts, additional information from the OSR could assist WA Treasury in better understanding the effect of aggregation and 'bracket creep' on the level of land tax revenue.

7.3.2 Land value indicators and judgement

In the forecast years beyond the Budget year, growth in land tax revenue is largely judgement based, with consideration for the following leading indicators:

- REIWA median price of residential vacant land;
- REIWA vacant land transaction numbers; and
- Landgate data including property transactions for residential and commercial land.

For the 2017-18 Budget process, a five-year average underlying land tax growth rate was used to escalate land tax revenue. However, this is not a method applied consistently across Budgets. WA Treasury is currently in the process of developing a forecast model for land tax revenue.

KEY FINDING: The current land tax revenue forecast methodology for forecast years beyond the Budget year is largely determined by judgement. WA Treasury is in the process of developing a forecast model.

7.3.3 Capability and resourcing

The staff member previously responsible for forecasting land tax revenue has transferred to a different section within WA Treasury due to the lack of career progression opportunities in the ERF team. The staff member responsible for transfer duty (among a number of other responsibilities) has taken on the additional responsibility of forecasting land tax. The workload being assigned to this individual presents a risk, both in terms of that individual's capacity to adequately prepare revenue forecasts and in terms of key person risk in forecasting revenue from specific taxes.

WA Treasury should consider, at a minimum, assigning an additional staff member to shadow and assist the staff member responsible for preparing the land tax forecasts. User guides should also be prepared in order to enable other staff members to quickly gain an understanding of the land tax model, once it has been developed.

KEY FINDING: The task of forecasting land tax revenue has been assigned to the staff member responsible for forecasting transfer duty. This workload presents risks to model development plans and continuity.

7.4 Alternative approaches to preparing revenue forecasts

Table 7.3 below provides a summary of the approach to forecasting land tax revenue in three other jurisdictions, while a brief overview of the two key approaches (based on property prices and nominal economic growth) follows.

Table 7.3: Summary of land tax revenue forecasting approach in other jurisdictions

Summary	Approach	Supplementary analysis
State A		
Budget year forecasts rely on information from the Office of State Revenue.	N/A	OSR incorporates unit record data from the Valuer General.
Forecast years beyond Budget year rely on an assumed relationship between land values and property price growth.	Forecast growth in residential and non-residential property prices are consistent with forecasts used in transfer duty forecasts. These property price growth forecasts are assumed to equate to growth in (residential and non-residential) land values. The residential and non-residential land value growth rates are combined using a 60:40 weight in favour of non-residential growth in order to generate a forecast for overall growth in land values. Base year land tax revenue is grown in line with the estimate of overall growth in land values. The impact of policy changes are added, and eliminations (government agency land tax) are deducted.	N/A

State B		
Budget year forecasts rely on information from the Office of State Revenue.	N/A	Aggregate valuations split by residential, industrial and commercial. There are some regional splits.
Forecast years beyond Budget year rely on an assumed relationship between land values and nominal Gross State Product.	The approach to forecasting land tax revenue in this State has been simplified in recent years. Base year land tax revenue is growth in line with nominal economic growth (nominal GSP), drawn from broader macroeconomic modelling. Historically, the approach had been to use property price growth forecasts to forecast unimproved land values. The property price growth was adjusted to account for the estimated growth in the price of the 'improved' portion of land. A number of different tax brackets for land tax also required the State Treasury to account for changes to the effective average tax rate, due to land values moving into higher tax brackets. The rate at which the effective tax rate rises for a given rise in land values was governed by a progressivity elasticity, which was assumed to be greater than zero. The change to a more simple approach has not had any apparent impact on forecast accuracy.	N/A

7.4.2 Property price growth as a proxy for land value growth

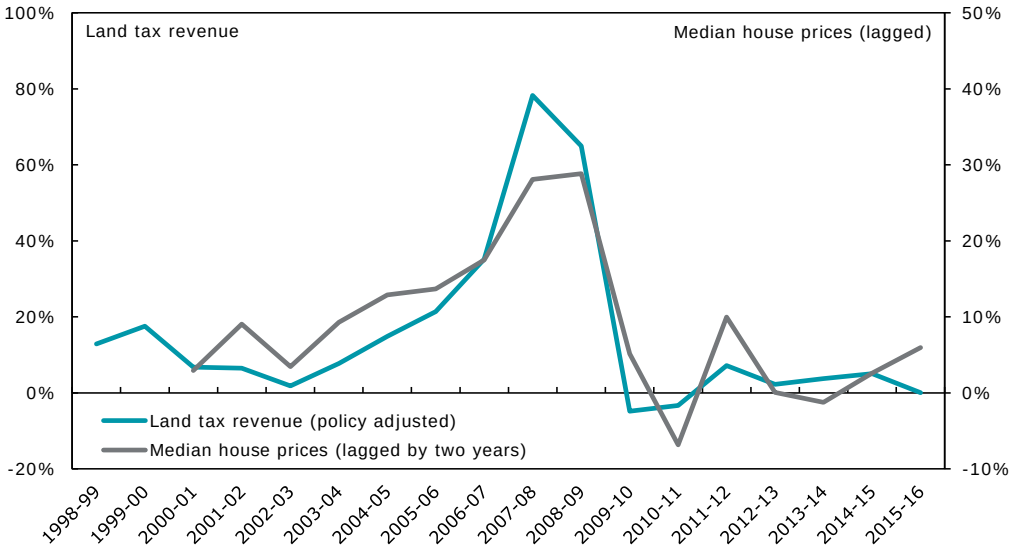
Across a number of other State Treasuries, land tax revenue is forecast as a function of land values. Land value data is obtained from the respective OSR, and is forecast to grow in line with property price growth. The underlying assumption of this approach is that property price growth is correlated with growth in land values.

Chart 7.4 below explores this relationship for Western Australia by showing growth in land tax revenue (policy adjusted series[25]) and growth in median house prices in Western Australia (sourced from Landgate). For the purpose of comparison, the median house price data has been lagged by two years, which is broadly consistent with the timing of land valuation for the purpose of land tax assessments (see Figure 7.2 earlier).

Using this approach, it is evident that a relatively strong relationship between property prices and policy adjusted land tax revenue exists, with a correlation coefficient of 0.91.

[25] The surge in growth in 2008-09 and subsequent decline in 2009-10 is also apparent in the unadjusted series.

Chart 7.4: Annual growth in land tax revenue (policy adjusted) and median house prices (lagged)



Source: WA Treasury, Landgate median house price data

KEY FINDING: WA Treasury is in the process of developing a model for the out-year forecasts. During this process, WA Treasury should further explore the relationship between (lagged) property prices and land values, in line with the methodology used by some other State Treasuries.

7.4.3 Nominal economic growth as a proxy for land value growth

Some other State Treasuries forecast land tax revenue beyond the Budget year by assuming that land values grow in line with expected nominal economic growth.

In Deloitte Access Economics' view, the approach of using expected nominal economic growth to drive forecasts for land values – and therefore land tax revenue – beyond the Budget year is unlikely to produce accurate forecasts in Western Australia. A number of the many factors that influence nominal economic growth in Western Australia – including commodity prices – are not sufficiently related to land values to suggest a meaningful or reliable relationship. This result is borne out in the data, with the correlation between policy adjusted land tax revenue and lagged nominal GSP growth calculated to be around 0.40 (well below that for property prices and policy adjusted land tax revenue).

KEY FINDING: While some State Treasuries use nominal economic growth to forecast land tax revenue beyond the Budget year, Deloitte Access Economics' view is that this would not be an appropriate approach to adopt in Western Australia.

7.5 Key findings and recommendations

7.5.1 Key findings

Forecast performance

- WA Treasury's Budget year forecasts for land tax revenue display a relatively high degree of accuracy. For the Budget year, land tax revenue estimates and advice are provided from OSR. In the remaining years of the forward estimates, forecast errors increase and patterns of under estimation are observed.
- After adjusting for historical volatility, WA Treasury's forecasts of land tax have performed comparatively well relative to those of other States examined since 2002-03.

Modelling methodology

- The current land tax revenue forecast methodology for forecast years beyond the Budget year is largely determined by judgement. However, WA Treasury is in the process of developing a forecast model.
- The task of forecasting land tax revenue has been assigned to the staff member responsible for forecasting transfer duty. This workload presents risks to model development plans and continuity.

Alternative approaches

- WA Treasury is in the process of developing a model for the out-year forecasts. During this process, WA Treasury should further explore the relationship between (lagged) property prices and land values, in line with the methodology used by some other State Treasuries.
- While some State Treasuries use nominal economic growth to forecast land tax revenue beyond the Budget year, Deloitte Access Economics' view is that this would not be an appropriate approach to adopt in Western Australia.

7.5.2 Recommendations

- **Expand analysis of OSR data** – Historically, forecasts of land tax revenue in the Budget year have been relatively accurate. The current approach for producing land tax revenue estimates in the Budget year should be maintained, including liaising with OSR for land tax revenue estimates and advice. However, there is the potential for WA Treasury to expand its analysis of OSR data by gaining access to additional information showing trends in aggregation, land holdings, type of land, and taxed land values (as opposed to general land values). Access to this OSR data would provide WA Treasury with greater clarity on the impact of trends that are otherwise difficult to understand and predict.
- **Further explore the relationship between house prices and land values for forecasts beyond the Budget year** – WA Treasury is planning to develop a model to forecast land tax. During this development process, WA Treasury should explore the relationship between property prices and land values, in line with the methodologies adopted by some other State Treasuries.

Conclusion

Preparing revenue forecasts that underpin the Western Australian Budget is a core function of WA Treasury. Budget estimates are used as the basis for policy decisions, and forecasts produced by ERF frame the economic and revenue policy advice provided by WA Treasury.

Accurately forecasting Western Australian government revenue is intrinsically difficult. The forecasting task has become more complex over time, reflecting increasing volatility in Western Australia's economy and revenue base. Uncertainty is inherent in forecasting, and while errors will always exist, certain measures can be adopted to increase the accuracy and reliability of forecasts.

This review makes a number of recommendations aimed at improving WA Treasury's revenue forecasting function.

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Appendix A – Performance of Treasury's revenue forecasts

This section describes the methodology and criteria used to assess the performance of WA Treasury's forecasts.

A.1. Data

Forecasts are assessed over the period of 2002-03 to 2016-17, encompassing the beginnings of the resource boom and its decline in subsequent years. Within this period, forecasts are also assessed over three distinct sub-periods: 2002-03 to 2006-07, 2007-08 to 2011-2012, and 2012-13 to 2016-17. These periods were selected to reflect distinct periods of Western Australian economic cycles.

Western Australia revenue forecasts were obtained for each Budget and Mid-year Review between 2002-03 and 2016-17. These forecasts are compared against published actual figures or actual figures provided by WA Treasury. All revenue estimates assessed in this review are subject to revision over time, and some forecasts are likely to have been produced at a time prior to these revisions.

A.2. Measuring forecast performance

It is important to assess performance of forecasts through different lenses to reflect the varying attributes required for desirable estimates. This review does so in four primary ways:

- Accuracy – How well the forecasts reflect the actual values observed;
- Bias – Whether the forecasts display patterns of over–or–under–estimating;
- Efficiency – How well available data is used to inform the forecasts; and
- Benchmarking – Comparison with comparable forecasts from other agencies or institutions.

Measures of accuracy, bias and efficiency are not necessarily independent of each other. Indeed, forecasts that are efficient are likely to be more accurate than those that ignore additional useful information. Similarly, consistent over–estimation of forecasts will likely lead to poorer accuracy than those that are unbiased. Regardless, analysis of each component is useful to identify areas where process improvement is available.

A.2.1. Accuracy

There are many approaches available to measuring forecast accuracy, each with differing attributes, benefits and drawbacks. This review bases its accuracy analysis on the mean absolute percentage error (MAPE). The MAPE is a measure of accuracy expressed as a percentage of the actual value observed. All things equal, a smaller mean absolute percentage error is desirable.

Formally, it can be expressed as:

$$Mean\ absolute\ percentage\ error\ (MAPE) = \frac{\sum_{t=1}^{T} \left| {}^{e_t}/_{f_t} \right|}{T} * 100 \qquad \text{Eq (1)}$$

Where the forecast error in period t is defined as $e_t = \hat{f}_t - f_t$, with f_t denoting the observed outcome and $\hat{f}_t$ denoting the forecast value in the same period.

The MAPE was selected for a number of reasons. First, the measure has been widely used in many academic papers and forecast reviews. Second, the measure is scale-independent, allowing for accuracy comparisons to be made across different time periods, jurisdictions and data sets.

The period of analysis of this review covers a period of significant economic volatility and change in the Western Australian economy. These circumstances were not consistent across all States. To account for the differences in volatility of tax revenue between States, MAPE adjusted by the historical standard deviation of the annual growth in the tax has also been calculated. Formally, it can be expressed as:

$$Adjusted\ MAPE\ (ADJ\ MAPE) = \frac{MAPE}{\sigma_t} \qquad \text{Eq (2)}$$

Where MAPE is calculated according to equation 1 and where σ_t denotes the standard deviation of annual growth in the relevant tax over period *t.*

Accuracy can also be analysed in the level of each measure. That is, the variation between the forecast and observed value measured in the appropriate units. The measure most commonly used in this instance is the mean absolute error (MAE).

This can be formally expressed as:

$$Mean\ absolute\ error = \frac{\sum_{t=1}^{T}|e_t|}{T} \qquad \text{Eq (3)}$$

Where the forecast error in period *t* is defined as $e_t = \hat{f}_t - f_t$, with f_t denoting the observed outcome and $\hat{f}_t$ denoting the forecast value in the same period.

It is important to note here that MAE is scale-dependent, and unable to be used to compare performance of different series or measures, nor can it be used to compare the performance of a forecast where the series is increasing or decreasing over time.

Additionally, interpretation of forecast performance can be limited. This is particularly true in instances of small sample size or where outliers can unduly skew sample averages.

Another measure used to account, in part, for the differences in volatility of tax revenue between states, the Mean Absolute Scaled Error (MASE). It is formally expressed as:

$$MASE = \frac{\sum_{t=1}^{T}|e_t|}{\frac{1}{T-1}\sum_{t=2}^{T}|f_t - f_{t-1}|} \qquad \text{Eq (4)}$$

Where the forecast error in period *t* is defined as $e_t = \hat{f}_t - f_t$, with f_t denoting the observed outcome and $\hat{f}_t$ denoting the forecast value in the same period.

If a scaled error is greater than one, a naïve forecast − where the forecast for the next period is equal to the current period − would have performed better than the forecasts used. Conversely, if a scaled error is less than one, the forecasts performed better than a naïve forecast.

A.2.2. Bias

Forecast bias occurs when there are consistent and repeated differences between forecasts and actual outcomes observed. That is, the forecasts display a persistent pattern of being either higher or lower than the actual values.

Plotting the distribution of the relative forecast error can be used as a measure of bias in forecast performance. The relative forecast error can be expressed as:

$$Relative\ forecast\ error = {}^{e_t}/_{f_t} * 100 \qquad \text{Eq (5)}$$

Where the forecast error in period *t* is defined as $e_t = \hat{f}_t - f_t$, with f_t denoting the observed outcome and $\hat{f}_t$ denoting the forecast value in the same period.

A positive value indicates the forecast is overestimating the series, while negative values indicates under-estimating. On average, the expected value of the relative forecast error should be equal to zero if the forecasts are unbiased.

In analysing the bias of forecasts, this review examines the error distributions over each step in the horizon period. Where the estimated distributions show skewness, the forecasts are likely to have suffered from either positive or negative bias.

A.2.3. Efficiency

A qualitative analysis of forecast efficiency has been undertaken to examine the extent of available information to help inform the forecasting process.

A.2.4. Benchmarking

To provide a benchmark comparison of forecast performance, where data availability allows, a comparison between the performances of different forecasts of the same or similar series is undertaken.

The main sources of comparison were other State Government revenue forecasts, Commonwealth forecasts and Consensus Economics. These forecasts were chosen due to their comparability to those produced by WA Treasury in terms of use, scope and information available to each agency.

At times, forecasts are not published for comparable years, or horizon periods. These are noted where applicable. It should also be noted that there is not significant commonality between State Treasuries, Consensus Economics and Commonwealth Treasury on when forecasts are prepared and finalised. Forecasts prepared at a time closer to the horizon period are likely to perform with greater accuracy than those produced earlier. This may be due to greater information available, knowledge of macroeconomic development and reduced uncertainty. Such discrepancies are discussed where appropriate in the performance evaluation section of each revenue head.

Appendix B – Model evaluation

This section presents a review of the econometric models considered above. The review focuses on methodology and model validation. The models are validated using a method known as cross validation, a technique used widely in statistical learning problems. Forecast performance is compared to those of univariate and naïve benchmark models.

B.1. Econometric review

B.1.1. Labour market model

WA Treasury forecasts employment, unemployment, and average compensation of employees (ACoE) using an econometric framework. Other labour market variables: the participation rate, unemployment rate, and the working age population are generated using identities.

Two econometric models are used to generate the key labour market variables. Short and long run dynamics between ACoE and employment are captured using a vector error correction (VEC) framework. Short and long run dynamics in unemployment are captured through an autoregressive distributed lag framework (ARDL).

Both models use exogenous variables in their specification, which require forecasts of their own in the out-of-sample periods. In addition, the models use forecasts from one another in a recursive fashion.

The standard post estimation diagnostics of the VEC model suggest that the model is not unreasonable. Indeed, the model's residuals appear to be normally distributed and free of any deterministic structure. Beyond normal regression diagnostics, a VEC requires two major considerations, lag length and determination of the number of cointegrating rank. Determining optimal lag length is important because the Johansen (1991) integration test is highly susceptible to specification errors. Inclusion of trends in the data can also influence the outcome. Lag length criteria checks in the VAR object indicate that lag length of five is optimal. Considering this, the VEC has the correct lag length of four (since one lag is differenced out). The VEC is also specified with an intercept in both the long and short run equations. Considering the visual inspection of data, as well as the outcomes of the unit root tests, this trend specification is not unreasonable. Under this specification, the cointegrating rank is estimated to be 1.

Importantly, the parameter estimate of the cointegrating vector is statistically significant and has the correct sign, indicating that the model is dynamically stable. The parameter is -0.09, suggesting that is takes employment roughly 11 quarters to return to its steady state relationship with ACoE.

Unemployment is modelled using the ARDL approach to long run relationships. It is assumed that unemployment has a stable long run relationship with State Final Demand (SFD) and the employment to population ratio. The ARDL specification has considerable advantages over other methods for estimating long run relationships. Importantly, the ARDL method does not suffer from small sample bias, the parameters are super consistent, and the model does not require the normal pre-testing to determine the order of integration (given the variables are not I(2)).

The ARDL approach requires that the correct lag length be specified, as any residual autocorrelation can bias the parameter estimation and invalidate the results of the model. The optimal lag length is selected using the Akaike information criterion (AIC) and inspection of the correlogram of the model residuals indicates that there is no autocorrelation.

Like the VEC, there are some other important considerations when estimating an ARDL model, namely none of the variables can be I(2) and the model needs to be dynamically stable. Standard unit root testing shows that none of the variables used in the ARDL specification are integrated of order two. Finally, respecifying the model using ARMA residuals (rather than lagged dependent variables) shows that none of the inverse roots of the characteristic polynomial lie outside the unit circle, suggesting that the model is dynamically stable.

The long run relationship between unemployment, the employment to population ratio, and SFD is confirmed by the bounds test. The estimation of the error correction term has the correct sign and suggest a speed of convergence of around 5 quarters.

B.1.2. Payroll tax

Payroll tax is modelled as a function of employment, cost of employment, and previous payroll tax. The forecasts of the exogenous variables are informed by the labour market model discussed above. The model is specified in approximate growth rates, difference of natural logarithms, and includes a pulse dummy variable and seasonal variable for the September quarter.

The inclusion of the seasonal variable in the September quarter, and no other quarters, suggests that no deterministic variation in payroll tax occurs outside of the September quarter. That is, the intercept captures all other seasonal variation. To investigate further, the model is estimated with all seasonal dummies included. The standard model validation statistics, such as the AIC and adjusted R squared are improved marginally. However, forecasting often favours more parsimonious models and the current specification may be superior. Indeed, the Schwarz information criterion (SIC) statistic, which has a harsher penalty for including variables, suggest this is the case.

All standard post estimation diagnostics suggest the model is not unreasonable. Specifying the model in growth rates accounts for the non-stationary nature of the data, avoiding the problems of spurious regression. However, like the labour market model, it stands to reason that there may be a long run level relationship between these variables. It is not clear from the documentation provided if WA Treasury has explored this avenue. However, failing to account for cointegration may result in misspecification error.

B.1.3. Underlying transfer duty

Underlying transfer duty is generated through the use of three models: a housing finance model, a house price model, and a model for underlying transfer duties.

The housing finance model is used to proxy transactions. The model is specified in approximate growth rates to account for the non-stationary nature of the data, and population variables have been differenced twice. The standard post estimation diagnostics suggest the model is sound. The model has no dynamic specification − the forecast is purely driven by exogenous variables.

The house price model is a structural model with ARMA errors. The structural component models the growth rate in house prices as a function of the lagged transactions. The errors of this model are modelled as an ARMA process. The correlogram of the residual from the structural model, prior to estimating the ARMA errors, suggests that there is serial correlation at lags three and four. This indicates that the inclusion of an AR3 and AR4 term in the model is warranted. Indeed, the correlogram of the final model shows no signs of autocorrelation. An inspection of the inverse roots of the characteristic polynomial suggests that this model is dynamically stable.

An additional consideration is around the specification of the model in growth rates, as opposed to levels. There are sound theoretical reasons to suggest that house prices are tied to transactions in the long run. That is, prices do not tend to deviate from their long run trends for too long. Further, the determinates of long and short run price dynamics are likely to include more variables than just transactions. As such, other functional forms, such as cointegration, and experimenting with other variables should be investigated, if they have not been already.

An ARDL framework is used to model the underlying level of transfer duties. The same considerations mentioned above hold true here. First, no variable can be I(2) and the model needs to be dynamically stable. The null hypothesis of a unit root in the second difference of all variable in the underlying transfer duty model is rejected. The model is dynamically stable and standard residual diagnostics suggest the model is not unreasonable. The long run relationship between the variables is confirmed by the bounds test and the estimation of the speed of adjustment parameter has the correct sign.

B.2. Model validation

The models discussed above are validated using a method known as cross validation, a technique used widely in statistical learning problems. The cross validation approach follows a simple iterative algorithm. The data is partitioned into training and testing samples, the model is parameterised on the training sample, forecasts are generated, then the training sample is incrementally increased and the process repeated. This results in a number of forecast samples that are independent of the testing sample which can then be used to validate the model(s).

The cross validation procedure applied to the models is set out below:

- Restrict the sample to March 2012;
- Estimate the model(s);
- Forecast 16 periods ahead;

Increase the estimation sample by one quarter and repeat until there is no more data left.The results of this process are then compared to the actual observations at each horizon and forecast statistics are calculated. The metric used to compare forecasts is the root mean squared error:

$$RMSE = \sqrt{mean(e^2)}$$

This measure penalises larger errors, since the cost of the error increases with its square. It is important to recognise that many of the models considered are dynamic. That is, they use their own forecasts recursively to drive the forecast forward. In addition to this, many of the exogenous variables used in the models are forecast through other models. In conducting the validation exercise, Deloitte Access Economics has taken care in recreating these forecast where possible. However, some variables, namely SFD − used in the labour market model − and the some of the variables used in the underlying transfer duties model have not been recreated due to data limitations.

To aid the analysis, each model considered is compared against naïve and univariate model benchmarks:

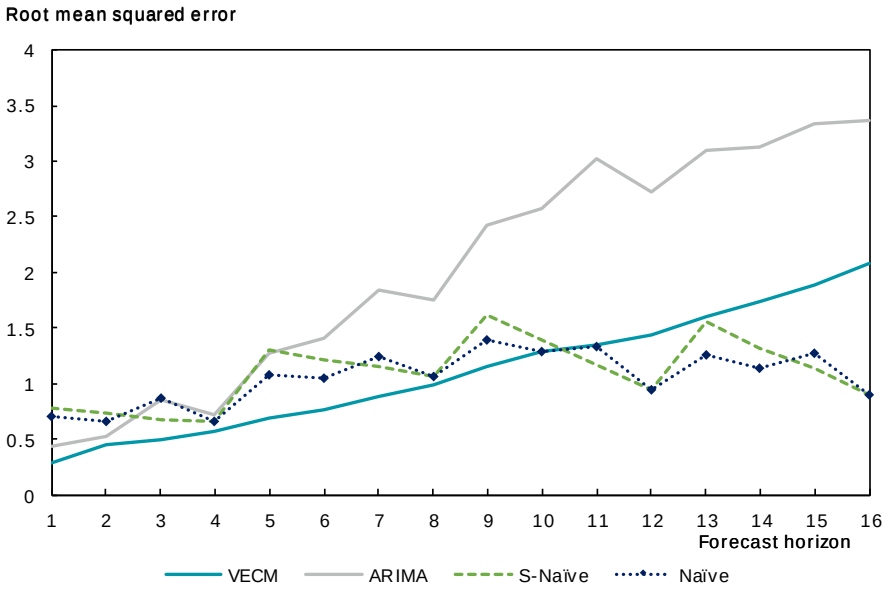
- An ARIMA(p,d,q)(P,D,Q) model, specified optimally following the procedure set out in Hyndman and Khandakar (2008);
- An ARIMA(0,0,0)(0,1,0) model - otherwise known as a seasonal naïve model; and
- An ARIMA(0,1,0) model - otherwise known as a naïve model.

B.2.1. Labour market model validation

The three key labour market variables are considered in the validation exercise: employment, ACoE, and unemployment. To create the iterative forecast of these variables the VEC and ARDL models are estimated on the restricted sample, the EViews model object is then solved dynamically over the pseudo-forecast sample, and the process is repeated. It is important to note that SFD and the population variable (used to construct e2p) are used in this process in a static nature. That is, historical observations are used in place of forecasts of these variables.

The results of the validation exercise for ACoE are presented in Chart B.1. In the short term, the labour market model outperforms the benchmark models. As expected, the longer term performance deteriorates. However, the labour market model longer term forecast performance surpasses that of the ARIMA model.

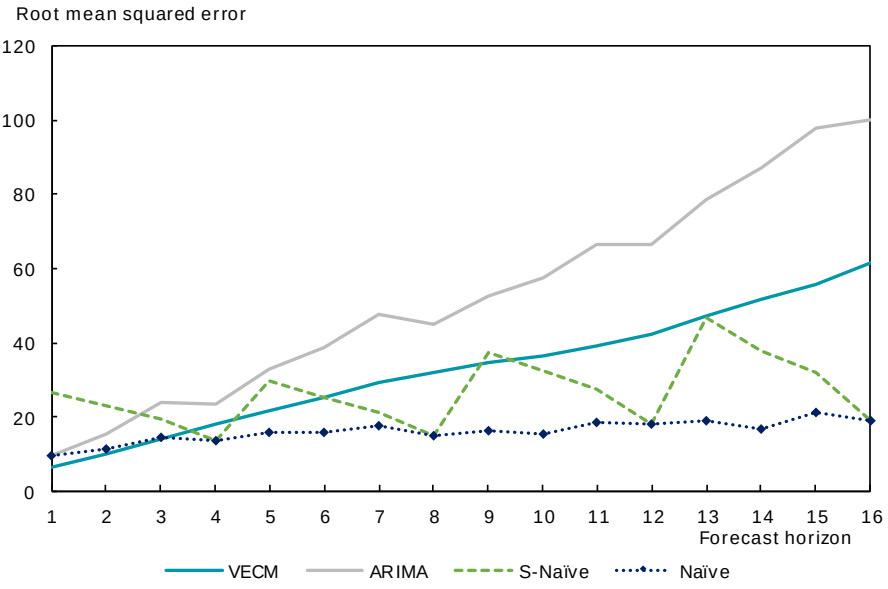
Chart B.1: Root mean squared error ACoE – four year forecast horizon



Source: Deloitte Access Economics, WA Treasury.

The results of the validation exercise for employment are presented in Chart B.2. The labour market model forecast performance is much the same as ACoE. As was the case with ACOE, the employment forecast outperforms the ARIMA model, yet underperforms the naïve benchmarks.

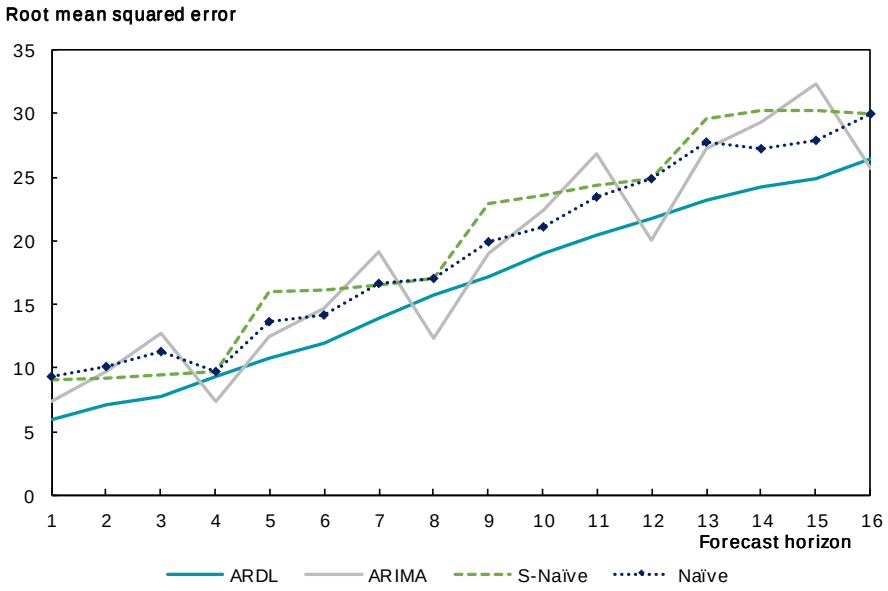
Chart B.2: Root mean squared error employment – four year forecast horizon



Source: Deloitte Access Economics, WA Treasury.

The third variable considered is unemployment. Unemployment is forecast using and ARDL framework, as opposed to a VECM. The results of which are used in the labour market model to create the unemployment rate, the lagged value is used in the VECM. The results of the validation exercise are presented in Chart B.3. The forecasts from the ARDL model outperform all other benchmarks. This is the only variable considered to outperform all of the benchmark models, at every horizon.

Chart B.3: Root mean squared error unemployment– four year forecast horizon



Source: Deloitte Access Economics, WA Treasury.

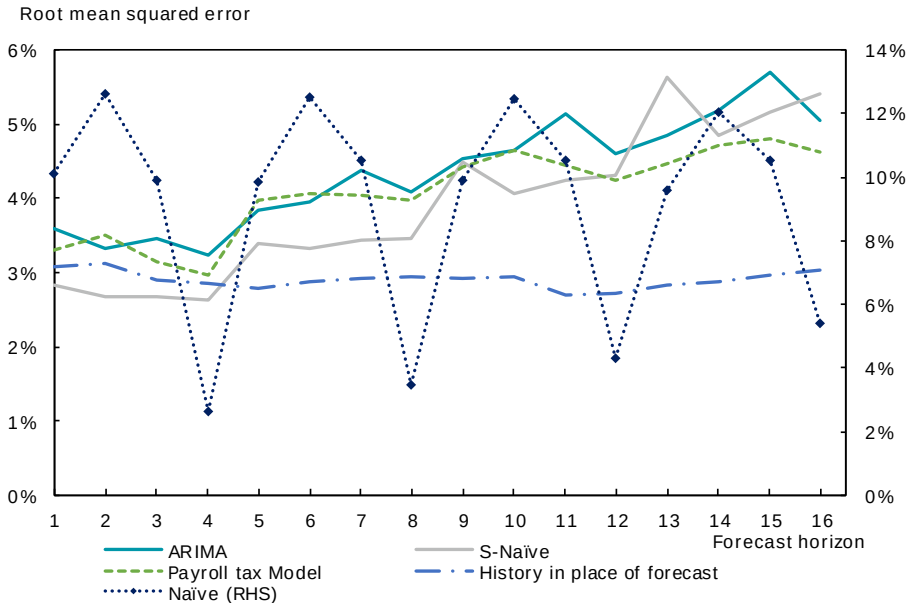
To summarise, the labour market model consists of a VEC model and ARDL model for labour market variables. The forecasts of the VEC model do not perform better than the naïve benchmarks, but do outperform the univariate benchmarks. On the other hand, the ARDL model performs the best out of all the models considered. Considering this, Deloitte Access Economics suggests investigating this framework for other variables within the labour market model. Once a preferred ARDL specification is settled on, a similar validation exercise can be employed to determine whether it is a superior model to the VEC.

B.2.2. Payroll tax

The payroll tax model uses forecasts from the labour market model as well dynamic forecast, generated recursively from the payroll tax model. Chart B.4 shows the outcome of the validation exercise. The chart illustrates that in the short run the seasonal naïve model outperforms the other models. However, the payroll tax model outperforms the benchmarks in the longer term. The chart shows the naïve benchmark (the random walk model) on the right hand axis, as the error is larger than the other three models. Importantly the error has a clear seasonal pattern, suggesting that seasonality should not be overlooked. Taken together, the forecast performance of the seasonal naïve model and the improvement in the validation statistics mentioned in the section above, there appears to be a case for the inclusion of seasonal dummy variables in the payroll tax model.

To illustrate the error that using forecasts of other variables introduces, the chart also shows the model run using exogenous historical data as the independent variables to isolate the performance of the payroll tax model itself. That is, it represents the forecast error from the payroll tax model assuming that the input data from the labour market model is perfectly accurate.

Chart B.4: Root mean squared error payroll tax – four year forecast horizon



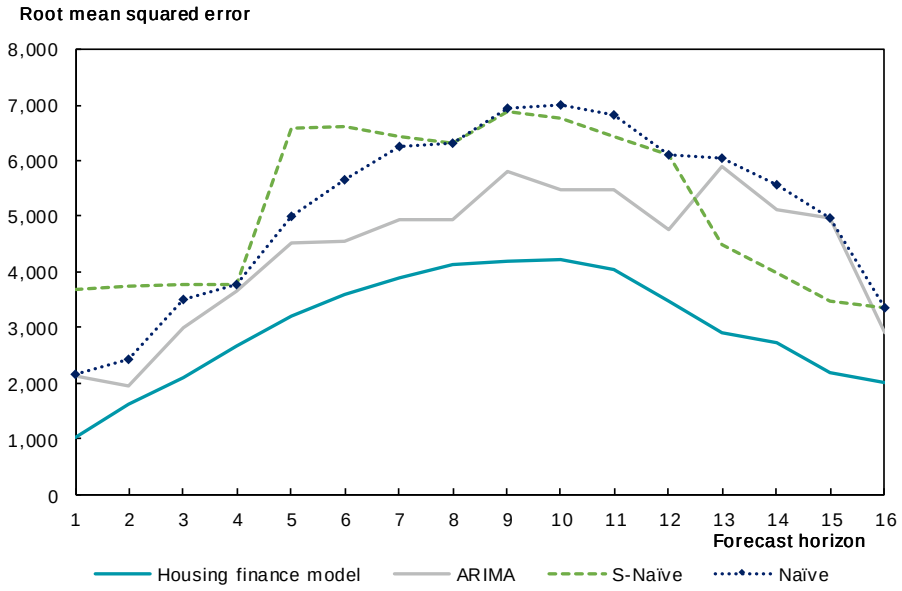
Source: Deloitte Access Economics, WA Treasury.

B.2.3. Underlying transfer duty model

The three variables that are forecast as a part of the underlying transfers duties model are considered below. Like the labour market model, it is important to note that some of the exogenous variables have not been recreated due to data limitations. This pertains to the exogenous variables used in the housing finance model, meaning that static (actual values) are used in place of forecasts. However, this also affects the forecasts generated through the other models during the validation exercise.

The root mean squared error from the housing finance model at each horizon is presented in Chart B.5. The housing finance model clearly outperforms the benchmark models. This is likely due to the actual values of the exogenous variables used in place of forecasts.

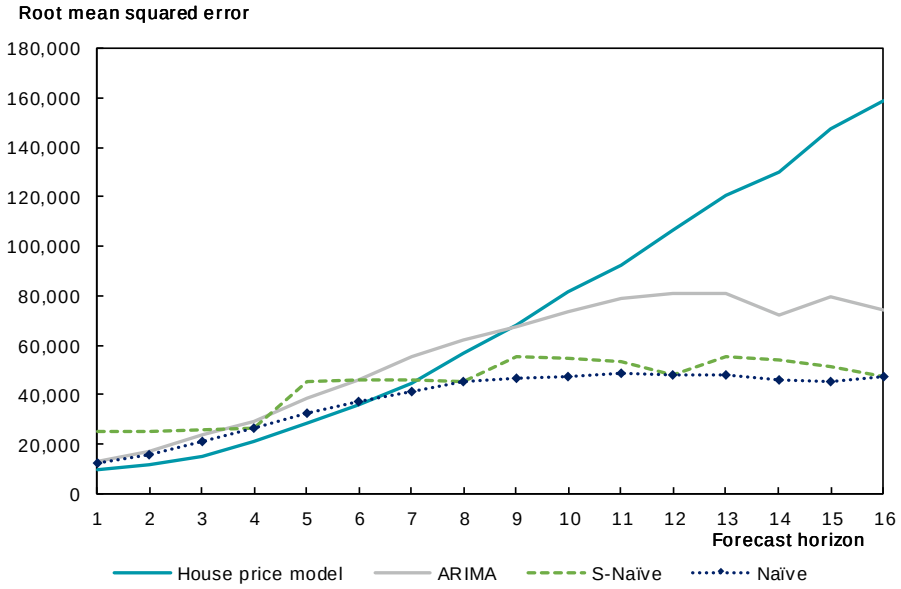
Chart B.5: Root mean squared error housing finance – four year forecast horizon



Source: Deloitte Access Economics, WA Treasury.

Chart B.6 presents the results of the validation exercise for house prices. The house price forecast from the underlying transaction model marginally outperforms the benchmarks in the short term. However, forecast error increases considerably with the forecast horizon. While it is noted that there are fewer observations underpinning the results as the forecast horizon increases, this finding lends further support to the hypothesis that other factors may influence house prices beyond transactions.

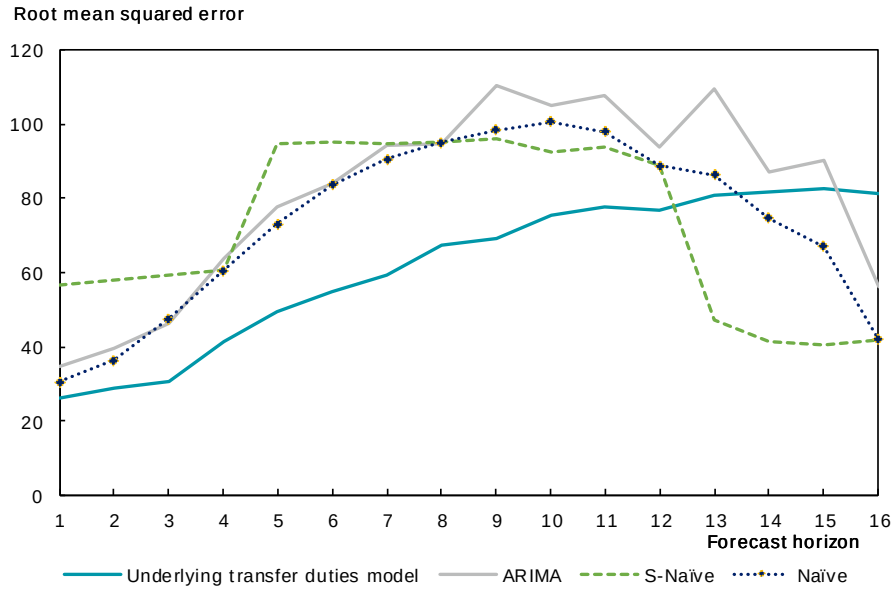
Chart B.6: Root mean squared error house prices – four year forecast horizon



Source: Deloitte Access Economics, WA Treasury.

Finally, the results of the validation exercise for underlying transfer duties are presented in Chart B.7. The underlying transfer duties model generally outperforms the benchmark models. However, the longer term forecast tends to deteriorate. This is to be expected, considering the forecast from this model is the combination of forecasts from the previous models. Again it is important to keep in mind that the housing transaction model performance is not an accurate reflection of the model's forecast ability – it is biased towards low error given it is using actual data for the exogenous variables – and part of this bias is transferred into the underlying transfer duties model.

Chart B.7: Root mean squared transfer duties – four year forecast horizon



Source: Deloitte Access Economics, WA Treasury.

To summarise, the validation exercise demonstrates that the models used to forecast underlying transfer duties generally outperform the standard benchmarks. However, the limitations of this analysis cannot be overstated; it is difficult to properly validate the housing finance model without forecasts of the exogenous variables. The validation exercise suggest that the house price model could be improved. Even with the static forecasts derived from the housing finance model, the house price models longer term forecast performance is a concern.

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