Who Would Win from a Multi-rate GST in New Zealand: Evidence from a QUAIDS Model

Alastair Thomas

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Further enquiries to:
The Administrator
Chair in Public Finance
Victoria University of Wellington
PO Box 600
Wellington 6041
New Zealand

Phone: +64-4-463-9656
Email: cpf-info@vuw.ac.nz

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ABSTRACT

Who would win from a multi-rate GST in New Zealand: Evidence from a QUAIDS model

This paper provides the first estimates of a Quadratic Almost Ideal Demand System (QUAIDS) for New Zealand and uses this model to investigate the distributional effects of a move to a multi-rate GST system. The estimated QUAIDS model covers nine non-durable expenditure groups and produces highly plausible expenditure and price elasticity estimates. Behavioural simulation results show that a multi-rate GST structure would, on average, benefit poorer households relative to richer households – both in terms of the tax households pay and money-metric welfare. However, around 27% of the poorest decile would lose from the reform due to their particular consumption preferences, while around 19% of the richest decile would gain. Behavioural simulation results also confirm the finding from previous non-behavioural analysis that the distributional impact of reduced GST rates can vary significantly depending on the type of expenditure subject to the reduced rate. Overall, the GST system is found to be a poor mechanism for targeting support to poorer households.

Keywords: GST, VAT, QUAIDS, reduced rates, distributional effects
JEL Codes: H23, H24.

WHO WOULD WIN FROM A MULTI-RATE GST IN NEW ZEALAND: EVIDENCE FROM A QUAIDS MODEL

Alastair Thomas[1]

1. Introduction

New Zealand's goods and services tax (GST) is often highlighted as an example of best practise design of a value-added tax system.[2] Its broad-based, single-rate structure minimises compliance and administrative costs, avoids distortions to consumption decisions, and raises significant revenue despite a moderate rate of 15%. In contrast, most other OECD countries have adopted multi-rate systems that apply reduced rates to a selection of goods and services. A key motivation for such concessionary rates has been to target support to the poor. This paper investigates the distributional effects of a move to a multi-rate GST system in New Zealand and, in particular, whether the introduction of reduced GST rates would be an effective way of providing support to poorer households.

As the move to a multi-rate GST system will alter the relative prices of goods and services, it is important to account for the resulting changes in consumption patterns as these will affect the revenue raised post-reform. This is achieved through the estimation of a Quadratic Almost Ideal Demand System (QUAIDS) for New Zealand. As the QUAIDS model is based on consumer demand theory and imposes restrictions consistent with utility maximisation, it also allows money-metric welfare measures to be estimated. The modelling is based on household expenditure microdata from the four most recent Household Economic Surveys (HES) and corresponding consumer price index (CPI) price data, both provided by Statistics New Zealand.[3]

The QUAIDS model developed by Banks et al. (1997) is the quadratic extension of the Almost Ideal (AI) demand system of Deaton and Muellbauer (1980a). The QUAIDS model provides greater flexibility than the AI model, allowing a good to be a necessity at one expenditure level and a luxury at another expenditure level. Estimation of the QUAIDS model has substantial data requirements beyond those of the AI model,

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[1] Thanks to John Creedy and Norman Gemmell for helpful comments. Thanks also to Statistics New Zealand's microdata access team for assistance with the Household Economic Survey microdata.

[2] See, for example, Cnossen (2002).

[3] Access to the New Zealand Household Economic 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 the study are the work of the author, not Statistics New Zealand.

and hence a QUAIDS model has not previously been estimated using New Zealand data. However, the availability of price data at a regional level corresponding to the four most recent years of the HES now provides sufficient price variation to feasibly estimate the model for New Zealand. This paper therefore provides the first estimates of a QUAIDS model based on New Zealand data.

The estimated QUAIDS model covers nine non-durable expenditure groups. Expenditure and price elasticity estimates are highly plausible. All expenditure elasticities are positive, with the “food and non-alcoholic beverages”, “transport fuels”, and “household utilities, communication and education” expenditure groups found to be necessities. The “clothing and footwear”, “recreation and culture”, and “transport (excluding transport fuels)” groups were clear luxuries. Meanwhile, the “food and non-alcoholic beverages” and “recreation and culture” groups were the least price responsive, although “food and non-alcoholic beverages” – with an uncompensated own-price elasticity of -0.566 – was slightly more responsive than may have been anticipated. The general “personal expenditure” and “household utilities, communication and education” expenditure groups were found to be the most price-responsive.

The QUAIDS model is used to examine two multi-rate GST reforms. For each reform the paper estimates both the change in tax paid and the welfare change (as measured by the compensating variation). While the welfare change can be calculated directly from the QUAIDS model, the QUAIDS model must be incorporated into a consumption tax microsimulation model to calculate the change in tax paid. Simulations results are for 2015-16, the most recent year for which HES data is available.

The first reform considers the introduction of reduced GST rates on two of the nine non-durable expenditure groups from the QUAIDS model: “food and beverages” and “recreation and culture”. These groupings include all food (including restaurant food), newspapers, books, magazines, cinema, theatre, concerts, hotels and other accommodation services. As such, the reform covers eight of the 11 most common expenditure groups to be taxed at reduced rates in OECD countries (OECD, 2014). Both tax and welfare change results show that such a reform will have a small progressive effect – providing greater support to poorer deciles when measured as a proportion of their total spending. However, richer deciles are shown to gain considerably more in absolute terms – highlighting the poorly targeted nature of the GST system as a tool for supporting poorer households. Results are also found to differ between the two expenditure groupings. While the reduced rate on food largely mimics the overall results (and indeed drives them due to its greater budget share), the reduced rate on recreation and culture actually has a regressive effect.

The second reform scenario introduces the same reduced rates as the first reform while increasing the standard rate applying to other expenditure groups to ensure revenue neutrality (thereby eliminating broader effects of the reform on the economy). Tax results show that, on average, poorer deciles benefit from the reform and richer deciles lose. However, around 27% of the poorest decile lose from the reform due to their particular preferences for consuming standard-rated vs reduced-rated goods. Meanwhile, around 19% of the richest decile gain from the reform due to their particular consumption preferences. While both tax and welfare change results are broadly similar, some small differences arise. For example, some richer households adjust their consumption patterns sufficiently so that they pay less tax following the reform, but still suffer a welfare loss due to this tax-induced distortion to their behaviour.

Overall the results for both reforms show the poorly targeted nature of the GST as a means of supporting poorer households. The results for the reduced rate on food and beverages are consistent with those obtained for food in Ball et al. (2016) for New Zealand. The differing results for recreation and culture highlight that the effect of a reform can vary significantly depending on the type of expenditure subject to a reduced rate. This finding is consistent with the non-behavioural analysis undertaken for New Zealand in Thomas (2015) and for 20 OECD countries in OECD (2014) – both of which found significant variation in the distributional impact of reduced rates across expenditure groups. The QUAIDS-based results of this paper show that such variation is still present once behavioural responses to the tax changes are accounted for.

The paper proceeds as follows: section 2 provides a literature review on demand system modelling with specific emphasis on previous modelling with New Zealand data; section 3 discusses the methodological approach adopted to estimate the QUAIDS model, including the data used; section 4 presents the results of the QUAIDS model; section 5 presents the multi-rate GST simulation results; section 6 concludes.

2. Literature Review

The first full demand system to be estimated was the linear expenditure system (LES) by Stone (1954), who algebraically imposed the theoretical restrictions of adding-up, homogeneity and symmetry on a general linear functional form. The LES functional form is, however, quite restrictive: for example, it excludes the possibility of inferior goods or of complements. Subsequent research has therefore investigated less restrictive functional forms. Important models that have been developed include the Rotterdam model (Thiel, 1965; Barten, 1966) and the translog model (Christensen et al., 1975). However, the most popular model has been the Almost Ideal (AI) model of Deaton and Muellbauer (1980a), and its quadratic extension (QUAIDS) by Banks et al. (1997). In particular, whereas previous models impose a linear relationship between budget shares and the log of total expenditure, the QUAIDS model allows for a non-linear relationship – thereby allowing a good to be a necessity at one level of income and a luxury at another.

There have been a large number of applications of the AI and QUAIDS models since their introduction, though limitations in data availability – as has been the case in New Zealand – have tended to limit such studies to a small range of countries. However, as availability of expenditure microdata and disaggregated price data has increased, so too has the feasibility of QUAIDS modelling. In particular, the analysis of indirect tax reforms has motivated the estimation of QUAIDS models in a number of countries in the last few years, including: Bover et al. (2017) for Spain; Cseres-Gergely et al. (2017) for Hungary; Abramovsky et al. (2015) for Mexico; Jansky (2014) for the Czech Republic; and IFS (2011) which included five separate case studies covering Belgium, France, Germany, Spain, and the United Kingdom. Meanwhile, several recent studies have been motivated by food policy issues (including taxation), and have therefore limited their models to food expenditure. These include: Caro, Smith-Taillie et al. (2017) for Chile; Caro, Ng, et al. (2017) for Colombia; and de Agostini (2014) for the United Kingdom. Other papers have focused purely on demand behaviour, such as Gostkowski (2018) for Poland.

There are a number of commonalities in the methodological approaches adopted by these recent studies. With the exception of Gostkowski (2018) and some of the case studies in IFS (2011), durable goods have been excluded from the analyses.[4] This is to remove the potentially distorting impact of large one-off purchases that: (1) would only be partially captured in the fixed coverage period of a household survey; and (2) do not reflect actual consumption (which is instead spread over the life of the durable). In most cases, the standard QUAIDS model is also extended to incorporate demographic variables following the translating approach of Pollak and Wales (1978) which incorporates demographics as taste-shifters within the intercept term of the demand equations. Price variation has been maximised by using multiple years of household expenditure survey and price data and, where possible, by obtaining regional and monthly/quarterly breakdowns of this data. Estimation typically follows an iterated seemingly unrelated regression approach, with most studies instrumenting for the potential endogeneity of total expenditure using disposable income.

Given the significant data requirements for demand system modelling, the New Zealand-specific literature in this area is sparse. Given the even greater demands of the QUAIDS model, no QUAIDS modelling has previously been undertaken in New Zealand. That said, several AI and Rotterdam models have been estimated.

[4] Abramovsky et al. (2015) only exclude large durables such as house and vehicle purchases.

Michelini (1999) uses semi-aggregated annual household expenditure data from 1983-84 to 1991-92 to estimate an AI model for New Zealand covering six expenditure groups. To aid estimation, the linearised version of the model is adopted (using the Stone price index instead of the translog price aggregator of the full AI model). Housing is excluded from the model, but other durables are included. Michelini finds plausible estimates of own-price and total expenditure elasticities, with two of the six expenditure groups – food and "household operational expenditure" – found to be necessities. These two groups are also found to be highly price inelastic. Other expenditure groups are also price inelastic, with the exception of apparel which was highly elastic.

In two similar papers, Khaled and Lattimore (2006, 2008) estimate Rotterdam demand models focusing, respectively, on the apparel sector and the housing sector in New Zealand. In both cases they rely on household economic survey microdata from 1981 to 2004 and CPI price data and follow a two-step budgeting process whereby total expenditure is first allocated across six broad expenditure groups, and then expenditure is allocated within those groups. Among their six broad expenditure groups, they find, in both papers, housing and transport to be luxury goods, and the other groups to be necessities. Frisch own-price elasticities showed all groups to be inelastic, except apparel – mirroring the findings of Michelini (1999).

In their 2006 paper, Khaled and Lattimore break the apparel expenditure category into eight sub-groups and find demand to also be elastic amongst apparel types, together with significant cross-price effects. In their 2008 paper, they break housing expenditure into rented and owner-occupied housing (estimating the price they need for owner-occupied housing following a user cost of capital approach). In their conditional model of housing demand, they find owner-occupied housing to be a luxury and rental housing to be a necessity. They find very small cross-price effects on housing demand.

Most recently, Ni Mhurchu et al. (2013) estimate a linearised AI model for food expenditure in New Zealand. They use data from the 2006-07 and 2009-10 household economic surveys together with highly disaggregated Food Price Index (FPI) data. The FPI data was available on a monthly basis across 15 regions which could be matched to the six regions in the HES data, thereby providing substantial price variation. The estimated model was extended to include demographic variables and covered 24 food groups. Given this large disaggregation of food expenditure, and hence large number of observations with zero expenditure for particular categories, they address potential censoring bias by applying a Heckman two-step procedure. They find significant variation in own-price elasticities ranging from -0.44 to -1.78, while cross-price estimates are typically (but not always) small. They also estimate the model on several ethnic and income subsets of the data finding that own-price elasticities tended to be stronger (i.e. more negative) for lower as compared to higher income quintiles, and for Maori as compared to non-Maori.

While not modelling full demand systems, two other papers are of particular relevance given their focus on New Zealand's GST rate structure. Ball et al. (2016) examine the welfare effects of zero-rating food in New Zealand's GST system. They incorporate demand responses into their microsimulation analysis following the approach introduced by Creedy (1998), which itself draws on a result established for directly additive utility functions by Frisch (1959). This approach is based on the linear expenditure system and relates price elasticities to total expenditure elasticities, budget shares and the elasticity of the marginal utility of income. As such, it requires only the estimation of expenditure elasticities and can therefore be undertaken on cross-sectional data without information on prices. Based on 2009-10 HES data, they find that zero-rating food expenditure produces a small amount of progressivity in the GST, measured as the change in equivalent variation as a proportion of total expenditure, but that better off households receive greater absolute welfare gains. Under a revenue neutral reform, the welfare gain to poorer households remains positive but richer households who spend a greater proportion of their expenditure on standard rated goods are made worse off. Redistribution is also found to occur from high spending households without children towards lower spending households with children and to older households.

Finally, Thomas (2015) uses a non-behavioural microsimulation model to simulate (holding quantity constant) the introduction of a European-style GST rate structure including zero rates for a large number of expenditure items. Results suggest that such a reform would provide greater support to poorer households when measured as a proportion of total spending, but that richer households would gain considerably more in absolute terms. Results were also found to differ depending on the particular reduced rate, with some reduced rates (such as on hotel accommodation and restaurant food) providing a greater benefit to richer households both proportionately and in absolute terms. The current paper is, in broad terms, an extension of this analysis taking into account consumer behavioural responses.

3. Methodology

The quadratic almost ideal demand system

The Quadratic Almost Ideal Demand System (QUAIDS) was developed by Banks et al. (1997) as an extension of the Almost Ideal Demand System (AI) of Deaton and Muellbauer (1980a). The AI model is derived from a specific class of preferences – price-independent generalised logarithmic (Muellbauer, 1976) (PIGLOG) – that permit aggregation over consumers. PIGLOG preferences produce a demand function that is linear in prices and log expenditure. Banks et al. (1997), however, observe that the addition of a quadratic term in log expenditure will often provide a better fit for their long time series of British data. They show that an indirect utility function of the following form will produce such a demand function:

$$\ln V = \left[\left(\frac{\ln m - \ln a(p)}{b(p)}\right)^{-1} + \lambda(p)\right]^{-1} \tag{1}$$

where V is indirect utility, m is total expenditure, and $\ln a(p)$, $b(p)$ and $\lambda(p)$ are differentiable functions defined as:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln p_i \ln p_j \tag{2}$$

$$b(p) = \prod_{i=1}^{N} {p_i}^{\beta_i} \tag{3}$$

$$\lambda(p) = \sum_{i=1}^{N} \lambda_i \ln p_i \tag{4}$$

Equations 2 and 3, respectively, are the translog price aggregator and Cobb-Douglas price aggregator functions of the AI model.[5] Substituting equations 2-4 into 1, differentiating with respect to p_i and m and then applying Roy's identity, gives the budget share equations of the QUAIDS model[6]:

$$w_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{m}{a(p)}\right) + \frac{\lambda_i}{b(p)}\left[\ln\left(\frac{m}{a(p)}\right)\right]^2 \tag{5}$$

Setting $\lambda_i = 0$ would result in the AI specification, and enables easy testing of the empirical relevance of the quadratic term. To be consistent with utility maximisation, demand theory implies the following constraints:

Adding up: $\sum_{i=1}^{N} \alpha_i = 1$; $\sum_{i=1}^{N} \beta_i = 0$; $\sum_{i=1}^{N} \gamma_{ij} = 0$ for all j ; $\sum_{i=1}^{N} \lambda_i = 0$

Homogeneity: $\sum_{j=1}^{N} \gamma_{ij} = 0$

Symmetry: $\gamma_{ij} = \gamma_{ji}$

These constraints can be imposed during estimation. A fourth requirement of demand theory – negativity – cannot be imposed, but can be tested for.

[5] As specified in Banks et al. (1997). The original specification in Deaton and Muellbauer (1980a) varies slightly. Note that setting $\lambda(p)$=0 reduces equation 1 to the indirect utility function of the AI model.

[6] Alternatively, one could rearrange for the expenditure function and apply Sheppard's lemma, as in the original derivation of the AI budget share equations in Deaton and Muellbauer (1980a,b).

Expenditure and price elasticities can be obtained from equation 5. Following the concise presentation in Banks et al. (1997), first differentiate equation 5 with respect to $\ln m$ and $\ln p_j$:

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(p)}\left[\ln\left(\frac{m}{a(p)}\right)\right] \tag{6}$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_{k=1}^{N}\gamma_{jk}\ln(p_k)\right) - \frac{\lambda_i\beta_j}{b(p)}\left[\ln\left(\frac{m}{a(p)}\right)\right]^2 \tag{7}$$

The expenditure elasticities are then $e_i = \mu_i/w_i + 1$, while uncompensated price elasticities are $e_{ij}^{u} = \mu_{ij}/w_i - \delta_{ij}$, where $\delta_{ij}$is the Kronecker delta ($\delta_{ij} = 1$ if $i = j$, and zero otherwise). Compensated elasticities can of course be calculated using the slutsky equation ($e_{ij}^{c} = e_{ij}^{u} + e_i w_j$). Unlike the original AI model, the QUAIDS model enables a good to be a necessity at one expenditure level and a luxury at another expenditure level. This can be seen from the expenditure elasticity: for a positive β_i and negative λ_i, the expenditure elasticity will be greater than unity at low expenditure levels, but will fall as expenditure increases eventually falling below unity.

A key benefit of demand system modelling is the ability to carry out welfare analysis. To calculate the welfare change of a reform, the compensating or equivalent variation can be calculated from the expenditure function. The compensating variation (CV) can be calculated as:

$$CV = E(u^0, p^1) - E(u^0, p^0) \tag{8}$$

$$= e^{\ln a(p^1) + b(p^1)\{(1/\ln u^0)\lambda(p^1)\}^{-1}} - e^{\ln a(p^0) + b(p^0)\{(1/\ln u^0)\lambda(p^0)\}^{-1}} \tag{9}$$

where p^0 and p^1 and pre- and post-reform prices, respectively, and u^0 is pre-reform utility. Pre-reform utility is calculated from the indirect utility function using pre-reform prices.

As equation 5 shows, the QUAIDS model explains demand for each good in terms of prices of all goods and total expenditure. Implicit in the inclusion of total expenditure rather than income in the model is intertemporal separability – i.e. that the decision on how to allocate total expenditure in the current period can be made separately from the decision on how to allocate expenditure across periods (through borrowing and saving). As some degree of aggregation of goods is required, it also assumes separability of preferences between the broad expenditure groups modelled. Additionally, the model assumes separability of consumption and labour supply decisions, and that no externalities exist. These last two assumptions, in particular, are restrictive and should be borne in mind when using the model.

Data

Estimation of the QUAIDS model requires data on both household expenditure and prices. Expenditure data are obtained from the Household Economic Survey (HES). The HES is a sample survey of household expenditure conducted once every three years. HES data was made available by Statistics New Zealand for the six most recent surveys (2000-01, 2003-04, 2006-07, 2009-10, 2012-13 and 2015-16). Each survey covers approximately 3000 households (different households each year) resulting in a total possible sample size of 18,190 households. The HES breaks expenditure into almost 2000 different categories, and also contains a range of demographic variables. While there have been some minor variations in categorisation at a detailed level across the six HES surveys, these disappear on aggregation into broader categories.

Price data are taken from Statistics New Zealand's publically available Consumer Price Index series. National level price data is available for more than 100 different expenditure categories from 1999 onwards. Additionally, regional price data is publically available for 12 expenditure categories, but only from 2006 onwards. This data breaks the country into five regions: Auckland, Wellington, the rest of the North Island, Christchurch, and the rest of the South Island. The available categories in both the national and regional price data follow the same classification system as the HES data – making matching the datasets a relatively simple process. All price data is available on a quarterly basis and can be matched to the HES data based on the month of survey response.

The QUAIDS model was initially estimated with two different matched datasets: first with all six available HES surveys matched to national price data for each quarter (18,190 observations); second with the four most recent HES surveys matched to regional price data for each quarter (12,266 observations). Unfortunately, the degree of price variation available from the larger national price dataset[7] proved insufficient for identification, and so only the smaller regional price dataset is utilised in the analysis in this paper.[8]

[7] 24 different sets of prices (6 years x 4 quarters) vs 80 (4 years x 4 quarters x 5 regions).
[8] Modelling was attempted for a range of expenditure groupings and compositions using the larger dataset, with group prices initially calculated as averages of the prices of the constituent expenditure items weighted by their average population within-group expenditure shares. Following IFS (2011), attempts were made to increase price variation by calculating group average prices based on the within-group expenditure shares of each household, so that the average price varied depending on each household's actual consumption pattern. However, this approach risks conflating quality variation with price variation resulting in spurious relationships. This was indeed the case here, leading, for example, to positive price elasticities for some expenditure groupings.

While there is a large gain in terms of price variation with the use of the regional price data, it comes with two clear costs. First, the sample size is reduced by around one third. Second, very little flexibility is provided regarding the choice of expenditure groupings to be used in the analysis.

The limited number of groupings available is not a significant issue because it would in any case be necessary to limit the number of expenditure groups to feasibly estimate the QUAIDS model due to the large number of parameters that must be estimated. However, the restricted choice of composition of those categories is a significant limitation as ideally expenditure would be grouped in a way that best matches the policy reforms to be simulated (while at the same time grouping similar goods together to conform as closely as possible with the separability assumption[9]).

An additional problem also faced by studies in this area is the impact of infrequently purchased durable goods on the analysis. Ideally, the consumption benefit from a durable good would be apportioned across its useful life, and so only the component "consumed" in the year of the survey would be taken account of in the analysis. However, the HES only reports the actual purchase of durable goods – meaning either a large or zero expenditure amount is reported depending on whether these infrequent purchases are made during the survey period. This can significantly distort the analysis and hence – as noted above – the typical approach adopted in recent studies has been to exclude durables. Inclusion of durables poses similar problems in the current analysis and hence durables are also excluded from the QUIADS model here.[10] However, for the policy simulations in section 5, durables are included as an additional expenditure category – with their demand unaffected by the price changes to non-durables. This effectively assumes separability of durable and non-durable consumption decisions. That is, households are assumed to first decide how much of their total expenditure to spend on durables vs non-durables, before then considering how to allocate their non-durable expenditure.

As part of the durables category, expenditure on rented housing is also excluded. While actual rental expenditure is included in the HES data, imputed rental expenditure from homeowners is not. As such, inclusion of rental expenditure would have resulted in only a partial inclusion of total housing consumption, with the absence of imputed rental expenditure potentially biasing results. While beyond the scope of this

[9] Expenditure groupings can be justified on the basis of weak separability which requires that preferences for goods within a particular group can be described independently of the quantities in other groups (Deaton and Muellbauer, 1980b).
[10] Including durables for either of the two datasets led to clearly spurious results, including several positive own-price elasticities.

paper, a potential future extension of this work would be to estimate imputed rental expenditure and to include both this estimate, and the reported actual rental expenditure, in the modelling.[11]

Regional price data were available for the following broad expenditure categories: food and beverages; alcohol and tobacco; clothing and footwear; housing and household utilities; household contents and services; health; transport; recreation and culture; miscellaneous goods and services. Additionally, regional prices were separately available for petrol (which is part of the wider transport category) and for actual rentals for housing and purchase of housing (which are both part of the wider housing and household utilities category). While these classifications match largely with the classifications in the HES, they entirely miss two HES expenditure groups: communications and education.

From these 12 partially overlapping categories, those that entirely or predominantly contain durables are excluded: housing and household utilities; household contents and services; actual rentals for housing; and purchase of housing. While the "household contents and services" category contains, on average, 80.4% durables, removing the "housing and household utilities" category is more problematic as household utilities (comprising household energy and property rates) make up on average 8.5% of total consumption reported in the HES. Exclusion of the communications and education categories is also problematic as they make up on average another 5.4% of total consumption in the HES. As such, these three categories are included in the modelling based on just national price data.

Separate inclusion of these three extra categories was not feasible due to the more limited price variation in the national price data. They are instead combined into one additional category and the necessary price variation is obtained by calculating an average price for the category weighted by each household's expenditure. While this approach poses some risk of conflating quality effects with price effects, it is the only means available to include the additional expenditure in the model. Sensitivity analysis shows that the inclusion of this additional category only has a small impact on the elasticity estimates for the categories that are based on regional price data, and hence any risks are judged to be outweighed by the benefit of being able to include an extra 13.9% of total household expenditure in the model.

The final expenditure groupings are as follows:

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[11] Imputed rental expenditure of homeowners is estimated by a number of national statistics agencies in their household expenditure surveys, following a range of different methodologies. One possibility would be to base estimation of imputed rental on factors such as region, house size and property rates paid to local councils and reported in the HES (such an approach was undertaken, for example, for the United Kingdom by Brewer and O'Dea, 2012).

1. Food and beverages (including restaurant food)
2. Alcohol and tobacco
3. Clothing and footwear
4. Healthcare
5. Transport (excluding transport fuels)
6. Transport fuels
7. Recreation and culture
8. Other personal expenditure
9. Household utilities, communication and education

There are several additional compromises that are made in order to obtain the above expenditure groupings. Petrol, diesel and LPG are included in the "transport fuels" category, but the petrol price is used to proxy the average price for the category as it is the only one available on a regional basis. These three transport fuels, as well as vehicle purchases, are consequently excluded from the broader transport category. However, as no further breakdown is available in the regional price data, the average price of the transport category cannot be adjusted. As such, it still incorporates the prices of transport fuels and vehicle purchases in its calculation. This is of some concern as transport fuels and vehicle purchases comprise on average 28.7% and 33.4%, respectively, of the total transport category, and hence can be expected to have a strong influence on the average price of the category.

Similarly, three durable goods categories are removed from the wider "recreation and culture" grouping, but the average regional price for the whole category is used.[12] This presents a similar concern as these durables constitute on average 40.0% of the "recreation and culture" grouping.

Estimation

To estimate the QUAIDS model I follow the iterated linear least squares approach proposed by Blundell and Robin (1999), utilising the "AIDSILLS" Stata program developed by Lecocq and Robin (2015). This approach takes advantage of the fact that the QUAIDS demand system is linear in all parameters conditional on the price indexes, and so standard linear estimation techniques can be utilised.

[12] The three excluded categories are "audio-visual and computing equipment", "major recreational and cultural equipment" and "other recreational equipment and supplies".

An iterative process is followed. First, the two price indexes, $a(p)$ and $b(p)$, are fixed (with the stone price index and 1 used, respectively, as their initial values[13]). With these fixed values, the budget share equations are then estimated using the seemingly unrelated regressions (SUR) approach – which adjusts the variance-covariance matrix for correlation of the error terms across equations[14]. Using the resulting parameter estimates, the two price indexes are then re-calculated and the budget share equations are re-estimated. This process is then repeated until the parameter estimates converge to more than four decimal places. Blundell and Robin (1999) show that this process produces consistent and asymptotically normal parameter estimates.

To avoid singularity (as the dependent variables of all the equations sum to one), the last equation is dropped during estimation, with its parameter estimates being recovered via the adding-up constraints (and thereby automatically imposing additivity). Homogeneity is imposed by including the first *N*-1 prices as relative prices using the *N*th price as the reference price, and then removing the *N*th price as an explanatory variable.[15] Symmetry is then imposed via linear restrictions on the parameters.[16]

As is common in the literature, I extend the QUAIDS model to incorporate demographic variables following the "translating" approach of Pollak and Wales (1978) in which demographic variables enter as taste-shifters through the intercept term in the budget share equations.[17] Specifically, α_i is replaced by α_i^Z, in both equations 2 and 5, where:

$$\alpha_i^Z = \alpha_i + \sum_{k=1}^{K} \alpha_{ik}\, z_k \qquad (10)$$

[13] These are the most commonly applied initial values used in the literature. The stone price index is calculated as the average price weighted by the mean budget shares: $\sum \overline{w}_i\, p_i$.
[14] As Lecocq and Robin (2015) note, OLS and SUR would produce identical parameter estimates as the right hand variables in each budget share equation are identical.
[15] Following estimation, absolute price effects are then recovered from the relative price effects.
[16] Symmetry is only imposed following the iterative process. Lecocq and Robin (2015) note that imposing symmetry during each iteration produces almost identical results but increases the number of estimations that do not converge.
[17] This approach has been adopted in a range of recent studies, including: Cseres-Gergely (2017), Abramovsky et al. (2015), Jansky (2014) and IFS (2011), and in the AIDSILLS program of Lecocq and Robin (2015). There are however a range of way to include demographic effects (Pollak and Wales, 1981). For example, Poi (2012) applies the demographic scaling approach of Ray (1983) in his "quaids" Stata program. The scaling approach is arguably more flexible than the translating approach, but the translating approach maintains the conditional linearity of the demand system thereby increasing computational ease and speed. For comparison, I apply both Lecocq and Robin's (2015) AIDSILLS program and Poi's (2012) quaids program to model the demand system with the same 11 demographic variables (but without instrumenting total expenditure in either case) and find very similar results. I prefer the AIDSILLS program as it enables potential endogeneity in total expenditure to be instrumented for and is computationally faster.

and z_k is a set of K demographic variables. This allows the budget shares to vary depending on the demographic variables while maintaining the conditional linearity of the model. A further adding-up condition must also be included to ensure consistency with demand theory and enable welfare analysis:

$$\sum_{i=1}^{N} \alpha_{ik} = 0.$$

The demographic variables included are:

- The adult equivalent size of the household.[18]
- The number of adults in the household.
- The number of children in the household.
- The age of the household reference person.[19]
- The gender of the household reference person (set to 1 if male; zero otherwise).
- A regional dummy (set to 1 if the household lives in Auckland; zero otherwise).
- An ethnicity dummy (set to 1 if the household reference person is European/pakeha; zero otherwise).
- A tertiary education dummy (set to 1 if the household reference person's highest qualification is at tertiary level; zero otherwise).
- A secondary education dummy (set to 1 if the household reference person's highest qualification is at secondary level; zero otherwise).
- A full-time employment dummy (set to 1 if at least one adult in the household is in full-time employment; zero otherwise).
- A time variable specifying the quarter during which the HES questionnaire was completed (between 1 (Q3 2006) and 40 (Q2 2016)).

Another common issue in demand system estimation is the potential endogeneity of the total expenditure variable.[20] Specifically, the error term may be correlated with the total expenditure variable if, for example, tastes and total expenditure are both affected by the same shocks. To address this concern I instrument for total expenditure using disposable income. This approach was adopted by Banks et al. (1997) in their original empirical illustration of the QUAIDS model and subsequently by various authors including the recent studies by Cseres-Gergely et al. (2017), Abramovsky et al. (2015), and Jansky (2014). It is included as a key feature of Lecocq and Robin's (2015) AIDSILLS Stata program and I therefore follow their approach, which

[18] The adult equivalent size is calculated using the parametric equivalence scale presented in section 5.
[19] The reference person is normally determined by who takes responsibility for answering the questionnaire.
[20] In studies that use unit values (expenditure divided by quantity from household expenditure survey data) rather than separate price data, endogeneity can also be a problem as quality affects captured in the unit values may be correlated with the error term. As argued by Jansky (2014), the use of CPI price data – as used here – mitigates such concerns.

includes all price and demographic variables, together with log disposable income, as independent variables in the first stage regressions.[21]

4. QUAIDS results

Expenditure and own-price elasticities

The expenditure and own-price elasticity estimates (evaluated at the means of all the variables) from the QUAIDS model are presented in Table 1. As expected, all expenditure elasticities are positive. Three expenditure groupings are found to be necessities, with elasticity values less than unity: food and beverages; transport fuels; and household utilities, communications and education. This broadly conforms with ex ante expectations of typical necessity goods. That said, within the latter group, education may not necessarily be expected to be a necessity given that roughly half of this category in the HES data constitutes either private primary and secondary education expenditure or tertiary education expenditure. The influence of education expenditure on the results may therefore have been outweighed by the necessity nature of household utility and communication expenditure. The empirical need to group these three expenditure categories together (as only annual price data was available for them) means that this potential problem was unavoidable.

Table 1. Budget shares, expenditure and own-price elasticities

	Observed shares	Predicted shares	Expenditure elasticity	Uncompensated price elasticity	Compensated price elasticity
1. Food and non-alcoholic beverages	0.291	0.292	0.776***	-0.566**	-0.333
2. Alcohol and tobacco	0.045	0.045	1.144***	-0.951	-0.898
3. Clothing and footwear	0.040	0.040	1.668***	-0.632	-0.568
4. Healthcare	0.040	0.040	1.161***	-0.711	-0.666
5. Transport (excluding transport fuels)	0.076	0.076	1.485***	-1.474	-1.368
6. Transport fuels	0.069	0.069	0.789***	-0.613*	-0.555
7. Recreation and culture	0.073	0.073	1.486***	-0.535	-0.430
8. Other non-durable personal expenditure	0.145	0.145	1.393***	-2.339*	-2.137
9. Household utilities, communication and education	0.221	0.221	0.618***	-1.612***	-1.479***

* p<0.05, ** p<0.01, *** p<0.001

The remaining expenditure groupings can be classified as luxuries, with expenditure elasticities in excess of unity. These include goods typically thought of as luxuries such as: clothing and footwear; recreation and culture, and other personal expenditure. In contrast to transport fuels, the general transport category is also

[21] The instrumental variable (two-stage least squares) procedure has two stages: in the first stage, log total expenditure is regressed on the instrumental variable (log disposable income) and the price and demographic variables; in the second stage, the demand equations are estimated with the error term from the first stage regression added as an additional explanatory variable. As two-stage least squares is combined with SUR, the process becomes equivalent to three-stage least squares regression.

a luxury. The elasticity estimates for alcohol and tobacco and for healthcare are the closest to unity (in fact, alcohol and tobacco is not statistically significantly different from unity).

Comparison of results with other studies can be difficult as the composition of expenditure groupings tends to vary across studies. However, a number of results are broadly comparable. Food is unsurprisingly found to be a necessity in virtually all recent QUAIDS studies.[22] Most recent studies also find household utilities to be necessities and clothing and footwear to be luxuries (e.g. Bover et al., 2017, for Spain; Cseres-Gergely et al., 2017, for Hungary; Jansky, 2014, for the Czech Republic). Results for other expenditure groupings tend to be more mixed. The previous AI and Rotterdam model studies of New Zealand by Michelini (1999) and Khaled and Lattimore (2006, 2008) present consistent expenditure elasticity results for food and transport. However, they find clothing to be a necessity rather than a luxury. Those papers were based on data predominantly from the 1980s and 1990s, suggesting that, as living standards have continued to rise, a greater component of clothing consumption now appears to be of a luxury nature.

As expected, all own-price elasticities are negative. The least responsive groupings are: food and beverages; and recreation and culture. While the food and beverages grouping would be expected to be relatively unresponsive to price changes, the elasticity, at -0.566, is less inelastic than might be expected – certainly in comparison to recent studies in other countries (for example, Bover et al., 2017, find an uncompensated own-price elasticity of -0.109 for Spain; Cseres-Gergely et al., 2017, find an elasticity of -0.32 for Hungary; Jansky, 2014, finds an elasticity of -0.311 for the Czech Republic[23]). For New Zealand, Michelini (1999) and Khaled and Lattimore (2006, 2008) find food to be more inelastic than found here. However, Ni Mhurchu et al. (2013), in their food expenditure AI model, tend to find less inelastic results between different food items for New Zealand than have been typically found for other countries. They argue this may reflect greater access to substitutes than comparable countries due to New Zealand’s large agricultural sector, and also that lower per capita income levels than comparable countries may make New Zealand food consumers more responsive.

The comparatively inelastic result for recreation and culture may hide some greater price responsiveness for some of its components. Recreation and culture is a wide grouping, including recreational expenditure such as books, magazines and newspapers; cultural activities such as cinema, theatre and concerts; and a range of

[22] The case study for the United Kingdom in IFS (2011) found an expenditure elasticity of 0.25 for food subject to the zero VAT rate, but an expenditure elasticity of 1.15 for their standard-rated food and drink category which included restaurant food, takeaways and alcohol.

[23] Food own-price elasticity estimates vary considerably across the case studies included in IFS et al., 2011, with estimates of: -0.11 for the United Kingdom; -0.23 for Belgium; -0.43 for Germany; -0.74 for France; and -0.92 for Spain. The latter is a surprisingly large result, particularly in light of the more recent analysis of Bover et al., 2017.

accommodation services. Expenditure such as on hotel accommodation, or cinema, theatre and concert tickets may be expected to be more price responsive, but it is not possible to break these components out due to the limited price data available. Comparison with other studies is difficult for such an amalgamated grouping. That said, the IFS et al. (2011) case studies for Belgium, France, Germany, Spain and the UK have broadly similar "leisure" groupings, finding widely varying elasticity estimates of -0.21, -1.2, -1.68, -1.07 and -0.50, respectively. Meanwhile, Bover et al., 2017 find an elasticity of -2.253 for their "leisure and culture" grouping for Spain, and Abramovsky et al. (2015) find an elasticity of -2.09 for "leisure and hotel services" in Mexico.

Another grouping issue arises with alcohol and tobacco which is found to be slightly inelastic. Tobacco – given its addictive qualities – may be expected to be less price responsive than alcohol, but it was not possible to separate the two in the analysis. That said, Bover et al., 2017 – who are able to separate the two categories in their Spanish data – find similar price elasticities of -0.933 and -0.833 for alcohol and tobacco, respectively.

The most price-responsive grouping is "other personal expenditure", while the "household utilities, communication and education" grouping and the transport grouping are also elastic. The influence of private education on the second grouping may explain to some extent the elastic result. Again, comparison with results for similar groupings in other countries are difficult to make, but where it is possible, results tend to vary significantly (for example, the transport categories in the IFS et al., 2011, case studies for Belgium and Germany are -0.22 and -0.41; -0.76 for "cars and transport" in France, and -1.02 for "private transport" in the United Kingdom). In contrast to the general transport grouping, transport fuels are found to be inelastic (a similar finding was made by Bover et al., 2017, for Spain). This is unsurprising given New Zealand's high dependence on private transport.[24] In their New Zealand studies, Michelini (1999) and Khaled and Lattimore (2006, 2008) include a single broad transport grouping that includes transport fuels, and each find demand to be inelastic.

While expenditure elasticities are all statistically significantly different from zero, the majority of own-price elasticities are not. This is a consequence of the limited price variation. The "household utilities, communication and education" grouping, which increased price variation using household-specific expenditure weights, is statistically significant. But, as mentioned, a greater reliance on this source of price variation carried with it the risk of conflation of quality effects with price effects.

[24] New Zealand had the seventh highest rate of passenger vehicle ownership out of 171 countries considered in World Bank (2011)

As expected, uncompensated price elasticities are higher (in absolute value terms) than compensated price elasticities. This is because the income effect – which is captured only in the uncompensated elasticities – reinforces the price effect, thereby increasing responsiveness to a price change.

Cross-price elasticities

Cross-price elasticities (evaluated, again, at the means of all the variables) are presented in Tables 2 and 3. In general, groupings are far less responsive to changes in other prices than their own. However, there are a number of expenditure group pairings with large cross-price elasticities and where at least one is statistically significantly different from zero (although, in general, results again tend not to be statistically significant). For example, the results show "recreation and culture" and "clothing and footwear" to be strong complements, with large negative cross-price elasticities, meaning that increases in the price of one will strongly reduce consumption of the other.

Transport and healthcare are also shown to be strong complements (with large negative cross-price elasticities), whereas transport fuels and healthcare are substitutes (with large positive cross-price elasticities). Transport and other personal expenditure are substitutes, while transport fuels and other personal expenditure are complements. Transport and transport fuels are unsurprisingly substitutes, though estimates are not statistically significant. Transport and food are also complements, while clothing and other personal expenditure are substitutes.

In general, patterns are very similar for both compensated and uncompensated elasticities. However, both the other personal expenditure and clothing groupings are complements with the "household utilities, communication and education" group in table 2, but substitutes according to table 3. The difference in signs between the uncompensated and compensated elasticity results highlights the impact of the income effect on the results (which is only captured in the uncompensated results).

Overall, the magnitude of some of the cross-price elasticity estimates, and the general lack of statistical significance of these as well as the majority of own-price elasticity estimates, casts some doubt on their reliability. This is particularly the case in light of the limited price variation available in the data and highlights the need for some caution in interpreting the results.

Table 2. Uncompensated cross-price elasticities

	1. Food and non-alcoholic beverages	2. Alcohol and tobacco	3. Clothing and footwear	4. Healthcare	5. Transport (excluding transport fuels)	6. Transport fuels	7. Recreation and culture	8. Other non-durable personal expenditure	9. Household utilities, comms & education
1. Food and non-alcoholic beverages	-0.566**	0.027	0.034	0.091	-0.316	-0.094	0.109	-0.245	0.183***
2. Alcohol and tobacco	0.062	-0.951	-0.067	0.212	0.083	-0.141	0.227	-0.658	0.089
3. Clothing and footwear	0.004	-0.106	-0.632	0.114	-1.151	-0.244	-2.594	3.080	-0.139
4. Healthcare	0.589	0.253	0.130	-0.711	-3.400*	1.109*	0.473	0.113	0.284
5. Transport (excluding transport fuels)	-1.528*	0.038	-0.601	-1.853	-1.474	0.690	-0.504	3.397	0.351***
6. Transport fuels	-0.385	-0.072	-0.092	0.597	0.720	-0.613*	-0.090	-1.247	0.393***
7. Recreation and culture	0.248	0.133	-1.379*	0.246	-0.510	-0.145	-0.535	0.148	0.308***
8. Other non-durable personal expenditure	-0.689*	-0.222	0.813*	0.021	1.682**	-0.678**	0.079	-2.339*	-0.061
9. Household utilities, communication and education	0.302	0.044	0.015	0.072	0.179	0.148	0.163	0.072	-1.612***

* p<0.05, ** p<0.01, *** p<0.001

Table 3. Compensated cross-price elasticities

	1. Food and non-alcoholic beverages	2. Alcohol and tobacco	3. Clothing and footwear	4. Healthcare	5. Transport (excluding transport fuels)	6. Transport fuels	7. Recreation and culture	8. Other non-durable personal expenditure	9. Household utilities, comms & education
1. Food and non-alcoholic beverages	-0.333	0.063	0.064	0.122	-0.260	-0.037	0.164	-0.132	0.350***
2. Alcohol and tobacco	0.404	-0.898	-0.023	0.257	0.165	-0.057	0.308	-0.492	0.335*
3. Clothing and footwear	0.503	-0.029	-0.568	0.179	-1.031	-0.121	-2.475	3.323	0.220
4. Healthcare	0.936	0.307	0.174	-0.666	-3.317*	1.195*	0.555	0.282	0.534***
5. Transport (excluding transport fuels)	-1.084	0.107	-0.545	-1.796	-1.368	0.800*	-0.399	3.613	0.670***
6. Transport fuels	-0.149	-0.036	-0.062	0.628	0.777	-0.555	-0.034	-1.132	0.563***
7. Recreation and culture	0.692	0.202	-1.322*	0.304	-0.404	-0.035	-0.430	0.365	0.628***
8. Other non-durable personal expenditure	-0.272	-0.157	0.866*	0.075	1.782***	-0.575**	0.178	-2.137	0.239***
9. Household utilities, communication and education	0.486	0.072	0.039	0.096	0.223	0.193	0.207	0.162	-1.479***

* p<0.05, ** p<0.01, *** p<0.001

5. Simulated reforms

In contrast to New Zealand's "broad-base single-rate" GST structure, most other OECD countries – particularly those in Europe – have multi-rate systems that apply reduced GST rates to a selection of goods and services. The most common reason for these concessionary rates is to provide support to the poor – hence a significant number of OECD countries apply reduced rates to food and other items such as domestic energy and utilities that typically make up a greater proportion of poorer households' total budgets. That said, reduced rates are often also introduced to support cultural and other activities considered to be of social or economic importance (OECD, 2014).

This section uses the estimated QUAIDS model to investigate the distributional effects of a move to a multi-rate GST system in New Zealand and, in particular, whether the introduction of reduced GST rates is an effective way of providing support to poorer households. By using the QUAIDS model, the behavioural responses induced by the consequent price changes are taken into account. While the demand system was estimated using data from the four most recent household economic surveys, the simulations in this section are based on just the most recent data available (2015-16).

Two reform scenarios are considered. The first scenario simply introduces reduced GST rates of 7.5% on two of the nine non-durable expenditure groups from the QUAIDS model: "food and beverages" and "recreation and culture". These groupings include all food (including restaurant food), newspapers, books, magazines, cinema, theatre, concerts, hotels and other accommodation services. As such, the reform covers eight of the 11 most common expenditure groups to be taxed at reduced rates in OECD countries (OECD, 2014).[25] The standard GST rate on other expenditure remains unchanged at 15%, so the reform is revenue negative. The second reform scenario introduces the same reduced GST rates while also increasing the standard GST rate applying to other expenditure groups from 15% to 18.5% in order to ensure revenue neutrality (thereby eliminating broader effects of the reform on the economy).

It would also have been informative to separately examine the effects of a reduced GST rate on different types of food, for example, food consumed in the home vs food consumed outside the home (e.g. restaurant food), and on different types of recreation and cultural activities. However, the available groupings of the QUAIDS model preclude this.

To assess the distributional effect of the simulated reforms, two indicators are calculated for each household: the change in tax paid, and the money-metric welfare change as measured by the compensating variation

[25] The exceptions being pharmaceuticals, water supply and passenger transport.

(CV). While the CV can be calculated directly from the demand system (as per equation 9), the demand system must be incorporated into a consumption tax microsimulation model to calculate the change in tax paid.

The QUAIDS model provides the basic input into the microsimulation model in the form of the predicted pre- and post-reform budget shares for the nine non-durable expenditure groups for each household. Total expenditure is assumed to remain unchanged, so it is only the budget shares that change. The predicted pre-reform budget shares are used rather than the actual budget shares from the microdata to avoid "ascribing deviations from the model to effects of the tax reform" (Capéau et al., 2014, p242). Post-reform budget shares are calculated under the assumption that the tax rate changes are fully passed on to the consumer in prices (this is also assumed for the CV calculations).[26] In addition to the nine non-durable expenditure groups, two durable expenditure groups (taxed and non-taxed durables) are included in the microsimulation model, with durable expenditure assumed to remain constant across all scenarios.

The microsimulation model allocates the applicable pre- and post-reform GST rates to the 11 expenditure groupings and then calculates the tax paid in each scenario. GST rates for the pre-reform scenario are those for the 2015-16 tax year. Despite the restricted number of expenditure groupings in the QUAIDS model, there is minimal loss of precision in modelling the pre-reform GST rate structure thanks to its broad-based design. Where multiple rates do apply within an expenditure grouping, a weighted GST rate is applied based on the average expenditure proportions in the sample. The most significant example is the "other personal expenditure" grouping which includes exempted financial services.[27]

The underlying tax (and CV) calculations are made per household and are then weighted up to the population using household survey weights. Average tax and CV results are presented across equivalised pre-tax expenditure deciles. (For completeness, results across equivalised disposable income deciles are also presented in the annex).[28] In each case, results are presented for the entire population and separately for both

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[26] This is a standard assumption in the literature, motivated at least in part by pragmatism. That said, recent studies suggest it is not an unreasonable assumption to make, particularly in relation to VAT increases (Benzarti et al., 2017; Carbonnier, 2007). Theoretically, it is also possible for VAT to be less than fully or more than fully passed on to consumers depending on the structure of the particular market. See IHS (2011) for a detailed discussion of the theoretical and empirical literature.
[27] Exemptions are treated as zero rates in the simulations.
[28] Results across income deciles are very similar to (and show the same patterns as) results across expenditure deciles, though they are slightly more truncated. When distinguishing between "poor" and "rich" based on data for a single year a case can be made for ranking by either expenditure or income. Current expenditure has arguably a more direct link to wellbeing as it is the consumption of goods and services that produces utility rather than the earning of the income that funds the consumption. Additionally, ranking by current income can misrepresent some households – e.g. students, retirees – as poor when they may be significantly better off in a lifetime context. That said, ranking by current

winners and losers from each reform (although in the case of reform 1, where tax rates only fall, there are only winners). While the modelling is based on household expenditure data, the unit of analysis is changed to the individual by further weighting the household results by the number of individuals in each household. This ensures that equal weighting is given to each individual in the analysis. Implicit in this approach is the assumption of equal sharing of resources within a family so that the measured tax and welfare changes of each household member are identical.[29]

Equivalisation is undertaken using the parametric equivalence scale $m_i = \left(n_{a,i} + \theta n_{c,i}\right)^{\alpha}$ where m_i is the equivalent size of household i, θ measures the degree of need of children relative to adults; α specifies economies of scale in consumption; $n_{a,i}$ is the number of adults in household i and $n_{c,i}$ is the number of children. As noted by Creedy and Sleeman (2006), this parametric scale was introduced by Cutler and Katz (1992) and is an extension of the simpler n_i^{α} form used by Buhmann et al. (1988) and Coulter et al. (1992). The scale explicitly allows for adjustment of need between adults and children, and of economies of scale with increases in need-adjusted household size. The parameters adopted in the paper are $\theta = 0.5$ and $\alpha = 0.7$.[30]

Reform 1

Table 4 presents results for reform 1 measured in terms of the change in tax paid across equivalised pre-tax expenditure deciles.[31] As the reform only involves a reduction in tax rates, there are no losers from the reform. When measured as a percentage of pre-tax expenditure, reform 1 benefits the poor proportionately more than the rich. This is because poorer households spend a greater proportion of their total expenditure on reduced-rated goods than richer households do.

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expenditure can also misrepresent some households – e.g. those currently saving heavily to fund future spending – as worse off than they are in a lifetime context. As such, both sets of results are presented. Proportional results, whether across expenditure or income deciles, are calculated as a percentage of expenditure to avoid the distortionary impact of borrowing and savings behaviour. See OECD (2014) for further discussion.

[29] The overall tax revenue calculations for ensuring revenue neutrality are only weighted by the household survey weights.

[30] A commonly used alternative equivalence scale is the "OECD modified" scale which gives a fixed weighting of 1 to the first adult household member, 0.5 to the second and additional household members aged 14 and over, and 0.3 to each child under 14. While this scale adjusts for the relative need of adults and children, it does not continuously adjust for economies of scale as second and subsequent children all receive the same weighting. The equivalence scale parameters chosen in this paper produce a close match with the OECD modified scale, but provide for additional economies of scale at greater household sizes. Sensitivity analysis conducted on the two parameters shows some variation in results for changes in both parameters, but not significant enough to alter the paper's overall conclusions.

[31] Note that some minor variation occurs in the estimated number of individuals within each decile due to the need to allocate unweighted household observations that overlap the boundary between two deciles into one decile. Some additional variation occurs in deciles 1, 2, 3 and 6 due to the droping of 48 observations for which the QUAIDS model produced negative predicted budget shares.

However, looking at the average gain amounts shows that the rich benefit substantially more than the poor in absolute dollar terms. Indeed, the average gain to the top expenditure decile is more than six times that of the bottom expenditure decile. This result is driven by the fact that richer households simply spend more in absolute terms than the poor, and thereby save more tax from the reduction in the GST rates. This result illustrates the poorly targeted nature of the GST system as a tool for supporting poorer households.

Table 5 presents results for reform 1 measured in terms of the compensating variation (CV) across equivalised pre-tax expenditure deciles. Negative CV results reflect a welfare gain as they show the amount of money that would need to be taken off the household following the reform in order for them to maintain their pre-reform utility level. A similar pattern is found in these results as in the tax change results in Table 4. The welfare gain to poorer households is proportionately greater than for richer households, whereas the absolute welfare gain is greater for richer households. The average gain to the top expenditure decile is just under six times times that of the bottom expenditure decile.

Table 6 provides additional detail on this reform by presenting the change in tax paid results separately for the two expenditure groups subject to reduced rates. As with the overall results in Table 4, the reduced rate on food and beverages provides a greater proportional benefit to poorer households than richer households, but a greater aggregate benefit to richer households. In contrast, the reduced rate on recreation and culture provides a greater benefit to richer households both in aggregate and proportional terms. That is, while the reduced rate on food has a small progressive effect, the reduced rate on recreation and culture has a regressive effect. Overall, though, the significantly greater budget shares devoted to food and beverages than to recreation and culture means that the progressive impact of the reduced rate on food and beverages outweighs the regressive impact of the reduced rate on recreation and culture.[32]

The results for the reduced rate on food and beverages are consistent with those obtained for food in Ball et al. (2016) for New Zealand. The results for recreation and culture highlights that the effect of a reform can vary significantly depending on the type of expenditure subject to a reduced rate. This finding is consistent with the non-behavioural analysis undertaken for New Zealand in Thomas (2015) and for 20 OECD countries in OECD (2014) – both of which found significant variation in the distributional impact of reduced rates across expenditure groups. The QUAIDS-based results in Table 6 show that such variation is still present once behavioural responses to the tax changes are accounted for.

[32] The total gain reported in Table 5 from reduced rates on food/beverages and recreation/culture is greater than that presented for the overall reform in Table 4. This is because the overall reform results in Table 4 capture some additional revenue generated as a result of some taxpayers shifting some consumption away from reduced rated goods towards standard rated goods in response to the change in relative prices.

Table 4. Gain/loss in dollar terms from reform 1

	Total			Winners			Losers		
Expenditure decile	Number of individuals	Average gain or loss	% of expenditure	Number of individuals	Average gain	% of expenditure	Number of individuals	Average loss	% of expenditure
1	397,000	329	2.116%	397,000	329	2.116%	0	-	-
2	424,000	530	2.064%	424,000	530	2.064%	0	-	-
3	433,000	650	2.020%	433,000	650	2.020%	0	-	-
4	445,000	803	2.010%	445,000	803	2.010%	0	-	-
5	440,000	898	1.929%	440,000	898	1.929%	0	-	-
6	439,000	1,045	1.939%	439,000	1,045	1.939%	0	-	-
7	443,000	1,128	1.852%	443,000	1,128	1.852%	0	-	-
8	443,000	1,270	1.779%	443,000	1,270	1.779%	0	-	-
9	441,000	1,473	1.715%	441,000	1,473	1.715%	0	-	-
10	442,000	2,073	1.500%	442,000	2,073	1.500%	0	-	-

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table 5. Gain/loss in money metric welfare (compensating variation) terms from reform 1

	Total			Winners			Losers		
Expenditure decile	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure
1	397,000	-381	-2.458%	397,000	-381	-2.458%	0	-	-
2	424,000	-601	-2.345%	424,000	-601	-2.345%	0	-	-
3	433,000	-733	-2.279%	433,000	-733	-2.279%	0	-	-
4	445,000	-898	-2.252%	445,000	-898	-2.252%	0	-	-
5	440,000	-1,001	-2.152%	440,000	-1,001	-2.152%	0	-	-
6	439,000	-1,161	-2.154%	439,000	-1,161	-2.154%	0	-	-
7	443,000	-1,253	-2.056%	443,000	-1,253	-2.056%	0	-	-
8	443,000	-1,403	-1.965%	443,000	-1,403	-1.965%	0	-	-
9	441,000	-1,613	-1.878%	441,000	-1,613	-1.878%	0	-	-
10	442,000	-2,242	-1.624%	442,000	-2,242	-1.624%	0	-	-

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table 6. Gain/loss in dollar terms from reform 1 for different expenditure groups

	Total			Food and non-alcoholic beverages			Recreation and cultural activities		
Expenditure decile	Number of individuals	Average gain	% of expenditure	Number of individuals	Average gain	% of expenditure	Number of individuals	Average gain	% of expenditure
1	397,000	354	2.273%	397,000	315	2.018%	397,000	39	0.255%
2	424,000	572	2.227%	424,000	494	1.916%	424,000	77	0.311%
3	433,000	702	2.183%	433,000	588	1.822%	433,000	114	0.362%
4	445,000	869	2.176%	445,000	716	1.789%	445,000	152	0.388%
5	440,000	974	2.094%	440,000	785	1.688%	440,000	189	0.405%
6	439,000	1,135	2.106%	439,000	905	1.675%	439,000	230	0.431%
7	443,000	1,229	2.017%	443,000	954	1.566%	443,000	275	0.451%
8	443,000	1,386	1.941%	443,000	1,056	1.478%	443,000	330	0.464%
9	441,000	1,612	1.877%	441,000	1,180	1.375%	441,000	431	0.502%
10	442,000	2,284	1.652%	442,000	1,537	1.123%	442,000	748	0.529%

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Reform 2

Table 7 presents results for reform 2 measured in terms of the change in tax paid across equivalised pre-tax expenditure deciles. The overall results show that poor households gain, on average, from the reform while rich households lose. However, the average gain is now quite low compared to reform 1 because the impact of the increased standard GST rate counters the effect of the reduced rates. This again highlights the poor targeting of the GST as a tool to support poorer households as the increased standard rate (which is used to fund the reduced rates), has to be paid by both poor and rich.

While poorer households benefit on average from the reform, Table 7 also shows that there are now a significant number of poorer households that are made worse off. For example, around 109,000 individuals in the bottom expenditure decile – 27% of that decile – are in households that now pay more tax. This further highlights the difficulty in attempting to target poorer households through the GST system. Patterns of consumption are not identical across the households a government may wish to target, and hence some households will still lose from a reform aimed to help them due to their particular preferences for consuming standard-rated vs reduced-rated goods. Additionally, some households not targeted will gain from the reform due to their particular consumption preferences. For example, around 82,000 individuals in the top expenditure decile – 19% of that decile – are in households that benefit from this reform, even though it aims to support the poor.

Table 8 presents results for reform 2 measured in terms of the compensating variation across equivalised pre-tax expenditure deciles. Table 8 presents a similar pattern of results to the tax change results in table 7 – with poorer households gaining, on average, from the reform and richer households losing, but with winners and losers present across all deciles. Results in Table 8 show a slightly lower number of losers in the bottom four deciles than in Table 7, however this is due to the QUAIDS model not taking account of the additional tax now paid on standard-rated durables (as these are excluded from the QUAIDS model).

In contrast to the lower decile results, Table 8 shows a greater number of losers in the top six deciles than in Table 7 – despite not accounting for the additional tax paid on durables. That is, some taxpayers who are better off in terms of tax paid are actually worse off in terms of utility (assuming the QUAIDS utility function accurately reflects their preferences). This may occur, for example, where some households substitute more away from the now relatively higher taxed goods than other households do in response to the change in relative prices, thereby reducing the tax they pay, but increasing their welfare loss due to the greater distortion in their behaviour. This difference highlights the importance of considering the welfare effects of the reform in addition to the change in tax paid.

Table 7. Gain/loss in dollar terms from reform 2

	Total			Winners			Losers		
Expenditure decile	Number of individuals	Average gain or loss	% of expenditure	Number of individuals	Average gain	% of expenditure	Number of individuals	Average loss	% of expenditure
1	397,000	33	0.137%	289,000	53	0.275%	109,000	-19	-0.228%
2	424,000	48	0.134%	293,000	79	0.261%	131,000	-24	-0.150%
3	433,000	51	0.117%	301,000	86	0.232%	132,000	-30	-0.148%
4	445,000	65	0.117%	303,000	113	0.239%	142,000	-36	-0.143%
5	440,000	43	0.059%	265,000	97	0.178%	175,000	-39	-0.123%
6	439,000	50	0.065%	275,000	107	0.177%	164,000	-45	-0.123%
7	443,000	7	-0.011%	239,000	76	0.114%	204,000	-75	-0.157%
8	443,000	-4	-0.026%	183,000	120	0.149%	260,000	-92	-0.150%
9	441,000	-59	-0.086%	137,000	111	0.118%	305,000	-135	-0.177%
10	442,000	-247	-0.178%	82,000	108	0.078%	361,000	-328	-0.236%

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table 8. Gain/loss in money metric welfare (compensating variation) terms from reform 2

	Total			Winners			Losers		
Expenditure decile	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure
1	397,000	-56	-0.289%	322,000	-73	-0.411%	75,000	18	0.234%
2	424,000	-64	-0.194%	323,000	-92	-0.308%	102,000	25	0.169%
3	433,000	-62	-0.147%	316,000	-97	-0.263%	117,000	32	0.168%
4	445,000	-69	-0.122%	304,000	-121	-0.257%	141,000	42	0.169%
5	440,000	-34	-0.038%	251,000	-99	-0.187%	189,000	53	0.160%
6	439,000	-33	-0.030%	260,000	-99	-0.165%	179,000	63	0.166%
7	443,000	21	0.060%	180,000	-84	-0.126%	262,000	93	0.188%
8	443,000	49	0.094%	158,000	-103	-0.127%	285,000	134	0.217%
9	441,000	146	0.189%	87,000	-112	-0.122%	354,000	210	0.266%
10	442,000	448	0.320%	30,000	-119	-0.088%	412,000	490	0.350%

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

6. Conclusion

This paper provides the first estimates of a QUAIDS model for New Zealand and uses the model to investigate the distributional effects of a move to a multi-rate GST system. The QUAIDS model is estimated using household expenditure microdata from the four most recent HES surveys together with matching regional price data that provides sufficient price variation to estimate the model.

The estimated QUAIDS model covers nine non-durable expenditure groups. Expenditure and price elasticity estimates are highly plausible. All expenditure elasticities are positive, with the "food and non-alcoholic beverages", "transport fuels", and "household utilities, communication and education" expenditure groups found to be necessities. The "clothing and footwear", "recreation and culture", and "transport (excluding transport fuels)" groups were found to be clear luxuries. The "food and non-alcoholic beverages" and “recreation and culture” groups were found to be the least price-responsive, while the general “personal expenditure” and “household utilities, communication and education” expenditure groups were found to be the most price-responsive.

Two multi-rate GST reforms were simulated. For each reform both the change in tax paid and the welfare change (as measured by the compensating variation) were estimated. The first reform considers the introduction of reduced GST rates on two of the nine non-durable expenditure groups from the QUAIDS model: “food and beverages” and “recreation and culture”. Both tax and welfare change results show that such a reform will have a small progressive effect – providing greater support to poorer households when measured as a proportion of their total spending. However, richer households are shown to gain considerably more in absolute terms – highlighting the poorly targeted nature of the GST system as a tool for supporting poorer households. Results are also found to differ between the two expenditure groupings. While the reduced rate on food largely mimics the overall results (and indeed drives them due to its greater budget share), the reduced rate on recreation and culture actually has a regressive effect.

The second reform scenario introduces the same reduced rates as the first reform while increasing the standard rate applying to other expenditure groups to ensure revenue neutrality. Tax results show that, on average, poorer households benefit from the reform and richer households lose. However, a significant number of poorer households lose from the reform, while some richer households gain from it, due to their particular preferences for consuming standard-rated vs reduced-rated goods. While both tax and welfare change results are broadly similar, some small differences arise. For example, some richer households adjust their consumption patterns sufficiently so that they pay less tax following the reform, but still suffer a welfare loss due to this tax-induced distortion to their behaviour.

Overall the results for both reforms show the poorly targeted nature of the GST as a means of supporting poorer households. The results for the reduced rate on food and beverages are consistent with those obtained for food in Ball et al. (2016) for New Zealand. The differing results for recreation and culture highlight that the effect of a reform can vary significantly depending on the type of expenditure subject to a reduced rate. This finding is consistent with the non-behavioural analysis undertaken for New Zealand in Thomas (2015) and for 20 OECD countries in OECD (2014) – both of which found significant variation in the distributional impact of reduced rates across expenditure groups. The QUAIDS-based results of this paper suggest that such variation is still present once behavioural responses to the tax changes are accounted for.

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ANNEX: SIMULATION RESULTS ACROSS INCOME DECILES

Table A1. Gain/loss in dollar terms from reform 1

	Total			Winners			Losers		
Income decile	Number of individuals	Average gain or loss	% of expenditure	Number of individuals	Average gain	% of expenditure	Number of individuals	Average loss	% of expenditure
1	435,000	615	2.050%	435,000	615	2.050%	0	-	-
2	422,000	639	1.953%	422,000	639	1.953%	0	-	-
3	436,000	816	2.011%	436,000	816	2.011%	0	-	-
4	420,000	847	1.943%	420,000	847	1.943%	0	-	-
5	435,000	1,018	1.955%	435,000	1,018	1.955%	0	-	-
6	433,000	1,026	1.833%	433,000	1,026	1.833%	0	-	-
7	440,000	1,120	1.854%	440,000	1,120	1.854%	0	-	-
8	442,000	1,171	1.849%	442,000	1,171	1.849%	0	-	-
9	446,000	1,249	1.767%	446,000	1,249	1.767%	0	-	-
10	438,000	1,765	1.686%	438,000	1,765	1.686%	0	-	-

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table A2. Gain/loss in money metric welfare (compensating variation) terms from reform 1

	Total			Winners			Losers		
Income decile	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure
1	435,000	-678	-2.286%	435,000	-678	-2.286%	0	-	-
2	422,000	-705	-2.187%	422,000	-705	-2.187%	0	-	-
3	436,000	-899	-2.245%	436,000	-899	-2.245%	0	-	-
4	420,000	-939	-2.180%	420,000	-939	-2.180%	0	-	-
5	435,000	-1,125	-2.183%	435,000	-1,125	-2.183%	0	-	-
6	433,000	-1,137	-2.047%	433,000	-1,137	-2.047%	0	-	-
7	440,000	-1,238	-2.066%	440,000	-1,238	-2.066%	0	-	-
8	442,000	-1,299	-2.067%	442,000	-1,299	-2.067%	0	-	-
9	446,000	-1,390	-1.984%	446,000	-1,390	-1.984%	0	-	-
10	438,000	-1,948	-1.881%	438,000	-1,948	-1.881%	0	-	-

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table A3. Gain/loss in dollar terms from reform 1 for different expenditure groups

	Total			Food and non-alcoholic beverages			Recreation and cultural activities		
Income decile	Number of individuals	Average gain	% of expenditure	Number of individuals	Average gain	% of expenditure	Number of individuals	Average gain	% of expenditure
1	435,000	665	2.211%	435,000	559	1.893%	435,000	106	0.318%
2	422,000	692	2.110%	422,000	564	1.747%	422,000	128	0.363%
3	436,000	884	2.175%	436,000	715	1.799%	436,000	170	0.376%
4	420,000	917	2.101%	420,000	739	1.733%	420,000	178	0.368%
5	435,000	1,105	2.119%	435,000	876	1.720%	435,000	229	0.399%
6	433,000	1,116	1.992%	433,000	881	1.597%	433,000	236	0.395%
7	440,000	1,221	2.016%	440,000	938	1.584%	440,000	283	0.433%
8	442,000	1,278	2.015%	442,000	968	1.560%	442,000	310	0.456%
9	446,000	1,367	1.930%	446,000	1,013	1.467%	446,000	354	0.463%
10	438,000	1,945	1.852%	438,000	1,331	1.312%	438,000	614	0.540%

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table A4. Gain/loss in dollar terms from reform 2

	Total			Winners			Losers		
Income decile	Number of individuals	Average gain or loss	% of expenditure	Number of individuals	Average gain	% of expenditure	Number of individuals	Average loss	% of expenditure
1	435,000	57	0.154%	317,000	86	0.259%	119,000	-20	-0.124%
2	422,000	40	0.080%	249,000	94	0.258%	173,000	-37	-0.178%
3	436,000	51	0.112%	301,000	93	0.224%	135,000	-41	-0.136%
4	420,000	63	0.146%	322,000	103	0.233%	98,000	-68	-0.140%
5	435,000	62	0.113%	306,000	112	0.213%	129,000	-56	-0.126%
6	433,000	26	0.032%	269,000	77	0.129%	164,000	-58	-0.127%
7	440,000	9	0.013%	233,000	89	0.154%	206,000	-81	-0.147%
8	442,000	-22	-0.047%	181,000	73	0.106%	262,000	-88	-0.152%
9	446,000	-73	-0.090%	131,000	92	0.158%	314,000	-142	-0.194%
10	438,000	-227	-0.190%	58,000	88	0.112%	380,000	-275	-0.237%

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

Table A5. Gain/loss in money metric welfare (compensating variation) terms from reform 2

	Total			Winners			Losers		
Income decile	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure	Number of individuals	Average CV	% of expenditure
1	435,000	-43	-0.148%	305,000	-84	-0.292%	131,000	52	0.188%
2	422,000	-24	-0.077%	241,000	-93	-0.316%	181,000	67	0.240%
3	436,000	-28	-0.102%	271,000	-96	-0.272%	165,000	83	0.177%
4	420,000	-51	-0.161%	307,000	-115	-0.289%	113,000	124	0.188%
5	435,000	-38	-0.103%	285,000	-115	-0.253%	150,000	109	0.182%
6	433,000	0	-0.011%	241,000	-85	-0.164%	192,000	107	0.181%
7	440,000	27	0.019%	213,000	-93	-0.183%	227,000	140	0.209%
8	442,000	59	0.080%	160,000	-79	-0.138%	282,000	138	0.203%
9	446,000	114	0.116%	137,000	-108	-0.208%	308,000	213	0.261%
10	438,000	336	0.255%	71,000	-88	-0.140%	367,000	418	0.331%

Note: number of individuals rounded to nearest thousand to meet HES confidentiality rules

About the Author

Alastair Thomas is A PhD student at School of Accounting and Commercial Law at Victoria University of Wellington, New Zealand.
Email: alastair.thomas@vuw.ac.nz