

Patrick Nolan, Yvonne (Yikun) Wang  
and Meghan Stephens<sup>1,2</sup>

# Modelling Child Poverty and Wellbeing the Treasury's TAWA microsimulation model

---

## Abstract

Large tax–transfer microsimulation models can play a key role in guiding tax–transfer analysis and reform. This article discusses the Treasury's microsimulation model of the tax–transfer system (the Tax and Welfare Analysis (TAWA) model), including how it is used and the standard outputs it produces. The article also considers whether these standard outputs continue to be fit for purpose. This includes a discussion of different ways of estimating poverty impacts, the role reporting should give to financial incentives to work, and the opportunities provided by improved data. This final point is particularly important for understanding take-up and the prospect for extending the model to cover non-financial measures.

**Keyword** poverty measurement, microsimulation modelling

---

Patrick Nolan is the manager, analytics and insights at the Treasury. Yvonne (Yikun) Wang is a modelling analyst, analytics and insights at the Treasury. Meghan Stephens is a principal advisor, analytics and insights at the Treasury.

## Technological change, evidence and policy

Technological change is transforming governments' ability to monitor and understand activity. As Eppel and Lips (2021) noted, there is a trend towards more sophisticated digital government and the use/reuse of data and information from these transactions to improve the design and delivery of government services.

One of the most high-profile recent examples of this trend in New Zealand is Statistics New Zealand's Integrated Data Infrastructure (IDI) (see Box 1). As Jones (et al, 2022) noted, this is having an impact in a number of areas, ranging from modelling the performance of the benefit system, to better targeting school-based equity funding, to modelling the potential spread of Covid-19.

This growing availability of data, along with improved modelling techniques, is also having an impact in areas like poverty measurement. As Stephens (2022) notes, we have an opportunity to use tools like

microsimulation models to better understand the incidence and causes of poverty and, in turn, help lift the living standards of New Zealand's poorest families.

#### The role of the TAWA model

Tax-transfer reform has always required hard choices (e.g., the Beveridge Report (1942), discussed in Nolan, 2006). A balance needs to be struck between alleviating poverty, improving financial incentives to work and minimising fiscal costs (or maximising revenue) to the government (Nolan, 2018b). These trade-offs can be difficult to evaluate given the complexity of tax-transfer systems and population heterogeneity.

As Alinaghi, Gemmell and Creedy (2021) noted, large tax-transfer microsimulation models can play a key role in helping answer practical policy questions and encouraging rational policy development. Microsimulation models can take cross-sectional datasets and apply tax and transfer rules to them. They can cope with the complexities of both the tax-transfer system and population heterogeneity. This article discusses the Treasury's microsimulation model of the tax-transfer system (the Tax and Welfare Analysis (TAWA) model).

TAWA is the only model in the public sector with combined person/family/household-level microsimulation capability. It is used to estimate fiscal costs and the distributional impacts of tax-transfer reforms and produce child poverty projections for the child poverty report (Stephens, 2022). As the model utilises data from the IDI, it is also used for a range of analytical projects to help inform strategic policy advice, including on wealth (Symes 2021, 2022), expenditure (Wang, 2022) and climate change (Davis, 2022).

The uses that the model has been put to have changed over time and this can be expected to continue. Trends for the model's use include:

- being used to answer more complex distributional questions. At the Treasury, microsimulation modelling was originally developed to help with policy costings, which is a very different exercise from producing distributional estimates and projections. In particular,

## BOX 1 The Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD)

The Integrated Data Infrastructure consists of over 400 tables across 33 distinct data supplies, comprising over 6 billion rows of data centred around people and households. The database is updated three times a year, and the latest update added an additional 700GB of data. Along with these regular refreshes of data, Statistics New Zealand processes about 15 additional datasets per quarter on an ad hoc basis; these are datasets related to Covid-19 and Statistics New Zealand official statistics production which require data to be made available earlier than usual data refreshes.

The Longitudinal Business Database consists of over 250 tables from 13 distinct data supplies, and holds over 1 billion rows of business-centred data. The LBD is updated annually, with each update holding around 200GB of data.

#### Data lab researchers, projects and research outputs

As of June 2022 there are 991 people with active access to the data. Two-thirds of these people work with the data directly for their projects, while the remaining third have viewing access and provide a support role to the research (e.g., as a supervisor or subject matter expert).

There are currently 330 active projects from a range of organisations: government, tertiary sector and other organisations (such as private sector research firms). There are many types of projects that researchers undertake, from society/community-related research to modelling for different agencies.

In 2021 over 2,000 research outputs were checked for confidentiality and released, following similar levels in 2019 and 2020. There is likely to be an increase in the total research outputs submitted for checking in 2022.

Source: Statistics New Zealand (personal correspondence)

distributional questions are relatively more sensitive to data issues at the top and bottom of the income distribution and projections are sensitive to the economic forecasts used.

- being used as an analytical tool for strategic policy. As the model can draw on a range of data, it can be used to consider broader questions, such as the wealth distribution, expenditure distribution or the distributional impacts of climate change mitigation policy. A useful feature of the model is its ability to estimate offsets (e.g., the degree to which the tax-transfer system offsets the impacts of a policy change).
- increasing interest in non-financial measures. The TAWA model was primarily developed to model income transfers (taxes and cash benefits), but there is growing interest in understanding the interaction of a wider range of government programmes (such as consumption taxes and spending in kind (Crawford and Johnston, 2004; Aziz et al., 2012)) and outcomes like subjective wellbeing (Crichton and Nguyen, forthcoming).

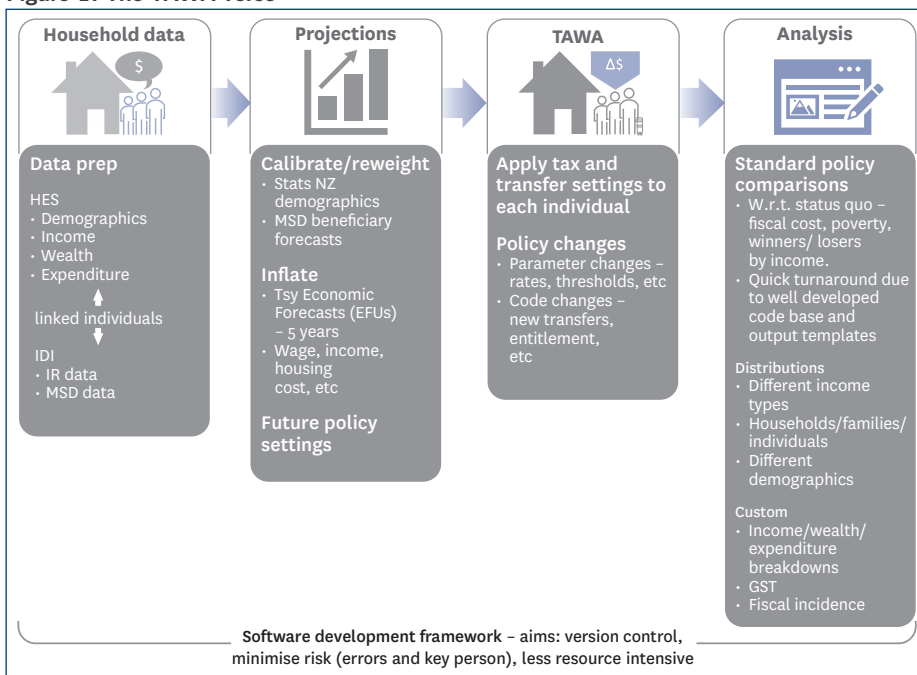
- increasing expectations regarding model governance. Not only is the model being used for more complex tasks, but there is a diminishing appetite for modelling errors. Addressing this requires a focus on ensuring both that the modelling process is transparent and safe and that uncertainties in the model's outputs are properly understood by users (Beer, 2018). These issues will continue to grow in importance, given the increasing role of data and models in the policy process.

#### The TAWA-verse

TAWA can best be seen as a modelling system covering the core input dataset, data for reweighting the population and inflating incomes and costs, code for modelling the tax-transfer system and policy changes, and the code that produces the model outputs. This system is pictured in Figure 1.

TAWA is a simplified version of an individual, family or household's economic reality for a tax year. It provides a 'snapshot' of their situation. This simplification is a necessary feature, not a bug. As Rogers

Figure 1: The TAWA-verse



Source: Symes and Davis, 2020

(2018) noted, just as with maps (which are ‘highly stylized, unrealistic models of real topography’), ‘[t]he trick is to have ... just enough detail to let me get from point A to point B without confusing me with superfluous details and without omitting important details ... unrealism is precisely what makes it useful’. There is still, however, value in discussing how the model operates and the key modelling assumptions. This is not a question of judging whether a model is ‘right’ or ‘wrong’, but is instead a question of better understanding how it operates and the sensible uses to which it could be put. Is it, in other words, the right map for the journey?

**Data and forecasts**

A processed dataset is used as an input to the model. This contains data on household and family structures, demographics (including age and ethnicity), housing costs, regions and material hardship from the Household Economic Survey (HES), which is then linked with individual wage, salary or self-employment income, and core beneficiary status from the IDI. In the input dataset approximately 95% of the adult HES survey respondents are linked to the administrative data. For the remaining records, HES survey responses are used.

TAWA can be used to project up to five years into the future. To do this, the survey data is transformed to align with various

economic and demographic characteristics of the target tax year. For tax years in the future, forecasts of these characteristics produced by Stats NZ, the Ministry of Social Development and the Treasury are used. There are two transformations to time-shift the raw HES data: inflating and reweighting. These transformations are applied sequentially, so the reweighting step uses the output of the inflation step.

In the inflation step, variables are scaled by the relative change in certain economic indices. For example, raw wage income is scaled by the relative change in an average earnings index. In the reweighting step, each household’s weight is scaled such that the weighted sums of particular variables align with benchmarked aggregate values. For example, the number of men and women in five-year age bands is benchmarked to the population projections of Statistics New Zealand.

**Modelling assumptions**

A key assumption in TAWA is that no allowance is made for the possible effects of tax-transfer changes on a modelled individual’s consumption plan or labour supply. The model is, in other words, static arithmetic or non-behavioural (Creedy et al., 2002). Further, take-up of different programmes is modelled in different ways in the model. For core benefits, administrative data is used to determine take-up, while the

accommodation supplement take-up is based on probabilities (Davis, 2021) and Working for Families is assumed to have full take-up.

There are also several other assumptions relating to the incorporation of economic forecasts into TAWA projections (Wang, 2021). These include:

- wage growth is applied uniformly to all observed wages of individuals (the wage distribution is shifted to either the right or the left);
- the same inflator is used for wages and rents (as there is no existing forecast for rents);
- the 90-day rate is used to inflate income from interest, overseas income and trust income;
- the entire working population is upweighted (downweighted) when the forecast number of jobseeker support recipients decreases (increases); and
- if the number of recipients of main benefits increases, these new recipients will have the same characteristics as existing beneficiaries.

**Standard outputs**

The TAWA model produces both standard and custom outputs. Standard outputs are based on a template and are produced with R Markdown so that the process is largely automated. This helps reduce error and supports the communication of risk and uncertainty. These standard outputs cover:

- fiscal impacts: showing the total fiscal cost/revenue – gross or net – and the cost of or revenue from different tax and transfer policies;
- population: showing the total population and population in income deciles; these can also be shown for different family types;
- poverty measures: showing (headcount measures of) the number of children living in households under different poverty measures (both changes and levels). The average income depth of households in poverty in the status quo and scenarios is also shown; measures are reported for the status quo and for scenarios, and the difference between the status quo and scenarios is shown;
- winners and losers: when comparing two policies (or a policy with the status quo) it is possible to show the numbers

advantaged ('winners') and disadvantaged ('losers') in each grouping, and by how much they gain or lose (on average and in total for the group); and

- modelling assumptions and disclaimers: this outlines the key assumptions used in the modelling, along with a risk/reliability assessment. All figures include confidence intervals (reflecting the potential for sampling error, not underlying modelling uncertainty). The IDI disclaimer is included.

### Using the model to measure poverty and wellbeing

#### Benchmarking performance

Model outputs have been compared with Stats NZ data on child poverty. Model outputs have also been benchmarked against Ministry of Social Development research using administrative data (McLeod and Wilson, 2021). Some differences between the different data sources are inevitable, given time frames and differences in methodology. Nonetheless, this benchmarking has shown:

- the importance of take-up, including for Working for Families;
- challenges in modelling family and income dynamics; and
- the inherent uncertainty in prospective estimates – e.g., using a past year's data to model future periods (based on forecasts for economic and employment prospects).

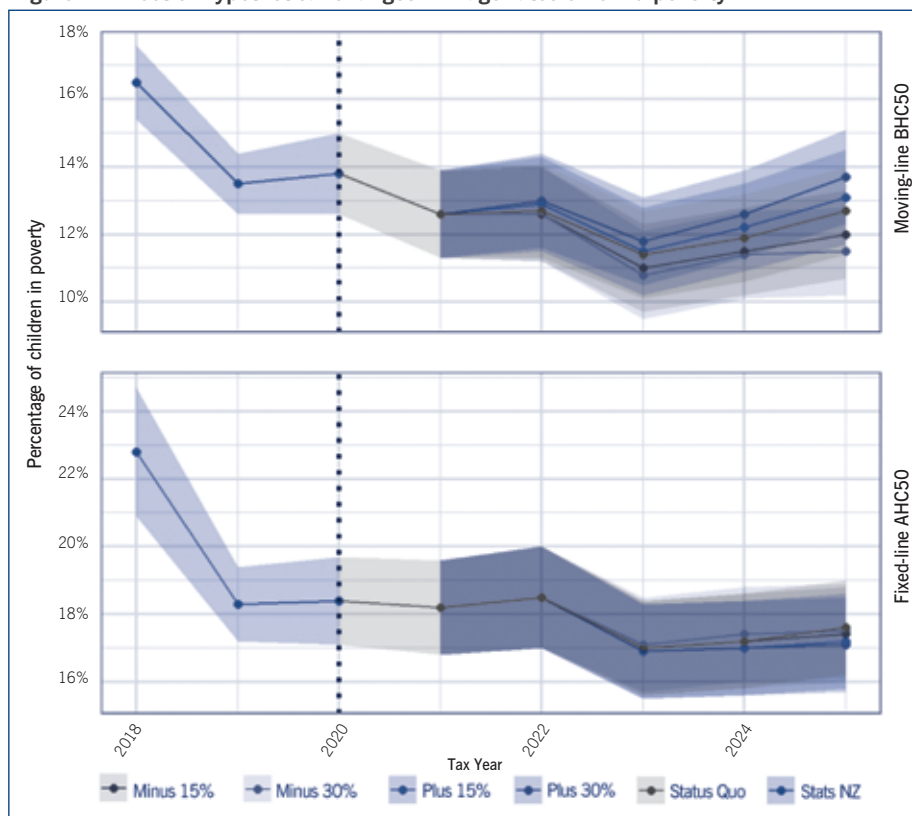
Implications of these issues are discussed in more detail below.

#### Poverty measures

Poverty is measured against a poverty threshold, which defines the level below which income is deemed inadequate. Different levels of inadequacy are reflected in different income thresholds, and these thresholds vary according to a range of characteristics.

They can, for instance, be expressed in absolute (nominal) or relative (inflation-adjusted) terms. An absolute threshold terms people poor if their incomes are below the level necessary to maintain a minimum standard of living that does not change over time, while a relative one terms people poor if their incomes are judged inadequate in relation to those of other

Figure 2: Effect of hypothetical changes in wage rates on child poverty



Source: Wang, 2021

people in society. They also often vary depending on whether they are before or after housing costs.

Figure 2 illustrates why it can be useful to distinguish between absolute and relative child poverty measures. The figure shows the sensitivity of child poverty projections to increases or decreases in wage growth, holding all else constant. As noted above, in TAWA wage growth rates are applied uniformly to all observed wages of individuals in the input data, which means the entire wage distribution is shifted to either the right or the left.

In the figure the 'moving-line BHC50' measure is a relative poverty threshold and the 'fixed-line AHC50' is an absolute one (for further discussion on poverty thresholds used in New Zealand, see Stephens, 2022 and Wang, 2022). A wide range of wage growth shocks are shown – with wages changing from anywhere between –30% and +30%. Looking at the results for the child poverty projections for the final year shows that the relative (BHC50) measure is more sensitive to these hypothetical changes in wage rates.

This should not come as a surprise, as with the fixed-line measure the only effect of an increase in wages is to shift those

people in poverty who have wage income across the poverty line. This assumes no behavioural change and that wage growth applies uniformly. In contrast, with the relative poverty threshold (the BHC50 measure) two things take place: not only is there a change in income among the working poor, but median income changes and, in turn, the poverty threshold moves. This move in the threshold can dominate the increase in incomes among the poorest, meaning that measured poverty increases when wages grow.

This latter effect is often not what people think of when they think about poverty measurement. But both approaches are useful; they illustrate different things. Absolute measures show the incidence of low incomes, while relative ones illustrate broader questions relating to the width of the income distribution.

And the complexities do not stop there. The simplest poverty measures are headcount ones, which show the number or proportion of families below the poverty threshold. However, these measures are only concerned with the fact that these incomes fall below the poverty line. They give no weight to how far families are below the line. A policy that lifts the incomes of

the very poor but fails to bring them above the poverty threshold would be seen to achieve nothing.

It is thus useful to also consider measures that illustrate the extent to which families fall below the poverty threshold (the poverty depth) and the total cost of bringing all the poor up to the poverty line (the poverty gap) (Creedy, 1999). Measures along these lines are already produced as standard outputs in the TAWA model.

Their use is important. For example, consider two hypothetical policies that may lead to the same reduction in absolute poverty (in headcount terms), but one

above the poverty line receive some financial assistance; spill-over to the pre-transfer poor occurs when the transfers received by the pre-transfer poor are greater than those needed to lift their incomes to the poverty threshold (Creedy, 1999; Stephens and Waldegrave, 2001).

#### *Efficiency measures*

As Gemmell (2021) noted, it is important to not lose sight of the efficiency aspects of tax-transfer changes. Indeed, as the Mirrlees Review (2011) noted:

As the TAWA model is able to draw on a range of data, including non-income data, it can be used to answer a wide range of questions, including those related to wealth ..., household expenditure ... and climate change ...

policy may have a larger effect on relative poverty (again in headcount terms). Does this mean that the policy with the larger effect on relative poverty is the better one? Reaching this judgement requires understanding how much of the reduction in relative poverty is due to changes in the median income and the degree to which the very poor have their incomes lifted towards (but not necessarily above) the poverty threshold.

The TAWA model can also produce measures that illustrate how to most effectively reduce poverty. These include poverty reduction effectiveness and targeting efficiency measures.

- Poverty reduction effectiveness shows the ratio of benefits going to the pre-transfer poor to the total benefits needed by that group (Creedy, 1999; Stephens and Waldegrave, 2001).
- Targeting efficiency indicates the extent that expenditure goes to the poor. This is reduced by spillover. Spillover to the pre-transfer non-poor occurs when families with pre-transfer incomes

above the poverty line receive some financial assistance; spill-over to the pre-transfer poor occurs when the transfers received by the pre-transfer poor are greater than those needed to lift their incomes to the poverty threshold (Creedy, 1999; Stephens and Waldegrave, 2001).

It is impossible to take 40% or more of national income in tax – as most advanced economies do – and not have major economic impacts. Most taxes influence people's behaviour in unhelpful ways and all reduce the welfare of those who bear their economic burden. The challenge for tax design is to achieve social and economic objectives while limiting these welfare-reducing side effects. (quoted in Gemmell, 2021, p.2)

One key efficiency dimension is the degree to which tax-transfer changes reduce incentives to work. As noted above, TAWA does not account for the fact that policy changes may lead to people changing their behaviour, although encouraging behavioural changes may be one of the objectives of reform. Yet measuring behavioural responses can be a difficult exercise. Challenges include the sensitivity of results to the assumed labour supply elasticities, and the degree to which earnings elasticities and participation

elasticities are held constant among different population groups.

Nonetheless, in TAWA financial incentives to supply labour can be illustrated on two margins. The extensive margin relates to choices about labour force participation, and the intensive margin relates to choices about hours or weeks of work (Blundell, Bozio and Laroque, 2013).

- The strength of incentives on the intensive margin reflects the impact of the tax-benefit system on the net hourly wage rate.
- The strength of incentives on the extensive margin reflects the income effect of the tax-benefit system. The income effect is the income available for consumption that is independent of the labour supply decision itself.

The effect on the net hourly wage can be illustrated by effective marginal tax rates (EMTRs) (Nolan, 2018a). These show the percentage of an extra dollar earned that the recipient loses due to taxes and loss of transfers. A higher EMTR reduces the incentive for an individual to work an extra hour, so EMTRs are useful when considering work incentives and poverty persistence.

It is also possible to produce budget constraints that can show the net income after taxation and the payment of abated assistance that is received at different levels of time in paid employment. Net income when out of work is the height of the budget constraint at zero hours of work. The height of the budget constraint illustrates the income effect. The slope of the budget constraint is equal to the marginal rate of substitution between time in paid employment and time in other activities. The slope of the budget constraint illustrates the substitution effect. Whether these two effects reinforce or offset each other depends on the case at hand.

#### *Moving into wellbeing*

As the TAWA model is able to draw on a range of data, including non-income data, it can be used to answer a wide range of questions, including those related to wealth (e.g., Symes, 2022), household expenditure (Wang, 2022) and climate change (Davis, 2022).

The model can potentially provide a fuller picture of the interaction of a wider

range of government programmes (such as consumption taxes and spending in kind (Crawford and Johnston, 2004; Aziz et al., 2012)). Fiscal incidence studies can illustrate the distributional effects of indirect taxes and expenditure on key in-kind government services, such as health and education, along with income taxes and transfers.

Work along these lines could potentially be combined with data on subjective wellbeing (e.g., Crichton and Nguyen (forthcoming)) to provide a picture of the wellbeing effects of various policies. This approach would provide a person-centric view of wellbeing across multiple dimensions of wellbeing and complement other approaches which typically consider each wellbeing domain in turn.

## Conclusion

This article has discussed the TAWA model and the uses to which it could be put. One goal was to illustrate how this model operates so that its outputs can be better understood and used. Another goal was to encourage further work in this area to better exploit the potential of the model. To help with this the Treasury also intends to make TAWA freely available to researchers within the IDI. The capabilities of microsimulation models will continue to grow as techniques and data improve, and encouraging people to use these models will help make the most of this potential. This would, in turn, lift understanding of the incidence and causes of poverty and improve the living standards of New Zealand's poorest families.

## References

- Alinaghi, N., N. Gemmill and J. Creedy (2021) 'Designing personal income tax and transfer reforms: alternative modelling approaches', *Australian Economic Review*, 45 (4), pp.445–61
- Aziz, O., M. Gibbons, C. Ball and E. Gorman (2012) 'The effect on household income of government taxation and expenditure in 1988, 1998, 2007 and 2010', *Policy Quarterly*, 8 (1), pp.29–38
- Beer, G. (2018) *Review of the Treasury's Usage of its Tax and Welfare Analysis Model to Provide Advice on Numbers of Children in Low Income Households*, Department of the Treasury, Australia
- Blundell, R., A. Bozio and G. Laroque (2013) 'Extensive and intensive margins of labour supply: work and working hours in the US, the UK and France', *Fiscal Studies*, 34 (1), pp.1–29
- Crawford, R. and G. Johnston (2004) *Household Incomes in New Zealand: the impact of the market, taxes and government spending, 1987/88–1997/98*, working paper 04/20, Treasury
- Creedy, J. (1999) 'Taxation, redistribution and progressivity: an introduction', *Australian Economic Review*, 32 (4), pp.410–22
- Creedy, J., A. Duncan, M. Harris and R. Scutella (2002), *Microsimulation Modelling of Taxation and the Labour Market: the Melbourne Institute Tax and Transfer Simulator*, Cheltenham: Edward Elgar
- Crichton, S. and H. Nguyen (forthcoming) 'Wellbeing in New Zealand: a population segmentation analysis', Treasury Paper
- Davis, C. (2021) 'Using administrative data to better model receipt of transfers', paper presented to the 61st annual meeting of the New Zealand Association of Economists, Wellington
- Davis, C. (2022) 'Households distributional impacts of NZ Emission Trading Scheme carbon prices', paper presented to the 62nd annual meeting of the New Zealand Association of Economists, Wellington
- Eppel, E. and M. Lips (2021) 'Statistics, big data and digital government', in G. Hassall and G. Karacaoglu (eds), *Social Policy Practice and Processes in Aotearoa New Zealand*, Wellington: Massey University Press
- Gemmill, N. (2021) *Economic Lessons for Tax Policy Advisers*, working paper in public finance 02/21, Wellington: Victoria Business School
- Jones, C., A. McDowell, V. Galvin and D. Adams (2022) 'Building on Aotearoa New Zealand's Integrated Data Infrastructure', *Harvard Data Science Review*, 4.2, Spring
- McLeod, K. and M. Wilson (2021) *Estimates of the Change in Family Incomes after the Introduction of the Families Package*, Wellington: Ministry of Social Development
- Nolan, P. (2006) 'Tax relief for breadwinners or caregivers? The designs of earned and child tax credits in five Anglo-American countries', *Journal of Comparative Policy Analysis: Research and Practice*, 8 (2), pp.167–83
- Nolan, P. (2018a) *Effective Marginal Tax Rates: the New Zealand case*, working paper 7/2018, Canberra: Tax and Transfer Policy Institute
- Nolan, P. (2018b) 'The tax–benefit interface', *Policy Quarterly*, 15 (1), pp.17–22
- Rogers, J. (2018) 'Assumptions in economics are like maps', *Law and Liberty*, 21 December, <https://lawliberty.org/assumptions-in-economics-are-like-maps/>
- Stephens, M. (2022) 'The art of the possible: data driven insights into child poverty in New Zealand', *Policy Quarterly*, 18 (3)
- Stephens, R. and C. Waldegrave (2001) 'The effectiveness of the transfer and tax system in reducing poverty in 1998', *Social Policy Journal of New Zealand*, 16, pp.77–107
- Symes, L. (2021) 'The wealth ladder: house prices and wealth inequality in New Zealand', Treasury Analytical Note
- Symes, L. (2022) 'House prices and wealth inequality in New Zealand', *Policy Quarterly*, 18 (3)
- Symes, L. and C. Davis (2020) 'The TAWA tax and welfare microsimulation model', internal Treasury presentation, 10 August
- Wang, Y. (2021) 'Analytical report: sensitivity of child poverty projections to economic forecasts', paper presented to the 61st annual meeting of the New Zealand Association of Economists, Wellington
- Wang, Y. (2022) 'An expenditure-based approach to measuring child poverty in New Zealand', *Policy Quarterly*, 18 (3)

- 1 The views, opinions, findings and conclusions or recommendations expressed in this article are strictly those of the authors. They do not necessarily reflect the views of the Treasury or the New Zealand government. The Treasury and the New Zealand government take no responsibility for any errors or omissions in, or for the correctness of, the information contained in this article. The article is presented not as policy, but with a view to inform and stimulate wider debate.
- 2 The results in this article are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI), which is carefully managed by Statistics New Zealand. The IDI is a large research database which contains administrative data about people and households. These data come from government agencies and non-government organisations: for example, income and tax records from Inland Revenue and social benefit records from the Ministry of Social Development. For more information about the IDI please visit <https://www.stats.govt.nz/integrated-data/>. The results are based in part on tax data supplied by Inland Revenue to Statistics New Zealand under the Tax Administration Act 1994 for statistical purposes. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes and is not related to the data's ability to support Inland Revenue's core operational requirements. Access to the survey data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics New Zealand or individual data suppliers.