UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Vulnerable households and fuel poverty: policy targeting efficiency in Australia's National Electricity Market

EPRG Working Paper 2108

Cambridge Working Paper in Economics 2129

Paul Simshauser

Abstract When Australia established its National Electricity Market (NEM) during the 1990s, reforms were focused on maximising economic efficiency. Little thought was given to distributional outcomes. However, by the 2010s sluggish growth in household incomes, sharp rises in electricity prices and material increases in quantities consumed through surging uptake rates of air-conditioning units led to the possibility of (hot climate) fuel poverty. In the NEM's Queensland region, longstanding customer hardship policy pre-dated the NEM. With the benefit of hindsight, the policy was poorly configured as it focused exclusively on the aged population and was delivered by way of fixed payment. Low income households in the family formation cohort were excluded from the policy despite obvious need. In this article, Queensland's longstanding customer hardship policy is refined using pre-existing (means-tested) welfare mechanisms in order to target low income households including families, and the payment structure is altered from fixed ($ pa) to variable (% of the bill) while holding the budget constraint constant. Changes to policy targeting produce material improvements in horizontal and vertical efficiency while changes to payment structure further enhance vertical performance, with the incidence and depth of residual fuel poverty reduced.

Keywords Energy Affordability, Fuel Poverty, Policy Targeting, Targeting Efficiency, Customer Hardship Policy

JEL Classification D25, D80, G32, L51, Q41

Contact p.simshauser@griffith.edu.au
Publication April 2021

Vulnerable households and fuel poverty: policy targeting efficiency in Australia's National Electricity Market

Paul Simshauser[♣♠♥]
April 2021

Abstract
When Australia established its National Electricity Market (NEM) during the 1990s, reforms were focused on maximising economic efficiency. Little thought was given to distributional outcomes. However, by the 2010s sluggish growth in household incomes, sharp rises in electricity prices and material increases in quantities consumed through surging uptake rates of air-conditioning units led to the possibility of (hot climate) fuel poverty. In the NEM's Queensland region, longstanding customer hardship policy pre-dated the NEM. With the benefit of hindsight, the policy was poorly configured as it focused exclusively on the aged population and was delivered by way of fixed payment. Low income households in the family formation cohort were excluded from the policy despite obvious need. In this article, Queensland's longstanding customer hardship policy is refined using pre-existing (means-tested) welfare mechanisms in order to target low income households including families, and the payment structure is altered from fixed ($ pa) to variable (% of the bill) while holding the budget constraint constant. Changes to policy targeting produce material improvements in horizontal and vertical efficiency while changes to payment structure further enhance vertical performance, with the incidence and depth of residual fuel poverty reduced.

Key words: Energy Affordability, Fuel Poverty, Policy Targeting, Targeting Efficiency, Customer Hardship Policy.

JEL Classification: D25, D80, G32, L51, Q41.

1. Introduction

Australia was an early mover vis-à-vis economic liberalisation policies, undertaking extensive and broad-ranging microeconomic reforms across many industries during the 1980s and 1990s. Policymakers throughout this period focused on maximising economic efficiency and in the aggregate, the 1990s proved to be golden decade of productivity, efficiency and improved living standards.[1] Vertical state-based electricity supply monopolies were a central target of reforms.

Establishment of Australia's National Electricity Market (NEM) during the 1990s formed part of a broader (world-wide) electricity industry microeconomic reform experiment. As Pollitt (2004) and Schmalensee (2021) explain, the 'reform wave' commenced in Chile in 1982 before moving to England & Wales, and then spreading to various jurisdictions throughout Asia-Pacific, the US and Europe. Considerable policymaking effort went into institutional design, industry restructuring and privatisation programs (Kessides *et al.*, 2009). Template objectives included improvements in productive, allocative and dynamic efficiency and early results would typically include falling generation costs, tariff reductions (including unwinding certain cross-subsidies), and a clearing of generation plant oversupply.

♣ Professor of Economics, Griffith Business School, Griffith University.
♠ Research Associate, Energy Policy Research Group, University of Cambridge.
♥ Chief Executive Officer, Powerlink Queensland. I am grateful for helpful comments on an earlier draft by Gavin Dufty (St Vincent de Paul) and Dr Joel Gilmore (Infigen Energy). The usual caveats apply – the views and remaining errors are those of the authors.
[1] It also underscored a record run for the Australian economy comprising 29 years of continuous economic growth (ie. 1991-2020, ending with Covid-19).

Yet with the benefit of hindsight, too little thought went into second- and third-round effects of microeconomic reform, and in particular, the possibility of economic gains being unevenly distributed throughout Australian communities (Argy, 1999; CEDA, 2018). To be sure, adverse distributional effects and rising inequality *are not* inevitable outcomes of a microeconomic reform. As Creedy and Dixon (1998) demonstrate, structural reforms often prove to be progressive in nature, and while it is conceivable that monopoly reforms may produce regressive impacts, sizable initial gains in productive, allocative and dynamic efficiency would ordinarily offset any adverse distributional effects (Argy, 1999). Further, it would be unfair (and inaccurate) to suggest broader distributional impacts were ignored. As Section 2.9 subsequently reveals, Australia has the most targeted tax and transfer system in the world and the practical evidence suggests Australia's welfare system achieved its underlying purpose of protecting the poor from the *harshest impacts* of the broader liberalisation agenda (Argy, 1999).

However, on energy reform it is not at all obvious that *any* thought went into policies relating to vulnerable households and energy affordability when Australia's NEM was being formed – something which Kessides *et al.*, (2009) suggests was a global trend. Energy reforms typically have the effect of converting the grindingly slow and stable pace of the traditional monopoly utility environment into one involving highly volatile, real-time commodity markets and establishment of contestable consumer markets – including retailer practices quite unfamiliar to utility customers.

In the NEM's second largest zonal market (Queensland: population 5 million, peak demand 10GW, energy demand 54TWh), inadequate thought vis-à-vis vulnerable households and energy affordability was apparent. Queensland's customer hardship policy was established in 1993 (five years prior to the establishment of the NEM) and there is little evidence that (household-level) distributional impacts of energy market reform were seriously examined by policymakers prior to reviews undertaken in 2015-2017 (see QPC, 2016). Refinements to policy targeting were subsequently made in 2017 by the Queensland Government to include low income families, and the analysis in this article confirms these were warranted.

Context to this statement is important. The NEM's centrepiece, an intensely competitive energy-only, gross pool wholesale market and its ultra-high velocity contestable retail market delivered low and stable prices throughout most of the late-1990s and 2000s. Indeed, as New Zealand's Ministry of Economic Development noted in 2009, Australia had the second lowest residential electricity tariffs in the world[2]. However, a series of industry structural events and policy responses that slowly built-up from 2004 onwards led to sharply rising electricity prices from 2007-2015 (as Fig.5 later illustrates).[3]

Escalating energy prices can be expected to produce real and growing affordability problems (Kessides *et al.*, 2009). In the case of Queensland, by 2010 the run-up in electricity tariffs and a coincident stalling of household incomes following the 2008 Global Financial Crisis would bring the matter of vulnerable customers and energy affordability into sharp focus. The concept of *fuel poverty,* the inability of a household to afford a social and materially necessitated energy supply (Guertler, 2012) – and a term quite unfamiliar to Australian policymakers at the time – was being introduced as a potentially material problem (see Simshauser *et al*., 2011; Chan, 2016; Awaworyi Churchill *et al.*, 2020).

[2] See Simshauser, Nelson and Doan (2011).

[3] To summarise a complex set of structural and policy dynamics, blackouts in Southeast Queensland in 2004 led to a tightening of reliability standards, which led to a wave of new capital into the regulated electricity networks. Various solar PV feed-in tariff subsidies (at both State and Commonwealth level) and transient carbon pricing schemes added another layer of costs. And finally, gas prices rose sharply as the domestic market synchronised with export markets. For details, see Simshauser (2014).

Energy market policymakers dealing with vulnerable households and the acute subset in fuel poverty typically approach the problem from three broad policy angles, 1). tariff design and pricing policies, 2). quantity-based initiatives including energy efficiency, and 3). targeted income supports to subsidise utility bills.[4] Quantity measures relate more specifically to a household's capital stock (i.e. housing structure, insulation, appliances, solar PV etc) and were historically considered the more important source of fuel poverty owing to the works of Boardman (1991). But as definitions of fuel poverty expanded beyond *'adequate warmth'*, so too has the necessary policy mix. And as Awaworyi Churchill and Smyth (2020)[5] explain, in the Australian context refining income supports is now critical.

Settling on a suitable policy mix is an especially difficult problem because intuitive, broad-based responses may do more harm than good. As Bennett et al., (2002) illustrate in the case of households in Great Britain, and as Figure 1 subsequently illustrates in the case of Australian households, Engel's Law applies – energy costs form a higher proportion of household expenditure as incomes falls. Consequently,

- Apparently logical tariff policy strategies such as reducing or eliminating the fixed charge of the two-part tariff, or switching to inclining block tariff structures which assist low income, low consumption households (e.g. Pensioners) will simultaneously harm low income, large family households with high consumption (Bennett et al., 2002; Fankhauser and Tepic, 2007; Waddams Price et al., 2012; Simshauser and Downer, 2016).

- Similarly in contestable retail energy markets, policies designed to limit the practice of price discrimination or place regulatory price caps on otherwise competitive market outcomes predictably leads to the evaporation of deep discounts – the very products which benefit vulnerable households (Hviid and Waddams Price, 2012; Littlechild, 2015, 2018a, 2018b; Waddams Price and Zhu, 2016; Simshauser and Whish-Wilson, 2017; Simshauser, 2018b; Esplin *et al.*, 2020).

- Further, quantity-based schemes in their various forms are complex and often not well understood by intended market recipients. They frequently suffer from split incentives and are usually funded through raising tariff structures – a form of regressive taxation which harms intended beneficiaries (Nelson et al., 2011; Guertler, 2012; Nelson et al., 2012; Rosenow et al., 2013; Simshauser, 2016).

The purpose of this article is to examine the role and function of 'targeted income supports' that directly subsidise utility bills, and in particular, the targeting efficiency of Queensland's longstanding (1993) customer hardship policy. As with Skoufias and Coady (2007), modelling and policy prescriptions are grounded firmly in standard welfare analysis with a focus on coverage, under-coverage and leakage in an ostensibly two period model. Household Expenditure and Household Energy Consumption Survey data from the Australian Bureau of Statistics (ABS) form critical inputs to the analysis.

Principle findings are that Queensland's longstanding (1993-designed) customer hardship policy which focused exclusively on the aged population was poorly targeted and the mechanism, a fixed $329 pa income support, was structured sub-optimally. OECD analysis indicates Australia has the most accurate tax and transfer system in the world vis-à-vis its distributive capacity, and when existing welfare flags

[4] See variously Bennett, Cooke and Waddams Price, 2002; Komives *et al.*, 2006; Fankhauser and Tepic, 2007; Guertler, 2012; Nelson, Simshauser and Nelson, 2012; Simshauser and Nelson, 2012; Waddams Price, Brazier and Wang, 2012; Rosenow, Platt and Flanagan, 2013; Belaïd, 2018)
[5] See in particular Awaworyi Churchill and Smyth (2020, p.14).

within that system are used for transfers (i.e. means-tested welfare cardholders), material welfare gains are achievable. Specifically, model results demonstrate refining the targeting to include (means-tested) low income families and pensioners produces sizeable improvements in horizontal efficiency, vertical efficiency, vulnerable customer spill-over benefit efficiency, and reduce the incidence and depth of fuel poverty. Furthermore, when the policy mechanism is altered from a fixed payment to 'percentage of the utility bill' (holding program budgets constant), vertical efficiency, spill-over benefits and fuel poverty indicators improve further.

This article is structured as follows. Section 2 provides a review of relevant literature and modelling frameworks. Section 3 introduces the data. Section 4 examines model results and Section 5 provides background insights as to why policy performance improves so significantly. Policy implications and concluding remarks follow.

2. Review of Literature

The nature of the quantitative analysis in Sections 3-5 warrant coverage of the literature on the origins of customer hardship and fuel poverty, the nature of poverty and its measurement (i.e. horizontal and vertical targeting efficiency), and a brief background to Australia's tax and transfer system given its central role to improving program performance.

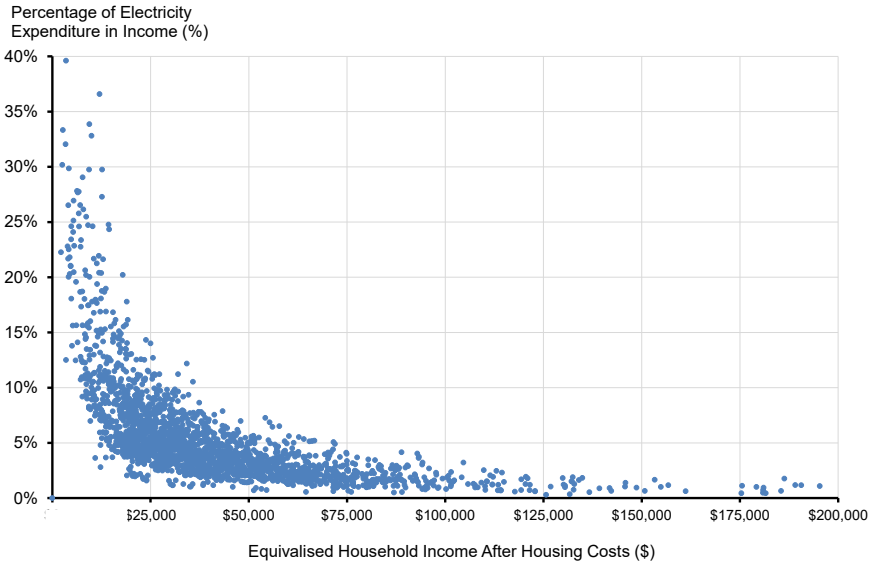
2.1 Origins of Customer Hardship

The relationship between energy and incomes has a surprisingly long history. The first analysis by economists of household expenditure and the role of energy within it can be traced back to Engels in 1857 (energy was then categorised as *'fuel and light'*). However, it was not until Engels reframed his analysis in 1897[6] that its complex relationship was revealed – the poorer the family, the greater the proportion of total expenditure devoted to energy (Stigler, 1954).

More than 100 years later, the pattern of energy consumption amongst households continues to follow Engels Law – the relationship discovered by Engels in 1897 is very much in-tact in 2020 - Fig.1 illustrates an *Engels Curve* for energy utilising Queensland data. Such a relationship makes dealing with customer hardship and the acute subset of households in fuel poverty a particularly complex problem (Fankhauser and Tepic, 2007; Waddams Price et al., 2012; Welsch and Biermann, 2017). Compounding matters, energy is extremely price- and income-inelastic, which has important distributional implications for policymakers (Kessides *et al.*, 2009; Byrne *et al*., 2021).

[6] The original analysis in 1857 categorised Utility 'fuel and light' but segregated household expenditures into socio-economic groups, which revealed very little variation in energy cost across groups (i.e. 5.4 – 5.6% of income). However, when Engels revised the analysis and segregated households by income rather than social group, total expenditures on 'fuel and light' fell as income rose (see Stigler, 1954, especially pp97-99).

Figure 1: QLD Energy Consumption (% of Income) vs Household Income



Data Source: Australia Bureau of Statistics

2.2 Origins of Fuel Poverty

Conceptually, fuel poverty (sometimes referred to as energy poverty[7]) refers to the inability of a household to afford a socially and materially necessitated level of domestic energy supply (Guertler, 2012). The term 'fuel poverty' can be traced at least as far back as Bradshaw and Hutton (1983) and originated in response to adverse impacts of the 1973 OPEC oil crisis, viz. rapidly rising electricity and gas prices in Great Britain and Europe (see also Boardman, 1991).

To generalise a complex literature, the measurement of fuel poverty has historically been defined as binding when household energy costs, based on a normative standard, exceed 10% of household disposable income. More recent variations include relative thresholds, contrasting *equivalised* household disposable incomes after housing costs with relative energy costs, as Section 2.5 subsequently explains.

While initially a northern hemisphere concept, a warming climate and widespread take-up of air-conditioners and other appliances has meant the problem of fuel poverty has, over time, migrated to the southern hemisphere (Simshauser, Nelson and Doan, 2011; Awaworyi Churchill and Smyth, 2020; Awaworyi Churchill, Smyth and Farrell, 2020; Mazzone, 2020). Heat-related deaths are a problem in Australia (Awaworyi Churchill and Smyth, 2020) and globally, have risen by 53.7% over the past 20 years for those aged 65+ (Watts *et al.*, 2021).

Fuel poverty is a difficult concept, and is *not* the same as poverty (Boardman, 1991; Bennett et al., 2002; Hills, 2012). A household can be poor but afford their energy, and conversely, a household with income demonstrably above the poverty line may not be able to afford their energy costs due to household structure, or may do so only at the expense of other essential items such as diet (Bradshaw and Hutton, 1983). Most importantly, not every energy consumer who spends above fuel poverty thresholds feels poor, and conversely, not every household who feels poor meets typical thresholds (Waddams Price et al., 2012). This complex income expansion path vis-à-vis energy consumption is why fuel poverty warrants attention at all (Bennett et al, 2002).

[7] Belaïd (2018) notes the term "fuel poverty" is used in Great Britain, New Zealand and Ireland, while "energy poverty" tends to be used in Eastern Europe. Other strands of the literature distinguish between fuel poverty as an inability to afford utility bills in the world's most advanced economies, and energy poverty as a general lack of energy infrastructure in developing economies (Welsch and Biermann, 2017). Yet another set of definitions distinguishes energy poverty as household electricity and gas only, with fuel poverty referring to any and all fuels used by a household (Thomson, Snell and Liddell, 2016). In this article, the term fuel poverty is used as per Great Britain.

Tangential to fuel poverty is the term *'energy affordability'* – which has a more widespread use in countries such as Australia. It can be taken to encompass a much broader cohort than those characterised as being in fuel poverty. *Energy affordability* as a policy concept is, I believe, a direct adjunct (in meaning and cause) to 'housing affordability'. As Bramley (2012, p.2) explains, many countries (e.g. Great Britain, US, Australia) simultaneously experienced *'massive'* growth in real house prices between the 1990s and late-2000s, which induced a housing affordability problem in multiple jurisdictions. As Tanton and Phillips (2013) explain, from 1991-2011 Australian house prices increased by 263% (real incomes increased 95%) and in the capital cities of Brisbane, Sydney and Melbourne were among the most expensive in the world. Axiomatically, housing stress, which is driven by the largest and least flexible claim over household incomes, can be expected to amplify latent energy affordability problems.

2.3 Principles of the measurement of poverty

The identification and measurement of fuel poverty comprises a steadily growing body of research (see Jessel et al., 2019). In the subsequent analysis, measurement concepts vis-vis targeting policy performance are derived from the poverty literature and thus it provides an important foundation for the subsequent analysis, particularly the seminal works of Nobel Laureate Amartya Sen, and those of Peter Townsend.

Sen (1976) explains the two basic problems with measuring poverty, 1). identifying vulnerable households in the total population, and 2) constructing indices that capture changes in hardship intensity, and tax and transfers that make the problem worse. Simple headcount ratios are a crude index that fail on 2). and consequently gave rise to Sen's *monotonicity* and *transfer axioms* (see also Beckerman, 1979; Tanton and Phillips, 2013):

- Monotonicity axiom: headcount ratios fail to capture the change in the intensity of (fuel) poverty if incomes and/or (energy) prices change.

- Transfer axiom: headcount ratios fail to reflect changes in the intensity of (fuel) poverty if transfers occur from (fuel) poor to higher income households[8].

While Sen's preferred approach to poverty analysis was normative, Townsend (1962, p.225) approached poverty in advanced economies as relative:

> *…individuals and families whose resources, over time, fall seriously short of the resources commanded by the average individual or family in the community in which they live, are in poverty…*

Professors Sen and Townsend argued furiously over the relative merits of their positions yet as with Yamamori (2019), this article sits comfortably within them.

2.4 Vulnerable Households in Advanced Economies

Beckerman (1979) noted long ago there is no objective general theory of poverty. Poverty lines may be established through normative standard (satisfying Sen), while a broader definition of 'vulnerable household' can be derived through a relative measure (satisfying Townsend).

When using rule-of-thumb thresholds such as 10% for fuel poverty, 3.5% for water poverty or 30% for housing stress, placing coincident bounds around household income is important. For example, housing studies in Australia apply a "40/30 rule". Here, low income is defined as the lowest 40th percentile of household incomes, and housing stress is defined as more than 30% of income (Tanton and Phillips, 2013;

[8] For an analysis of such transfers in Queensland's electricity industry, see Nelson et al (2012) on solar PV feed-in tariffs, and Simshauser (2016) and Simshauser & Downer (2016) on tariff design.

Rowley, Ong and Haffner, 2015). Komives *et al.*, (2006) and Chan (2016) use 40th percentile for low income in their analysis of energy and water utility bills while Fahmy (2011), Hills (2012). Moore (2012), Bramley (2012) and Yamamori (2019) use 60% of median disposable household income.

When analysing vulnerable households, measurement of disposable incomes should be *equivalised*. Doing so recognises that two households with equal incomes but different compositions are not the same. For example, a household with one adult and two children has substantially more necessities for the same quality of life than a household with one adult and no children (Oorschot, 2002; Stone, 2006; Kessides *et al.*, 2009; Moore, 2012; Simshauser and Nelson, 2012; Waddams Price, Brazier and Wang, 2012). For this purpose, the Modified OECD Scale is frequently used which recognises the economies of scale associated with multi-person families, and of differential consumption needs of adults and children (Beckerman, 1979; Stone, 2006; Bramley, 2012; Hills, 2012; Moore, 2012; Tanton and Phillips, 2013; Rowley, Ong and Haffner, 2015).

When examining vulnerable households and energy affordability, equivalised disposable income *'after housing costs'* is appropriate, and consistent with the findings of Hills (2012) and others (see also Moore, 2012; Chan, 2016). As Beckerman (1979) observed, quite often the reason households are vulnerable in the first place is due to housing costs, noting this is usually the single largest and least flexible charge over household disposable incomes (Stone, 2006). Housing structures are also fundamental drivers of energy use (Simshauser et al., 2011; Simshauser and Downer, 2016).

To summarise, *equivalised* disposable income *after* housing costs provides an important variable for defining vulnerable households and the acute subset in fuel poverty. In this research, the definition of vulnerable household used is based on the framework contained in Balestra and Tonkin (2018) and forms the Australian Bureau of Statistics' (ABS) preferred benchmark of vulnerable households, viz. those characterised by Low Income *and* Low Net Wealth, referred to by the ABS as '*Low Economic Resource*[9]' households.

2.5 Fuel Poverty Measurement

Recall from Section 2.2 that fuel poverty largely originated in Great Britain and Europe with reference to Boardman's 1991 framing, viz. a household was said to be in fuel poverty when the normative cost of energy exceeded 10% for the lowest 30% of household incomes (see Boardman, 1991, 2012). The 10% ratio is easily grasped, and is the equivalent of the 'housing stress' ratio of 30% used in the housing literature (Stone, 2006; Tanton and Phillips, 2013; Rowley, Ong and Haffner, 2015).

Stone (2006) observes 'rule-of-thumb' ratios fail to define an adequate minimum residual equivalised income after housing costs. Rowley et al., (2015) highlight fixed ratios applied to *all households* will overstate a problem (i.e. high-income households can tolerate high energy costs), consequently some benchmark level of income is necessary to bound the definition.

Operationalising equivalised incomes after housing costs and then deriving a normative standard of consumption is a complex task as Stone (2006) explains. Ratios such as the 10% fuel poverty threshold (and 30% housing stress) have the benefit of being simple to understand and apply, and generally align with people's common-sense experience. But as Stone (2006) argues, such convenience doesn't

[9] See ABS 'Household and Income Distribution, Australia' Cat 6523.0 (Dec 2013) at https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6523.0Main+Features62011-12?OpenDocument

diminish the intellectual responsibility of policymakers for rigorous and sound conceptualisations.

Prima facie, the fuel poverty ratio of 10% presents as part relative metric (i.e. Boardman's 10% equated to approximately twice the median household expenditure on energy by the poorest 30% of households) and part normative standard, because the cost of energy was derived through a constructed standard to acquire warmth and the balance of energy (i.e. cost of energy required to maintain household with central living areas at 23^{o} C, and outer areas at 18^{o} C). Observed energy costs were not used in original definitions and calculations (see for example Bennett et al., 2002; Fankhauser and Tepic, 2007; Fahmy, 2011; Boardman, 2012; Moore, 2012; Waddams Price, Brazier and Wang, 2012).

However in a major Review in Great Britain, Hills (2012) recommended moving away from a normative standard to a relative analysis (i.e. empirical observation) comprising a low income / high cost metric. It was noteworthy that empirical analysis by Hills (2012) of revealed household energy costs demonstrated use deviated materially from the normative standard, reinforcing the view that there is not necessarily any agreement on what normative standards should in fact be (Bramley, 2012). Evidently, British households were not maintained at normative levels of warmth, with residents opting for cooler configurations (on average). Bramley (2012) finds similar results vis-à-vis normative standards and empirical costs for housing.

This lends weight to the use of traditional affordability ratios (i.e. 10% for fuel poverty, 30% for housing stress) since they are broadly representative of peoples reported payment problems. On this basis, Bramley (2012) argues rule-of-thumb ratios can be justified for measurement (but not forecasting). Similarly, the Hills Review recommended using 60% of the median equivalised household income after housing costs and the median energy spend to define the fuel poverty threshold.

As an aside, only Great Britain and three EU member states (Ireland, France Slovakia) have formal definitions of fuel poverty. The EU has resisted providing a common definition of fuel poverty but the EU's Second and Third Energy Packages (ca.2011 onwards) have directed extensive efforts towards identifying vulnerable customers and addressing affordability. Thomson et al. (2016), Welsch and Biermann (2017), Belaïd (2018), Charlier and Kahouli (2019) and Charlier and Legendre (2019) amongst many others provide helpful overviews of the various definitional options, and draw on a range of metrics to measure the depth of the problem.

2.6 Targeted Income Supports for Utility Bills

Income supports to subsidise the utility bills of vulnerable households and the acute subset in fuel poverty may be constructed as part of a 1). universal policy (i.e. payments made to all households) or 2). category targeting policy. This research focuses exclusively on the latter.

Category targeting via *means-testing* is a way of limiting social expenditure while simultaneously flattening the distribution of market incomes, thereby contributing to social equality (Oorschot, 2002; Komives *et al.*, 2006). As a policy, 'category targeting' is typically capable of achieving a united political view because all political perspectives – both *right and left* – invariably agree on the importance and need to protect vulnerable households (see Besley, 1990; Oorschot, 2002). Indeed, the politics of policy targeting is robust because Labor/Democrats support the effects of targeting (i.e. flattening market incomes and reducing inequality), while

Conservatives/Republicans support category targeting because the normative design of policy focuses on the truly needy (Oorschot, 2002).[10]

2.7 Measuring the Horizontal & Vertical Efficiency of Targeted Policy

As Hoddinott (1999) notes, household-level targeting requires an aggressive effort to seek out the poorest in society – consequently performance measurement to ensure net benefits (*cf.* universal benefits policy) is important. The targeting efficiency framework subsequently applied in Section 4 can be traced back to Beckerman (1979). Specific variations relating to energy affordability and the acute subset in fuel poverty have been guided by Chan (2016), albeit with modifications to suit a broader definition of vulnerable households.

When applied to energy, Beckerman's framework elegantly captures changes in the depth and intensity of vulnerable households and the acute subset in fuel poverty along with residual fuel poverty gaps, thus satisfying Sen's axioms (Besley, 1990; Besley and Kanbur, 1990; Harding and Mitchell, 1992; Creedy, 1996; Hoddinott, 1999). The framework analyses policy targeting through the lens of 1). horizontal efficiency, and 2). vertical efficiency:

1) Horizontal efficiency measures the extent to which a policy treats 'like households' the same way. Horizontal measurement therefore aims to capture the percentage of target households successfully included (vs. those excluded in error), and the percentage of households successfully excluded (vs. those included in error). This is illustrated in Table 1.

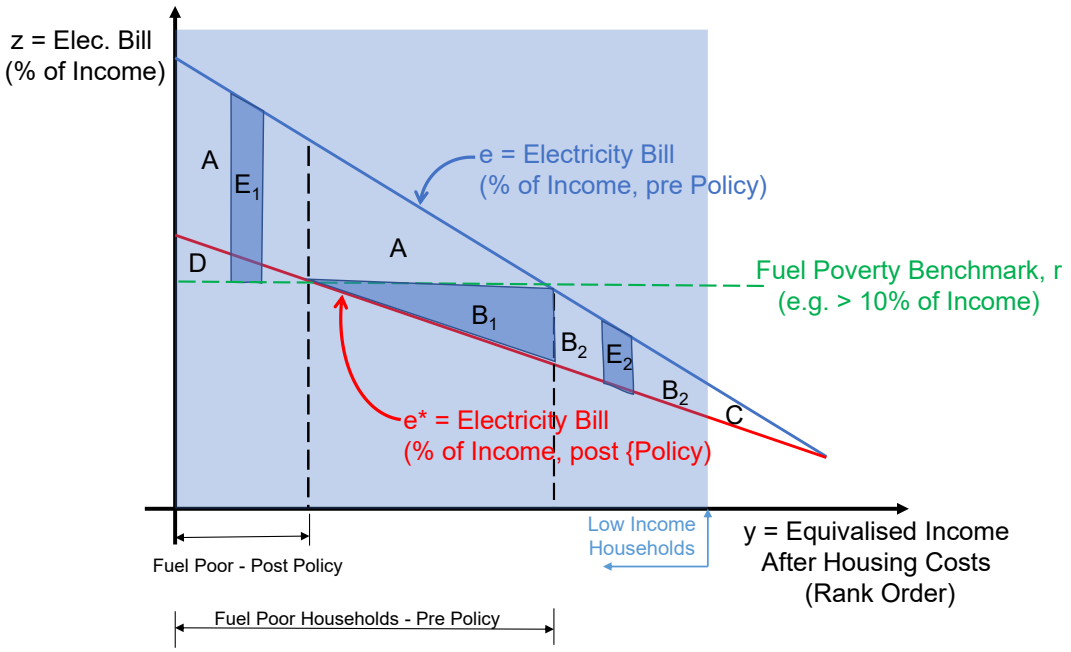
Table 1: Horizontal Targeting Efficiency

	Low Income	**High Income**
Included	Success	Inclusion Error
Excluded	Exclusion Error	Success

2) Vertical efficiency aims to measure the extent to which a policy provides greater support to those households that need it the most. When both horizontal *and* vertical target efficiency is improved, the prevalence, incidence, and depth of customer hardship and fuel poverty is reduced (Beckerman, 1979; Harding and Mitchell, 1992; Creedy, 1996; Herscovitch and Stanton, 2008; Chan, 2016). The measurement of vertical efficiency is illustrated in Fig.2.

[10] Policy targeting should not be taken for its own sake because means-testing is ultimately costly (Besley and Kanbur, 1990; Hoddinott, 1999; Oorschot, 2002; Komives *et al.*, 2006). Nonetheless, the case for targeting vulnerable households and the acute subset in fuel poverty (*cf.* universal provision of income supports) is both logical and intuitive when budget constraints are binding (Creedy, 1996; Hoddinott, 1999; Oorschot, 2002).

Figure 2: Targeting Efficiency of Policy



Where:

A = Fuel Poor Household, successfully targeted
B_1 = Fuel Poor Household, successfully targeted, spill-over benefit
B_2 = Low Income Household, successfully targeted, spill-over benefit
C = Not Low Income, inclusion error
D = Fuel Poor Household, successfully targeted, inadequate benefits provided
E_1 = Fuel Poor Household, exclusion error
E_2 = Low Income Household, exclusion error

From these variables, various measures of vertical efficiency can be constructed, as follows:

$$Total\ Policy\ Cost = \int_{y=0}^{z} e(y)d(y) - \int_{y=0}^{z} e^{*}(y)d(y) \quad (1)$$

$$Benefits\ received\ by\ Fuel\ Poor\ Households = A + B_1\,, \quad (2)$$

$$Vulnerable\ Household\ Vertical\ Efficiency = \frac{(A+B_1+B_2)}{Total\ Policy\ Cost}\,, \quad (3)$$

$$Vulnerable\ Household\ Spillover\ Impacts = \frac{(B_1+B_2)}{(A+B_1+B_2)}\,, \quad (4)$$

$$Fuel\ Poverty\ Reduction\ Efficiency = \frac{A}{Total\ Policy\ Cost}\,, \quad (5)$$

$$Non-Vulnerable\ Inclusion\ Error\ Inefficiency = \frac{C}{Total\ Policy\ Cost}\,, \quad (6)$$

$$Vulnerable\ Household\ Exclusion\ Error\ Inefficiency = \frac{(E_1+E_2)}{Total\ Policy\ Cost}\,, \quad (7)$$

$$Fuel\ Poverty\ Inadequacy\ Error = \frac{D}{(A+B_1+B_2)}\,, \quad (8)$$

2.8 Modified FGT Fuel Poverty Index - depth of customer hardship

An important contribution to the analysis of poverty is contained in Foster, Greer and Thorbecke (1984) and in particular, what has since become known as the 'FGT

Poverty Rate' (see also Besley, 1990; Besley and Kanbur, 1990; Creedy, 1996; Hoddinott, 1999; Skoufias and Coady, 2007; Tanton and Phillips, 2013). Foster et al.'s (1984) measure of poverty satisfies Sen's axioms with the help of the variable (α) which when set to a value of 2 (or higher) places a greater weight on those below the defined poverty threshold. Critically, the metric intensifies as conditions worsen:

$$ES(\alpha) = \frac{1}{n} \cdot \int_{y=0}^{z} \left(\frac{|z-e_i|}{z}\right)^{\alpha} d(e) \mid z = \frac{e_i}{y_i}, \quad (9)$$

In Eq.9, z forms the poverty benchmark, relevant household expenditure is represented by e_i and in this instance z is calculated by reference to a rule-of-thumb ratio relative to household income, y_i for the i^{th} household. When the variable (α) is set to a value of 0, the formula collapses to a simple headcount ratio. As with the horizontal and vertical target efficiency metrics contained in Section 2.7, the FGT Poverty Rate can also be modified for use in the analysis of energy affordability, viz. 'Modified FGT Fuel Poverty Index' focused on fuel poverty.

2.9 Australia's tax and transfer system

Before turning to the quantitative analysis of policy targeting of Queensland's vulnerable households and the acute subset in fuel poverty, it is helpful to provide a brief overview of Australia's tax and transfer system given its central role to refining policy.

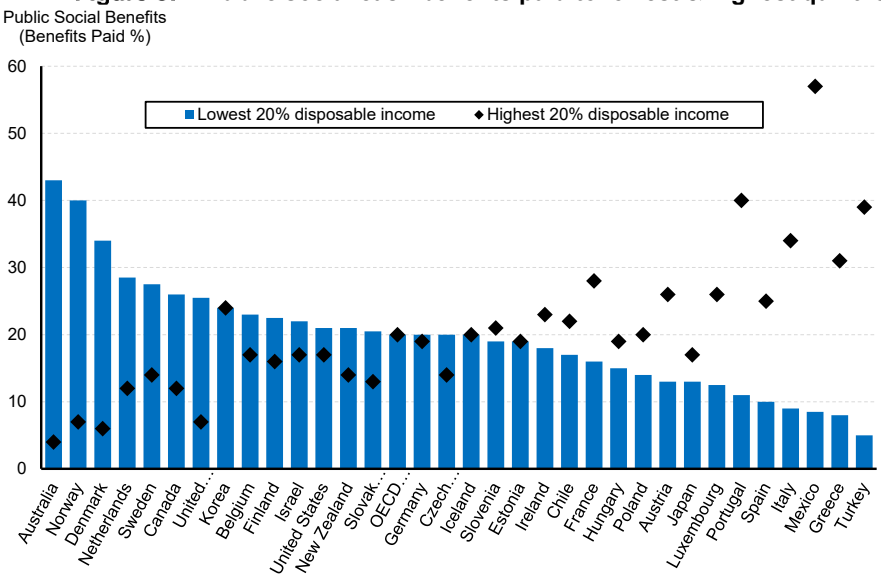
Australia's tax and transfer system differs markedly from international norms. The current system was gradually built up and refined over more than a century, and, has proven to be remarkably resilient throughout time (Herscovitch and Stanton, 2008). It is characterised by a highly targeted redistributive strategy (*cf.* market incomes) with an overall objective of reducing the incidence and depth of poverty, and an emphasis on horizontal and vertical efficiency. Policy architectures aim to maximise economic and social participation subject to minimising administrative burdens and budget constraints – an approach which has long enjoyed bipartisan support for reasons set out in Section 2.6 and in particular those highlighted more generally by Besley (1990), Oorschot (2002) and Komives *et al.*, (2006).

Australian welfare strategy has a long history of targeting. Targeting can be traced back to 1900 when a means-tested Aged Pension Scheme funded through general revenues with no link to prior earnings was established, making it the third aged pension scheme deployed globally (following Denmark in 1891 and New Zealand in 1898). Means-tested Pension schemes were initially established by Australia's three largest States, viz. New South Wales and Victoria (1900) and Queensland (1907) before being consolidated by Australia's Commonwealth Government in 1909 (Herscovitch and Stanton, 2008). Queensland also has a long history of targeted policy. Beyond the Pension scheme in 1907, Queensland introduced the nation's first unemployment scheme in 1923, more than two decades before being absorbed by a Commonwealth scheme. Many other welfare developments in Australia, while initially fragmented at the State level, were consolidated at the national level and by the end of World War II, a highly stable and mature welfare state existed (Herscovitch and Stanton, 2008).

Australia's tax and transfer system can be thought of as part of an 'Anglo-Saxon model' (i.e. small cash transfers, tax mix focusing on redistribution). However, Australian transfers are characterised by being *very highly targeted* to low income groups with extensive use of means-testing, funded by a progressive taxation system[11]. Indeed, as Joumard et al., (2012) explain, Australia's welfare state has the highest target efficiency vis-à-vis lowest quintile income households amongst OECD countries, as illustrated in Fig.3.

[11] See also Joumard et al., (2012), especially Figures 4 and 7 respectively.

Figure 3: Public social cash benefits paid to lowest & highest quintiles



Source: OECD Social Expenditure Update (2014)[12]

While the welfare state is largely the domain of the Commonwealth Government, energy and utility policy resides with State Governments, and consequently targeted income supports to subsidise the energy bills of vulnerable customers and the acute subset in fuel poverty are orchestrated at the State level. State Governments are able to draw on Commonwealth means-tested welfare flags (i.e. various cardholders), meaning that at the margins administrative setup costs of refining State-based programs to target vulnerable households can be considered trivial. And as Awaworyi Churchill and Smyth (2020) explain, doing so has become critical.

3. Data

In the analysis of affordability and poverty, use of microdata is considered the 'gold star standard' (Skoufias and Coady, 2007). In this article, microdata compiled by the Australian Bureau of Statistics (ABS) is used. The 2015 Survey of Income and Housing (Series 6541) comprises household-level data from across Australia on incomes, assets and liabilities, housing type, housing costs, and welfare flags (i.e. Commonwealth Cardholders) from a sample of ~14,000 households. Furthermore, the ABS's accompanying Household Expenditure Survey (Series 4670) is also used as it incorporates detailed energy consumption by household type (e.g. dwelling structure, family composition, region and so on) and has been matched by the ABS to Series 6541 data, making the broader dataset quite unique. Survey results are appropriately weighted to Queensland's 1.765 million households with one noteworthy caveat – 'very remote' areas of Queensland are not captured or represented by the data (i.e. approximately 30,000 households).

3.1 Defining Vulnerable – Low Income vs. Low Economic Resource

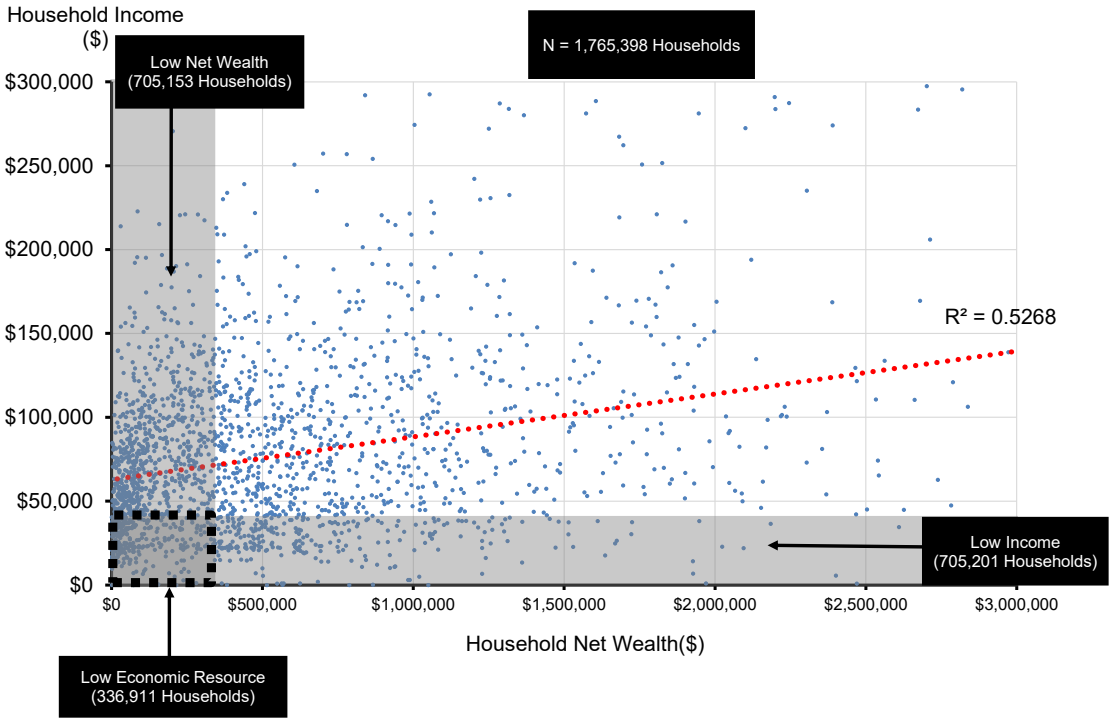
Recall from Section 2 that definitions of 'low income' varied, for example 1). 60% of median income (Bramley, 2012; Hills, 2012; Moore, 2012; Yamamori, 2019), and 2). 40th percentile income (Komives et al., 2006; Tanton and Phillips, 2013; Rowley, Ong and Haffner, 2015; Chan, 2016). Recall also from Section 2.4 that Balestra and Tonkin (2018) and the Australian Bureau of Statistics' preferred definition of vulnerable household is those characterised as 'Low Economic Resource'. In an applied sense, this is derived by reference to the cross-over between the 40th percentile equivalised household disposable income, and 40th percentile equivalised household net wealth. For policy targeting of vulnerable households and the acute

[12] Available at OECD Social Expenditure Update, 2014, https://www.oecd.org/…/OECD2014-Social-Expenditure-Update-Nov2014- 8pages.pdf

subset in fuel poverty, this provides a very robust definition of the poorest Queensland households (i.e. lowest 20th percentile). It is therefore the definition used in the subsequent analysis of horizontal and vertical targeting efficiency.

ABS microdata for Queensland's Low Economic Resource households is illustrated in Fig.4, with Equivalised Household Wealth measured on the x-axis, and Equivalised Household Income measured on the y-axis.

Figure 4: Low Income + Low Net Wealth = Vulnerable / Low Economic Resource Household



The intuition of this approach is that Household Net Wealth represents the *stock* of material resources and is complementary to the *flow* of Household Incomes (Balestra and Tonkin, 2018). Conditions facing low income households are axiomatic, and evidently, a household with Low Net Wealth is 'economically vulnerable'.

To summarise the data in Fig.4, recall there are 1.765m households in Queensland. The 40th percentile equivalised income is $669.46 per week, which captures 705,201 households. The 40th percentile equivalised net wealth is $258,772 and captures 705,153 households. The cross-over of these two segments (dashed boxed area in Fig.4) captures 336,911 'Low Economic Resource' households. They form the lowest quintile – Queensland's 'vulnerable households'.

3.2 Queensland Customer Hardship Policy: Old (1993) vs. Revised

Queensland's longstanding customer hardship policy was implemented in 1993, pre-dating NEM commencement by at least five years. The policy delivery mechanism comprises a payment of ~$329 per annum, applied in equal Quarterly instalments against target household energy bills, delivered directly from the Queensland Government to the household's energy retailer.[13] The 1993 policy's category targeting framework comprised two targets, as follows:

1) means-tested Pension Cardholders, and

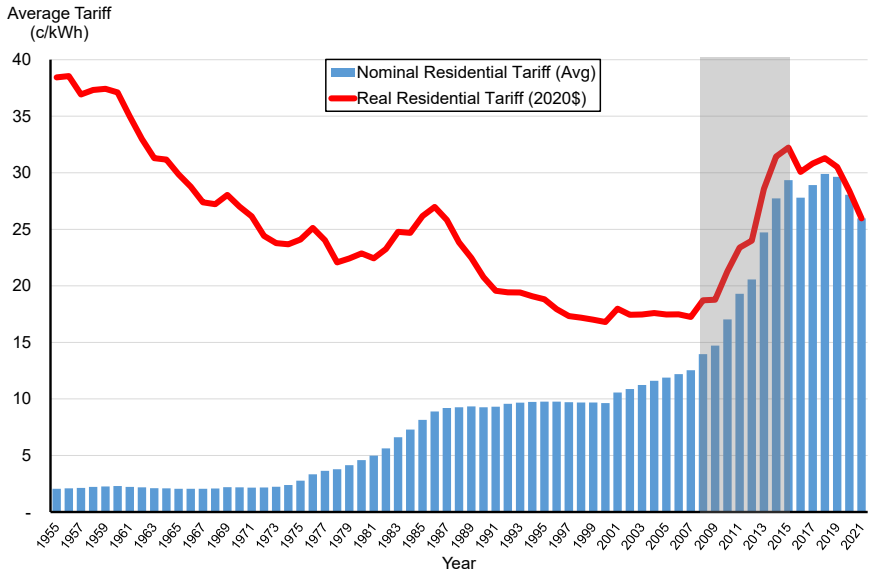
[13] Queensland households are primarily 'all electric'. Being a hot climate, natural gas has a very low market share in Queensland (~150,000 households) and use is typically minimal and limited to cooking appliances. Some households with access to natural gas also use the fuel for their hot water system. However, many households (including the author) will have electric or solar hot water systems.

2) *non means-tested* Queensland Seniors Cardholders.

The program budget (2017$) was ~$160m per annum and as the parameters above make clear, *category targeting* centred on the aged (65+ years) demographic. Policymakers were aware policy parameters required some level of revision and adjustment from ~2012, when the concept of energy affordability began to take on a central narrative in Australian media[14].

However, the business of government is congested. Policymaking in highly specialised areas such as energy typically do not follow a conventional or methodological process. On the contrary, policymaking is *'often chaotic, fragmented, contingent and arational'* as Tiernan and Burke (2002) explain (see also Jones, 2014; Peters and Hertel, 2017; Simshauser, 2018a). In a practical sense, a political window needs to be 'prised open' to create the opportunity for review and deployment (Tiernan and Burke, 2002; Jones, 2014; Howlett, McConnell and Perl, 2015; Simshauser and Tiernan, 2019). The sustained run-up in residential electricity tariffs during 2008-2015 (see Fig.5) created these conditions, and a window appeared in 2015-2017 at which point welfare enhancing refinements were made. However, for the purpose of defining optimal policy, the subsequent analysis ignores these changes and commences with the 1993 'Old Policy'.

Figure 5: QLD Average Residential Electricity Tariff (1955-2021)



Data Sources: ESAA, QCA, ABS.

To be welfare enhancing, revision of the 1993 policy requires focus on two key objectives, improving horizontal target efficiency and vertical target efficiency, holding program budgets constant:

- Improving the horizontal efficiency of the 1993 'Old Policy' hinges on improving the accuracy of category targeting via use of existing welfare flags. Available welfare flags from the Commonwealth Government's various means-tested schemes exist in the ABS data set (e.g. Pension Card, War Veterans Card, Family Tax Rebate Beneficiaries, Health Cardholders amongst others). To simplify an otherwise lengthy description of available options – given an objective function of enhancing energy affordability for vulnerable households, and to reduce the incidence and depth of the acute subset of households in fuel poverty, a combination of the Commonwealth

[14] For example, see Fig.7 in Simshauser and Laochumnanvanit (2012) which shows the sharp runup in media coverage of the term "electricity price" over the five-year period 2007 – 2011 in Queensland and New South Wales.

Government's 'Pension Card' and 'Health Card' provides an unambiguously optimal set of welfare flags.

- To further improve scheme *vertical efficiency*, the payment mechanism of $329 per annum can be enhanced by shifting to a variable rate based on the *'percentage of the bill'* for households. Given a program budget constraint, equivalence occurs when the variable rate is set to 22.5% of qualifying household energy bills (as Table 3 later reveals).

A summary of the Old Policy and 'Revised Policy' is presented in Table 2.

Table 2: Queensland Vulnerable Customer Policy

	Old Policy Targeting	Revised Policy Targeting
Category Target Inclusions	Pension Card Holder (means-tested)	Pension Card Holder (means-tested)
	Qld Seniors Card Holder *(non-means tested)*	Health Care Card Holder (means-tested)
Policy Benefit Mechanism	$329 pa	22.5% of Elec Bill
Category Target Exclusion/Omission	Health Care Card Holder (means-tested)	Qld Seniors Card Holder (non-means-tested)

Shifting from fixed ($329) to variable (22.5%) targeted income supports to subsidise utility bills has two primary benefits, 1). greater support is provided to *very high* summer invoices (the point a vulnerable household is likely to tip into energy bill distress), and 2). households with greater need receive greater absolute support.

I am aware of the argument that 'percentage of the bill' targeted income supports to subsidise utility bills encourages the inefficient use of energy (see for example QPC, 2016, pp302-303). In a mature debate on customer hardship and the acute subset in fuel poverty, such arguments are not helpful. The problem with *truly* vulnerable households is not that they use too much energy. The problem is that vulnerable households don't have enough money. They have insufficient funds to pay for their energy bills, to buy more efficient appliances, to install solar PV, to generally improve their capital stock and reduce consumption.

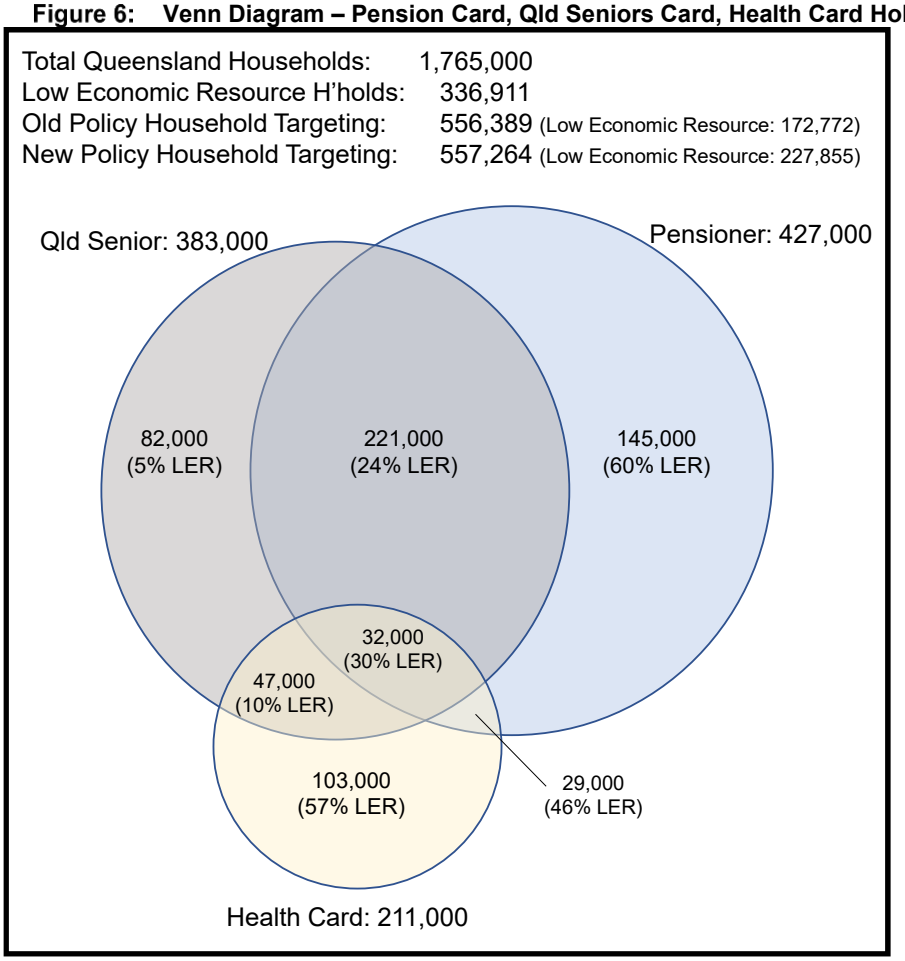
Fig.6 provides a Venn Diagram to conceptualise likely effects of targeting vis-à-vis inclusions and exclusions given the three welfare flags. Note in Fig.6 there are 1,765,000 Queensland households in total. Of these, 336,911 are defined as vulnerable, i.e. Low Economic Resource (LER). There are 383,000 (non means-tested) Queensland Senior Cardholders, 427,000 means-tested Pension Cardholders, and 211,000 means-tested Health Cardholders. There are two key results in Fig.6 relating to targeting:

1. By excluding Queensland Seniors, 82,000 Cardholders will be excluded and of these, 5% are 'LER' vulnerable households. All other vulnerable Seniors Cardholders either have a Pension Card (221,000 households), a Health Card (47,000 households) or both, i.e. Pension *and* Health Cards (32,000 households).

2. By including Health Cardholders, 103,000 households excluded under the Old Policy would become Revised Policy targets. The importance of this is that

more than half (57%) are defined as LER vulnerable households, many from the 'family formation' cohort where energy affordability problems are prevalent as Section 5 and Fig.10 subsequently reveal.

Figure 6: Venn Diagram – Pension Card, Qld Seniors Card, Health Card Holders



Data Source: ABS.

4. Modelling Results

Model results focus on the analysis of three key aspects of the change in policy targeting as presented in Section 2, specifically - 1). horizontal target efficiency, 2). vertical target efficiency, and 3). Modified FGT Fuel Poverty Index.

4.1 Horizontal Target Efficiency

Recall horizontal efficiency measures the extent to which a policy treats 'like households' in the same way. Measurement focuses on the accuracy of successful targeting of the 336,911 vulnerable households in Fig.6. The analysis contrasts horizontal efficiency of the Old and Revised Policy, the extent of inclusion error (i.e. non-vulnerable households who benefit from the policy), and of exclusion error (i.e. vulnerable households *not captured* by the policy), and 'successful exclusion' – the raison d'etre for means-testing in the first place.

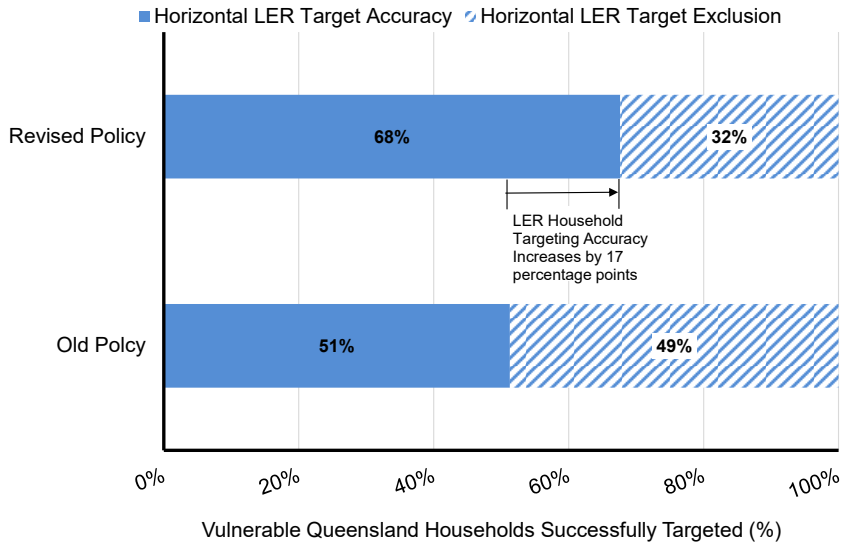
Model results are illustrated in Fig.7. Successful targeting of Queensland's vulnerable households under the Revised Policy increases from 51% to 68% (Fig.7a) – a material step-change improvement through a relatively straight forward administrative decision involving a pre-existing, means-tested welfare flag (i.e. inclusion of Commonwealth Health Cardholders).

Fig.7b provides the detailed analysis of horizontal efficiency. Notice the Old Policy successfully targets 172,772 of Queensland's 336,911 vulnerable households. Therefore, the Old Policy exclusion error is (336,911 – 172,772) = 164,139

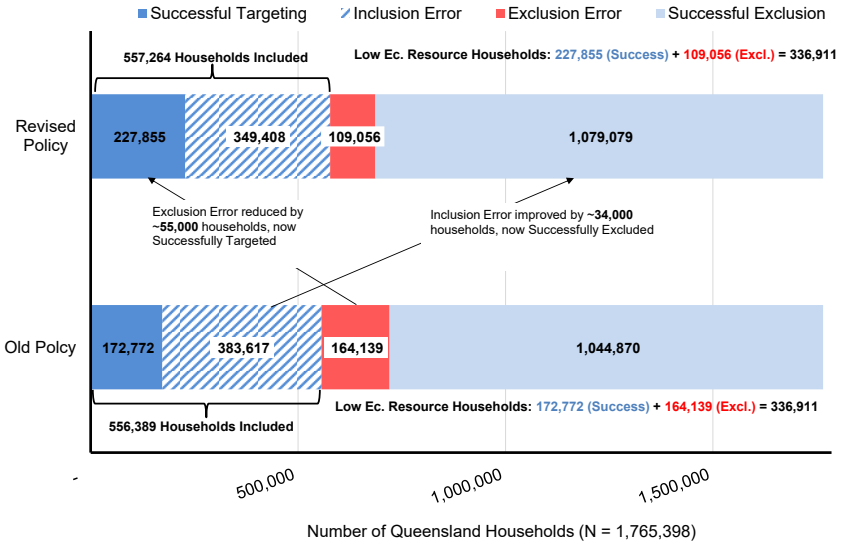
households. By expanding category targeting to include Health Cardholders, the Revised Policy captures an additional ~55,000 households, which move from the Old Policy Exclusion Error 'bucket' to the Revised Policy Successful Targeting 'bucket', with the total rising from 172,772 to 227,855 households. Furthermore, by removing Queensland Seniors Cardholders, ~34,000 non-means tested households exit the scheme and the horizontal 'Inclusion Error' reduces from 383,617 to 349,408 households.

Figure 7: Horizontal Target Efficiency – Old Policy v Revised Policy

7a – Horizontal Efficiency (% of Vulnerable Households)



7b – Horizontal Efficiency (Household numbers)



4.2 Vertical Target Efficiency

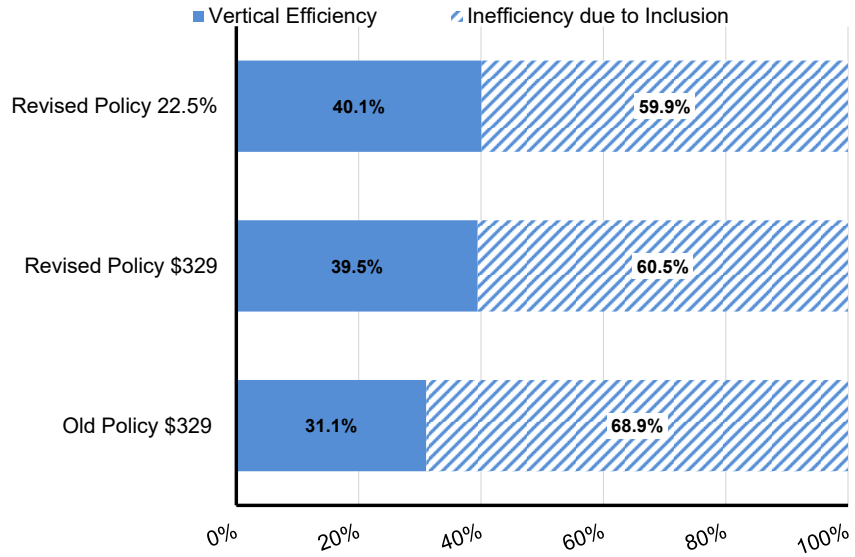
A significant limitation of the horizontal efficiency analysis presented in Fig.7 is that it measures 'headcount'. It says nothing of the depth of hardship facing vulnerable households and the acute subset in fuel poverty. Thus, our analysis must now turn to a vertical analysis. Recall vertical efficiency measures are designed to gauge the incidence and depth of the problem, and the extent to which a policy provides greater support to those households that need help the most. Three distinct policy scenarios are analysed in Fig.8 and Tab.3:

1) The Old Policy (1993) comprising Pension Card and Queensland Seniors Cardholders, with targeted income support of $329 per annum.
2) A Revised Policy, Queensland Seniors Cardholders excluded, Health Cardholders included, with targeted income support maintained at $329 per annum, and
3) Revised Policy with the mechanism changed to 22.5% of the household electricity bill.

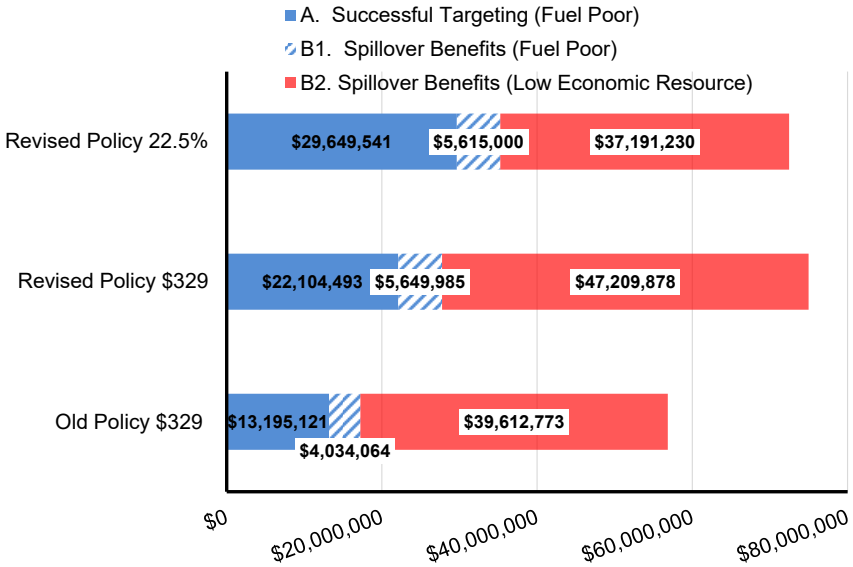
Critically, the difference between 2) and 3) provides vertical efficiency insights over the payment mechanism, i.e. fixed vs. percentage of the bill. The first point to note (Fig.8a) is that Vertical Efficiency (the ratio of Successful Targeting of fuel poor + Spill-Over Benefits to vulnerable households to Total Program Cost) improves considerably, from 31.1% to 40.1%. Second, note in Fig.8b the quantum of funds going directly to the fuel poor more than doubles, from $17.1m (i.e. $13.1m + $4.0m in '$B_1$' Spill-Over Benefits) to $35.2 million (i.e. $29.6m + $5.6m in '$B_1$' Spill-Over Benefits).

Figure 8: Vertical target efficiency – Old vs Revised ($329 & 22.5% Policy Revisions)

8a – Vertical Efficiency ($ delivered to Vulnerable Households as % of Total)



8b – Vertical Efficiency ($ delivered to Vulnerable Households, including Fuel Poor)



The full vertical analysis of policy targeting efficiency is presented in Tab.3. Note vertical efficiency Eq.1-7 outlined in Section 2.6 appear at Lines 9-15. With Tab.3 the first point worth noting is Total Program Costs (Line 7). The Old Policy equates to $183.0m (100% enrolment) and the New Policy ranges from $180.7-$189.9m. Second, benefits received by the most vulnerable households (Line 8) increases significantly with the Revised Policy mechanism, from c.$17.2m to $35.2m per annum.

Table 3: Vertical Target Efficiency – Old Policy v New Policy

		POLICY VERTICAL EFFICIENCY ($ per annum)		**Old Policy**	**Revised Policy**	**Revised Policy**
LINE		Benefit per annum		**$329**	**$329**	**22.5%**
1	A.	Successful Targeting (Fuel Poor)		$13,195,000	$22,104,000	$29,650,000
2	B1	Spillover Benefits (Fuel Poor)		$4,034,000	$5,650,000	$5,615,000
3	B2	Spillover Benefits (Low Economic Resource, not Fuel Poor)		$39,613,000	$47,210,000	$37,191,000
4	C	Inclusion Expense (Not Low Ec. Resource, not Fuel Poor)		$126,210,000	$114,955,000	$108,305,000
5	D	Included but Inadequate (Still Fuel Poor)		$19,961,000	$38,716,000	$31,390,000
6	E	Exclusion Inadequacy (Low Economic Resource)		$54,002,000	$40,096,000	$40,096,000
7		Total Program Cost	∑ (A, B1, B2, C)	$183,052,000	$189,920,000	$180,761,000
8		Benefits Received by Fuel Poor	∑ (A, B1,)	$17,229,000	$27,754,000	$35,265,000
		POLICY VERTICAL EFFICIENCY (%)				
9		Vertical Efficiency	∑ (A, B1, B2) / Total Prog. Cost	31.1%	39.5%	40.1%
10		Spill-over benefits	∑ (B1, B2) / ∑ (A,B1, B2)	76.8%	70.5%	59.1%
11		Poverty reduction efficiency	A / Total Program Cost	23.2%	29.5%	40.9%
12		Spill-over Excess (% of Total)	∑ (B1, B2) / Total Prog. Cost	23.8%	27.8%	23.7%
13		Inefficency due to inclusion	C / Total Program Cost	68.9%	60.5%	59.9%
14		Ineffeciency due to exclusion	E / Total Program Cost	29.5%	21.1%	22.2%
15		Inadequate concession benefits	D / Total Program Cost	10.9%	20.4%	17.4%
16		Benefit inadequacy	∑ (D, E) / Total Prog. Cost	40.4%	41.5%	39.5%
		NUMBER OF HOUSEHOLDS		**Old Policy**	**Revised Policy**	**Change**
17	A.	Successful Targeting (Fuel Poor)		52,368	84,360	31,992
18	B1	Spillover Benefits (Fuel Poor)		20,817	29,320	8,503
19	B2	Spillover Benefits (Low Economic. Resource)		120,404	143,495	23,092
20	C	Inclusion Expense (Not Low Ec. Resource)		383,617	349,408	-34,209
21	D	Inadequate Included		31,551	56,839	25,288
22	E	Exclusion Inadequacy		164,139	109,056	-55,083
23	F	Total Households Included	∑ (A, B2, C)	556,389	577,264	20,875
24		% of Total Households	F / 1,765,398	31.5%	32.7%	1.2%

Vertical efficiency metrics (Tab.3, Lines 9-16) all favour the Revised Policy with a payment mechanism in the form of 22.5% of the electricity bill. The one metric which deteriorates relative to the Old Policy is 'Inadequate Concession Benefits' at Line 15 (where a lower result represents improvement). However, while it appears to have deteriorated, recall the Old Policy captures less of Queensland's vulnerable households.

4.3 Analysis of Fuel Poverty - Modified FGT Fuel Poverty Index

The final aspect of analysis focuses exclusively on the acute subset of vulnerable households in fuel poverty. Thus far in the analysis, a fuel poverty threshold of 10% has been used and this is, of course, a generalised rule-of-thumb. It is helpful to illustrate alternate metrics and thresholds and for this purpose a Modified FGT Fuel Poverty Index is used. The nature of the FGT calculation is that it is well suited to a fixed benchmark.

To illustrate an alternate threshold suitable for a Modified FGT Fuel Poverty Index calculation, the analysis turns to the framework contained in Great Britain's Hills (2012) Review. This defines fuel poor households by reference to 60% of Median Household Equivalised Income After Housing Costs *and* Median Household Electricity Costs. The Index analysis for Queensland (Eq.9) is presented in Tab.4.

Note in Tab.4 there are 299,117 Queensland households (Line 2) that meet the Hills (2012) definition of 'low income', households with equivalised income after housing

costs less than 60% of the median (i.e. $343.20 per week). Median household energy costs are $24.43 (Line 4) and with No Policy, 155,447 households (8.8% of Queensland) are in fuel poverty. The depth of fuel poverty is measured at $103.8 million (Line 7). The Revised Policy reduces the number of households in fuel poverty to 115,812, and the depth of the problem falls to $67.4m.

Table 4: Modified FGT Fuel Poverty Index
(Fuel Poverty = 60% x Median Equiv. Household Income *and* > Median Energy Cost)

	FGT Poverty Analysis	No Policy	Old Policy	Revised Policy
1	Total Households	1,765,000	1,765,000	1,765,000
2	Total Number of Low Income Households	299,117	299,117	299,117
3	Benchmark (60% of Median Equiv. Income)	$343.20	$343.20	$343.20
4	and Median Household Energy Cost	$24.43	$24.43	$24.43
5	Households in Fuel Poverty	155,447	123,884	115,812
6	Ratio of Households in Fuel Poverty	8.8%	7.0%	6.6%
7	Depth of Fuel Poverty	$103,866,000	$83,689,000	$67,462,000
8	FGT Poverty Index	0.043	0.038	0.029

In Tab.4, the Modified FGT Fuel Poverty Index commences at 0.043 with No Policy. The Old Policy did reduce the incidence and depth of hardship with the Index falling to 0.038. However, note the Revised Policy has a profound effect with the Index reducing to 0.029 noting that doing so is done with the same program budget, thus adding further weight to horizontal and vertical results.

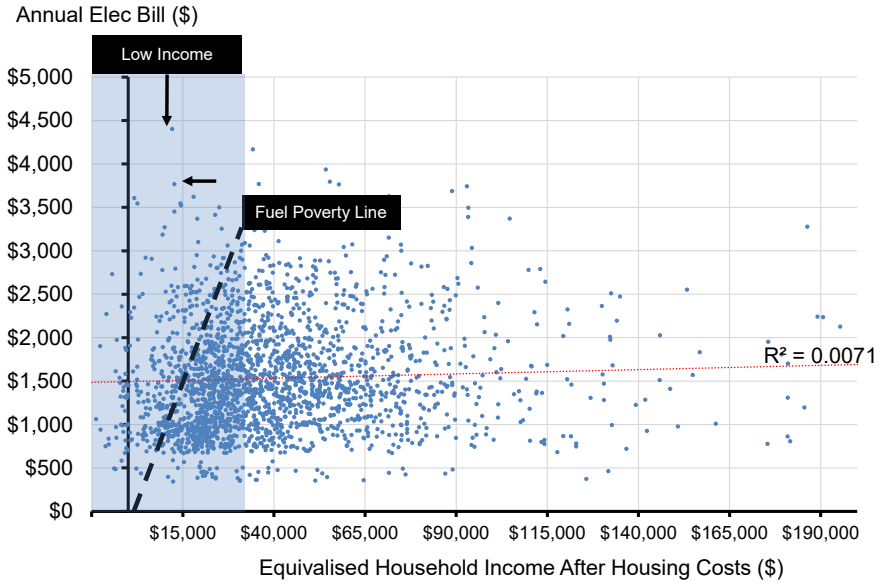
5. Source of improved targeting efficiency

The horizontal efficiency, vertical efficiency and Modified FGT Fuel Poverty Index results presented in Section 4 show material improvements via a Revised Policy. Category targeting of means-tested Health Cardholders was central to the improvement. Recall from Tab.3 changing the mechanism from fixed ($329) to variable (22.5%) further enhanced vertical[15] efficiency.

Why is this? The answer can be derived from Engel's (1897) analysis and relates to the relationship, or lack thereof, between absolute household incomes and energy consumption. Fig.9 presents Queensland household data and highlights an R^2 of just 0.007. This chart replicates Bennett et al., (2002) who similarly plotted British household incomes and energy consumption, and derived an R^2 of 0.04. As they explain, the household energy cost relationship with income expansion is complex – it *'scatters'* rather than *trends*.

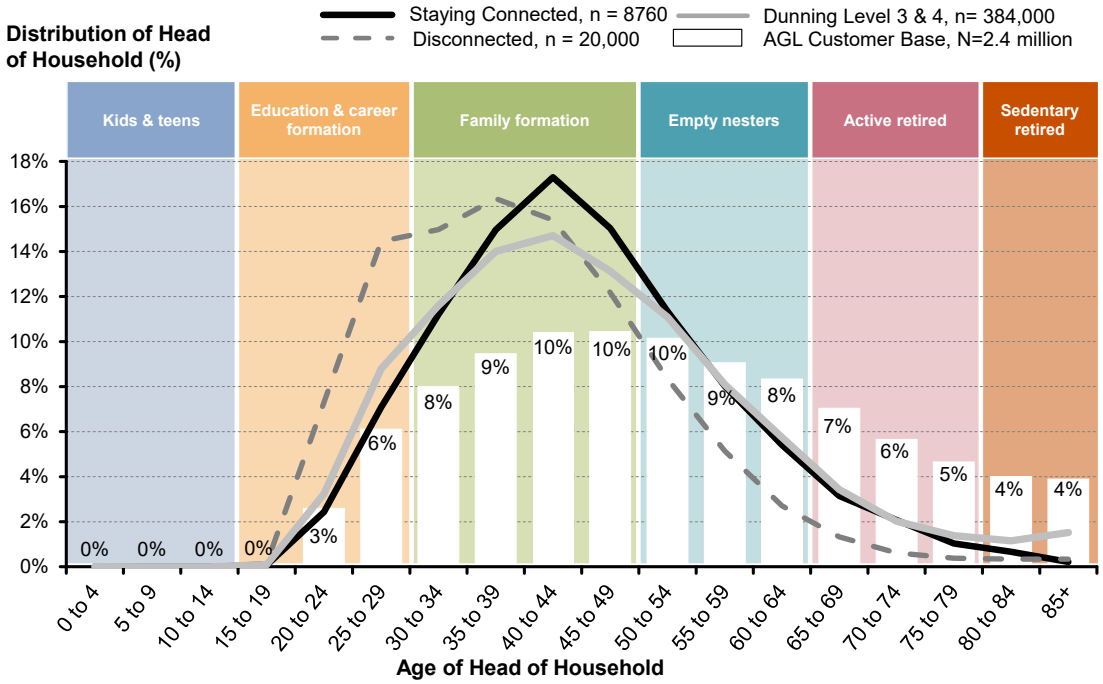
[15] For clarity, changing the mechanism has no impact (either way) on horizontal efficiency.

Figure 9: Qld Equivalised Incomes (after housing costs) vs Electricity Bill



An important piece of the 'vulnerable customer puzzle' is presented in Fig.10, which has been reproduced from Simshauser and Nelson (2012). Fig.10 presents an 'age' and 'hardship' analysis of 2.4 million residential energy customers, incorporating 3 million electricity and gas accounts and spanning more than 12 million (Quarterly) invoices from the NEM's Queensland, New South Wales, Victorian and South Australian regions (i.e. 25% of NEM households). The 2012 data allocates households into 'age buckets' (x-axis) which are then grouped into various 'demographic cohorts'. For example, energy accountholders in the '30 to 34' year 'age bucket' form part of the *Family Formation* cohort.

Figure 10: Energy Market Death Spiral



Source: Simshauser & Nelson (2012)

The white bar series in Fig.10 plots the distribution of household customers (average age 52 years). The black and grey line series present various customer payment metrics which help explain the nature of customer hardship, and why changed policy targeting was successful (nb. 'Staying Connected' are households with the

willingness, but not the capacity, to pay their energy bill while 'Dunning Level 3 & 4' households have *very overdue* accounts). Note that the distribution of the line series visibly peaks in the *Family Formation* cohort (i.e. 40 to 44 year age bucket), and *not* the aged cohorts. The average age of Hardship Customers is 45 years. While not illustrated in Fig.10, the Family Formation cohort spend considerably more on energy (i.e. between +13 to +30% above average), while all other cohorts spend less than average. These results are consistent with the findings of Waddams Price et al., (2012), who also found the role of incomes *and* family structure (in Great Britain) to be important in the analysis of vulnerable households and the more acute subset in fuel poverty.

6. Policy implications and concluding remarks

The purpose of this article was to analyse the efficacy of a long-standing customer hardship policy in the NEM's Queensland region. Designed in 1993, the policy targeted aged households via Pension Card and Queensland Seniors Cardholders. Following reviews in 2015-2017, policy targeting was altered by the Queensland Government to include means-tested Health Cardholders. Modelling results in this article suggest policy changes were warranted.

The matter of energy affordability in Australia rose to prominence from 2012. Preceding this, housing prices in Australian capital cities had risen by 263% over the period 1991-2011. Further, average household energy consumption in Queensland increased markedly between 1993-2010 given a warming climate, rising incomes, and the widespread uptake of air-condition units. Compounding matters, electricity tariffs surged from 2007-2015 (Fig.5). Large households in the Family Formation cohort were adversely affected, noting they consume (on average) between 13-30% more than other cohorts. Collectively, these conditions led to a sharp focus on energy affordability and introduced the possibility of rising fuel poverty – terminology quite unfamiliar to Australian policymakers at the time.

In the case of Queensland, the architecture of the longstanding 1993 policy was poorly targeted. It did not envisage customer hardship beyond the aged (65+ years). The Family Formation cohort in particular was excluded in spite of results in Fig.10. Analytical results from Section 4-5 confirm cohorts other than the aged are prevalent in the customer hardship statistics.

6.1 Improving targeting efficiency

Improving horizontal efficiency, vertical efficiency and Modified FGT Fuel Poverty Index efficiency of Queensland's customer hardship policy at low administrative cost is credible because of Australia's tax and transfer system. No other country in the OECD has a system with such accurate transfer capacity (Fig.3). Using existing Commonwealth welfare structures enables vulnerable households – those defined as *Low Economic Resource* (i.e. low income *and* low net wealth) – to be more effectively targeted by expanding the policy to Health Cardholders, which has a prevalence of low-income families. Cash benefits to families are known to have strong redistributive impacts (Joumard, Pisu and Bloch, 2012). At the same time, the economy of the program could be maintained by excluding Queensland Seniors Cardholders, who are *not* means tested.

Economic calculus frequently differs from political calculus – a decision to exclude Queensland Seniors Cardholders is likely to be very difficult. Yet a genuinely vulnerable Queensland Seniors Cardholder will qualify for the Pension Card.

The Fig.6 Venn Diagram demonstrated conceptually how including Health Cardholders and excluding Queensland Seniors Cardholders would capture a greater number of vulnerable households. Results in Figs.7-8 showed the Revised Policy increases horizontal efficiency from 51% to 68%, and vertical efficiency increases

from 31.1% to 40.1%. Tab.3 revealed altering category targeting would result in Poverty Reduction Efficiency rising from 23.2% to 29.5% with the payment mechanism maintained at $329 per annum. Poverty Reduction Efficiency could be further improved, from 29.5% to 40.9%, by altering the payment mechanism to '22.5% of the electricity bill'.

6.2 Minimising program leakage and inclusion error

An objective function of policy targeting is to minimise inclusion error. However, it is important to note that inclusion error is inevitable. As Hills (2012) explains, it would be naïve to think policies aimed at removing problems faced by 336,000 households could be dealt with by only treating 336,000 homes. In practical terms a wider group *must* be targeted. To be perfectly clear on this point, acknowledging budget constraints, it is generally more desirable to minimise under-coverage and exclusion error than to limit leakage and inclusion error (Hoddinott, 1999).

As an absolute general conclusion, income supports and targeting are not solely designed to reduce poverty, and this notion should extend to policies designed to provide targeted income supports to subsidise energy bills. Spill-over benefits (recall segments B_1 and B_2 from Fig.2, and Lines 2 & 3 in Tab.3) should not be viewed as *'bad'*. In my view, spill-over benefits to genuinely vulnerable households are desirable because they contribute to social welfare (see also Creedy, 1996) and consequently Eq.3 was adjusted to reflect this (i.e. by adding B_1, B_2). And while the economic principles of optimal targeting may be straightforward, other political and policy objectives such as reducing inequality, societal perceptions of equity, administrative efficiency and the political economy of decision making are all important and will invariably influence and guide targeting policy in practice as Beckerman (1979) and Besley and Kanbur (1990) explain.

6.3 Practical limitations of Successful Inclusion (i.e. exclusion error)

The sobering aspect of the analysis presented in Section 4 is that, despite having the world's most targeted tax and transfer system, horizontal targeting of vulnerable households in Queensland *'maxed out'* at 68%. By implication, 32% of vulnerable households will slip through the net, absent other initiatives.

Program targeting of Queensland's vulnerable households could be improved, *albeit marginally,* through ongoing inclusion of Queensland Seniors Cardholders, and expanding the policy by adding, for example, Veterans Cardholders. But this would present as a very different proposition from a program economy perspective. The benefit would be an increase of 2-3 percentage points in vulnerable household horizontal targeting coverage, but with a program cost blow-out of ~30+%, a very large increases in inclusion error, and deteriorating aggregate horizontal and vertical efficiency metrics. Proceeding with such a broad policy is of course a legitimate political decision, but unlikely to be an economic one given other important competing claims over scarce State Government fiscal resources.

Finally, there are reasons why higher levels of vulnerable household coverage are rarely achieved in practice under a targeting policy. First, as Skoufias and Coady (2007) note, receipt of transfer benefits is contingent on category targeting parameters and multiple objectives lie behind transfer programs and welfare flags including the use of rules that are not perfectly optimal, but the best that can be done given complex budgetary, political and administrative constraints. And second, and again as Skoufias and Coady (2007) note, receipt of transfer benefits is contingent on enrolment.

Means-testing impacts enrolment because it imposes a burden on otherwise legitimate recipients through 1). psychological stigmatisation (i.e. screening processes can be humiliating, for households where English is a second language

filling out forms can be overly complex, questioning can overlook sensitive cultural issues[16], or individuals may be subjected to hostile screening interviews) and 2). pecuniary costs (including transaction costs). Such characteristics are known to deter full participation (Besley, 1990; Oorschot, 2002). As Oorschot (2002) explains, citizens from genuinely vulnerable households do not always behave as calculating, well informed 'surplus maximisers' and consequently, participation rates frequently peak at 80%. As a result, *non take-up rates* will remain a serious policy problem warranting continuous research in the field.

In the meantime, changing the category targeting to include means-tested Health Cardholders, excluding non-means-tested Queensland Seniors Cardholders and altering the payment mechanism from $329pa to 22.5% of the bill is capable of delivering substantial improvements in the horizontal efficiency and vertical efficiency of Queensland's longstanding customer hardship policy, and is therefore materially welfare enhancing.

7. References

Argy, F. (1999) 'Distributional effects of structural change: some policy implications', in *Structural Adjustment - Exploring the Policy Issues*. Productivity Commission, Canberra., pp. 39–93.

Awaworyi Churchill, S. and Smyth, R. (2020) *Energy Poverty and Health: Panel Data Evidence from Australia*. doi: 10.13140/RG.2.2.28826.08642/1.

Awaworyi Churchill, S., Smyth, R. and Farrell, L. (2020) 'Fuel poverty and subjective wellbeing', *Energy Economics*, 86, p. 104650.

Balestra, C. and Tonkin, R. (2018) 'Inequalities in household wealth across OECD countries: Evidence from the OECD Wealth Distribution Database', *OECD Statistics Working Papers*, 33, pp. 1–69.

Beckerman, W. (1979) 'The impact of income maintenance payments on poverty in Britain, 1975', *The Economic Journal*, 89(354), pp. 261–279.

Belaïd, F. (2018) 'Exposure and risk to fuel poverty in France: Examining the extent of the fuel precariousness and its salient determinants', *Energy Policy*, 114(June 2017), pp. 189–200.

Bennett, M., Cooke, D. and Waddams Price, C. (2002) 'Left Out in the Cold? New Energy Tariffs, Low-Income Households and the Fuel Poor', *Fiscal Studies*, 23(2), pp. 167–194.

Besley, T. (1990) 'Means Testing versus Universal Provision in Poverty Alleviation Programmes', *Economica*, 57(225), pp. 119–129.

Besley, T. and Kanbur, R. (1990) *The Principles of Targeting*, *The World Bank Working Paper 385*. doi: 10.1007/978-1-349-21587-4_5.

Boardman, B. (1991) 'Fuel Poverty is Different', *Policy Studies*, 12(4), pp. 30–41.

Boardman, B. (2012) 'Fuel poverty synthesis: Lessons learnt, actions needed', *Energy Policy*, 49, pp. 143–148.

Bradshaw, J. and Hutton, S. (1983) 'Social policy options and fuel poverty', *Journal of Economic Psychology*, 3, pp. 249–266.

Bramley, G. (2012) 'Affordability, poverty and housing need: Triangulating measures and standards', *Journal of Housing and the Built Environment*, 27(2), pp. 133–151.

Byrne, D. P., La Nauze, A. and Martin, L. A. (2021) 'An Experimental Study of Monthly Electricity Demand (In)elasticity', *The Energy Journal*, 42(2), pp. 205–222.

CEDA, C. for the E. D. of A. (2018) *The Economic Disconnect*.

[16] One screening question for households seeking to access the Queensland Hardship Policy used to be "Do you have a dog?". The purpose of the question was well intentioned – the data was collected to help inform the safety of manual meter readers for the purpose of quarterly billing. In Queensland's remote aboriginal communities, meters are typically of the pre-payment type and therefore there are no meter readers. I am personally aware of aboriginal households in remote Queensland that withdrew from the application process (i.e. mid-way through the phone call) because this very question presented as the start of an interrogation by the authorities.

Chan, W. W. (2016) *Rethinking water and energy affordability in Australia: an analysis of the efficiency, effectiveness and equity of current policy*. PhD Thesis, Australian National University.

Charlier, D. and Kahouli, S. (2019) 'From residential energy demand to fuel poverty: Income-induced Non-linearities in the Reactions of Households to Energy Price Fluctuations', *Energy Journal*, 40(2), pp. 101–137. doi: 10.5547/01956574.40.2.dcha.

Charlier, D. and Legendre, B. (2019) 'A multidimensional approach to measuring fuel poverty', *Energy Journal*, 40(2), pp. 27–53. doi: 10.5547/01956574.40.2.bleg.

Creedy, J. (1996) 'Comparing Tax and Transfer Systems: Poverty, Inequality and Target Efficiency', *Economica*, 63(250), p. S163.

Creedy, J. and Dixon, R. (1998) 'The Relative Burden of Monopoly on Households with Different Incomes', *Economica*, 65(258), pp. 285–293.

Esplin, R. *et al.* (2020) 'The impacts of price regulation on price dispersion in Australia's retail electricity markets', *Energy Policy*, 147(July 2019), p. 111829. doi: 10.1016/j.enpol.2020.111829.

Fahmy, E. (2011) *The definition and measurement of poverty*, *A Briefing Paper to inform Consumer Focus' submission to the Hills fuel poverty review*.

Fankhauser, S. and Tepic, S. (2007) 'Can poor consumers pay for energy and water ? An affordability analysis for transition countries', *Energy Policy*, 35, pp. 1038–1049.

Foster, J., Greer, J. and Thorbecke, E. (1984) 'A Class of Decomposable Poverty Measures', *Econometrica*, 52(3), pp. 761–766.

Guertler, P. (2012) 'Can the Green Deal be fair too? Exploring new possibilities for alleviating fuel poverty', *Energy Policy*, 49, pp. 91–97.

Harding, A. and Mitchell, D. (1992) 'The efficiency and effectiveness of the tax-transfer system in the 1980s.', *Australian Tax Forum*, 9(3), p. 277.

Herscovitch, A. and Stanton, D. (2008) 'History of Social Security in Australia', *Family Matters (Aust Institute of Family Studies)*, (80), pp. 51–60.

Hills, J. (2012) *Getting the measure of fuel poverty*.

Hoddinott, J. (1999) *Targeting: Principles and Practice*. International Food Policy Research Institute - Technical Guide #9.

Howlett, M., McConnell, A. and Perl, A. (2015) 'Streams and stages: Reconciling Kingdon and policy process theory', *European Journal of Political Research*, 54(3), pp. 419–434.

Hviid, M. and Waddams Price, C. (2012) 'Non-Discrimination Clauses in the Retail Energy Sector', *Economic Journal*, 122(562), pp. 236–252. doi: 10.1111/j.1468-0297.2012.02537.x.

Jessel, S., Sawyer, S. and Hernández, D. (2019) 'Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature', *Frontiers in Public Health*, 7(December), pp. 1–19.

Jones, S. (2014) 'Flirting with Climate Change: A Comparative Policy Analysis of Subnational Governments in Canada and Australia', *Journal of Comparative Policy Analysis: Research and Practice*, 16(5), pp. 424–440. doi: 10.1080/13876988.2014.942570.

Joumard, I., Pisu, M. and Bloch, D. (2012) 'Income inequality and growth: the role of taxes and transfers', *OECD Journal: Economic Studies*, p. 14.

Kessides, I. *et al.* (2009) *Toward defining and measuring the affordability of public utility services*, *World Bank Policy Research Working Paper 4915*.

Komives, K. *et al.* (2006) *The Distributional Incidence of Residential Water and Electricity Subsidies*, *World Bank Policy Research Working Paper 3878*.

Littlechild, S. (2015) 'The CMA energy market investigation, the well-functioning market, Ofgem, Government and behavioural economics', *European Competition Journal*, 11(2–3), pp. 574–636. doi: 10.1080/17441056.2016.1153311.

Littlechild, S. (2018a) 'Competition, regulation and price controls in the GB retail energy market', *Utilities Policy*, 52(63), pp. 59–69. doi: 10.1016/j.jup.2018.04.007.

Littlechild, S. (2018b) ‘Competition, regulation and price controls in the GB retail energy market’, *Utilities Policy*, 52(63), pp. 59–69. doi: 10.1016/j.jup.2018.04.007.

Mazzone, A. (2020) ‘Thermal comfort and cooling strategies in the Brazilian Amazon. An assessment of the concept of fuel poverty in tropical climates.’, *Energy Policy*, 139(December 2019), p. 111256.

Moore, R. (2012) ‘Definitions of fuel poverty: Implications for policy’, *Energy Policy*, 49, pp. 19–26.

Nelson, T., Simshauser, P. and Kelley, S. (2011) ‘Australian Residential Solar Feed-in Tariffs: Industry Stimulus or Regressive form of Taxation?’, *Economic Analysis and Policy*, 41(2). doi: 10.1016/S0313-5926(11)50015-3.

Nelson, T., Simshauser, P. and Nelson, J. (2012) ‘Queensland Solar Feed-In Tariffs and the Merit-Order Effect: Economic Benefit, or Regressive Taxation and Wealth Transfers?’, *Economic Analysis and Policy*, 42(3), pp. 277–301. doi: 10.1016/S0313-5926(12)50030-5.

Oorschot, V. (2002) ‘Targeting welfare: on the functions and dysfunctions of means-testing in social policy.’, in. World Poverty: Studies in poverty, inequality and social exclusion. P. Townsend, & D. Gorden (Eds.), Bristol: Policy Press., pp. 171–193.

Peters, J. C. and Hertel, T. W. (2017) ‘Achieving the clean power plan 2030 CO2 target with the new normal in natural gas prices’, *Energy Journal*, 38(5), pp. 39–66. doi: 10.5547/01956574.38.5.jpet.

Pollitt, M. G. (2004) ‘Electricity reform in Chile: Lessons for developing countries’, *Journal of Network Industries*, 5(3–4), pp. 221–262.

QPC, Q. P. C. (2016) *Electricity Pricing Inquiry: Final Report*. Queensland Productivity Commission, Brisbane.

Rosenow, J., Platt, R. and Flanagan, B. (2013) ‘Fuel poverty and energy efficiency obligations - A critical assessment of the supplier obligation in the UK’, *Energy Policy*, 62, pp. 1194–1203.

Rowley, S., Ong, R. and Haffner, M. (2015) ‘Bridging the Gap between Housing Stress and Financial Stress : The Case of Australia’, *Housing Studies*, 30(3), pp. 473–490.

Sen, A. (1976) ‘Poverty: An Ordinal Approach to Measurement’, *Econometrica*, 44(2), pp. 219–231.

Simshauser, P. (2014) ‘From First Place to Last: The National Electricity Market’s Policy-Induced “Energy Market Death Spiral”’, *Australian Economic Review*, 47(4), pp. 540–562. doi: 10.1111/1467-8462.12091.

Simshauser, P. (2016) ‘Distribution network prices and solar PV: Resolving rate instability and wealth transfers through demand tariffs’, *Energy Economics*, 54. doi: 10.1016/j.eneco.2015.11.011.

Simshauser, P. (2018a) ‘Garbage can theory and Australia’s National Electricity Market: Decarbonisation in a hostile policy environment’, *Energy Policy*, 120(June), pp. 697–713. doi: 10.13140/RG.2.2.34021.91367.

Simshauser, P. (2018b) ‘Price discrimination and the modes of failure in deregulated retail electricity markets’, *Energy Economics*, 75(August), pp. 54–70. doi: 10.1016/j.eneco.2018.08.007.

Simshauser, P. and Downer, D. (2016) ‘On the inequity of flat-rate electricity tariffs’, *Energy Journal*, 37(3), pp. 199–229. doi: 10.5547/01956574.37.3.psim.

Simshauser, P. and Laochumnanvanit, K. (2012) ‘The Political Economy of Regulating Retail Electricity Price Caps in a Rising Cost Environment’, *Electricity Journal*, 25(9). doi: 10.1016/j.tej.2012.10.013.

Simshauser, P. and Nelson, T. (2012) *The Energy Market Death Spiral - Rethinking Customer Hardship*, *AGL Applied Economic and Policy Research - Working Paper No.31, Brisbane.* Available at: http://aglblog.com.au/wp-content/uploads/2012/07/No-31-Death-Spiral1.pdf.

Simshauser, P., Nelson, T. and Doan, T. (2011) ‘The Boomerang Paradox, Part I: How a Nation’s Wealth Is Creating Fuel Poverty’, *Electricity Journal*, 24(1), pp. 72–91. doi: 10.1016/j.tej.2010.12.001.

Simshauser, P. and Tiernan, A. (2019) ‘Climate change policy discontinuity and its effects on Australia’s national electricity market’, *Australian Journal of Public Administration*, 78(1), pp. 17–36. doi: 10.1111/1467-8500.12328.

Simshauser, P. and Whish-Wilson, P. (2017) ‘Price discrimination in Australia’s retail electricity markets: An analysis of Victoria & Southeast Queensland’, *Energy Economics*, 62, pp. 92–103. doi: 10.1016/j.eneco.2016.12.016.

Skoufias, E. and Coady, D. (2007) ‘Are the Welfare Losses from Imperfect Targeting Important ?’, *Economica*, 74, pp. 756–776.

Stigler, G. J. (1954) ‘The Early History of Empirical Studies of Human Behaviour’, *Journal of Political Economy*, 62(2), pp. 95–113.

Stone, M. E. (2006) ‘What Is Housing Affordability? The Case for the Residual Income Approach’, *Housing Policy Debate*, 17(1), pp. 151–184.

Tanton, R. and Phillips, B. (2013) ‘A Measure of the Depth of Housing Stress and its Application in Australia’, *Economic Papers*, 32(1), pp. 99–109. doi: 10.1111/1759-3441.12015.

Thomson, H., Snell, C. and Liddell, C. (2016) ‘Fuel poverty in the European Union: a concept in need of definition?’, *People Place and Policy Online*, 10(1), pp. 5–24.

Tiernan, A. and Burke, T. (2002) ‘A load of old garbage: Applying garbage-can theory to contemporary housing policy’, *Australian Journal of Public Administration*, 61(3), pp. 86–97. doi: 10.1111/1467-8500.00287.

Waddams Price, C., Brazier, K. and Wang, W. (2012) ‘Objective and subjective measures of fuel poverty’, *Energy Policy*, 49, pp. 33–39. Available at: http://dx.doi.org/10.1016/j.enpol.2011.11.095.

Waddams Price, C. and Zhu, M. (2016) ‘Non-discrimination clauses: Their effect on British retail energy prices’, *Energy Journal*, 37(2), pp. 111–132. doi: 10.5547/01956574.37.2.cpri.

Watts, N. *et al.* (2021) ‘The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises’, *The Lancet*, 397(10269), pp. 129–170.

Welsch, H. and Biermann, P. (2017) ‘Energy affordability and subjective well-being: Evidence for European Countries’, *Energy Journal*, 38(3), pp. 159–176. doi: 10.5547/01956574.38.3.hwel.

Yamamori, T. (2019) ‘The Smithian ontology of “relative poverty”: revisiting the debate between Amartya Sen and Peter Townsend*’, *Journal of Economic Methodology*, 26(1), pp. 70–80.