CGE Microsimulation Analysis of Electricity Tariff Increases: The Case of South Africa

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Abstract

This paper analyses the economy-wide and distributional impacts of the increase in electricity tariff in the South African economy. Use is made of CGE-microsimulation to this end. The paper simulates both an actual price increase experienced in the economy and an increase linked to inflation. While the macro results show a negative impact on the economy in terms of a decrease in GDP, an increase in prices and an increase in unemployment, the micro results indicate that poverty, as measured by the headcount rate and poverty incidence curves, declines. This finding is similar to the finding by Boccanfuso et al. (2009) that when a significant proportion of households is connected to the grid, electricity sector reforms in the form of increasing tariffs to expand power generation can lead to poverty reduction.

1. Introduction

The centrality of electricity in the battle with social ills, particularly poverty, inequality and unemployment, in Africa in general and South Africa in particular, cannot be overstated. From the mid-1990s the South African electricity public utility, Eskom, commenced a rapid electrification programme as the new democratic government aimed to re-dress the inequities in access to electricity, particularly for households (Ziramba, 2008). Unequal access to electricity was created by the economic isolation policy of previous governments. The post-1994 rapid electrification programme saw the number of households connected to the grid increasing from 36% in 1994 to 72% in 2004 (Pegels, 2010, p. 4947). As a result, access by households that had previously been excluded resulted in an accelerated increase in demand for electricity and the subsequent need for investment in infrastructure to expand capacity. The accelerated increase in demand was compounded by the problem of insufficient investment in additional electricity generation (Pegels, 2010) . However, Eskom faced inadequate funding challenges for its capital expenditure to invest in power infrastructure, both for replacing old equipment and expanding capacity.

The resultant undersupply led to power shortages from 2007, and load-shedding from 2008, owing to the narrowing of the reserve margin (De Lange, 2008). In his budget speech the then finance minister, Nene (2015), pointed out that load-shedding incurs costs on the economy in terms of foregone production and income, which ultimately negatively impacts on job creation initiatives. This inadequate supply of electricity compelled Eskom to increase its power generation capacity. Eskom estimated that it would need R300 billion to expand its power generating capacity over the 10-year period to 2019 (Pegels, 2009, p. 11; Eskom, 2012, p. 3). However, as Pegels (2011) points out, the high levels of social spending needed to reduce the effects of the three socio-economic problems cited above, especially unemployment, lower the extent to which other policy issues, like expansion of electricity generation can, be supported through public funding. One option, Eskom (2012) argues, would be for government to collect more taxes. However, studies that assessed the comparative impacts of increasing electricity tariffs on the one hand and taxes (both income and value added tax) on the other, found that taxes affected the economy more severely than any path of tariff increases adopted (Bohlmann & van Heerden, 2012; Jordaan, 2012). Bohlmann and van Heerden (2012, p. 5) recommended a prolonged path towards cost-reflective tariffs, "with increases of lower than 25% per annum1"

The nominal average annual price of electricity increased by 27.5% for 2008/9 (National Energy Regulator of South Africa (2013). Prior to 2008/9, the increases had not exceeded 10% since 1988, except in 1990, when it was 14% (Eskom, n.d.). An abrupt rise in electricity prices was triggered by multiple reasons. Increased primary energy costs in the form of a sharp increase in fuel costs caused coal shortages (Winkler & Marquand, 2009; Inglesi & Pouris, 2010), which necessitated an increase in the price of electricity to cover the associated costs. The need to enhance incentives for energy efficiency and make renewable energy technologies more attractive contributed to the sharp price rise (Winkler & Marquand, 2009). Furthermore, there was a need to raise funds for power generation expansion (Inglesi & Pouris, 2010).

Electricity plays a very important role in the economy, both as an intermediate input and as final consumption. Thus, any change in its price is expected to have significant impacts on the economy. Eskom (2009) acknowledges the potentially negative economic impacts of the electricity tariff increases, for example on employment and the poor. However, Eskom (2009) asserts that the economic impact of insufficient capacity would be more severe. The position of Eskom is backed by Abelson (2009), who argues that an increase in demand for a sector's output can result in an increase in supply if the price of that sector's output is allowed to increase. Thus, an increase in the price of electricity can enable Eskom to increase its supply of electricity. This is especially true for South Africa, whose electricity sector has been operating below capacity, as evidenced by the power shortages. To increase its output production, the sector requires additional intermediate inputs and labour. As the electricity sector demands more intermediate inputs, the sectors that supply it are in turn expected to increase their production. The electricity sector also needs to pay higher wages in order to attract labour from other sectors. This will potentially increase overall production across sectors, affecting GDP and employment positively. This could result in an increase in household income, contributing to poverty reduction.

Examples of situations in which an increase in the price of a sector's output can lead to a decline in poverty are inivestigated by a number of studies. For example, Boccanfuso, Estache and Savard (2009) show that an increase in electricity tariffs results in poverty reduction among urban households and households connected to the electricity grid. It is however important to note that Boccanfuso et al. (2009) also simulated a policy to mitigate against the negative effects of increasing the price of electricity in form of transfers to poor households which most likely significantly impacted on the results they observed. Moreover, Cororaton and Orde (2008) observe a decline in poverty among households receiving income (labour and capital) from the cotton sector following an exogenous increase in the world price of cotton.

However, a number of studies support the negative impact an increase in the electricity price could have of the different sectors on the economy (see Deloitte, 2012; He, et al., 2010; Nguyen, 2008; Silva, et al., 2009). It is important to note that the channel through which an increase in the price of electricity negatively affects some sectors of the economy often occur when it leads to inflation, reducing electricity consumption, which can trigger a decline in production across sectors, ultimately leading to an increase in poverty (Altman, et al., 2008; He, et al., 2010; Nguyen, 2008). This happens when the electricity tariff increase has a negative impact on productive activities through an increase in the cost of an intermediate input. As the cost of production increase, other sectors can pass-on the costs to consumers, resulting in price increases across the economy (Deloitte, 2012; Nguyen, 2008). Alternatively, they can reduce production, leading to an overall decline in GDP (He, et al., 2010). If sectors reduce their levels of production, employment levels decline or payment to labour falls and either way, households will earn less from labour. In addition, electricity price increases affect households directly as they are direct consumers. Thus poverty may increase from the direct effect of higher electricity prices as well as indirect effects due to reduced employment and/or higher prices of other commodities. Given these dynamics, it is not clear in which direction poverty and inequality move following an electricity price increase.

Studies analysing the impact of an increase in electricity tariffs on the South African economy focused on its impact on other sectors (Pan-African Research and Investment Services, 2011;

Deloitte, 2012) and on its economy-wide impact (Altman et al., 2008; Altman et al., 2011; Pan-African Research and Investment Services, 2011). Altman et al. (2011) use a Leontief-type price model to assess the impact of electricity price increases on households across income deciles by evaluating this impact on household expenditure on electricity and on overall consumer price index per household. Similar to Altman et al. (2011), Pan-African Research and Investment Services (2011) also analyse the distributional impacts of increasing the price of electricity using the representative household across income decliles. The Pan-African Research and Investment Services (2011) study uses the integrated household approach in a Computable General Equilibrium (CGE) model to assess the impact of the electricity price increase on household consumption expenditure and Equivalent Variation as a measure of change in welfare.

Given the intricacies in the South African electricity sector in particular and the economy in general (the need to increase power generation to ensure an adequate and sustainable supply of electricity and the threat that this poses to economic growth on the one hand, and the need to improve employment levels and reduce poverty and inequality on the other), it is interesting to know how the rise in electricity prices affects poverty and inequality in the country. While studies by Altman et al. (2011) and the Pan-African Research and Investment Services (2011) provide an indication of the distributional impacts in terms of which household groups benefit or lose relative to others in terms of changes in expenditure or income, they do not capture the actual impact on poverty and inequality.

It is in that context that this study contributes to the literature on the impact of the increase in the price of electricity on poverty and inequality by making use of CGE-microsimulation modelling. To do this an economy-wide impact assessment of an increase in electricity on the South Africa economy is carried out using CGE analysis. Then selected relevant results from the CGE modelling are used as inputs into a microsimulation model to assess the poverty and inequality impacts of the electricity price increase. Linking CGE modelling and micro data enables analysis of the aggregate impact of a shock as well as the resulting individual/household inequality and poverty impacts.

2. South African Electricity Sector

Electricity prices in South Africa remained at around 40% of US prices for four decades (Winkler & Marquand, 2009, p. 52). This is partly because South Africa's low-grade coal which is used for power generation cannot be economically exported, thus world energy prices cannot significantly influence its price (Winkler & Marquand, 2009). However, as Pegels (2009, p. 14) argues, the traditionally low electricity prices in South Africa were not only due to the abundance of cheap coal reserves, but also because most of the power stations were built at low costs when the exchange rate was favourable in the 1970s and 1980s. Thus, due to the power stations being fully depreciated, price increases were necessitated by Eskom's need to invest in new power stations.

2.1 Structure of the electricity sector

Eskom accounts for 95% to 96% of the country's electricity generation and supply (Amusa et al., 2009, p. 4169; Baker, 2011, p. 8; Global Business Reports, 2014, p. 1). Despite the involvement of

Independent Power Producers (IPPs) in the South African electricity sector, Eskom still dominates the sector and will, according to Global Business Reports (2014), continue to do so, as it is the sole buyer from IPPs. Coal, from which Eskom's produces around 90% of its electricity, dominates the South African energy sector (StatsSA, 2015).

Prior to 2008 electricity prices in South African were relatively low for several decades, both for households and industry (Das Nair, et al., 2014). Das Nair, Montmasson-Clair and Gaylor (2014) claim that interruptions in the supply of electricity in 2007 increased fears that Eskom's underinvestment in electricity to improve generation capacity and ineffective coal stocks management could have a strong negative effect on the economy. Eskom subsequently embarked on a large-scale capital expansion programme to generate the necessary electricity to cater for the shortfall. The electricity utility has thus been compelled to raise prices significantly to amass enough financial resources to invest in and meet the continuously increasing demand for electricity (Thopil & Pouris, 2013). Thus, a multi-year price determination mechanism (MYPD) was adopted to determine the price increases required to fund this expansion.

Table 1: Household electricity connection to the mains, by Province, 2012

	Western Cape	Eastern Cape	Northern Cape	Free State	KwaZulu-Natal	North West	Gauteng	Mpuma-langa	Limpopo	South Africa
Total number of households	1461	1304	272	767	1970	935	3479	947	1247	12383
Connected households	1 619	1 631	296	843	2 504	1 105	4 153	1 088	1 392	14 631
Connected households (%)	90	80	92	91	79	85	84	87	90	85

Source: StatsSA (2013)

The implemented electricity tariff increases, which are based on Eskom's proposed increases, apply to all consumers across the board (Thopil & Pouris, 2013). This has had a significant impact on price and has led to a public outcry by both residential and industrial customers alike. Quite a significant proportion of South African households have access to electricity, as shown in Table 1.

2.2 Tariff determination

The price of electricity in South Africa is not subject to the forces of supply and demand but is determined and regulated by the NERSA. The pricing mechanism used by NERSA is called the Multi-Year Price Determination (MYPD). Eskom applies to NERSA for approval to increase electricity tariffs through the MYPD. Three MYPDs have been implemented to date: MYPD1, MYPD2 and MYPD3 respectively for the periods 2006/07 to 2008/08, 2010/11 to 2012/13 and 2013/14 to 2017/18. There was no MYPD for the 2009/10 period.

Error! Not a valid bookmark self-reference. gives the outcomes of the MYPDs over the years. As **Error! Not a valid bookmark self-reference.** shows, the average price of electricity increased from about R0.1871 per kWh in 2006/2007, almost doubling to R0.3314 per kWh after the end of MYPD1. The average electricity price continues to increase, with the approved tariff for 2017/18 at 93c per kWh; and, according to Creamer (2011), expected to be as high as 110c/kWh by 2020. NERSA implements the MYPD (NERSA, n.d.; NERSA, 2010) with objectives that include:

- to ensure consistency from one price control period to the other
- to ensure tariff stability so as not to contradict government's socio-economic objectives
- to take into account Eskom's cost recovery requirements to allow the utility to continue functioning sustainably and economically

Eskom (n.d.) refers to sustainability, among others, as the provision of affordable energy as well as related services through considering and integrating economic development and social equity so as to continually improve performance and reinforce development.

Table 2: Eskom Average Electricity Price Increases

	Nominal price increase	Nominal c/kWh	Inflation rate	Pricing
2006/07	5.1%	18.71*	7.1	**MYPD 1** • Revised for 2008/09 ○ initially to 14.2% ○ and later to 27.5%
2007/08	5.8%	19.80*	11.5	
2008/09	*6.2%*	*21.02**	6.6	
	14.2%	*22.61**		
	27.5%	25.24*		
2009/10	31.3%	33.14*	4.3	**No MYPD** • Interim increase
2010/11	24.8%	41.57	5	**MYPD 2** • Revised down for 2012/13[1] ○ to 16%
2011/12	25.8%	52.30	5.7	
2012/13	*25.9%*	*65.85*	5.8	
	16%	60.66*		
2013/14	8%	65.52	6.1	**MYPD 3** • Revised for 2015/16 ○ to 12.69%
2014/15	8%	70.76	4.6	
2015/16	*8%*	*76.42*		
	12.69%	79.74*		
2016/17	8%	86.11		
2017/18	8%	93.00		

Source: National Energy Regulator of South Africa (NERSA) (2013: 1, 7-8), Eskom (n.d.)
*Authors' calculations from the percentage increase

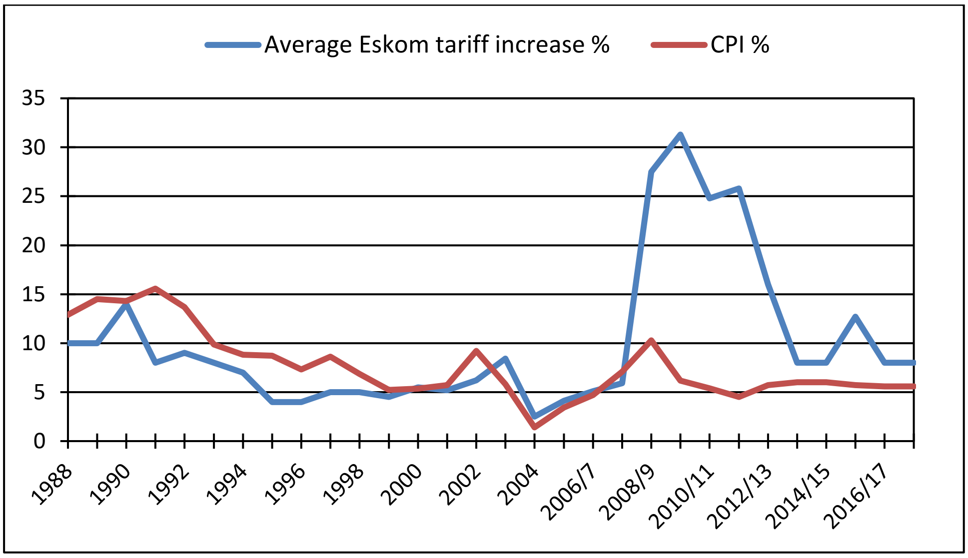
2.3 Impact on Poverty

Electricity supply capacity, cost and access are fundamental to an economy's functioning as they are vital not only for economic growth but also for social development and poverty reduction (Thopil & Pouris, 2013). Pegels (2011) argues that the rapidly increasing electricity prices in South Africa can be perceived to be an obstacle to achieving the objective of economic growth and poverty alleviation. As a result, Pegels (2011) continued, such price increases attract public

[1] To reduce allowed revenues

disapproval. Increases far above the inflation rate as shown in Figure 1 are likely to erode the purchasing power and worsen inequality.

Figure 1: Nominal average electricity tariff increase vs Consumer Price Index (CPI) (%)



Source: (Eskom, n.d.),

3. Review of Related Literature

A number of studies have analysed how increases in electricity tariffs impact on the economy and on household welfare, both on South Africa and internationally. Altman et al. (2011) assess how a 35% once-off tariff increase would impact on the South African economy. Their results indicate a relatively small impact on the economy, namely a decline of about 1% in GDP, a 1.3% rise in the producer price index and a 0.9% increase in the cost of exports (Altman et al., 2011, p. 11). The results are not surprising, Altman et al. (2011, p. 11) argue, because the electricity sector contributes only between 1.1% and 4% of procution costs. Based on a 25% electricity price increase, Altman et al. (2011) observe a 0.88% increase in the consumer price index, with a larger impact on poor households in comparison to rich households owing to differences in the relative shares of electricity spending on total expenditure.

In a related study, Pan-African Research and Investment Services (2011) evaluate the impact of increasing the price of electricity by between 8% and 24.8%. Their results indicate that GDP would decline by between 0.09% and 0.48% respectively. Pan-African Research and Investment Services (2011) reports that some sectors would experience an increase in output production and an increase in labour demand, while others would suffer decreases in both. The overall impact of the electicity price increase of 24.8% on employment would be a decline of 0.77% and a 0.86% in unskilled and skilled employment respectively, resulting in a decline in wages across all labour categories, which would consequently contribute to a 0.85% decrease in household expenditure (Pan-African Research and Investment Services, 2011). The electricity price increases would cause all consumers to experience a decrease in utility, as indicated by negative Equivalent Variation and poorer households experiencing higher utility losses (Pan-African Research and Investment Services, 2011).

In Senegal, Boccanfuso et al. (2009) use macro-micro modelling to analyse the impact of a price reform in the electricity sector on distribution. Boccanfuso et al. (2009) simulated increases in the electricity price, together with a combination of each of the two price increases and a compensatory transfer program policy to poor households connected to the electricity network that is funded by either foreign aid or an increase in import duties, value added tax, income tax or import duties (Boccanfuso, et al., 2009). Sectoral results indicate that some sectors would experience increases in output and demand for labour, while these would decline for others following an increase in the electricity price (Boccanfuso, et al., 2009). As explained by Boccanfuso et al. (2009), when the electricity price increases the cost of production for some sectors would increase, leading them reduce output production. As their output production declines, their demand for would labour also decline and move to other sectors resulting in increasing production for the sectors to which labour moves (Boccanfuso, et al., 2009). In general poverty increased for the rural households, other urban households and unconnected households but declined for the Dakar households and connected households (Boccanfuso, et al., 2009). Overall, Boccanfuso, et al. (2009) observe a decrease in inequality, except for the simulation with only a price increase. Boccanfuso et al. (2009) highlight that the simulations had fairly small impacts because of (i) relatively high electricity prices prior to the reforms, (ii) a small fraction of poor households connected to the grid and (iii) a somewhat limited electricity network for both households and non-households. Boccanfuso et al. (2009) conclude from the results that the direct price effects of the electricity price reform on most poor households were weaker in comparison to the general equilibrium impacts on poverty and inequality. For South Africa, we expect to find a relatively larger impact since electricity prices were comparatively lower before the sharp increase in prices and because a greater proportion of households are connected to the grid and the supply is more reliable, unlike the case of Senegal.

Nguyen (2008) and He et al. (2010) looked at the impact of increasing electricity prices in Vietnam and China respectively. Nguyen (2008) uses a static input-output model to assess the impacts of an electricity tariff increase in Vietnam. An increase in electricity prices, Nguyen (2008) concludes, would push up the prices of all other sectors' products. He et al. (2010) assess the impact of electricity price increase on the Chinese economy using CGE analysis. They observe that a rise in electricity prices would adversely affect GDP and CPI. An electricity price increase, He et al. (2010) conclude, has contractionary effects on economic development. In Montenegro Silva, Klytchnikova and Radevic (2009) use benefit incidence analysis to analyse the impact of a residential electricity tariff increase and found that it would significantly raise households' energy expenditures. Silva, et al. (2009) argue that if electricity tariff reforms were not accompanied by policy measures to assuage the effects of electricity price increases on the poor, the poor households would be heavily burdened by a substantial price increase.

The studies analysed show that electricity price increases can have both positive and negative impacts on sectors of the economy in terms of changes in output production and labour demand, thus the impact on poverty and inequality can take any direction. In addition, unlike the case of Senegal, which had a relatively smaller propotion of households connected to the electricity network (Boccanfuso, et al., 2009), about 85% of South African households are connected. Thus, the poverty and inequality impacts are expected to be higher.

4. Methodology

To assess the distributional impacts of an increase in the price of electricity on households, we link a household data-based micro-behavioural model with a CGE model in a top-down approach. Vandyck and Van Regemorter (2014, p. 191) mention that combining CGE-microsimulation modelling has the advantage of exploiting "the full detail captured by household-level data" while including general equilibrium feedbacks.

Linking microdata with macro-models effectively represents heterogeneity in responses to shocks by agents, which aids in the understanding of distributional issues of socio-economic policies or events (Campagnolo, 2014). Feedbacks and interrelations between macroeconomic variables and the household and individual dimensions established by a link between a CGE model and microdata enable an assessment of poverty and inequality at the individual/household level in a consistent framework (Campagnolo, 2014). Heindl and Löschel (2015) mention that CGE-microsimulation modelling combines the strong macroeconomic focus of CGE analysis on assessing complex, price-driven interventions and the detailed results from household-level data produced by microsimulation modelling. Thus, the growth and economy-wide effects of policies are captured by the CGE model, while the microsimulation model permits an evaluation of the poverty and inequality effects of the policy under study (Heindl & Löschel, 2015). Thus, to analyse the distributional impacts of electricity price increases in South Africa, we use a sequential top-down approach by integrating the macro results from a CGE model into a micro-economic household framework. Below we discuss the models that we use in this study.

4.1 CGE Model

CGE modelling is widely used to assess the economy-wide impacts of policy-induced shocks and external shocks. CGE models are able to mimic shock-induced changes. Another strength of CGE models is that they obtain their parameters from empirical work. However, because of its representative household structure, CGE analysis is not an effective tool for studying distributional impacts.

We adapt the static Poverty and Economic Policy (PEP 1-1) standard model by Robichaud, et al. (2013) to better reflect the South African economy. To account for the high unemployment in South Africa, unemployment is introduced into the model.

4.1.1 Closures

The numeraire is the price of electricity. The electricity price is determined by NERSA; thus, it is assumed to be fixed. Capital is sector-specific while labour is mobile across sectors. Government spending, public transfers and the rest of the world's savings are fixed.

4.2 Microsimulation

4.2.1 ADePT Simulation Module

The link from CGE simulations into the microsimulation model is made by feeding changes in prices, sectoral output and sectoral employment as inputs for the household-level analysis. A Household survey provides micro-data with household and individual characteristics, which give information on household-level income and/or consumption and individual-level labour force information on employment status and earnings. This constitutes an essential poverty and inequality analysis. This study uses the ADePT simulation module of the World Bank developed by Olivieri, et al. (2014), which accounts for labour and non-labour income. The household income-generation model that was developed by Bourguignon and Ferreira (2005) is the basis of the ADePT simulation module (Olivieri, et al., 2014). The model, which operates at the household and individual level, making allowance for multiple transmission channels, is described in four equations outlined below.

Total household income is determined by a combination of the household and its members' observed characteristics and the household members' unobserved characteristics in a nonlinear function (Robilliard, Bourguignon & Bussolo, 2008; Olivieri, et al., 2014). The function is determined by a set of parameters of (i) the occupational choice model for every level of skill and (ii) the earnings model for each skill level and economic sector (Olivieri, et al., 2014). As outlined by Olivieri et al. (2014), per capita household income is obtained from adding labour and non-labour income, the main two sources of income for the household, and is given by:

$$\boldsymbol{y_h = \frac{1}{n_h}\left[\sum_{i=1}^{n_h}\sum_{L=1}^{\Lambda}\sum_{j=0}^{J} I_{hi}^{Lj} y_{hi}^{Lj} + y_{0h}\right]} \qquad 1$$

where i is household member, L is the level of education, Λ is the maximum level of education of the individual, j is labour status, J is the economic sector, I_{hi}^{Lj} is an indicator function of labour status j of individual i with level of education L, y_{hi}^{Lj}, are earnings of individual i with level of education L in the economic sector J , y_{0h} is the total non-labour income received by household h. Total household income is the sum, across household members, of earnings from the various economic sectors.

Utility for individual U_{hi}^{Lj}, is assumed to be a linear function of observed household and individual attributes Z_{hi}^{L} as well as unobserved determinants of utility of the occupational status ν_i^{Lj} (Olivieri, et al., 2014) as indicated in equation 2.

$$\boldsymbol{U_{hi}^{Lj} = Z_{hi}^{L}\Psi^{Lj} + \nu_i^{Lj}} \qquad 2$$

$$\boldsymbol{I_{hi}^{Lj} = 1 \; if \; U_{hi}^{Lj} \geq U_{hi}^{Ll}} \qquad 3$$

with $j = 0, \ldots., J$ and L is level of education
for all $L = 0, \ldots., J \; \forall l \neq j$
Equation 3 shows that individual i chooses sector j, the indicator function $I_{hi}^{Lj} = 1$ if sector j gives the highest level of utility.

For this study, every individual is inactive, unemployed, or working in one of the economic sectors: primary, manufacturing, electricity or services. This means that the labour force status of the working age population (15 and 64 years old) is taken into account, distinguishing those who are inactive (out of the labour force) from the active but unemployed. A log-linear function of observed household and individual characteristics χ_{hi}^{L} and unobserved elements μ_{hi}^{Lj} can be applied in the modelling of observed heterogeneity in earnings in sector j, as presented in equation 4.

$$\boldsymbol{log\ y_{hi}^{Lj} = \chi_{hi}^{L}\Omega^{Lj} + \mu_{hi}^{Lj}} \qquad 4$$

for $i = 1, \ldots, n_h$ and $j = 1, \ldots, J$

Total household non-labour income, is the summation of all non-labour income elements, summed at the household level and is represented in equation 5 as:

$$\boldsymbol{y_{0h} = r_h^I + r_h^D + k_h + tr_h + z_h} \qquad 4$$

where r_h^I is international remittances, r_h^D are domestic remittances, k_h is capital, interest and dividends, tr_h are social transfers and z_h are other non-labour incomes.

4.3 Data

The model uses an aggregated version of the 2009 social accounting matrix (SAM) for South Africa. From three major sectoral categories: primary, manufacturing and services, four sectors are created by aggregating all other services and leaving electricity on its own. Thus, we have a four-sector SAM with i) primary, ii) manufacturing, iii) electricity and iv) services. The services sector is disaggregated in order to focus on electricity. There are two factors of production, capital and labour. Labour is disaggregated according to workers' levels of education: primary (primary school or less), middle (completed middle school), secondary (completed middle school) and tertiary (some tertiary education). The 2012 National Income Dynamics Study data set is used to estimate the microsimulation model.

4. 3.1 Weighting/consistency between survey and SAM data

The first step is concerned with consistency between aggregate and dis-aggregate data sources. Summing micro data employment figures does not, according to Vandyck and Van Regemorter (2014), produce consistency between SAM and micro-level data sources. Instead, changing the sample weights of the household survey data aligns the employment figures with the aggregate numbers from the SAM data used in the CGE model (Vandyck & Van Regemorter, 2014).

5. Simulations and Results

5.1 Simulations

We simulate an increase in the price of the commodity electricity. The price of electricity is assumed to be fixed in our model, an assumption that is not unrealistic for the South African economy, given that the price of electricity in the country is not determined by forces of supply and demand but is set by NERSA.

We apply two simulations to the model:

1. Actual increase in electricity price (sim1)
2. Inflation-linked increase in electricity price (sim2)

Table 3: Simulations

	Actual increase (sim1)	Inflation-linked increase (sim2)
Increase in electricity prices	57.8% increase	16.1% increase

Source: Simulation results

5.2 CGE Results

5.2.1 Macro Results

Table 4: Macro results (% change from base)

Variable	Base	Sim1	Sim2
GDP (R million)	2395967	-2.25	-0.90
CPI	1	56.48	15.76
Unemployment rate	22%	8.81	3.45
Labour income (R million)	1081402	51.08	14.17
Total government income	682848	54.97	15.29
Firm income	701879	53.98	
Household transfer income	372293	54.264	5.11
Household income (R million)	1756059	52.19	14.50

Source: CGE simulation results

This study applies a shock of 57.8% increase of the electricity price. This is the actual change experienced between 2009 and 2012. In addition, the study simulates a moderate scenario of a 16.1% increase of the electricity price, which is the change that would have been experienced had the electricity price increase been linked to inflation.

Selected macro results are given in Table 4. The results indicate that the increase in the price of electricity negatively affects the economy as indicated by the increase in the price level, rise in unemployment and the slight decrease in GDP. These contribute to making households worse off and poverty would be expected to increase. However, positive impacts are also observed in the form of an increase in the wage rate (discussed under sectoral impacts) and an increase in labour income. This indicates that the impact of the increase in unemployment is outweighed by an increase in wages, giving an overall increase in labour income. The macro results also indicate that the increase in prices and the increase in labour income contribute to an increase in government tax collections, which consequently results in an increase in total government revenue. On the other hand, firm income also increases. As government revenue and firm income increase, household transfer income from government and firms also increases. Because of both the positive and negative impacts of the electricity price increase on households, it is not clear, based on the CGE analysis alone what impact the price increase will have on households. The impact of an increase in the electricity price will be determined by the simulation analysis. Before proceeding to microsimulation, selected sectoral results, some of which are inputs into the microsimulation analysis, are presented next.

5.2.2 Sectoral Results

As the price of electricity increases, electricity production correspondingly increases. To meet this need for increased production, the electricity sector requires additional inputs, namely labour and intermediate commodities from across the sectors. The electricity sector, being a subsector of the services sector, is most likely to attract workers from within the services sector, as they would have more or less the same attributes. Thus, labour declines in the services sector as part of it moves to the electricity sector. Consequently, output production for services falls. Output production consequently increases by 1.92%, 1.89% and 0.41% respectively for the primary, manufacturing and electricity sectors, but declines for services by 1.46%.

Table 5: Selected results

Variable		Base	Sim1	Sim2
Value Added (R million)	Primary	260009	5.11	1.92
	Manufacturing	321848	5.08	1.89
	Electricity	50862	1.11	0.41
	Services	1512029	-3.87	-1.46
Labour demand (composite) (R million)	Primary	92244	14.85	5.48
	Manufacturing	179261	9.24	3.42
	Electricity	16647	3.40	1.24
	Services	795580	-7.28	-2.76
Wage rate	Primary	1	55.65	15.50
	Middle	1	55.72	15.52
	Secondary	1	55.09	15.34
	Tertiary	1	54.00	15.02
Unemployment rate (%)	Primary	20.7	5.50	2.27
	Middle	30	5.01	2.03
	Secondary	25	9.38	3.66
	Tertiary	12.5	17.32	6.57
Rental rate of capital	Primary	1	70.15	19.54
	Manufacturing	1	64.48	17.95
	Electricity	1	58.39	16.24
	Services	1	47.29	13.15
Household consumption (R million)	Primary	61237	-2.15	-0.86
	Manufacturing	514914	-2.78	-1.11
	Electricity	22952	-0.91	-0.36
	Services	650302	-2.83	-1.12
Price	Primary	1.12	60.65	16.92
	Manufacturing	1.38	59.02	16.47
	Electricity	1.03	57.80	16.1
	Services	1.02	53.29	14.86
Export demand (R million)	Primary	217877	6.87	2.61
	Manufacturing	303693	8.38	3.15
	Electricity	705	5.93	2.27
	Services	77155	5.12	1.98
Domestic demand (R million)	Primary	252810	3.96	1.48
	Manufacturing	996835	4.34	1.62
	Electricity	86158	1.07	0.39
	Services	3067777	-4.00	-1.51
Intermediate consumption of *i* by *j* (R million)	Primary	186874	5.11	1.92
	Manufacturing	872337	5.08	1.89
	Electricity	32647	1.11	0.41
	Services	1373797	-3.87	-1.46
Total intermediate demand for commodity *i* (R million)	Primary	263956	4.30	1.60
	Manufacturing	808476	1.34	0.50
	Electricity	64030	1.70	0.63
	Services	1329192	-1.68	-0.64

Source: CGE simulation results

On the other hand, as the price of electricity rises, the exchange rate depreciates. Export prices decline due to the weakening of the Rand, which makes South African products relatively cheaper. Export demand rises by more than 2% for the inflation-linked electricity increase, except for the services sectors. The reason is possibly a very low export intensity of the services sector. The result is possibly a shift of resources by enterprises away from services sector to primary, manufacturing and electricity sectors to benefit from the marked increased export demand for the primary and manufacturing sectors and an increase in the price of electricity. The changes in selected sectoral variables are shown in Table 5.

5.2.3 Microsimulation results

Headcount poverty rates (the share of the poor) and the proportion of the poor are given by education levels in Table 6. The results indicate that, following an increase in the price of electricity, people with tertiary education benefit the least under both simulations. However, a different pattern is seen for the winners. The least educated benefit more in terms of the decline in poverty headcount rate, with those with incomplete primary education and no school experiencing a decrease of 19.1 and 17.5 respectively. This is because CGE results indicate that the wage rate increases relatively more while labour demand declines relatively less for workers with less than secondary education in comparison with those that have secondary and tertiary education. For simulation 2 those with incomplete primary education are the winners with a decline of 6.5 followed by those with lower secondary (up to grade 9), whose poverty head count rate declines by 6.1. The magnitude of the decline in the poverty headcount rate for simulation 1 and simulation 2 is not proportional to the change in the price of electricity. The decline in poverty measures is largely caused by an increase in income.

Table 6: Poverty by Education Level (actual change)

	Poverty Headcount Rate			Distribution of the Poor		
	Original	Simulation1	Simulation2	Original	Simulation1	Simulation2
No Schooling	72.8	55.4 (-17.5)	67.0 (-5.8)	10.3	11.2 (0.9)	10.7 (0.4)
Incomplete Primary	65.0	45.9 (-19.1)	58.6 (-6.5)	10.5	10.6 (0.1)	10.7 (0.2)
Primary: up to grade 6	58.4	42.5 (-15.9)	53.4 (-5.0)	22.9	23.9 (0.9)	23.7 (0.7)
Lower Secondary: up to grade 9	50.4	34.4 (-16.0)	44.2 (-6.1)	36.4	35.5 (-0.9)	36.1 (-0.4)
Upper Secondary: up to grade 12	34.4	23.4 (-11.0)	29.0 (-5.4)	13.8	13.4 (-0.4)	13.1 (-0.7)
Vocational Certificates	18.5	11.9 (-6.6)	15.9 (-2.7)	5.5	5.1 (-0.5)	5.3 (-0.2)
Higher Education	4.8	2.3 (-2.5)	4.6 (-0.2)	0.4	0.3 (-0.1)	0.5 (0.0)
Total	50.5	36.4 (-14.1)	45.4 (-5.1)	100.0	100.0 (0.0)	100.0 (0.0)

Source: Microsimulation results

Table 7 shows that the decrease in poverty headcount rate is relatively higher for female-headed households (15.1) than for male-headed households (12.3) in simulation 1, while for simulation 2 the changes are 5.3 and 4.8 respectively for female-headed and male-headed households. However, the poverty distribution shows that the proportion of poor women-headed households increases.

Table 7: Poverty by Gender of the Household Head's (actual change)

	Poverty Headcount Rate			Distribution of the Poor		
	Original	**Simulation1**	**Simulation2**	**Original**	**Simulation1**	**Simulation2**
Male	37.0	24.7 (-12.3)	32.2 (-4.8)	26.4	24.4 (2.0)	25.5 (-0.9)
Female	58.2	43.1 (-15.1)	52.9 (-5.3)	73.6	75.6 (2.0)	74.5 (0.9)
Total	50.5	36.4 (14.1)	45.4 (-5.1)	100.0	100.0 (0.0)	100.0 (0.0)

Source: Microsimulation results

Although the poverty headcount declines, this positive effect of the increase in the price of electricity is countered by an increase in mean household expenditure. Table 8 gives the mean normalised expenditure, per capita or per equivalent adult; by rural and urban divide, by province and by quintiles, as well as the national average. Mean household expenditure under simulation 1 rises by 52.3% for all households, as shown in Table 8. Urban households experience a slightly higher increase (52.6%) than rural households (51.2%). The reason for this outcome could be that rural households have the option of using cheaper sources of energy including firewood, paraffin and gas. This same reason could also explain why relatively more rural provinces such as the Eastern Cape and Limpopo experience lower increases in household mean expenditure.

Table 8: Mean Expenditure by Province and Quintile (% change)

	Original	**Simulation1**	**Simulation2**
Urban	2 171.4	3 312.8 (52.6)	2 497.2 (15.0)
Rural	624.7	944.4 (51.2)	714.8 (14.4)
Western Cape	2 157.3	3 309.4 (53.4)	2 495.3 (15.7)
Eastern Cape	1 001.8	1 511.0 (50.8)	1 142.3 (14.0)
Northern Cape	1 898.1	2 926.4 (54.2)	2 196.6 (15.7)
Free State	1 191.2	1 791.7 (50.4)	1 364.5 (14.5)
KwaZulu-Natal	1 324.7	2 037.9 (53.8)	1 536.7 (16.0)
North West	1 226.7	1 898.7 (54.8)	1 422.1 (15.9)
Gauteng	2 259.6	3 429.7 (51.8)	2 584.4 (14.4)
Mpumalanga	1 381.2	2 103.8 (52.3)	1 594.2 (15.4)
Limpopo	779.0	1 141.1 (46.5)	867.5 (11.4)
Quintiles of WA			
Lowest quintile	158.0	230.5 (45.8)	176.5 (11.7)
2	310.1	458.8 (48.0)	351.8 (13.5)
3	555.4	835.1 (50.4)	636.2 (14.5)
4	1 202.3	1 831.3 (52.3)	1 388.3 (15.5)
Highest quintile	5 523.5	8 441.8 (52.8)	6 347.6 (14.9)
Average	1 550.0	2 360.1 (52.3)	1 780.7 (14.9)

Source: Microsimulation results

However, given the complexity of the South African population, some provinces are largely urban but with a significant number of their population living in informal settlements, hence with no access to electricity. These include Gauteng, where about 85% of the population has access to electricity. On the other a hand, a province such as the Free State has about 91.5% of its population connected to the electricity grid, but only 85.9% of its population uses electricity for cooking, in comparison to Gauteng where 82.2% of the population uses electricity for cooking (StatsSA, 2013). This indicates that access to electricity does not necessarily translate to its use. Provinces that experience a relatively lower increase in expenditure under simulation 1 are Limpopo (46.5%), the Free State (50.4%), the Eastern Cape (50.8%) and Gauteng (51.8%). The North West and Northern Cape provinces experience the highest increase in mean household expenditure of 54.8% and 54.2% respectively.

For simulation 2 the results are slightly different for provinces, with the highest increase in mean household expenditure observed for KwaZulu-Natal (16%), followed by the North West at 15.9%, while Limpopo (11.4%) and Eastern Cape (14.0%) experience the lowest increases.

When disaggregated by income levels, people with the lowest incomes in general suffer relatively less than higher income earners, as illustrated in Table 8. The increase in expenditure for the lowest quintile is 45.8%, compared to 52.8% for the highest quintile under simulation 1. For simulation 2, the lowest quintile again suffers least, with an increase in expenditure of 11.7%, but it is the fourth quintile that experiences the highest increase in expenditure of 15.5%, not the fifth quintile as under simulation 1.

The increase in the price of electricity yields favourable results in terms of the poverty headcount rate, with relatively better outcomes for the simulation of a higher actual increase in electricity price (simulation 1) in comparison to the inflation-linked increase in price (simulation 2). However, a different story emerges from inequality results. Inequality impact of the electricity price increase is analysed based on the Generalised Entropy (GE) inequality decomposition. GE is a family of measures, with parameter α, used to measure inequality impacts. Parameter α captures distributional sensitivity, with a large and positive α indicating the index GE(α) is sensitive to inequalities in the upper tail of the income distribution (Cowell, 2003). This study decomposes inequality resulting from the electricity price increase with three GE indexes: GE(0), which is equivalent to the mean log deviation of income measure, GE(1), a Theil index and GE(2), which is half the squared coefficient of variation. Results are shown by province in Table 9 and by rural-urban divide in Table 10. The decomposition gives the contribution of the within-group inequality, the between-group inequality and the between-group inequality as a percentage of total inequality.

Overall, while inequality increases for both simulations, it increases more under simulation 1 than under simulation 2. The same pattern is observed across provinces and across the rural-urban divide, with a few exceptions. Inequality results across provinces are discuss first, followed by results for rural and urban areas. The inequality results for provinces are shown in Table 9. There is no change in inequality under simulation 1 for Northern Cape and Free State as measured by GE(1). Under simulation 2 no change is observed for Eastern Cape and Northern Cape as measured by GE(1) and for North West as measured by GE(2).

A decline in inequality is observed under simulation 1 for Mpumalanga as measured by both GE(1) and GE(2), as well as the Northern Cape and North West as measured by GE(2). Under simulation 2 we observe a decrease in inequality using GE(0) in the Eastern Cape and in the Northern Cape using GE(2). Inequality also declines for Gauteng for simulation 1 as measured by GE(0) and GE(1). The same pattern is observed for within- and between-group inequality: a relatively higher increase under simulation 1 than simulation 2. For both simulations, between-group inequality as a share of total largely remains unchanged.

Table 9: Decomposition of inequality by regions

	Original			Simulation1			Simulation2		
	GE(0)	GE(1)	GE(2)	GE(0)	GE(1)	GE(2)	GE(0)	GE(1)	GE(2)
Total	85.1	88.1	178.6	87.2	89.3	182.2	86.4	88.6	180.6
Western Cape	69.4	66.5	116.5	70.3	67.3	118.4	70.0	66.9	117.2
Eastern Cape	69.9	79.9	179.5	70.5	80.5	181.5	69.7	79.9	180.6
Northern Cape	94.1	104.6	241.6	94.6	104.6	239.6	94.5	104.6	240.4
Free State	48.7	47.9	66.0	48.8	47.9	66.5	49.4	48.3	66.6
KwaZulu-Natal	108.8	125.4	326.8	111.3	127.4	334.1	110.1	126.4	330.4
North West	70.7	75.2	150.4	71.6	75.5	150.0	71.3	75.5	150.4
Gauteng	68.9	67.1	108.0	69.9	67.8	109.8	68.6	66.9	108.5
Mpumalanga	96.2	104.5	224.6	96.8	104.3	221.8	97.2	105.1	226.0
Limpopo	69.5	82.4	185.6	77.3	86.6	198.0	76.7	85.3	193.2
Within-group inequality	78.8	82.0	172.6	80.7	83.1	176.0	80.0	82.5	174.5
Between-group inequality	6.3	6.0	6.0	6.5	6.2	6.1	6.4	6.1	6.1
Between as a share of total	7.4	6.9	3.4	7.5	6.9	3.4	7.4	6.9	3.4

Source: Microsimulation results

Rural households experience significantly higher increases in inequality than urban households, as shown in Table 10. Within- and between-group inequality for rural and urban households is relatively higher for simulation 2 than for simulation 1. Between-group inequality as a share of the total falls for both simulation 1 and simulation 2 as measured by GE(0), but remains unchanged when measured by GE(1) and GE(2).

Table 10: Decomposition of inequality by urban and rural areas

	Original			Simulation1			Simulation2		
	GE(0)	GE(1)	GE(2)	GE(0)	GE(1)	GE(2)	GE(0)	GE(1)	GE(2)
Total	85.1	88.1	178.6	87.2	89.3	182.2	86.4	88.6	180.6
Urban	76.8	74.5	129.3	77.8	75.2	131.6	77.0	74.7	130.6
Rural	56.9	74.8	226.9	59.8	77.1	233.7	59.4	76.5	231.1
Within-group inequality	68.8	74.5	166.6	70.6	75.5	170.1	69.9	75.0	168.6
Between-group inequality	16.3	13.5	12.0	16.6	13.7	12.1	16.5	13.6	12.0
Between as a share of total	19.2	15.4	6.7	19.0	15.4	6.7	19.1	15.4	6.7

Source: Microsimulation results

It is interesting to note that the increase in inequality is not proportional to the increase in the price of electricity. The increase in the electricity price under simulation 2 is more than three times the increase under simulation 1. However, the change in inequality under simulation 2 is barely twice the change under simulation 1. Thus, even a relatively small increase in the price of electricity affects inequality significantly. This, however, should not be construed to mean higher increases in electricity prices are better in terms of inequality.

In

Table **11**, we assess the change in poverty in relation to the components that affect it. The table gives the results of the growth-inequality decomposition of the poverty changes between two scenarios, the total for the country and by urban-rural divide. Poverty can change owing to a change in growth that affects average per capita consumption expenditure, a change in redistribution which affects the distribution of consumption expenditure around the mean, or a combination of the two (Kakwani, 2000; Sboui, 2012). In the table the former is presented as growth while the latter is redistribution. Poverty is decomposed into these three effects to investigate the factors contribution to a change in poverty. Changes in poverty for simulation 1 and simulation 2 indicate that growth in consumption drove the decline in poverty. Under simulation 1, though almost negligible, redistribution and the interaction between growth and redistribution weigh down on poverty reduction almost equally for all households. Still, by very small magnitudes, redistribution weighs down poverty reduction for urban households while the interaction effect between growth and redistribution dampens the decline in poverty for rural households. Under simulation 2 the interaction effect is relatively larger for all households, as well as for rural households in the opposite direction of the overall change in poverty, but by very small magnitudes.

Table 11: Growth and redistribution decomposition of poverty changes (actual change)

				Change in incidence of poverty					
				Sim1			**Sim2**		
	Original	**Sim1**	**Sim2**	**Growth**	**Redistribution**	**Interaction**	**Growth**	**Redistribution**	**Interaction**
Total	50.55	36.44 (-14.1)	45.43 (-5.1)	-14.85	0.38	0.36	-5.31	0.03	0.17
Urban	34.65	21.65 (-13.0)	29.72 (-4.9)	-13.52	0.70	-0.18	-4.90	0.10	-0.14
Rural	74.21	58.40 (-15.8)	68.81 (-5.4)	-16.60	-0.25	1.04	-5.95	-0.25	0.80

Source: Microsimulation results

Lastly, we look at poverty curves. The poverty incidence curve is a comparison of the cumulative distribution function of per capita income or expenditure across the population, between two scenarios. At any level of per capita expenditure, the height of the poverty incidence curve indicates the proportion of the population consuming below the per capita expenditure given on the horizontal axis. Figure A1 in the appendix shows that poverty declined for simulation 1, but for simulation 2 the decline is quite minute and only visible for urban households.

6. Conclusion

This study analysed the economy-wide and distribution impacts of increasing the price of electricity in South Africa by simulating an actual price increase experienced in the economy and a less severe increase linked to inflation. The direction of change of impacts emanating from the simulations is largely the same, with higher magnitudes observed for the higher electricity tariff increase. Results of this study are similar in some respects to the results observed by Altman et al. (2011), Pan-African Research and Investment Services (2011) and Nguyen (2008) in terms of negative impacts on GDP and general price level. While the macro results show a negative impact on the economy in terms of a decrease in GDP, an increase in prices and an increase in unemployment, the micro results indicate that poverty, as measured by the headcount rate and poverty incidence curves, declines. This finding is similar to the finding by Boccanfuso et al. (2009) that when a significant proportion of households is connected to the grid, electricity sector reforms in the form of increasing tariffs to expand power generation can lead to poverty reduction. The results of this study show that an increase in the price of electricity results in an increase in output production and labour demand in some sectors through supply side effects and provides some relief to the challenge of poverty. However, inequality does not decline but generally increases. Based this study's results, the impact of an increase in electricity tariffs is not entirely negative on the economy, if it leads to an increase in production for some sectors.

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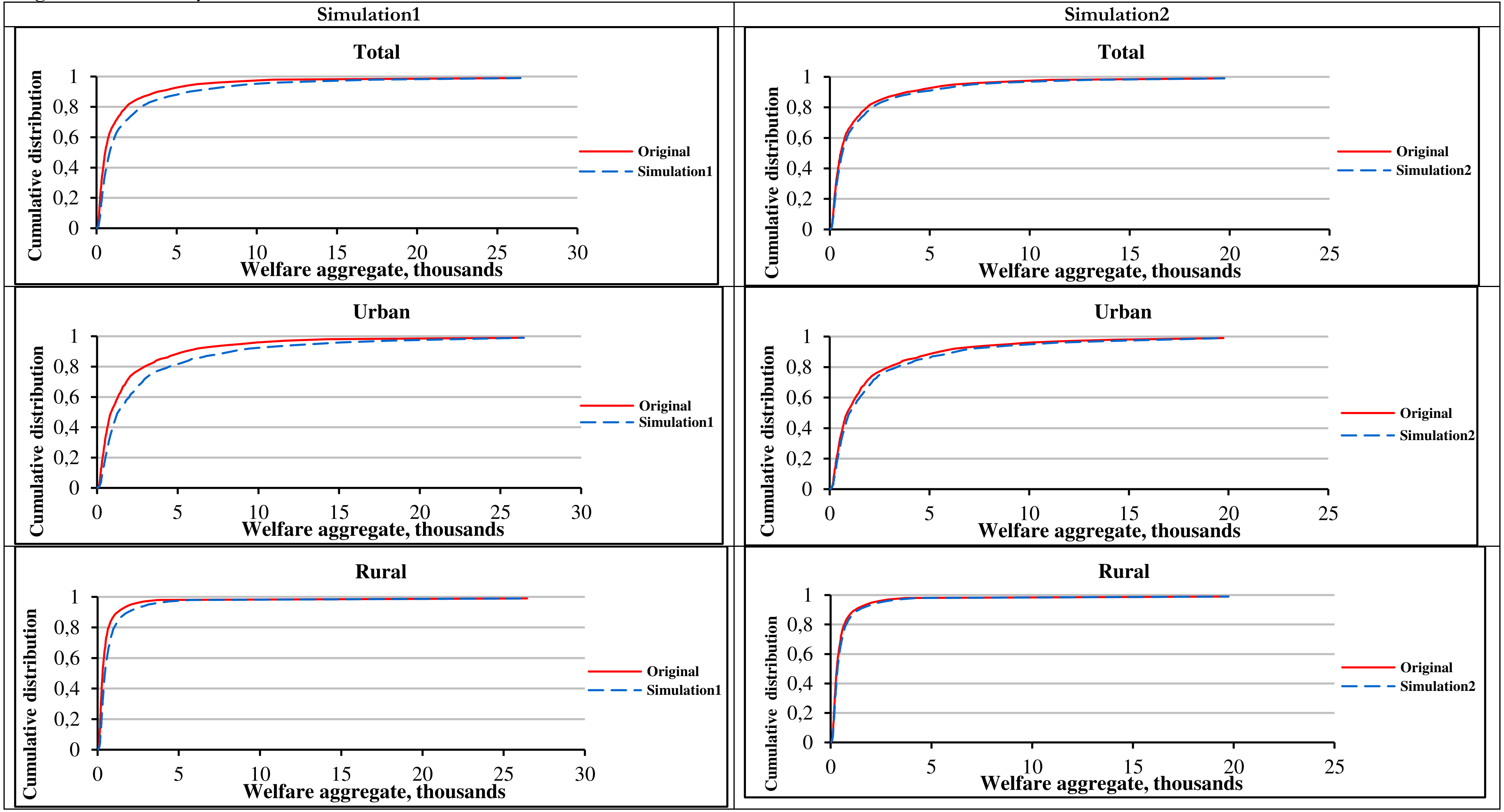
8. Appendix

Figure A1: Poverty Incidence Curve



Source: Microsimulation results