Università
Ca'Foscari
Venezia

Scuola Dottorale di Ateneo

Graduate School

Dottorato di ricerca

in Economia

Ciclo 25

Anno di discussione 2014

Distributional effects of energy policy: a micro-macro perspective

SETTORE SCIENTIFICO DISCIPLINARE DI AFFERENZA: SECS-P/06

Tesi di Dottorato di Lorenza Campagnolo, matricola 955700

Coordinatore del Dottorato

Prof. Michele Bernasconi

Tutore del Dottorando

Prof. Carlo Carraro

Contents

List of Tables

List of Figures

1 Introduction

Macroeconomic models are useful tools for describing future evolution of economy, taking in account behavioural responses of agents to price changes across time and under different scenarios, but they are ineffective in considering distributional issues. Microdata are a valuable source of information on intra-country inequality and poverty, but the problem of data availability, especially in developing countries, hampers dealing with these issues in a dynamic context.

For the last 30 years, a branch of literature focusing on the integration of macroeconomic models, in particular Computable General Equilibrium (CGE) frameworks, and microdata has been producing interesting developments. Several approaches can be counted, presenting different characterisation relatively to the used modelling tools (micro and econometric modelling), the sources of heterogeneity considered (factor endowment, consumption preferences and demographic characteristics) and the level of integration of households/individuals in the CGE structure (total integration, soft link, iterative procedure). The three main lines of research are: Representative Households approach, Integrated Multiple Households approach, and microsimulation models.

The microsimulation models represent a valid approach to introduce the distributional dimension in a CGE framework and allow assessing inequality and poverty changes induced by a shock. The creation of a soft link between microdata and macro models will be applied for Indonesia and the effects of a fossil fuel reform will be assessed. Thanks to the microsimulation model, it will possible to evaluate the welfare change induced by the policy at household level, identifying winners and losers of the reform.

A first step beyond the non-behavioural microsimulation approach will imply the creation of an endogenous demand system regulating the household-specific expenditure choices on consumption goods and services. The empirical derivation of it will have to deal with the censoring problem characterising the expenditure for several commodities. Differentiating the demand parameters across groups and households will lead to heterogeneous reactions after a shock implementation, capturing the two components of the behavioural response: one induced by the initial preferences and the other one depending on the chosen utility function and the estimated elasticities.

1.1 Structure of the thesis

The second chapter explores different options of bridging micro and macro information in a unique consistent framework in order to capture the effects of a shock on inequality and poverty. The most common approaches in the literature are: Representative household, Integrated Multiple Household and Microsimulation models that can be further distinguished in non-behavioural Top-down, behavioural Top down and bidirectional approaches. The modelling options range from the fragmentation of the usual representative agent in a multi-household representation to the creation of a soft-link between the household data and the macro model. In the final section, it is presented a review of the literature analysing distributional issue in the context of environmental and energy policies.

The third chapter describes the development of a non-behavioural microsimulation model and its application to evaluate the distributional impacts of a policy reducing fossil fuel subsidies in Indonesia. The creation of the microsimulation link begins analysing the 2007 Indonesian household survey (IFLS4, World Bank); it follows a reconciliation procedure with the Indonesian Social Accounting Matrix using the Cross-Entropy method. Around 10000 different households heterogeneous with respect to income sources and expenditure choices and consistent with the macroeconomic variables are represented in the microsimulation module. The policy scenario, implemented using ENV-Linkages model, determines a change of prices, factor remuneration and transfers. The impact of this reform on households' welfare is analysed in a neighbourhood of the equilibrium considering two different revenue recycling schemes (unconditioned lump-sum transfer to all households and increased governmental expenditure).

The forth chapter, using the reconciled Indonesian household survey data, examines the behavioural response of household to energy policy. An Extended Linear Expenditure System is estimated at county level and for urban/rural households taking in account the zero expenditure bias issue. A shock equivalent to a fossil fuel phase-out policy is imposed on consumer prices. This determines a consumption behavioural response in the ELES system evaluated at country level and for different household categories (urban/ rural).

The fifth chapter will present main findings and future perspective of research.

2 Distributional issues and clean policies in a CGE framework

2.1 Introduction

The analysis of distributional issues and poverty is often tackled with empirical and econometric tools that allow highlighting the causality and dependency relations underlying the features of a certain variable. The approach is also valuable in assessing the effects of a shock unveiling the characteristic that determine the post-shock results. However, the data availability is a cogent issue especially when the aim is to explain the behavioural response of an individual or a sub-group of population in a developing country following an event not yet occurred. Whether the World Bank and other international and national institutions extensively collect information about population through surveys, but the coverage often does not allows constructing a panel or even a pooled cross section.

The macro-modelling approach, in particular CGE, has been widely used in development economics to assess the impacts of a shock. The economy-wide dimension considered is fundamental in order to capture the effects of external shock (world price volatility and trade fluctuations) and policy induced shocks (measure affecting consumer prices or specific population categories) on the macroeconomic structure of a country. CGE models are grounded on microeconomic relations and draw their behavioural parameters from empirical works; therefore they can be a valuable tool in mimicking a shock-induced change. Moreover, this macro approach is totally ineffective in capturing intra-country distributional dimension of principal economic variables due to its representative household modelling structure.

Establishing a link between a CGE model and microdata allows addressing inequality and poverty in a consistent framework, considering interrelations and feedbacks between the individual dimension and the macroeconomic variables, and predicting the aggregate impact of a shock and also the underlying consequences at individual/household level that can motivate a compensative policy intervention or help tuning a policy implementation.

The literature on micro-macro links is mainly focused on assessing the effects of pro-poor policies, liberalisation intervention, fiscal measures and exogenous macroeconomic shocks. It is less frequent to apply this framework to disentangle the distributional implications of environmental and energy policies, even though the micro-macro link can offers interesting insights on the trade-off among economic, social and environmental dimensions arising after a policy implementation of this kind.

The paper overview the most relevant methodological approaches in analysing distributional issues in a CGE framework, describing Representative Household models that are the easiest way to introduce household heterogeneity, Integrated Multi Household models that represent the most complete method of integrating microdata in a CGE framework and Microsmulation models that establish a soft link between micro and macro variables and in some cases imply an intensive micro-modelling effort. The following section briefly presents the most used tools in measuring distributional issues and poverty. The few examples from the literature addressing the distributional impacts of climate and energy policies in a CGE framework are presented in section 4. The last section concludes comparing the effectiveness of different methodologies.

2.2 Distributional issues in a CGE framework

Computable General Equilibrium (CGE) models describe production, consumption and trade relations for a large number of countries under general equilibrium theory and are computationally solvable. The functional formulation can widely differ across models as well as the choice of exogenous and endogenous variables considered. A CGE can produce results for different time frames and the modelling simulations can be obtained using several approaches (static, recursive-dynamic and dynamic). Since the 70s, the CGE modelling has been largely employed for generating future economic projections and assessing the impact of specific policy implementation.

All CGE models are rooted on Social Accounting Matrix (SAM) that are comprehensive and consistent accounts of all the flows characterising the economy of a country and its interactions with other countries in a specific year. The usual representation sees listed on the rows of the SAM all the outlays and on the column the receipts of the principal players of the economy: firms, household and government. Therefore a SAM is the a synthetic way to represent jointly and consistently input-output flows in the productive system, trade statistics, government and household accounts (Lofgren et al., 2003). The matrix structure of the SAM guarantees the identity between the sum of outlays and the sum of receipt for each specific account (Decalwé et al., 1999).

Given the multi-country feature of CGE models, the economy representation is stylised especially regarding the household accounts. The behaviour of all households in a country is described using a representative household formulation that synthesises the average characteristic of the population. Therefore in this framework there is no room for capturing distributional dimensions in income and consumption neither to assess poverty issues.

To overcome this problem is necessary to integrate the CGE framework with external and micro-based data; the principal sources of information are household surveys, producer surveys and integrated household surveys, nowadays extensively collected by national statistic institutions and international organisations. Therefore, analysing distributional issues in a CGE framework has as necessary condition the availability of exhaustive survey data, but also requires the construction of a link between these and the other three elements: the macro model, the SAM and the microdata.

The literature dealing with income distribution and poverty analysis in a CGE framework dates back to 80s'and followed different paths regarding the instruments used (micro and econometric modelling), the sources of heterogeneity considered (factor endowment, consumption preferences and demographic characteristics) and the level of integration of households/individuals in the CGE structure (total integration, soft link, iterative procedure). The three main lines of research analysed in this paper are: Representative Households approach, Integrated Multiple Households approach, and Microsimulation models (Savard, 2003).

2.2.1 Representative Household approach

The Representative Household (RH) approach introduces heterogeneity in the CGE context specifying in the SAM a small number of representative households grouped depending on several demographics: income, education level, rural and urban location, sectoral employment. The representative households reproduce the average behaviour of the considered groups with an underlying assumption of homogeneous characteristics of the individuals/households in each group. The functional relations of the pre-existing CGE model are not altered by this procedure that mainly affects SAM, but the introduction of new behavioural parameters to diversify the response across groups is required. The characterisation of utility functions across representative households is an important feature of this modelling approach, but a uniformity constraint on the functional form has to be imposed in order to guarantee the aggregation of preferences, i.e. the representative households in the considered country and also in the other countries have to share the same utility function.

One straightforward, but restrictive modelling option is to assume identical demand parameters across representative households; in this case the only source of heterogeneity introduced is coming from the differentiation of household-types accounts in the SAM and the distributional changes induced by a policy implementation respond to the initial consumption, factor and income differentiation. The other common approach is to indirectly derive type-specific utility parameters and price elasticities using income elasticities and a Frisch parameter coming from the literature (Dervis et al., 1982)1. Direct estimation of parameters or of price and income elasticities is rarer in the RH models.

The limited level of heterogeneity characterising this approach reduces the data requirement: it is possible to work with pre-existing statistics of the population instead of raw survey data, but it is still necessary that the information about household-types contemplate all household accounts (production, consumption, taxation and transfers). The drawback of this limited differentiation is it allows considering only the between-group heterogeneity and fails to capture the within-group one that is usually a not negligible component. This shortcoming is particularly evident in evaluating policy induced distributional changes.

The literature on RH models focuses mainly on income distribution and developed three approaches for dealing with the within-group heterogeneity of income: assuming equal within-groups distribution, estimating an empirical probability distribution from the survey data and directly using the survey variables. The first methodology clearly does not allow deriving distributional statistics about the population, but only assessing the different response of household-groups. In the second case, the within-group heterogeneity is described empirically with a lognormal distribution (Adelman and Robinson, 1978; Dervis et al., 1982) or with a beta distribution (Decalwé et al, 1999) fitted on survey data. It is worth to notice that a policy implementation determines changes only at the average income in each household-group, therefore not altering the within-group distribution that is exogenous. The derivation of inequality and poverty measures at country level can be obtained considering the mean translation of within-group distributions and summing them; this procedure gives reliable results only if the implemented policy alters does not alter within-group distribution; moreover, this is a quite unrealistic assumption. In the latter approach, the policy-induced changes directly shift into the household survey dataset and alter uniformly income or consumption of households belonging to the same group (Lofgren 2003).

[1] The Frisch parameter, connected to the Linear Expenditure System formulation widely used in CGE context, can be defined as the negative of supernumerary ratio and measures the elasticity of marginal utility of income to total expenditure (Luch et al., 1977).

2.2.2 Integrated Multiple Household approach

In the usual CGE framework, household/individual preferences are averaged to form a unique country specific utility function subject to a national budget constraint. The investigation on inequality and distributional issues leads as extreme consequence to the fragmentation of the representative household in multiple archetypal households differing for productive sector membership, location and income level. These type-representative households share the same behavioural equations of classical CGE and the effect of any exogenous shock determines an alteration of their income and expenditure choices, leaving unchanged the intra-household distribution of the variable of interest (RH approach). The Integrated Multiple Household (IMH) approach allows endogenizing the intra-group variance through the direct representation in a CGE framework of all agents described in a household survey (Decalwé, 1999; Rutherford et al., 2006). If from one side this approach does not implies many changes in the functional forms of demand and supply, the difficulties arise for several reasons: the detailed microdata required, the reconciliation process between microdata and SAM, the computational problems due to the increased number of equations and the issue of preferences aggregation.

The first concern in building an IMH model is data availability; in order to represent an entire household sample in the SAM is necessary to have complete information on household economy, e.g. consumption behaviours, income sources, transfers and direct taxation. Not many household surveys are so detailed, especially in developing countries. Whether all this information is available, a first reconciliation procedure is required in order to map the microdata categories into the SAM ones (Ivanic, 2004).

Micro-macro reconciliation

Household surveys and other types of microdata collect information regarding a sample totally or partially representative of the population. Using sample weights, whether they are available, it is possible to inflate sample statistics and obtain statistics for the entire population. It is unlikely that the total value of principal economic variables coincides with the figures in the SAM. Measurement errors and bias are widespread in both frameworks and determine the mismatching of expenditure, income and savings (Deaton, 1997).

Reconciliation is a necessary step for IMH approach; whether it is not compulsory to adjust survey figures to match SAM aggregates and instead it is possible to correct the SAM flows using the micro dataset, the former approach avoid the rebalancing process in the national accounting matrix.

Differently from the microsimulation approach, in the IMH case a full reconciliation is required because the household level figures have to replace completely the household accounts in the SAM. The SAM's matrices that have to be replaced are: household expenditure on each consumption good, household primary factor endowment, transfers and direct taxes per household.

The reconciliation process can be performed with several methods such RAS and Cross-Entropy. RAS (Miller & Blair, 2009) is an iterative method using "bi-proportional" row and column operators to update the original matrix and create a new matrix compliant with SAM figures and mirroring survey's distribution of principal variables across households. The Cross-Entropy method minimizes the sum of entropies between original and final coefficients under the constraints that column and row totals match the targets. Even if the RAS method seems less theoretically based, it leads to similar results of Cross-Entropy method: the RAS solution satisfies the first order conditions of Cross-Entropy minimisation (McDougall, 1999).

Multiple household representation

The reconciliation procedure returns a SAM with multiple household expenditure accounts and differentiated primary factor remuneration. The CGE equations have to match the SAM detail and usually it is not necessary to alter the original formulation of the model. Instead, what is required is the calibration of demand parameters for each household. In this case, the common procedure is to use household budget shares from the extended SAM, income elasticities and the Frisch parameter, as described in the RH approach.

The IMH approach outperforms the RH in describing distributional changes following a policy implementation because it allows endogenizing the intra household-type variance proper of RH models.

For example, Boccanfuso et al. (2003) includes 3278 household from a Senegal household survey into the SAM and simulate the effect of two development policies: an increase of capital in the food industry and a reduction of import duties. Income distribution and poverty index in the IMH case are compared with some parametric and non-parametric income distribution functions, in the base and policy case; in the policy scenario, IMH approach determines consistent changes in income distribution that cannot be represented using an income distribution fitted in the base case: the goodness of fit in the policy scenario is obtained with different functional form with respect to the baseline scenario. In Cogneau and Robillard (2000), the enhanced SAM for Madagascar can count 4500 different households with heterogeneous consumption and production factors. In addition, the used CGE is integrated with some econometrically estimated functions (agricultural production, income in the informal sector and wage in the formal one) and several shocks on poverty and inequality are performed. Rutherford et al. (2005) consider 55000 households in a CGE model for Russia and simulate the distributional implications of WTO accession. The number of households represented in the model coincides with the entire sample of Russian Household Budget Survey and generates computational issue. These are overcome using a two step procedure with the first step computing the after policy equilibrium for a representative household and a second step calibrating the change for each household.

2.2.3 Microsimulation approach

Microsimulation approach is characterised by two distinct components, a CGE and a microsimulation module linked together by the presence of common variables, such commodities prices and primary factor remuneration, which allow the propagation of a shock from one model to the other. The microsimulation method differs from the RH and IMH because it does not implies the replacement of the representative household in the CGE with multiple household, but works creating a soft-link between the two models. The microsimulation module can be seen as a partial equilibrium model, describing with high detail the households' economy.

As in the case of IMH, household surveys and other microdata are an avoidable source of information where to build the microsimulation module; although the harmonisation between the micro variables and the national accounting ones is desirable, it can be less stringent with respect to the case of direct integration of survey data in the SAM. Furthermore dealing with two separate frameworks gives more degree of freedom in searching more reliable and flexible functional formulation and in considering a large number of agents or the entire sample in the microsimulation module.

The linking procedure is sequential (Top-down approach): it begins in the CGE framework where the policy is implemented and determines changes in the main macroeconomic variables and it is translated in the micro module altering income distribution, consumption patterns and labour market conditions. The Top-down approach is also said "Open-loop" modelling approach because no feed-back effect from the micro module to the CGE framework is considered. Commonly, the policy exercises are generated by a static version of the CGE model. The micro-module complexity can be tackled at different levels usually depending on the focus of the research; it goes from a no-behavioural model to including a behavioural response.

Savard (2005) considers a bidirectional link from the CGE model to the microsimulation module and back until equilibrium is established (Bidirectional approach).

2.2.3.1 Top-down approach with no-behavioural response

The Top-Down approach with no-behavioural response is characterised by an”arithmetical” microsimulation module where a policy shock determines no changes in individual behaviour; this assumption appears legitimate only if the policy change is so small that doesn’t alter individual choices or if the impact assessment is evaluated rightly after the policy implementation end before an adaptive response takes place (Héraul, 2006; Ravallion and Chen, 2004). The link between the micro and the macro framework is sequential. In the CGE model, the introduction of a shock starts off sectoral interactions and behavioural responses until a new equilibrium is reached. The endogenous changes in primary factor remuneration, commodity prices, employment level, taxes and transfers are passed into the microsimulation module.

Micro-macro reconciliation

A prerequisite for the transmission of the policy shock is the consistency between the economic structure described in the household survey that shapes the microsimulation module, and the SAM of the CGE. This is less stringent compared to the RH and IMH case depending on the focus of analysis, e.g. if the analysis assesses the policy impact on income it is sufficient to obtain the coherence in the two frameworks of total and sectoral primary factors revenues, employment level, taxes and transfers. A sectoral production and primary factor mapping from the survey classification to the SAM aggregate guarantees a basic coherence between the two frameworks (Ivanic, 2004), but are not sufficient for assuring the shock response in the micro module is in line with the macro result.

Other techniques as RAS method and Cross-Entropy can be applied directly on survey data in order to rescale them to the macro aggregates; adjusting SAM flows to match the households data is also possible although is usually preferred not to alter the SAM balance. Moreover, if these adjusting methods are applied only on base year, the policy scenario may determine distributional changes that on aggregate diverge from the CGE result. The solution to this issue is to iterate the use of rescaling, also after the policy shock. This condition holds also in the case of multi-period microsimulation approach where the RAS or Cross-Entropy methods should be applied to each simulation year.

Instead of directly modifying household survey values, it is possible to rescale sample weights. When the statistics produced from the survey sample and inflated using the corresponding weights are not in line with the CGE values, it is possible to compute new sample weights matching the target ones, but not too different from the original one (Buddelmeyer et al., 2008). One option to compute the new weight matrix is the Cross-Entropy method, i.e. minimising a distance function between the original and rescaling weights under the constraint of identity between the value of the variable from the survey and from the CGE (Robilliard and Robinson, 2001). Ferreira and Horridge (2006) adjust weights to reproduce the changes in worked hour and wage following Brasil's tariff reduction; Buddelmeyer et al. (2008) applies the reweighting in each year of the simulation to reproduce in the microsimulation module the changes of population characteristics (age, gender and region), employment status (sectoral and regional employment or unemployment) and migration flows.

Microsmulation module

A no-behavioural microsimulation module is a set of equations that downscales the outcome of a CGE model at household or individual level. Although in this framework agents do not adapt to the changes in the economy, the outcome results enriched by household heterogeneous characteristics coming from the survey. In the microsimulation module capital and primary factor remuneration are exogenous; new prices coming from the CGE policy simulation are used to compute new household-specific price indices, expenditures and real incomes. Likewise, household incomes update following the new remuneration of primary factors (Dartanto, 2013).

The heterogeneous impact of the policy on different households depends on the income and expenditure mix characterising each household and they can be considered as an approximation of first order welfare change imposed by a policy implementation. Moreover, the discrepancy between the behavioural and the non-behavioural approach can vary depending on the magnitude of the policy intervention.

The theoretical rationale of the non-behavioural microsimulation derives from consumer utility theory and, more specifically, from indirect utility function and its property of measuring the welfare change induced by budget constraint variations (Bourguignon and Spadaro, 2006). The loss and gains of welfare is commonly computed in monetary terms using the following formulation:

$$\mu_i = [\sum_k x_{i,k}\, w_k \frac{dw_k}{w_k}] - \sum_j p_{i,j}\, c_{i,j} \frac{dp_{i,j}}{p_{i,j}}$$

This expression derived applying the envelope theorem highlights that individual (or household) welfare change is function of variations in primary factor remuneration and in commodity prices weighted by the original factor and expenditure distribution. This approach is widely used in development economics to assess the welfare implications of a reform. Ravallion and Chen (2004) apply this method to measure the effects on inequality and poverty due to China's WTO accession; they observe that the small impact displayed at aggregate level conceals welfare losses in rural areas and gains in urban areas. Similar results emerge from a cut of agricultural tariffs in Morocco: rural households loose welfare because the negative effect on agricultural revenues exceeds the benefit generated by lower prices of agricultural commodities (Ravallion and Loshkin, 2004). Dartanto (2013) uses the welfare change decomposition approach to derive an endogenous poverty line for Indonesia and assess the different impact of a fossil fuel subsidy reduction to household typologies classified according to their sectoral income sources. The same module can be integrated in a more complex framework as 123PRSP Model (Devarajan and Go, 2002) that put together the IMF's Financial Programming Model, a static general equilibrium mode, two growth models (short-run and long-run) and a non–behavioural microsimulation module. In a simulation exercise envisioning a shock of terms of trade for Zambia, poor households result more negatively affected than rich ones.

Despite the wide application of Top-down non-behavioural approach, a behavioural microsimulation with endogenous labour market or demand function seems to perform better in describing winners and looser of a reform; in assessing welfare implications of a trade liberalisation in South Africa, Hérault (2010) notices that a non-behavioural microsimulation performed with the reweighting procedure fails to capture the variation of country average welfare that instead are accounted in the behavioural approach.

2.2.3.2 Top-down approach with behavioural response

Behavioural microsimulation models downscale at household level the macro changes produced in the CGE model, but are also able to describe the behavioural responses that take place at micro level. The recent research focuses on two specific displays of behavioural response: choices in the labour market and consumption decisions. In the former case, the labour supply can be derived from a utility maximisation problem and empirically estimated (Bourguignon and Spadaro, 2006) or empirically estimated with a discrete choice model (Bourguignon et al., 2003; Hérault, 2006; Bussolo et al., 2006; Bussolo and Lay, 2003). Regarding the adjustment of the consumption preferences, it is necessary to characterise in the microsimulation module a household specific demand response to price and income changes originating after the policy implementation (Savard, 2005).

The variables establishing the link between micro and macro framework are, as usual, commodities prices, primary factor remuneration and labour market characteristics. The microsimulation module presents the all the relations that guarantee the consistency of each household accounts and the aggregation of individual/household variables into SAM flows: an income generation model for each household considering all the components of income (primary factor revenues and transfers) for all family members; the derivation of disposable income, consumption expenditure and savings when the CGE model considers it (Colombo, 2008).

Income generation model

In the behavioural case, the income generation model is enhanced with an adjustment rule to policy shocks: a discrete model of occupational choice describing the status switching in the labour market responds to the utility or value maximisation rule or directly to the highest income. The choice between working in one sector with respect another one can be determined randomly. Bussolo et al. (2008) use a probit structure with individual and household characteristics as explanatory variables to order the individual switching from agriculture to non-agricultural sectors. Colombo (2008) uses a binomial logit, function of wages, gender, education and skills, to assign an individual probability of being employed or unemployed. Bourguignon et al. (2003) present a more complex and realistic representation of the income generation model characterising separate wage and net-income functions, the former at individual level and the latter at household level to account for employment remuneration and business revenues; therefore, the resulting occupational status can range among no-employment, employment and self-employment and is regressed in a multi-logit form on individual and household characteristics.

An alternative approach links the choices relative to labour supply to the deriving utility level. An implicit utility function depending on personal characteristics and on the disposable income determines how much time to devote to a specific occupation (Bourguignon and Spadaro, 2006) or the probability of choosing a specific job status, e.g. unemployed, subsistence agricultural worker and informal/formal worker (Herault, 2010).

This endogenous determination of labour market conditions mirrors the endogeneity of labour supply in the CGE model, but this does not guarantee that the employment change due to a policy implementation is consistent with the CGE results. Therefore given the importance of employment status in determining income distribution is necessary to create some constraints in the microsimulation module. Their complexity is strictly correlated with the level of detail used in describing labour market. In Hérault (2010), the after policy employment level is reached moving workers from informal to formal sector according to the priority determined by the job choice model. Similarly, Colombo (2008) constrains the changes in the microsimulation module imposing that variations in wage rate and capita remuneration are on average equal to the simulated changes in the CGE and the percentage variation of unemployment rate has to match as well. In fact, like in Bourguignon et al. (2003), the after policy equilibrium in the CGE model is passed in the micro-module in a neutral way with respect to individual and household features, i.e. the updated labour and net-income remuneration shift in parallel the wage and net-income functions in the module and spread their effects to all agents irrespectively of their demographics.

Demand model

Most of the microsimulation literature focuses in modelling behavioural response in the labour market because its direct correlation with the income distribution effects in the after policy scenario. But it is also interesting to look at the experienced changes happening on the consumption demand side. There are few examples in the literature that look at both side of the problem. Savard (2005) reproduces in the microsimulation module the same equations characterising the CGE model but at individual level; whether income is a simple downscale of the macro aggregates using the survey data, the consumption function is endogenized using a household-specific Linear Expenditure System (LES) that aggregates to the CGE representative total expenditure. The most common procedure in deriving demand behavioural coefficients of LES is using the Frisch parameter like in the IMH approach. However, there are many possible specifications for the utility function describing individual consumption choices: Cobb-Douglas, Stone-Geary, and Constant Difference of Elasticities (CDE) are the most widely used in this context. The three condition to respect in choosing the demand function for the microsimulation module are: the utility function at agent level should have the same shape of representative agent in the CGE; the aggregation of individual consumption should give representative household consumption; it is preferable choosing a demand function that fit well the household survey observations; the choice of a specific demand function has to be conditioned to its aggregation properties given that even specifying the same demand function for all agents does not guarantee perfect aggregation.

2.2.3.3 Top-down (Closed-loop) approach

The closed loop model (Savard, 2005) is an iterative version of the Top-Down approach where the initial shock originated in the CGE model passes to the microsimulation module and then back again in the CGE until the shocks are homogenised. This approach allows skipping the reconciliation procedure between the SAM and the survey because the harmonisation is accomplished through the iteration. In detail, the CGE model (with exogenous expenditure) produces an alteration of primary factor remuneration and prices that is translated in a microsimulation module with the same behavioural equations, but specified at household level, and in addition two possible utility functions (Cobb-Douglas and LES). The shock rearranges income distribution, saving and ultimately household consumption choices. The resulting total change of expenditure in the micro module is imputed in the CGE model as an exogenous shock on demand that induces adjustments on primary factor remuneration and income. The procedure continues until the feed-back effect between the two frameworks is minimal.

2.3 Poverty and inequality analysis

In an enhanced CGE framework, poverty and inequality measures are used to assess the effect of a policy implementation on some variable of interest as income and consumption. The experienced changes are evaluated with respect to the initial characteristics directly extracted from household surveys. Therefore, in this context, the distributional analysis differs depending on the chosen modelling approach and by the level of heterogeneity introduced. The modelling approach determines the output features; e.g. in the case of RH approach, the model result is conditioned by the reduced number of types considered and requires to fit from the household survey data the distribution function and use it to build inequality and poverty indicators (Boccanfuso et al., 2003). In all other case, statistics and indices can be performed directly on model outputs.

The level of heterogeneity considered influences the bias of poverty and inequality measures: the highest bias characterises the RH approach where only between-group differences are considered; the IMH and Micosimulation models performs better the closer they reproduce micro behaviours.

The used inequality indicators are the ones common in development economics, such Gini index, Lorenz curve, the coefficient of variation, and Theil's "entropy" measure of inequality (Deaton, 1997) in addition to decile and quatile ratios. The CGE framework and the functional specification of all economic flows allow assessing households’ welfare and looser and winners after a policy implementation.

Among the most used poverty measures there is Foster-Greer-Torbecke indicator family that include headcount ratio, poverty gap index and squared poverty gap (Ravallion, 1994). In addition, given the CGE framework, the poverty level can be evaluated through an endogenous poverty line that couples the commodity basket satisfying basic needs with a consumer prices that are affected by policy changes (Decalwé et al., 1999).

2.4 Distributional effects of energy and climate policies

The literature focusing on distributional effects of a climate or energy policy are still limited, especially regarding developing countries, where data limitation does not allow to the micro-macro framework matching. This overview will focus on the most used climate policy instrument, a carbon tax, and on an energy policy related instrument, fossil fuel subsidy reduction, in a micro-macro perspective. The parallel between carbon tax and fuel subsidy cut is straightforward, but the implications of these policies can be heterogeneous. Nonetheless, the micro-macro approach is particularly interesting because it overcomes the usual efficiency evaluation of a policy and cost in terms of GDP, and shed some light on the intra-country burden sharing across different household typologies. The distributional effects deriving from a climate or energy policy should be carefully evaluated in order to reduce the negative impact on the entire population; despite the fact that that the outcome of any intervention determines winners and losers, it is important to identifies this latter categories and adjust the intervention to compensate them (Kriström, 2006).

The micro-macro approach allows considering jointly three relevant issues related to a policy intervention: efficiency, environmental outcome and distributional impacts.

Efficiency

In evaluation the efficiency of a policy two components has to be assessed: the tax interaction effect and the transfer effect (Goulder, 2013). On the one hand, a new tax generates distortions that decreases the efficiency of the economy and reduces welfare: this is the tax interaction effect. On the other hand, if the tax revenue is used to lower other existing taxes, distortions are reduced giving way to a positive impact on welfare: this is the transfer effect. The net benefit of a tax introduction for the households is a mix of these two effects. When the transfer effect offsets the tax interaction, the households are better off and a double dividend is achieved (Bovenberg and Goulder, 1996): on the top of the gains from improving environmental quality, the economy is more efficient. Policies have to exploit the transfer effect in order to have more efficient outcomes. The lump sum transfer of the revenues generate by the tax does not reduce distortions produced by the other intervention in place and therefore does not create a positive transfer effect. Consequently the reforms with a lump-sum transfer are outperformed by other policies envisioning a fiscal reform.

In the case of reducing subsidy the efficiency outcome is always positive. The deadweight loss generated by the subsidies decreases and the transfer effect is null in the case of lump-sum recycling of the revenues, and again positive if the recycling implies a reduction of other forms of distortion such as consumption taxes. A positive impact on welfare can be preserved with lump-sum transfers or complemented with a reduction of other taxes.

The deadweight loss from taxing a commodity increases with the price elasticity of demand for this commodity (Ramsey rule). In the case of subsidies reduction, the reduction of deadweight loss and the efficiency of the reform are higher when the price elasticity of energy demand is high.

Environmental performance

The environmental effect of a tax/subsidy on fossil fuel depends on the price elasticity of energy demand. The tax and subsidy reform increases fossil fuel and electricity prices for household and industrial consumers, creating an incentive to shift consumption towards other goods or other inputs. The higher the elasticity of demand is, the more the energy consumption can be reduced.

Distributional impacts

A policy reform will entail heterogeneous direct and indirect consequences across economic agents that can be summarised in impacts on commodity prices, income and public payments to households (transfers) using the CGE model. For instance, a carbon price on all sources of emissions translates into changes in taxes on fuel consumption, final consumer prices, sectoral wage rates and changes in government transfers. A myriad of market interactions emerges where relative prices adjust such that the equilibrium is reached in all markets simultaneously. The outcome of the policy on different households depends on a multitude of effects that can be classified within three broad categories: direct and indirect price effects, income effect and income-expenditure link.

Commodity prices for the consumer would increase either directly, for the commodity targeted by the policy, or indirectly as the policy will lead to an adjustment of prices of other consumption goods. For the fuel tax example, such indirect expenditure effects include (i) a change in the equilibrium price of fuel and (ii) a second-round effect through changes in the equilibrium market prices of other consumption goods, for instance as consumers substitute away from energy-intensive goods to other goods and services, thereby driving up their relative price. The magnitude of the impacts depends on how strong the relative price signal is across the different commodities, in the consumption mix characterising different households and on the possibilities to switch consumption towards less energy-intensive (and hence relatively cheaper) goods and services.

Secondly, households will see their income change when the policy impacts the sources of their income, such as wage income, land rental, capital income and the reliance on government transfers. What matters here is post-tax income, so changes in tax rates also affect disposable income. The individual impact for each household will depend on its structure of income and on its ability to change the sources of earnings. Market structures, such as labour market rigidities, also play a role here. For instance, an individual employed in an energy-intensive sector will be particularly negatively affected by a fuel tax, especially if they cannot find a job in a greener sector. The policy will also impact the household income through changes in government transfers. For instance, fuel tax revenues can be redistributed to target groups, such as through cash transfers for poor households. This latter government-transfer effect is particularly relevant when the policy is implemented in a budget-neutral fashion, i.e. if additional government revenues are compensated by reduced tax rates on other commodities. If the policies lead to increasing government expenditures, then the second-order effects through changes in equilibrium prices for different goods and services will be stronger.

Finally the purchasing power of a household depends on the relation between expenditure and income. For instance, even if income goes down, a household whose expenditures are concentrated on relatively clean goods and services may observe an increase in purchasing power due to the policy reform.

Whether policy induced efficiency change and environmental performance is usually assessed in most CGE models, in order to judge distributional impacts is necessary to use one of the enhanced CGE models described in the previous section. Clearly the complexity and the integration of the micro-macro link affect the ability in capturing the distributional effect. It will follow some examples of distributional analysis in the case of carbon tax and fuel subsidy reduction.

Yusuf and Resosudarmo (2007) assess the effect of a climate policy in Indonesia using an extended version of RH approach and include 200 household in the SAM (100 urban and 100 rural). A carbon tax of 32.6 US$ per ton of CO_2 is introduced considering three recycling schemes of the revenues (deficit reduction, indirect tax on sales reduction and lump-sum) and determining a 6% reduction of emissions. The efficiency criterion favours the scenario that couples the climate policy with a reduction of consumption distortions and the best result in terms of GDP loss. Moreover the distributional impact of the carbon tax is progressive in rural areas due to low reliance on carbon intensive energy sources and progressive in urban areas only in the case of revenues recycling in a lump-sum. In Yusuf and Resosudarmo (2007), despite the high number of household represented in the SAM, still a big portion of intra-household type heterogeneity result missing.

Corong (2007) analyses the effect of a carbon tax of 385 peso (around 22 US$) in the Philippines and the possible interactions of this policy with a trade reform (reduction of import tariffs) using a RH approach linked to 1994 family income and expenditure survey. In the CGE model, 12 representative households (classified by education level) result differently affected by the policy and this behavioural adjustment to the new scenario is translated into the corresponding education categories in the household survey. Whether the trade reform reduces poverty indicators, the carbon tax is regressive even though it is recycled with a reduction of direct taxation. Coupling the two policies, the outcome is progressive but cancels the 2% emission reduction determined by the climate policy. Despite the downscale of results using a household survey, the policy impact is strongly limited in heterogeneity by the 12 representative households' model that determines the behavioural response.

When the policy reform considers a reduction of consumption subsidies the result in terms of efficiency is undoubtedly positive because economic distortions result reduced with any system of recycling revenues. Welfare and inequality changes do not move necessarily in the same direction and usually the final outcome is driven by the chosen recycling scheme. Dartanto (2013) offers an example simulating a reform of fossil fuel subsidies in Indonesia. A non-behavioural microsimulation approach reproduces the effect on poverty and inequality due to a 25%, 50% and 100% cut of fossil fuel subsidies under different recycling schemes (government spending and direct transfers to household). The welfare impact depends on the magnitude of imposed price changes of the reform, but results negative only in absence of revenue redistribution. The poverty indicators decrease even in the case of subsidies phase out and partial redistribution of revenues in additional government spending and transfers.

2.5 Conclusions

The research on macro-micro modelling has been producing new tools for addressing the inequality and poverty issues in developing countries and envisioning the distributional impacts of external and policy induced shocks. The micro-macro linking procedure allows introducing heterogeneity of behaviours in a representative household framework, increasing its ability to reproduce actual responses at individual and household level.

Among all the modelling examples surveyed in the paper, the IMH models and the behavioural top-down microsimulations are the ideal approaches to deal with the richness of detail of microdata, to maintain the coherence of micro and macro economic relations and to reproduce consistently agents' behavioural response after a shock. Within these two categories, there are several modelling options guaranteeing different degree of representation of agents' behaviour. Moreover, when it is possible, the integration of CGE structure with empirically derived functions should be privileged, e.g. describing consumption and labour supply choices.

In addition to the development of modelling tools, a challenge concerns the microdata availability and reliability that are unavoidable in the micro-macro procedure and constitute an obstacle to the most complete modelling approaches.

The distributional impacts of environmental and energy policies are usually not considered and the assessment of the induced benefit or damages is performed at country level using aggregate cost and benefit analysis or welfare change comparison. The micro-macro modelling allows going beyond in the evaluation of policy impacts and highlighting their distributional implications. These are relevant components when the intervention targets consumer and producer prices, therefore affecting all the entries of households' accounts in a heterogeneous way. Understanding who are the winners and losers of a reform could help the policymaker to improve the intervention design, to create correct compensative measures and also to understand the effects of composite policy interventions targeting the environmental, economic and social dimensions.

3 Distributional impact of reducing fossil fuel subsidies in Indonesia

Lorenza Campagnolo, Ca’Foscari Grduate School

Jean Chateau, Environment Directorate OECD

Rob Dellink, Environment Directorate OECD and Wageningen University and Research Center

Olivier Durand-Lasserve, Environment Directorate OECD

3.1 Introduction

Indonesia is a fast growing emerging country with a 6% average annual growth rate of GDP driven by demand expansion and a growth of the manufacturing sector, with limited inflation pressures (OECD 2012). In the perspective of a sustainable growth, Indonesia faces some important challenges. First, further growth requires improvements in infrastructure and investment in educations. Second, the increasing inequality (WB, 2013) has to be levelled out to in order to spread the benefits of economic growth to the entire population and to enforce the political stability of the country. Lastly, in a global perspective, Indonesia has to limit its CO^2 emission according to the pledges subscribed in Copenhagen (-24% by 2020 with respect to the Business As Usual scenario).

Meeting these challenges requires wide range changes. The fossil fuel subsidy system has been for decades one of the most characteristic feature of Indonesian economy. They were introduced in 1967 in order to redistribute the rents generated by natural resource extraction sector. But energy subsidies became a real burden for the Indonesia economy, especially since the early 2000s’.

The domestic fuel price stabilization, through adjusting subsidies to limit the pass through of international price, absorbed a considerable share of budget resources that could be otherwise allocated to crucial public investments. This situation worsened with the decline of domestic fossil fuel production and with the peaks of international oil prices, as in 2008. In addition, fuel subsidies stimulate higher fuel consumption and encourage the persistence of energy-intensive processes and behaviours. These consumption patterns contribute to the increase of CO^2 emissions and to air pollution. Last, the redistributive impact of the subsidies can be seriously questioned, especially compared with other types of transfers. The transfers due to energy subsidies benefit more in absolute terms the wealthiest households (IISD, 2012).

Despite these poor distributional performances, the subsidy system has proved to be very difficult to reform. In Indonesia, as in several developing countries, taxation on individual is very limited; subsidies are the only tool for redistributing revenues and for supporting the poorest layers of the population. Fossil fuel subsidy reforms potentially impact the life of millions of households and can raise a broad-based discontent, as recent chronicles can confirm. Consequently, the last decade experience has seen ad-hoc reforms to lessen the unbearable burden for the government budget and to safeguard the macroeconomic stability. These attempts lacked coordination and were partly repealed due to civil society discontent and political reasons.

A more coordinated reform of fossil fuel subsidy is necessary to meet the Indonesia commitment to fully phase out fossil fuel subsidies by 2014 (Mourougane, 2010). To be acceptable, the reform has to be accompanied by appropriate transfers in order to limit their detrimental effects on the most vulnerable part of the populations, to contribute to the reduction of inequalities to make energy more accessible. IEA (2010b) insisted on “the importance of providing those in need with essential energy services, including through the use of targeted cash transfers and other appropriate mechanisms”.

The paper aims to shed some light on the effects of a fuel subsidy reduction on households’ income distribution and energy consumption and to assess if this policy reverses or boosts the regressive effect of the pre-reform fuel consumption support (Dartanto, 2013).

In answering these questions, we will employ a CGE model, ENV-Linkages, a common tool for building different future scenarios and capturing interactions and feed-backs among domestic and international economic actors following a policy change. Moreover, given that the analysis deals with distributional issues, it is necessary to move on from the representative agent structure common in the CGE literature.

This step is realised creating a soft link between the macro aggregates in the model and household-level microdata. Fossil fuel subsidy reforms are simulated with the ENV-Linkages CGE model, which has a single representative household. The prices from ENV-Linkages are then used to shock income and expenditure of 10018 households included in the “Indonesia Family Life Survey 4” (IFLS4) realised in 2007 (Strauss et al., 2009). The household consumptions and primary factor supplies are assumed to be fixed, and the changes simulated with the CGE do not give way to behavioural adjustments from the households. Therefore the price shocks directly translate into expenditures and incomes variations. Following (Chen and Ravallion, 2004), we look at household’s change in money metric utility induced by the tax reforms as a proxy of welfare change. Various covariates are investigates, including initial revenues, and geographical location (rural or urban) in order to analyse the progressivity of the reforms and its incidence on particular population groups. The welfare analysis is performed using household survey information at its maximum extent (10018 observations), instead for sake of clarity, the results are presented at decile level. In order to have an additional synthetic measure for the goodness of the implemented policy, we also report the resulting change of Gini index.

Section 2 gives an overview of the importance of fossil fuel subsidies in Indonesia, of their cost and of the policy actions undertaken to reduce them. The methodological approach used in this study for measuring household-level welfare effects is presented in section 3. Then section 4 explains how social accounting data, used in the CGE, and household level-data from the survey are reconciled. The resulting distributional impacts of fossil fuel subsidy reform with specific revenue recycling schemes are presented in section 5. The last section concludes.

3.2 Fossil fuel subsidies in Indonesia: importance, performances and reforms

3.2.1 Fossil fuel subsidies: state of the art

Following the definition given by the IEA any government action that concerns primarily the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers (IEA, 1999). This definition includes large collection policy mechanisms, including direct final transfers, preferential tax rates, trade barriers, or some energy sector regulation such demand guarantees or mandated deployment rates (IISD, 2012).

Because of the variety of tools used to support the production and consumption of energy, subsidies are very difficult to assess. For measuring energy subsidies, IEA (2006) developed the so called “price gap approach”. It measures subsidies as the deviations between the consumer’s price and a reference non- distorted price; usually for tradable goods the international price is used. The price gap approach has been criticized mainly for its reliance on the ambivalent notion of reference price and for its weakness to capture the production subsidies. However, this method is very useful in practice for measurement and cross-country comparison of subsidies.

Fossil fuels subsidies, measured with the price gap approach are large in Indonesia given the domestic economy and the net energy importer position. In 2010, Indonesia was among the 7th country in the world in terms of fossil fuel consumption subsidies (IEA, 2013) following big energy exporter (Iran, Saudi Arabia, Russia and Venezuela) and larger economies (China and India). The subsidies represent a significant fraction of the country GDP, which has reached 4.5% in 2008 (Mourougane, 2010), when international oil prices were very high.

The Indonesian government subsidizes the price of retail petroleum, electricity and coal. The subsidies on retail oil products largely dominate. It includes support to transportation fuel, to kerosene used for cooking and lightening, and to liquefied petroleum gas (LPG). Electricity prices are administered for all consumers and set yearly, with the government financing the difference between the administered price and the production cost. Coal is subsidized through cost setting in the domestic market combined guaranteed supply.

3.2.2 The costs of heavily subsidising energy

In advocating a fossil fuel subsidies reform, the high fiscal, economic, environmental and social costs of supporting energy consumption are adduced (OECD, 2010).

3.2.2.1 Fiscal impact

Fossil fuel subsidies make the governmental budget vulnerable to the variation of oil price and subtract resources that could be used in financing the necessary investment in infrastructure and poverty reduction.

The pressure on fiscal balance is due to the large share of the government spending for financing fossil fuel subsidies (OECD, 2010). In 2008, when world oil price peaked, energy subsidies represented about 30% of the central government expenditures (IISD, 2012).

Originally, Indonesia was a net oil exporter, and the huge flow of oil revenues to the government's budget contributed to financing subsidies. In 2004, the Country became a net oil importer and the increasing domestic fossil fuel demand led to an uncontrolled rise of cost for supporting energy consumption contributing to the degradation of the government budget balance and to a custom of under investment in infrastructure and education crucial for development. The Indonesian government devoted to energy subsidies approximately the same amount of money used for investment, education, defence, health and social security[2]. This misallocation of fiscal resources is particularly detrimental given that investing in welfare system and infrastructure tends to have a

[2] These figure come from ISSD (2012), p.5, which quotes on the Indonesian Ministry of Finance

very high rate of social return in developing or emerging countries (Fan *et al.* 2000; Jung and Thorbecke, 2003).

3.2.2.2 Economic cost

The economic cost of fossil fuel subsidies is due to the wasteful consumptions behaviours (Chateau et al., 2011). Pushing downward final energy prices, subsidies generate higher fuel consumption from both firm and households and reduce incentives to invest in alternative energy sources and to pursue efficiency targets, conditioning the Indonesian position on energy security (Beaton and Lontoh, 2010; OECD, 2010). This leads to negative impacts on the external trade, through increase of net oil imports.

There have been various studies on the effect of removing fossil fuel subsides in Indonesia (Ellis, 2010). They gave way to different evaluations of the impact of the reform on GDP, depending on the modelling framework and the time horizon. Clements et al. (2007), with a static CGE model, suggest negative short term impacts of the reform on GDP, that are largely due to limited scope for reallocating production factors and adjusting consumption. Burniaux et al. (2009), considering a group of countries including Indonesia in a multi-period analysis, pointed out the beneficial impacts on GDP of multilateral removal, but negative impacts in case of unilateral removal. IEA (1999) estimates to .24% of GDP the yearly gains of removing subsidies.

Even if the results are different, they are consistent with the idea that the effect of subsidy removal is substantial.

3.2.2.3 Environmental cost

The rise of environmental cost is a direct consequence of increased consumption of fossil fuel resources. This induces higher concentration of air pollutant and GHG emissions that have a detrimental effect on health and on environment. Burniaux et al. (2009) simulated a 20.5% decrease of emissions for a group of countries including Indonesia in case of unilateral removal and a 37.4% decrease in case of multilateral removal. The IEA estimated to 16% the decrease in Indonesian emissions due to a unilateral phase out. Bulman et al. (2009) with an empirical model related a 500 rupiah per litre gasoline price increase to a 2.5 consumption decrease and 20% increase of kerosene price to a 3.5% decrease in consumption.

3.2.2.4 Social cost

Fossil fuel subsidies determine social costs; they should contribute to boost poor household consumption, but this support considerably leaks to the other layer of the population (Widodo et al., 2012, Dartanto, 2013; Arze de Granato et al., 2012). Due to the absence of restriction for purchasing subsidized fuels and to the limited access to modern energy, they tend to benefit more to the wealthiest households and end up being regressive and irrelevant in addressing the problem of access to modern energy: 40% of wealthiest households benefits of 70% of energy subsidies and only 15% goes to 40% of poorest families (OECD, 2010; OECD, 2008). Instead, increasing social spending and well-targeted cash transfers might contribute to reduce poverty (OECD, 2012).

However, inequalities and access to modern energy are crucial issues for Indonesia. During the last decade, economic growth has been accompanied by increasing inequalities as the evolution of the Gini coefficient between 2000 to 2012 shows (WB, 2013). And despite a rise of access to electricity, reaching the 94% in 2010 with a reduced disparity across urban and rural areas, in 2010 still 45% of population was relying on traditional solid energy sources (World DataBank).

3.2.3 Attempts to reform the subsidy mechanism

The fossil fuel subsidy mechanism has been progressively reformed since the early 2000's. In 2001, the fuel prices for industries were anchored to 50% of international prices provoking violent demonstrations (Dartanto, 2013; OECD 2010). In 2004-2005, the increase of international prices determined a rise of fossil fuel subsidy expenditure (Dartanto, 2013; Mourougane, 2010). In 2005, energy prices for households and small businesses were significantly increased, negatively affecting the poor households (Dartanto, 2013). To limit the poverty impacts, for the poorest households, unconditional cash transfers mechanisms through the postal system were introduced, but they also benefitted to wealthier households. In 2008, electricity subsidies ceased for large industrial consumers (OECD, 2010) and for households beyond a consumption threshold (Mourougane, 2010), and fuel prices increase, following the world prices, in order to limit the pressure on public finances. In 2010, the average electricity price increased for most consumers, including households (IISD, 2012).

In 2012, an attempt to prohibit government and four-wheel vehicles from using subsidized gasoline was abandoned due to strong public discontent and only the government vehicles were excluded from the subsidies (IISD, 2012).

In 2013, a revision of Indonesian Budget introduced the repeatedly announced cut of fossil fuel subsidies, increasing diesel and gasoline price of respectively 22% and 44% (IEA, 2013). This largely contributed to the overall price increase (WB, 2013). But the fiscal risk will rise to the fore again (WB, 2013).

3.2.4 Energy subsidy and economic theory: what we can expect

The neoclassical economic theory provides insights on the potential impacts of reducing fossil fuel subsidies. In a budget neutral setting, the efficiency impacts result from the combination of the subsidy reduction and from changes in the rest of the tax system (Goulder, 2013). The environmental performance relates to the price responsiveness of energy consumers (households and industries). The distributional impact depends on the heterogeneity among households and on the revenue recycling scheme that is used.

3.3 The modelling approach

In the proposed approach, small shocks will be simulated and the welfare impact will be assessed. A CGE and a micro simulation model will be combined in a top down fashion. The CGE generated price variations that are passed to a very simple micro simulation model where no behavioural response is assume. The variation in revenues and expenditures at household level will be used to compute a money metric welfare impacts. The impact on household will be analysed in terms of elasticity, i.e. the percent variation of monetary equivalent welfare following a 1% variation of the subsidy rate. This section proposes a brief literature review and explains the choice of the modelling approach. Then it outlines analytically the adopted methodology, inspired by the Chen and Ravaillon (2014). Details from the macro-micro integration are also provided with a preliminary overview of the notations used in the paper.

3.3.1 Literature review and justification of the approach

The General Equilibrium approach results extremely valuable in assessing the impacts of an energy policy targeting consumer prices, allowing to capture not only the direct effect on household expenditure, but also all the indirect effects on income remuneration, profit formation and trade position. However, this approach, generally based on a single representative consumer paradigm, tended to focus on the aggregate efficiency of the policies, with little attention paid to their distributional impacts. The general idea is that equity and efficiency could be considered separately and that potential regressive impacts of efficient policies could be offset by appropriate redistribution schemes. Consequently little is said regarding intra-country distributional impacts of policy reforms.

The literature of the past 30 years presents several attempts to fill this gap: directly transferring the variable changes produced in the CGE model in the household survey data or introducing a multi-household representation in the macro model or creating a micro simulation model linked to the macro one (Savard, 2004; Colombo, 2010). Most of these studies assessed the impact of trade liberalization on poverty (Hertel et al. 2006). More recently, following Metcalf (1999), some studies were specifically dedicated to the distributional effects on climate policy (Rausch et al., 2011).

A large part of the literature on distributional consequences of policies focuses on the consequences on income sources. The specification of the income side is generally considered to be crucial for distributional consequences of macroeconomic policies (Bouet et al. 2013). However, environmental policies are often aimed at changing relative prices (making polluting goods more expensive) and thus primarily affect the expenditure side of households. Consequently, more advanced modelling approaches are needed that can capture both income and expenditure consequences of policy shocks.

Different types of modelling framework exist that quantify household-specific impacts of environmental policies. The current section focuses on methodologies for combining CGE and household-level analysis that represent alternative ways to deal with (or to ignore) data and behaviour inconsistencies. We can distinguish approaches based on (i) econometrics, (ii) bottom-up linkage, (iii) top down-linkage, and (iv) representative household groups.

In the econometric approach, the effects of a policy shock on final consumption or primary factor prices are computed with a CGE model. Then household-level responses to price changes are simulated with an econometric model. Finally, effects on income or expenditure can be simulated. The econometric model represents one, or a very limited number of markets. This approach has two advantages: the empirical foundation and the limited household level data requirement. The drawback is that it is market specific and takes into account neither the impacts from other markets or the revenue recycling. In addition, there can be inconsistencies between the econometric and the macro model, since they use parameters with difference definitions and values.

In the bottom-up approach, information is passed from a standalone household-level micro model to a standalone CGE macro model with a single representative household. However, the inconsistencies can still arise, if the two elements are not based on the same theoretical framework. In addition, it can be impossible to represent the initial shock on the micro level model, in particular when tax reforms impact indirectly the whole price system. Effectively, in the bottom-up approach the micro model is assumed to reflect reality better than the macro CGE model, and as much information as possible is used from the micro model to reflect household behaviour in the CGE.

In the top-down approach, information is passed from a standalone CGE with a single representative household model to a standalone household-level model. The CGE model computes how policies translate into price and income shocks. The shocks are then used in the household level module to compute individual impacts. Two types of micro models can be combined with the CGE:

- *Micro models with no behavioural response*. In this case the households do not adjust their behaviour to the prices shocks simulated in the CGE model, but the set of price and income shocks are directly translated into effects for specific households (or household groups). While this sheds light on the direct consequences of the shocks for different households, and an aggregate behavioural response is captured through the CGE model, it necessarily leads to a partial analysis as there is no welfare maximization process at the individual household level. Furthermore, given that different households have different income sources and expenditure patterns, this analysis cannot ensure consistency between income and expenditure at the household level in the policy simulations (such consistency is only guaranteed at the aggregate level of the CGE model). However this approach is appropriate for dealing with marginal policy shocks. In this case, under some assumptions, the changes in expenditures and incomes provide a good approximation of the welfare impacts of marginal policy shocks (Chen and Ravallion, 2004). For bigger price changes, the changes in expenditures and incomes do not reflect well the welfare impacts.

- *The micro model with behavioural response.* In this case, the households respond to the price shock simulated with the CGE by specifying demand systems directly in the micro model. This modelling framework accounts for household level adjustments, and is more relevant when it comes to deal with larger policy shocks. But consistency between the CGE and the macro result is not guaranteed unless the data in the micro and CGE models are fully reconciled.

In the representative household groups approach, that can also be called integrated approach, the single representative agent is replaced in the CGE by a collection of representative households. Given the implications of this approach for the size of the (usually already very complex) CGE model, in general the number of households group represented is quite limited. This method cannot characterize how inequality within a household group is affected by a policy shock. The problem can be circumvented by increasing the number of household groups or by combining it with one of the other approaches for further result downscale, using e.g. the econometric or top-down approach to project how individual households within a particular group respond to the policy shock. An extreme case of integrated approach is the fully integrated approach (Rutherford et al. 2006, Rausch et al. 2011) where all the individual households contained in a survey are explicitly represented in the CGE. In this case, the numerical consequences for the CGE model will be considerable and its tractability requires a relatively simple (static) CGE model and a specific decomposition method (Rutherford et al., 2006; Rausch and Rutherford, 2010).

Given the numerical difficulty of introducing the household survey detail (10018 observations) in the CGE model and the complexity of calibrating individual preferences, we chose in this paper to use a top-down approach with no behavioural response. A soft link is established between the macro and the micro model and the macro results are downscaled at household level in order to disentangle the different outcomes of a fuel subsidy reform on Indonesian welfare.

3.3.2 Measurement of the distributional impacts

The following notations are used in throughout the text.

List of variables	
$\boldsymbol{m_i}$	Total revenue of household *i*
$\boldsymbol{c_{i,j}}$	Volume of good *j* consumed by household *j*
$\boldsymbol{p_j}$	Final price of commodity *j*
$\boldsymbol{x_{i,k}}$	Primary factors *k* own by household *i* in volume
$\boldsymbol{w_k}$	Net price paid by households for primary factor k
$\boldsymbol{s_i}$	Savings of household *i*
$\boldsymbol{tax^{inc}}$	Income tax value
$\boldsymbol{tax^{fct}}$	Primary factor tax
$\boldsymbol{tax^{cons}}$	Consumption tax
$\boldsymbol{tr_i}$	Lump sum transfers to the household *i* from government and no-profit organizations
$\boldsymbol{p_{j,j'}^{input}}$	Net price of intermediate input j in sector j'
$\boldsymbol{pa_j}$	Price of Armington commodity j
$\boldsymbol{tax_{j,j'}^{input}}$	*ad valorem* tax on intermediate input j in sector j'
$\boldsymbol{subs_{j,j'}^{input}}$	*ad valorem* subsidy on intermediate input j in sector j'
$\boldsymbol{tax_j^{cons}}$	*ad valorem* tax on final consumption of good j
$\boldsymbol{subs_j^{cons}}$	*ad valorem* subsidy on final consumption of good j

3.3.2.1 Simulation of the subsidy rate variation with the ENV linkage model

The analysis of fossil fuel phase effects is performed using the ENV-Linkages General Equilibrium (GE) model, a multi-sectoral and multi-regional model describing world economy. ENV-Linkages relies on national Social Accounting Matrices (GTAP database) that guarantees its consistency in the base year and produces future projection up to 2020 though a recursive dynamic process and reproducing the trend of exogenous variables in accordance with IEA's World Energy Outlook (2012) for GDP and fuel prices, IMF historical data for current account balances and government savings and US EPA for non-CO_2 emissions (Burniaux and Chateau, 2010).

The model is characterised by firms minimising production costs in perfectly competitive markets and under constant return to scale assumption; the sectoral production functions have a nested CES formulation where the top nest combines intermediates inputs, primary factors and GHGs emissions to generate the output. In each country a representative household maximizes the utility with an Extended Linear Expenditure System formulation. The government generates public expenditure increasing with GDP growth and collects taxes, adjusting income tax to follow the exogenous trend of deficits. In addition to the fiscal closure, the current account surplus remain constant through exogenous capital outflows and a change in exchange rates. International flows are characterised by an Armington specification.

The ENV-linkages model takes into account ad valorem subsidies on commodities, in particular on the final and intermediate energy consumption:

$$p_{j,j'}^{input} = \left(1 + tax_{j,j'}^{input} - subs_{j,j'}^{input}\right)pa_j$$

$$p_j = \left(1 + tax_j^{cons} - subs_j^{cons}\right)pa_j$$

The tax rates and subsidies on energy commodities are based on IEA calculation performed with the price-gap approach (IEA, 2006, 2001) for the year 2011. These rates are exogenous in the model, although they might be endogenous and adjust to the Armington commodity price variations, in order to represent adjustment made by the government to limit the pass-through to the domestic consumer price of an increase of international commodity prices.

The subsidy rates on fossil fuels and electricity $subs_j^{cons}$ and $sub_{j,j'}^{input}$ are the policy parameters that will be shocked in the CGE model.

The model is closed by setting an exogenous government deficit target. This target is met by adjusting the amount of transfer TR given to the households. When the subsidies are shocked, as they represent a change on the budget government revenue flows, the transfer will be adjusted to preserve the targeted budget deficit.

3.3.2.2 Household level welfare measurement

The microsimulation model translates the prices variation simulated with the CGE model into household welfare variations. For each household, the welfare variations are computed using the deviations of revenues and expenditures from their benchmark levels due to change in final consumption price, primary factor prices and transfers. The household benchmark level of incomes and expenditures are provided by the IFLS4 household survey data for Indonesia that is further described in Section 4.

The micro simulation model does not represent household's responses to changes in prices; in other words, households' consumption levels will be regarded as fixed. Nevertheless, the method proposed by Chen and Ravallion (2004) can be used to provide a good proxy of the welfare impact of small reforms.

The indirect utility function of each household has the following formulation:

$$v_i(p_j, p_s, m_i) = \max[u_i(c_{ij}, S_i)| \sum_j p_{i,j}\, c_{i,j} + S_i = m_i]$$

where utility is function of consumed quantity of each commodity, c_{ij}, and savings generated, S_i, and is maximised under the budget constraint characterised by the price consumption vector, $p_{i,j}$, and the household disposable income, m_i. Under all the assumption that characterise general equilibrium (the perfect competition, constant return to scale, full employment of factors and market clearing), the household disposable income can be described as:

$$\sum_k x_{i,k}\,(1 + tax_k^{fct})w_k + \; tr_i = m_i$$

where $x_{i,k}$ is the quantity of primary factor k that represents the household endowment, w_k,is the price of the primary factor and tr_i represents governmental transfers.

Using the envelope theorem on the indirect utility function, it is possible to derive the monetary value of a change in utility after a policy reducing fossil fuel subsidies which corresponds to a first-order approximation of welfare around of the optimum (Chen and Ravallion, 2003;Dartanto, 2013; Ju, 2011):

$$\frac{du_i}{(\frac{du_i}{dm_i})} = [\sum_k x_{i,k}\,(1 + tax_k^{fct})w_k \frac{dw_k}{w_k} + dtr_i \;] - \sum_j p_{i,j}\, c_{i,j} \frac{dp_{i,j}}{p_{i,j}}$$

The change in utility is evaluated over the responsiveness of utility to a change of income (the budget constraint multiplier) and depends on commodity and primary factor price changes weighted by the initial income and expenditure values and on change in transfer scheme. From this formula is clear how both income and expenditure enter with opposite signs in the determination of household welfare change.

Looking more closely to the household expenditure change, it is worth to notice that subsidy reduction affects directly the price of fuels and indirectly the price of all other commodities. In the firms' profit maximisation problem the price change works through three channels: increasing the revenues for selling the goods, increasing the cost of intermediate inputs and altering primary factor remuneration. In addition, whether a revenue recycling scheme is implemented by the government, the change in expenditure conveys the effect of an increased income due to transfers.

3.3.2.3 Micro macro integration

The CGE model simulates the impact of a shock on the subsidy rates, $dsubs_j^{cons}$ and $dsub_{j,j}^{input}$, on the other variables, in particular on those that directly affect households in the micro-simulation model: commodity, factor prices on total transfers. Then, based on the exogenous allocation rule, the total transfer variations are assigned to the individual households. The microsimulation model then computes the changes in individual welfare using the household level information, the changes in consumption good, factor prices and individual transfers.

$$d(subs_j^{cons}\ ,\ sub_{j,j'}^{input}) \xrightarrow{ENV-Linkages} d(p_j, \mathrm{w_k}\ , TR) \xrightarrow[Transfer\ rule]{Microsimulation\ +} d(Welf_1, \ldots., Welf_I)$$

3.4 Making data sets compatible

The modelling framework links two models that are built on different types of data sources. The CGE model is based on social accounting data structured in SAMs. The household-level data used in the micro-simulation model comes from a survey.

The two data sets are not consistent. More precisely, the aggregate structure of incomes and expenditures implied by the survey data is different from the values provided by the SAM. This type of inconsistency always occurs when comparing Social Accounting and household survey data, since they are based on different statistical categories and computation methodologies[3].

To restore consistency between the two data sources, two operations are needed (Ivanic 2004). Firstly, the household-level incomes by source and expenditures per product have to be imputed to the SAM primary factors revenues and final good consumption categories. Secondly, the household level incomes and expenditures must be modified so that the sum of consumption the household matches with the aggregates given by the SAM. This later operation is called reconciliation. The modification done during the reconciliation phase must preserve, as much as possible, the household heterogeneity observed in the survey data.

This section briefly presents the IFLS4 survey data and then describes how the household incomes and expenditure categories are imputed to social accounting categories. Then the reconciliation

[3] see Bussolo *et al. (2008*) for an illustration of the discrepancies between survey and social accounting data on revenues in Brazil, Chile, Colombia and Mexico.

methods are explained. The Social Accounting data are closely related to GTAP database and extensively described in Narayanan and Walmsley (2008).

3.4.1 The IFLS4 survey in a nutshell

The Indonesia Family Life Survey (IFLS) is a longitudinal panel started in 1993 (IFLS1) and carried out by Rand Corporation, collecting information at individual, household and community levels from November 2007 to May 2008. The fourth wave IFLS4 surveys 13,995 households: 9,962 households from the IFLS1, with a 90.6% re-contact rate, and 4,033 new split off households; therefore from IFLS1 stems the sample population of the subsequent waves. IFLS1 has a sample scheme stratified on rural/urban areas in 14 of the 27 Indonesian provinces and randomly sampled within strata (14 rural and 13 urban). The province selection maximizes the coverage of cultural, social and economic characteristics of the population and responds to a cost-effectiveness criterion; the resulting sample is representative for 83% of Indonesian population (Strauss et al., 2009).

The IFLS4 sample weights are post-stratification weights that correct for the over-sampling in urban areas and in provinces different from Java of the IFLS1 and are adjusted taking into account the sample attrition from 1993 to 2007. In order to produce statistics on the populations, we converted the proportional sample weights using the total population in 2007, its distribution across provinces and the average household size; in addition we rescaled the computed new weights to correct for observation dropped due to missing data in expenditure and income components.

The multipurpose nature of the survey allows examining the households' consumption characteristics together with income sources and production factors, presenting a complete picture of the Indonesian economy and offering an exhaustive framework to be matched with Social Accounting Matrix (SAM). The purpose of harmonising micro and macro data was a guideline in selecting expenditure and income elements and in the flow aggregation process, but implied also a certain level of subjectivity. The mapping of IFLS4's categories to SAM sectors is described below (Tables 1to 3).

3.4.2 Mapping survey data categories to Social Accounting aggregates

3.4.2.1 Expenditure

The expenditure module collects information on food, non-food goods and services on a weekly base, household items monthly and durable goods bought in the analysed year. For the sake of comparability with the national accounting data, the value of self-produced or not purchased goods was not considered as part of total expenditures as well as gifts given outside the household (Reimer and Hertel, 2003).

The survey offers a detailed breakdown of expenditure components including actual housing rents and estimated ones for self-owned or occupied dwellings. Special attention is devoted to this latter category that usually is not considered for the income and expenditure computations in a micro framework. Whether actual rent is clearly a cost for tenants and rent contributes to form income of housing owners, the macro framework, rooted in the System of National Account, classifies the ownership of dwellings as an industry that sells housing services to owners and receives a gross-rent at competitive prices (UNECE, 2011). This value, net of current expenses, enters also in the income computation of housing owners.

The general approach in analysing the database was to drop the few observations with missing data on expenditure. In the case of rent, missing data represent 6%. There are several ways to deal with missing data, the mean and the conditional mean imputations are among the most popular, but they imply a deterministic relation between the generated values and the observed data. The absence of errors in the imputed data can be partially corrected drawing the values from a distribution, but again this procedure underestimates the standard errors. Instead, the Multiple Imputation approach, using a Monte-Carlo technique, allows generating from an imputing model a sequence of simulated datasets that, pooled together, offers an estimate of the missing values accounting for uncertainty. The resulting standard error considers the variance across imputed values in each dataset and depends also on the number of simulated datasets and the variance across them (Little and Rubin 2002).

We used the predicted mean matching imputation method (PMM), this results more robust that a simple regression, replacing missing data with observed values drowned from a neighbourhood of the linear prediction, and allows restricting the range of simulated values to the observed ones.

Given that the number of missing data for rents is small, even a low number of imputations (e.g. 5) is sufficient to obtain an efficiency rate of 99%. In the choice of the imputation model, we followed the literature on estimation of dwelling services (EC, 2010) that considers location and household characteristics (rural/urban area, household size, availability of electric equipment and other facilities) as main explanatory variables, and expresses the rent in a logarithmic scale to better capture the non-linearity in the relation. Among explanatory variables we also considered non-food expenditure which results significant and positively correlated. Subsequently, we replaced the missing data with the average of generated values across imputations.

SAM sectors	IFLS4 data
Agriculture	Rice, corn, sago, cassava, other staple foods, vegetables, fruits, meat and fish
Food	Dried food, other prepared food, milk/eggs, spices, beverages and drinks, tobacco, prepared food eaten at home
Fuel	Kerosene and other fuel
Electricity	Electricity
Transport	Transportation(bus fare, cab fare, vehicle repair costs and the like)
Manufacturing	Personal items (soap, shaving supplies, cosmetics and the like); household items (laundry soap, cleaning supplies, anti-mosquitoes and the like); clothing; household supplies and furniture; other expenditures (purchase of cars, house, television sets, headphones, beds, livestock and the like)
Services	Water service; education costs; medical costs; prepared food away from home; domestic services; recreation and entertainment(movies, theatre, outings, sport equipment, newspapers, magazines and the like); ritual ceremonies and gifts; actual and imputed rent

Table 1 Mapping of IFLS4 consumption goods and services into SAM categories

3.4.2.2 Income

The IFLS4 also collects information on total income received by all household's members, surveying the five main components of income: flows connected to economic activities (cash and in-kind), remuneration due to assets ownership, value of services produced for own consumption, transfers and inter-household flows (e.g. gifts). Expected, but not materialized earnings are excluded from income computation as well as holding gains/losses and irregular gains: e.g. lottery winning and lump sum pensions (UNECE, 2011; UNSD, 2002).

The labour market section describes the occupation status of individuals (employed and self-employed), the sector of occupation and the remuneration (respectively wages and net-profits). For sake of micro-macro harmonization, the considered sectoral aggregation is: agriculture, electricity, manufacturing, transportation, construction and services (Table 2). When the information about occupation was completely missing, we dropped the observations; instead, the missing yearly salary was integrated using the monthly data multiplied by the number of working month in the year. The sectoral detail, in addition to province and urban/rural locations, was used for replacing the few left missing data using the conditioned mean technique. The year-end bonuses were included in the computation of yearly wage.

The salary section was merged with more specific information on net-profits of household businesses (farm and non-farm). Regarding the farm activity, the difference between revenues and total production costs was used to fill the numerous missing data on net-profits. For firm businesses, revenues used for household consumption were considered a more reliable estimate of net-profits; they were elicited as the sum of "the value of production used for household consumption, the value of business net income used on household expenditures and the amount of cash left over" (Strauss et al., 2009); whether missing, we used the net-profit data. Moreover, net-profits both for farm and non-farm businesses were complemented taking into account yield loss experienced and income generated from other production assets (purchases, sales and rent of land, livestock, buildings...) in order to obtain the total income from production.

The property income considers the revenues generated by household financial and non-financial assets not used in the production process. As anticipated before, the imputed rent (net of housing costs) from owned/occupied dwellings is an important component of income and is considered as the remuneration received for self-produced services.

SAM sectors	IFLS4 data
Agriculture	Agriculture, forestry, fishing and hunting
Food	* included in Manufacturing
Fuel	* included in Manufacturing
Electricity	Electricity, gas, water
Transport	Transportation, storage and communications
Manufacturing	Mining and quarrying; manufacturing
Services	Wholesale, retail, restaurants and hotels; finance, insurance, real estate and business services; social services
Construction	Construction

Table 2 IFLS4 wage categories into SAM sectors

SAM sectors	IFLS4 data
Agriculture	Agriculture, forestry, fishing
Food	Food processing
Fuel	* included in Manufacturing
Electricity	Electricity, gas, water
Transport	Transportation and communications
Manufacturing	Mining and quarrying; clothing; other industry
Services	Finance, insurance, real estate; food sales; non-food sales; governmental services; education; professional services; transportation services; other services
Construction	Construction

Table 3 IFLS4 net-profit categories into SAM sectors

The incomes are more difficult to be matched with the SAM categories. The main problems come from the choice of mapping procedure of business profits and wages from the survey to Capital, Labour, Natural Resources and Land remunerations in the Social Accounting Matrix. Following

Ivanic (2004), we consider wages directly as labour remuneration as well as a portion of profits in farm and non-farm business computed using the average wage, sector and region specific. The left over profits from business and self-employed activities, in addition to property rents and dividends are accounted as generalised capital factor remuneration (capital, land and natural resources). The repartition of this aggregate is operated using the sector specific ratio of capital, land and natural resources coming from the CGE model.

The transfer aggregate includes monetary flows from government and non-profit institutions in the form of conditional and non-conditional support programs. Only 300 households report positive transfers, therefore for the other observations we imputed an average transfer depending on household size and income decile. We excluded from the computation inter-household flows.

Disposable income is the resulting amount of total income left-over after deducting income taxes and is used to finance expenditure and savings. Table 4 offers a summary of the components of household account.

Income	**Outlays**
Wage	Food expenditure
+ Farm business	+ Non-food expenditure
+ Non-farm business	+ Housing expenditure
+ Rent	**= Total expenditure**
+ Other income	**+ Savings**
= **Total income**	**= Total outlays**

Table 4 Household account

When analysing household surveys, it is necessary to take in account that measurement errors and bias are quite common. Consumption expenditure can result often underestimated and income, an even more sensitive topic, is usually under-reported (Deaton, 1997; Chen and Ravallion, 2010). This pattern emerges clearly when analysing IFLS4: the dissaving phenomenon occurs at each decile and is more consistent for the top deciles. Therefore, we chose expenditure as more reliable proxy than reported income to assess welfare and we assume that income distribution tracks expenditure distribution. After trimming the distribution on both sides to remove outliers, the resulting expenditure distribution appears coherent with international statistics (Table 5).

	POVCALNet*		IFLS4+
Deciles	**2005**	**2008**	**2007**
1	3.7	3.6	2.55
2	4.7	4.6	3.71
3	5.6	5.5	4.73
4	6.5	6.4	5.79
5	7.4	7.4	6.96
6	8.4	8.5	8.27
7	9.7	9.8	9.95
8	11.4	11.7	12.43
9	14.3	14.8	16.57
10	28.5	27.8	29.02
Gini Index	**34.0**	**34.1**	**39**

* PovcalNet analyses Indonesian inequality using per capita consumption.
+ Own computation applying square root scale to deflate household consumption

Table 5: Percentage of household expenditure per decile and Gini index (POVCALNet vs. IFLS4)

The Gini coefficient for 2007 shows a higher level of inequality compared with World Bank figures for 2005 and 2007; this emerges also looking at the decile distribution. The discrepancy in the result can be explained by the partiality of the IFLS household survey, which covers 83% of the population, compared with the total coverage of National Socio-economic Survey (Susenas). Moreover, other studies register higher and increasing level of inequality in the last decade, with a Gini index around 37 and 38 in 2007; it is also worth to notice that inequality may be underestimated due to underreporting of consumption in the top deciles (WB, 2011; Miranti et al., 2013).

The expenditure profile of each household type shows, as expected, a decreasing food expenditure going towards up deciles and an opposite pattern occurs relatively to service consumption.

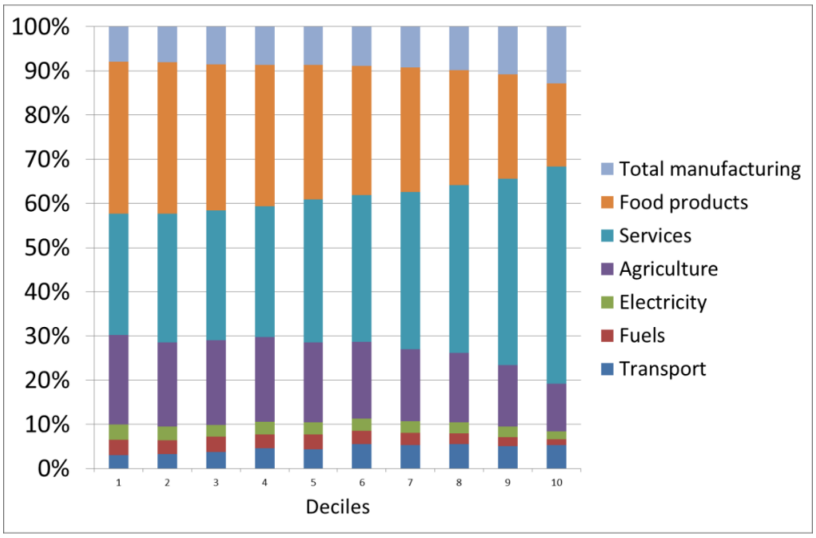

Figure 1 Households' expenditure in 2007 (IFLS4 survey results)

	IFLS4	ENV-Linkages SAM
Agriculture	14.94	9.69
Food Product	25.48	17.60
Electricity	2.42	1.22
Fuels	2.31	2.28
Transport	5.01	5.04
Total Manufacturing	10.42	16.92
Total Services	39.43	46.30

Table 6 Budget shares in IFLS4 and in ENV-Linkages (in % of total expenditure)

At country level, the average consumption mix presents significant differences when compared with the SAM structure. The discrepancy can be imputable to different reasons: measurement errors on both frameworks; sectoral classification not perfectly overlapping; bias induced by survey design, e.g. IFLS4 requires a detailed and more frequent reporting for primary consumption goods and less for durables, this approach can explain the underestimation of expenditure on Manufacturing and Services.

Keeping as reference the expenditure decile order, we observed the composition of income in terms of primary factor remuneration. Figure 2 presents the distribution of primary factors across deciles: the capital/labour ratio is 0.29 for the first decile and 0.53 for the 10th decile; Table 7offers a comparison of IFLS4 SAM data at country level.

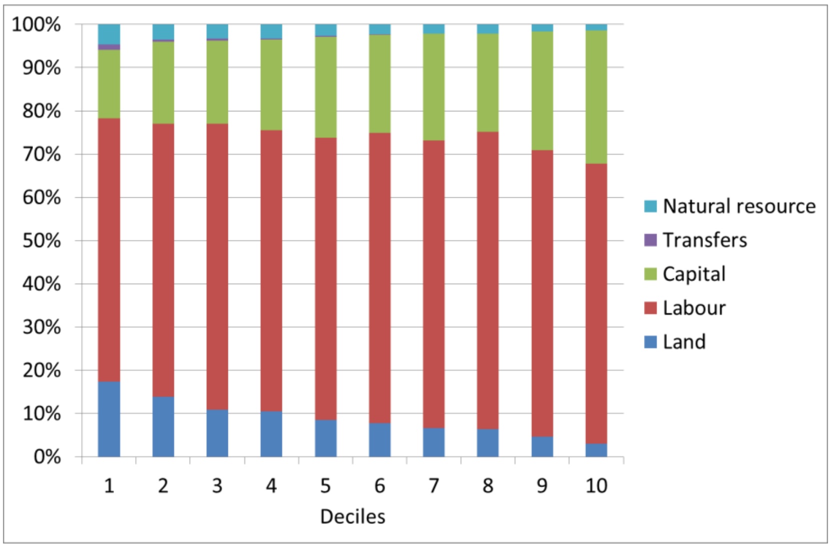

Figure 2 Revenue structure across deciles (IFLS4 survey result)

	IFLS4	ENV-Linkages SAM
Labour	65.85	60.43
Capital	25.07	25.47
Land	6.74	5.46
Natural resources	2.19	6.36
Transfers	0.15	2.29

Table 7 Structure of incomes in IFLS4 and in ENV-Linkages (in % of total expenditure)

Table 8 gives an overview of the distribution of transfers across deciles in the survey.

Deciles	Transfers
1	24.80
2	14.85
3	13.76
4	11.99
5	8.99
6	8.43
7	7.01
8	5.21
9	3.86
10	1.09

Table 8: Distribution of transfers across deciles (IFLS4 survey results)

3.4.3 Revenue and expenditure reconciliation between CGE and household survey data

3.4.3.1 Fully reconciliation of household survey and Social Accounting data

The household survey provides information for each household about expenditures by good ($E_{i,j}^{HS}$) and disposable income by source. The latter considers primary factor remuneration ($R_{i,k}^{HS}$), transfers received (TR_i^{HS}) and income tax payments (TAX_i^{HS}).

The corresponding aggregate levels, respectively denoted E_j^{SAM} , R_k^{SAM} , TR^{SAM} and TAX^{SAM}, are generated with the CGE model and they correspond to balanced incomes outlay. In other words, they satisfy:

$$\sum_k R_k^{SAM} - TAX^{SAM} + TR^{SAM} = \sum_j E_j^{SAM} + S^{SAM}$$

Where S^{SAM} denotes aggregate household savings.

The full reconciliation of household data corresponds to the generation of modified household-level information $\widetilde{E}_{i,j}^{HS}$, $\tilde{R}_{i,k}^{HS}$, $\widetilde{TAX}_i^{HS}$, $\widetilde{TR}_i^{HS}$, $\tilde{S}_i^{HS}$ that satisfy the three following types of requirements.

Firstly, the sum of household-level expenditure per products must be equal to aggregate expenditure per product given by the SAM:

$$\sum_i \tilde{E}_{i,j}^{HS} = E_j^{SAM} \tag{1}$$

Secondly, the sum of household-level net incomes by sources (including transfers received and tax payments) must be equal to aggregate net incomes per product given by the SAM:

$$\begin{gathered} \sum_i \tilde{R}_{i,k}^{HS} = R_k^{SAM} \\ \sum_i \widetilde{TAX}_i^{HS} = TAX^{SAM} \\ \sum_i \widetilde{TR}_i^{HS} = TR^{SAM} \end{gathered} \tag{2}$$

Thirdly, the household-level budget constraint must be balanced:

$$\sum_k \tilde{R}_{i,k}^{HS} - \widetilde{TAX}_i^{HS} + \widetilde{TR}_i^{HS} = \sum_j \tilde{E}_{i,j}^{HS} + \tilde{S}_i^{HS} \tag{3}$$

Fourthly, in the reconciled data set, the proportion of individual total income and total expenditure over their country totals must be the same as in the original survey data

$$\frac{\sum_j \tilde{E}_{i,j}^{HS}}{\sum_{i,j} \tilde{E}_{i,j}^{HS}} = U_i \equiv \frac{\sum_j E_{i,j}^{HS}}{\sum_{i,j} E_{i,j}^{HS}} \tag{4}$$

$$\frac{\sum_k \tilde{R}_{i,k}^{HS} + \widetilde{TR}_i^{HS} + \widetilde{TAX}_i^{HS}}{\sum_i(\sum_k \tilde{R}_{i,k}^{HS} + \widetilde{TR}_i^{HS} + \widetilde{TAX}_i^{HS})} = U_i \tag{5}$$

Note that in order to correct for income underreporting and the observed dissaving phenomena in all deciles, the distribution of total revenue is constrained to be equal to expenditure shares, U_i.

Last, the reconciliation must reflect as much as possible distribution of revenues and expenditure represented in the original survey data:

$$\tilde{E}_{i,j}^{HS} / \sum_i \tilde{E}_{i,j}^{HS} \approx E_{i,j}^{HS} / \sum_i E_{i,j}^{HS} \tag{6}$$

$$\begin{gathered} \tilde{R}_{i,k}^{HS} / \sum_i \tilde{R}_{i,k}^{HS} \approx R_{i,k}^{HS} / \sum_i R_{i,k}^{HS} \\ \widetilde{TR}_i^{HS} / \sum_i \widetilde{TR}_i^{HS} \approx TR_i^{HS} / \sum_i TR_i^{HS} \\ \widetilde{TAX}_i^{HS} / \sum_i \widetilde{TAX}_i^{HS} \approx TAX_i^{HS} / \sum_i TAX_i^{HS} \end{gathered} \tag{7}$$

The household dataset, satisfying conditions (1) to (7) is generated stepwise. Reconciled incomes, revenue and saving data are successively generated. Before providing a detailed description of the reconciliation of expenditure, the overall process can be described as follows.

- At step 1, expenditures $\tilde{E}_{i,j}^{HS}$ are generated so as to satisfy conditions (1), (4) and (6)

  At step 2, the revenue components $\tilde{R}_{i,k}^{HS}$ $\widetilde{TAX}_i^{HS}$ and $\widetilde{TR}_i^{HS}$ are generated so as to satisfy conditions (2), (5) and (7)
- At step 3, the $\tilde{S}_i^{HS}$ is computed from equation (3)

3.4.3.2 Reconciliation using the cross entropy method

The reconciliation for expenditure performed at step 1 is explained below, but it is very similar for incomes.

For the reconciliation, we want to transform the original expenditure survey data $E_{i,j}^{HS}$ into modified survey data $\tilde{E}_{i,j}^{HS}$ which satisfy (1), (4) and (6). The transformation of the original survey is realized using the cross entropy maximization method (Golan and Judge 1996).

The cross-entropy method is applied on the normalized expenditure matrix, $b_{i,j}$ defined as:

$$b_{i,j} = E_{i,j}^{HS} / \sum_{i} E_{i,j}^{HS}$$

The Cross-Entropy method consists in minimising the distance proposed by Kullback and Leibler (1951) between a new matrix $\tilde{b}_{i,j}$ and the original $b_{i,j}$ from HS, respecting consistency constraints on column and row totals.

The new matrix $\tilde{b}_{i,j}$ solves problem:

$$Max - \sum_{i,j} \tilde{b}_{i,j} \, log \left(\frac{\tilde{b}_{i,j}}{b_{i,j}} \right)$$

s.t:

$$\sum_{j} \tilde{b}_{ij} E_{j}^{SAM} = U_{i} \; . \sum_{j} E_{j}^{HS}$$

$$\sum_{j} \tilde{b}_{ij} = 1$$

Then, the adjusted expenditure matrix is:

$$\tilde{E}_{i,j}^{HS} = \tilde{b}_{ij} E_{j}^{SAM}$$

3.5 Simulation results

This section presents and comments the results of the simulation of two policy scenarios. The baseline and the policy implement in each scenario are presented. Then the simulation results are explained.

3.5.1 The scenarios simulated

The two policy scenarios considered correspond to the same small decrease of the energy subsidy rate with respect to the baseline, but the revenue recycling schemes are different.

3.5.1.1 Benchmark scenario

The policy scenarios are compared with a **baseline scenario**. For all the regions except Indonesia, it follows the definition of the current policy scenario from IEA (2011): the climate policy assumptions correspond to the government policies and measures that had been enacted or adopted at the base year. If this definition had been followed for Indonesia, there would have been a gradual phase out of the fossil fuel subsidies. But in the baseline scenario used here, Indonesian fossil fuel subsidies are assumed to remain constant.

The macroeconomic assumptions used in the baseline scenario are those of IEA World energy Outlook 2013 (IEA, 2013).

3.5.1.2 The policy scenarios

The two policy scenarios assume that Indonesia enforces in 2013 a 1% reduction of electricity and fossil fuel subsidies rates for final consumers (households) and for firms. In the other regions, the subsidies are not reformed and remain at the baseline level. Each scenario assumes a specific budget neutral revenue recycling mechanism for the government's expenditures spared by the subsidy reform.

In the first scenario, "**cash transfers**", additional revenues after the decrease of fossil fuel subsidies are used to finance unconditional cash transfers to households. This revenue recycling make the reform more progressive, since by construction, the transfers, as a proportion of revenue, will be more important for the poorer households.

The second scenario, "**government expenditures**", aims at representing a budget neutral policy without transfers to the households. In this scenario the decrease of fossil fuel subsidy expenditures is used to increase government consumption. This policy does no fundamentally affect aggregate demand as the decrease in household's consumption and the increase in investment due to lower savings are compensated by an almost equivalent increase of government consumption. However, the policy affects household savings, e.g. the capital supply to the economy, and creates crowding out effect. The simulation results for this scenario must be interpreted very carefully because it ignores the return of government's consumption on households, for instance, through better education, medial system and infrastructure (Fan et al., 2000; Jung and Thorbecke, 2003). This effect can be very high, especially in developing countries. Consequently, the interpretation of results in terms of total welfare gains or losses can be misleading in this scenario.

3.5.2 Impact of the reform on prices

The consumption good and primary factor prices simulated in the CGE for the various scenarios are given in Table 9. The fossil fuel subsidy drop directly impacts both electricity and fossil fuel prices, but indirectly influences the price of all the other commodities. In the “cash transfers”, and “government expenditure” scenarios, the prices increase in quite similar proportion, as the aggregate demand is very similar in these two scenarios.

The rent of natural resources, mostly oil and gas reserves, is indirectly impacted by the lower fossil fuel subsidies that limit the energy demand. In “government expenditure” case, the crowding out effect leads to a higher increase in rental rate of capital that in the “cash transfer” scenario.

		Cash transfers	**Government expenditures**
Consumption goods	Transport	0.002	0.006
	Fuels	1.410	1.408
	Electricity	1.012	1.022
	Agriculture	0.015	0.009
	Services	0.015	0.023
	Food products	0.016	0.018
	Total manufacturing	0.012	0.016
	Construction	0.015	0.024
Primary factors	Land	0.008	-0.001
	Labour	0.031	0.029
	Natural resource	-0.036	-0.056
	Capital (incl. depreciation)	0.003	0.034
	Depreciation	0.010	0.014

Table 9: Percentage change (w.r.t the baseline) of the primary factor and consumption good prices

3.5.3 Aggregate impact on welfare

The changes in primary factor and consumption good prices will affect the household’s welfare. Table 7 presents a decomposition of the aggregated welfare impact of the welfare policy shocks, considering the price change generated in the CGE model and the baseline aggregated consumption and primary factor endowment.

The “cash transfer” scenario is more favourable to the household than the “government expenditure” scenario, as the cost of the policy for the households is offsets by transfers.

In addition, this scenario leads to a positive double dividend effect and positive household welfare gain. Following the concepts of Goulder (2013), the tax interaction effects of the reform is positive because lowering subsidies decreases the deadweight loss they cause to the economy; and the transfer effect is null because the revenues are recycled not reducing other distortive supports but with a lump sum transfers. Therefore, the overall impact is positive in terms of efficiency and welfare. Last, the “cash transfer" policy seems to be beneficial to all groups, although some specific households within groups can be negatively affected.

The “government expenditure" scenario is characterised by a loss of welfare since the price increase is not compensated by transfers for the households. Even if this has to be cautiously judged given that the return on government’s consumption is not accounted here, this result can be explained within the framework of our model.

The policies have quite similar effects on expenditures (additional 162 million USD in the “cash transfer” and 175 million USD in the “government expenditure” scenario). The only difference is represented by a stronger rise of non-energy commodity prices in the second scenario due to the consumption drop when no transfers are implemented.

But the effect on income in the two scenarios is more diversified (it increases by 77 and 116 million USD respectively); this result is mainly attributable to the change of the capital revenues in the “government expenditure” scenario due to the crowding-out effect that increases the remuneration of capital in this scenario. The price of natural resources decreases because this factor is directly affected by the drop of subsidy on energy commodities. Instead labor remuneration rises due to the reallocation of this factor toward non-energy intensive sectors.

	Cash transfers	Government expenditures
Total Income related effects	77	116
Labour	*86*	*82*
Capital	*5*	*60*
Land	*2*	*0*
Natural resource	*-11*	*-16*
Depreciation	*-6*	*-9*
Total expenditure related effects	-162	-175
Elec. subsidy phase out	*-34*	*-34*
Elec. Producer price change	*0*	*0*
Fossil fuel subsidy phase out	*-92*	*-92*
Fossil fuel producer price change	*2*	*2*
Other commodity price changes	*-38*	*-50*
Transfers	266	2
Total	180	-57

Table 10 Aggregate welfare impacts in the in the scenarios, in Million USD

3.5.4 Aggregate impact on emission

The fossil fuel subsidy reduction determines a small decrease of total emissions: -0.18 % in the "cash transfer" scenario and -0.2 % in the "government expenditure" scenario; the GHG that mostly shrinks is CO_2 that represents 64% of total emissions. Fuel and electricity sectors reduce their emission around 0.27% and in the "cash transfer" scenario and 0.30% in the "government expenditure" scenario. The other sectors produce less emission in both scenarios, excluding Services that shows an opposite trend in both scenarios and Transport and Manufacturing that consume more Fuel and Electricity in the "cash transfer" scenario under the demand push. Regarding the emission attributable to household consumption of fossil fuels, they shrink of 0.98% in the "cash transfer" scenario and 1.02% in the "government expenditure" scenario.

3.5.5 Progressivity of the policy

The price change obtained from ENV-linkages and the household budget survey data are used to compute money metric welfare gains or losses at the household level with the measure defined in section 2. These welfare, gain or losses are related to the initial wealth of the household in order to provide, for each household the percent welfare variation induced by the policy shock. For the two scenarios considered, the average variations across income deciles are shown on Figure 3. First, despite the limited decrease in fossil fuel subsidy (-1%), the revenue redistribution has a significant impacts on welfare, especially for the lower deciles (+0.3% in the "cash transfer" scenario).

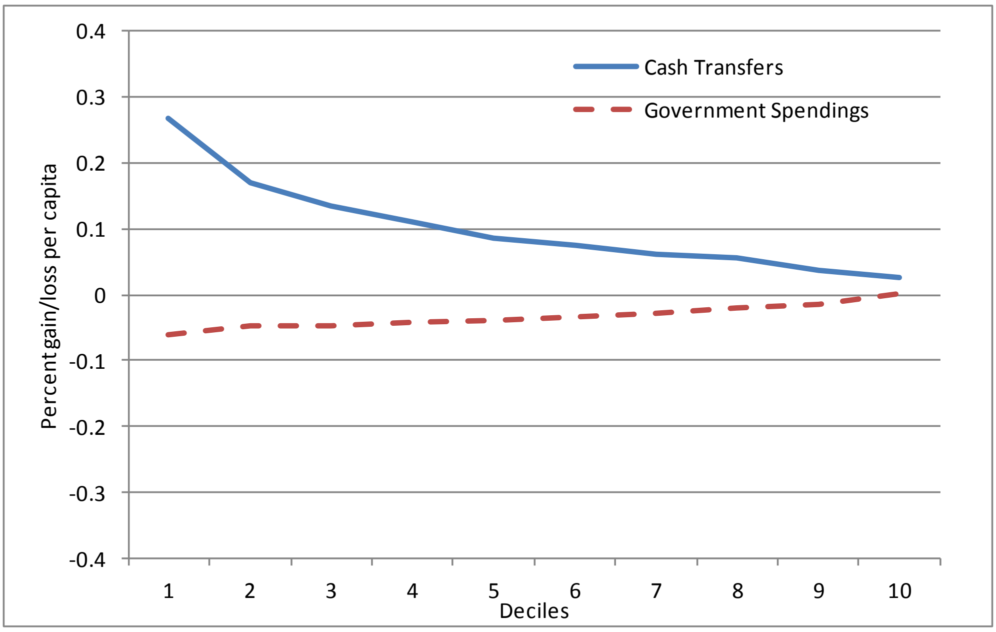

Figure 3: Mean Percentage Gain or Loss by per Capita Income deciles in the two scenarios

The "cash transfer" policy is very progressive; it largely benefits the lowest deciles of the population and is positive also for highest deciles. Therefore reducing fossil fuel subsidies with lump-sum transfers can strongly contribute to reducing inequality.

The "government expenditure" policy is almost distributional neutral, i.e. the percentage loss per capita is less than 0.07% for all deciles. This scenario gives an image of the effect of 1% reduction of fuel subsidies in absence of transfers and shows how the intervention is just slightly regressive. However, as explained in section 4, the welfare effect in this scenario cannot be fully assessed because the return on government's spending is not taken into account, but it can be used as reference level for lower bound of welfare loss.

The effects are decomposed for the scenarios in respectively figure 4 and 5. In the "cash transfer" scenario (Figure 4), the subsidy reduction determines the increase of prices of fossil fuels and electricity that are the main drivers of welfare loss in policy scenario; fossil fuel price change determines the strongest impact for all deciles, but with different magnitude. The Other commodity price increase implies just a slight drop of welfare. Income effect is positive for welfare that benefits from a rise of labour remuneration. Moreover, the overall welfare gain is determined by the lump-sum transfer that weights particularly on low income deciles.

In the “government expenditure” scenario, the absence of transfers leads to a slightly regressive outcome of the policy: the positive sign of income effect is wiped out by the negative expenditure effect especially for the lowest deciles that experience the highest welfare loss.

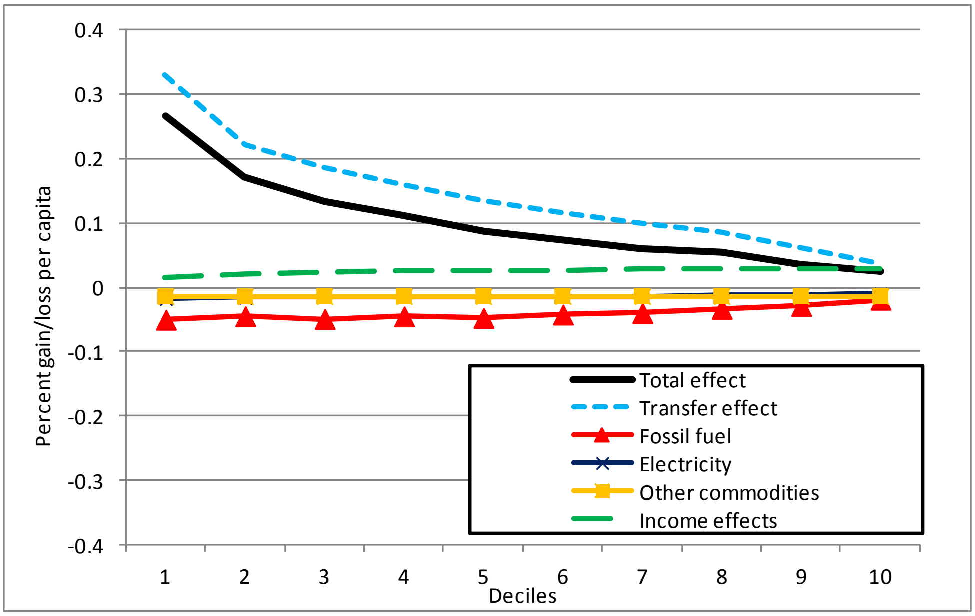

Figure 4 Contribution to the loss and gains per decile in the “cash transfer” scenario

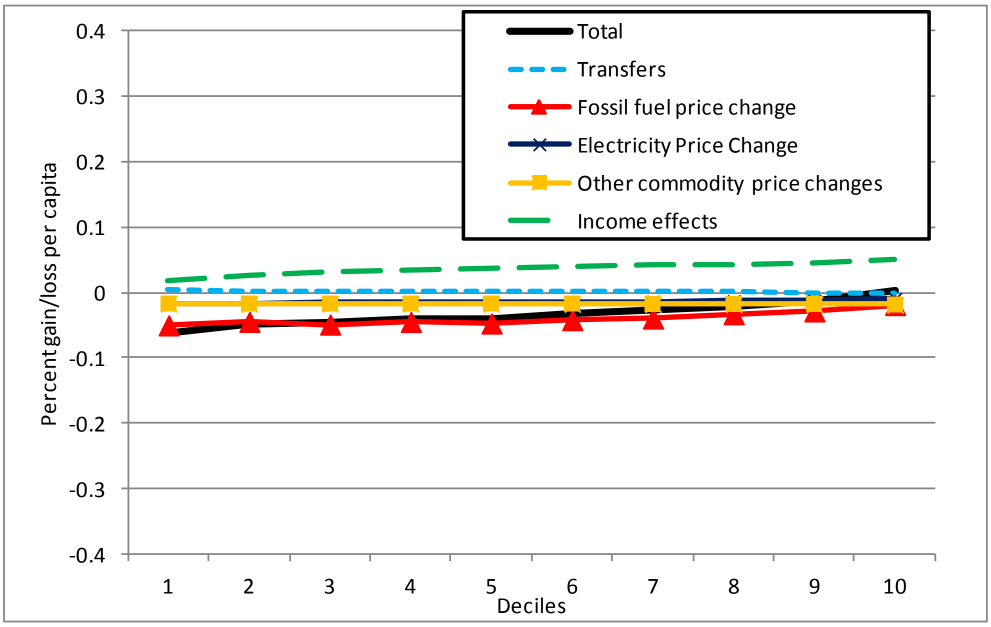

Figure 5: Contribution to the loss and gains per decile in the “government expenditure” scenario

3.5.6 Impacts on rural and urban population and depending on the access to energy

Table 11 allows analysing the effect of the reform for specific household categories. Specifically, the percentage welfare loss for rural and urban households is computed as well as the different impact of the policy on household with and without electricity. A discrete indicator of access to electricity is computed: household that have no TV and no refrigerator are regarded as having no access to electricity; they represent 20% of the sample.

Rural household are the winner of the "cash transfer "reform, as their energy budget coefficient is low and a higher share of their revenues is coming from labour remuneration. On the other side the "government expenditure" is comparatively less detrimental in urban area.

Household with no-access to electricity are the category benefiting most from the reform with a welfare gain of 0.09%.

	Rural		**Urban**		**Access to electricity**		**No access to electricity**	
	Cash Transfers	Gov exp	Cash Transfers	Gov exp	Cash Transfers	Gov exp	Cash Transfers	Gov exp
Labour	*0.03*	*0.02*	*0.04*	*0.03*	*0.03*	*0.03*	*0.04*	*0.03*
Capital	*0.00*	*0.02*	*0.00*	*0.02*	*0.00*	*0.02*	*0.00*	*0.01*
Land	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Natural resource	*-0.01*	*-0.01*	*0.00*	*0.00*	*0.00*	*-0.01*	*0.00*	*-0.01*
Elec. subsidy phase out	*-0.01*	*-0.01*	*-0.01*	*-0.01*	*-0.01*	*-0.01*	*0.00*	*0.00*
Elec. Producer price change	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Fossil fuel subsidy phase out	*-0.03*	*-0.03*	*-0.03*	*-0.03*	*-0.03*	*-0.03*	*-0.03*	*-0.03*
Fossil fuel producer price change	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Other commodity price changes	*-0.01*	*-0.02*	*-0.01*	*-0.02*	*-0.01*	*-0.02*	*-0.01*	*-0.02*
TOTAL	*0.08*	*-0.03*	*0.05*	*-0.01*	*0.06*	*-0.02*	*0.09*	*-0.01*

Table 11 Mean percentage gains and losses for rural and urban household, with and without access to electricity

3.6 Conclusion

Macroeconomic models are useful tools for understanding the behavioural responses of agents to a policy changes, capturing interactions and feed-backs among domestic and international economic actors, but they are ineffective in considering distributional issues. Microdata are a valuable source of information on intra country distribution of income and consumption, but especially in developing countries for lack of time series data, hamper dealing with inequality issues in a dynamic context.

This paper suggests that a soft link between microdata and macro models is an effective way to introduce heterogeneity in agent responses to shocks and to shed some light on distributional issues on income and consumption. This approach implies the analysis of income and expenditure components of an household survey, in this case the 2007 Indonesian household survey (IFLS4, World Bank); it follows a mapping procedure between the survey classification and the Social Accounting Matrix aggregates; it is also required a further reconciliation step in order to remove the leftover discrepancies with respect to total commodity-specific expenditure and total source-specific income. The approach adopted in this case is the Cross-Entropy method.

This procedure allows characterising about 10000 different households which are heterogeneous with respect to income sources and expenditure choices, but whose aggregate characteristics are consistent with the macroeconomic variables. Using the ENV-Linkages model, a 1% reduction of fossil fuel subsidies is simulated in Indonesia for 2013. Two scenarios are built envisioning different recycling schemes of subsidy reduction: one considering an unconditioned lump-sum transfers to all households and the other one the increase of governmental expenditure.

Following (Chen and Ravallion, 2004), the impact of this policy on households' welfare is analysed in a neighbourhood of the equilibrium, keeping constant the household consumptions and primary factor supplies. Therefore the price shocks directly translate into expenditures and incomes variations. The result is judged looking at household's change in money metric utility induced by the subsidy reform as a proxy of welfare change.

Despite the limited decrease in fossil fuel subsidy (-1%), the reform has a non-negligible impact on welfare, especially for the lower deciles (+0.3% in the "cash transfer scenario"). The "cash transfer" policy is very progressive. Instead the "government expenditure" policy is almost distributional neutral. Given that in this case no lump-sum transfers are considered, the result can be seen as a lower bound for welfare loss due to a fuel subsidy reduction. From this exercise, it clearly emerges that the regressive effect of the energy policy is limited and a simple neutral redistribution of fiscal revenues across household determines a strongly progressive results that could be also improved with transfers targeting special groups of the population.

4 Demand system and price change response: the case of energy policy in Indonesia

4.1 Introduction

Linking micro and macro data has big potentialities in describing household behaviour with attention to the underlying differences in productive and consumption patterns across agents. A reliable link between the two frameworks starts from the reconciliation of micro and macro data, but should be rooted on the micro derivation of demand behavioural parameters. Given the richness of information contained in household surveys, it is possible to explore group-specific demand responses and to unveil the heterogeneity underlying the representative household setting.

The paper gives an overview of the Extended Linear Expenditure System (ELES), widely used to describe preferences in Computable General Equilibrium models. The Seemingly Unrelated Regression (SUR) procedure is applied to the Indonesia Family Life Survey 4 (IFLS4) in order to estimate the key parameters of household demand: this approach allows considering the interaction among equations in the expenditure system. The derived coefficients are used to give a first assessment of demand system, but the presence of censored data for the expenditure of several commodities requires the adoption of a two-step procedure (Shonkwiler and Yen, 1999) to reduce the bias in estimations. This method is applied firstly on the entire sample and then on the urban and rural household groups. In this way a heterogeneous demand response is characterised for the two subgroups and is tested in a policy scenario.

The policy exercise deals with a really controversial topic in Indonesian and international debate: the effects of a fossil fuel phase out. Whether this intervention may lighten the governmental expenditure burden, there are several concerns regarding the spread of policy effects on households, heterogeneous in income endowment and commodity consumption (electricity and modern fuels).The proposed policy envisions an increase of 140% of fuel price and of 100% of electricity price. The magnitude of the change is consistent, but in line with the numerous subsidies cut implemented in Indonesia in the last years to reduce the gap between internal and international fuel price. An example can be the recent increase of diesel and gasoline price respectively of 22% and 44% introduced in the revision of 2013 Indonesian Budget. The policy implementation determines heterogeneous results in urban and rural areas, as it emerges observing group-specific parameters, and sheds some light on the potentialities of this approach in capturing the behaviour of different household types.

4.2 Engel curve shape

An Engel curve describes the relation between the consumption of a specific good or service and the total expenditure/income. It can be expressed as quantity or budget shares depending on income and other demographics. The functional form of the Engel curve can be derived directly from the consumer theory: it is linear in income and passing through the origin in the Cobb-Douglas case, linear but originating at the subsistence expenditure level in the case of Linear Expenditure System (Stone, 1954), linear in the logarithm of income in the Working-Leaser specification. More recent research on the topic aimed to obtain higher flexibility in Engel effects and introduced a more complex formulation as in the cases of Almost Ideal Demand System (AIDS), Quadratic Expenditure System (QES), An Implicitly, Directly Additive Demand System (AIDADS) and the Quadratic Almost Ideal Demand System (QUAIDS). The increasing complexity responds to the instance of higher accuracy in representing microdata and moves from a rank two demand system, as in the LES, ELES, CD and CDE case towards a rank three representation. Many empirical evidences support that Engel curves are better fitted using quadratic relations instead of linear functions (Banks et al., 1997). Moreover, this paper derives a relatively simple rank two demand system for Indonesia using the ELES formulation, aiming to deal with censoring issue and sub-population groups in a more controlled environment and to facilitate the inclusion of the demand system in a wider framework such as a CGE model.

4.3 Extended Linear Expenditure System

The Linear Expenditure System (LES) developed by Stone (1954) is a common formulation in the CGE context to describe the expenditure behaviour of a representative household due to its consistency with demand theory (continuity, homogeneity of degree zero and compliancy with Walras' low) and its empirical tractability.

The LES can be easily derived from the maximisation of a Stone-Geary utility function under the budget constraint and accounts for two components of consumption: the subsistence amount and the voluntary consumption. This characterisation makes the LES a rank two linear demand system able to capture the income dependent sensitivity of expenditure.

The Extended version of LES (ELES) includes savings among consumption goods and assumes null subsistence consumption level for this commodity (Lluch, 1973; Howe, 1975).

The expenditure formulation of ELES for J commodities and savings is:

$$\boldsymbol{E_j = p_j x_j = \theta_j p_j + \beta_j^* \left(Y^d - \sum_j \theta_j p_j\right)} \qquad \boldsymbol{j = 1, 2, \ldots, J} \tag{1}$$

$$\boldsymbol{s = \mu_s \left(Y^d - \sum_j \theta_j p_j\right)} \tag{2}$$

where $\beta_j^* = \mu_c \beta_j$ and $\sum_j \beta_j = 1$.

As anticipated, two elements characterise the expenditure function for good j: the subsistence expenditure, $\theta_j p_j$, and the supernumerary income, $(Y^d - \sum_j \theta_j p_j)$. The former is the minimum expenditure necessary to satisfy primary needs, the latter is also defined as discretionary expenditure, i.e. the disposable income left after satisfying primary needs. Differently from the LES case, the coefficient β_j^* is the partial marginal budget share and is equal to the product of marginal propensity to consume, μ_c, and the marginal budget shares, β_j; β_j^* is strictly positive but doesn't sum up to 1 given that the representative household allocates their supernumerary income in fixed proportions among commodities and savings, $\sum_j \beta_j^* = \mu_c$. Savings, *s*, depend on the marginal propensity to save, $\mu_s = 1 - \mu_c$, and on the supernumerary income.

The income elasticity describes the change of demand determined by a change in income. In the LES specification is no more unitary and can be defined as:

$$\varepsilon_y = \frac{\delta x_j}{\delta Y}\frac{Y}{x_j} = \frac{\beta_j^* \, Y^d}{\theta_j p_j + \beta_j^* \left(Y^d - \sum_j \theta_j p_j\right)} = \frac{\beta_j^*}{w_j}$$

The total expenditure function can be derived summing up the *j* expenditure equations and has the following formulation:

$$E = \mu_c Y^d + (1 - \mu_c) \sum_j \theta_j p_j$$

Rearranging the equation, solving it for the disposable income and substituting into equation (1), it is possible to express the ELES using the usual LES form:

$$p_j x_j = \theta_j p_j + \beta_j \left(E - \sum_j \theta_j p_j\right) \tag{3}$$

where the marginal budget share is $\beta_j = \frac{\beta_j^*}{\mu_c}$ and subsistence expenditures are the same as in the ELES case. Differentiating equation (2) with respect to prices, it is straightforward to derive the usual own and cross-prices elasticity that measure the change of consumption due to a price variation:

$$\varepsilon_{j,j} = \frac{\delta x_j}{\delta p_j}\frac{p_j}{x_j} = \frac{\theta_j(1-\beta_j)}{x_j} - 1 \qquad \varepsilon_{j,i} = \frac{\delta x_j}{\delta p_i}\frac{p_i}{x_j} = -\frac{\beta_i \theta_j p_j}{p_i x_i}$$

The "the expenditure elasticity of the marginal utility of expenditure" (Lluch & Williams, 1975), also known as the Frisch coefficient, φ, is widely used in macro-modelling context when data are not sufficient to estimate all parameters in ELES/LES framework (Annabi et al., 2006). It is defined as the negative ratio between the total expenditure level and the leftover expenditure after satisfying the necessary consumption: $\varphi = -\frac{\sum_j E_j}{\sum_j E_j - \sum_j \theta_j p_j}$.

The Frisch parameter creates a link between the subsistence minimum level and the marginal propensity to consume: its value is increasing as income share devoted to subsistence consumption rises and decreasing when marginal propensity to consume increases. Rearranging the equation (1) and using the definition of φ, the minimum consumption levels for each commodity can be derived without estimating them directly: $\theta_j = x_j + \beta_j \left(\frac{\sum_j E_j}{p_j \varphi}\right)$. In the original LES formulation, there are no specific constraints on the subsistence expenditure level, except that it has to be lower than the total expenditure, therefore estimates of $\theta_j$can also be negative. Even if it is difficult to interpret the negative subsistence expenditure, this characteristic allows taking in account high cross price elasticity levels.

4.4 ELES empirical results (representative household)

There are several approaches for estimating the ELES and LES systems (Annabi et al., 2006): i) estimating directly the subsistence quantity and the (partial) marginal propensity to consume (Pollak & Wales, 1969; Lluch & Williams, 1975; Sadoulet & de Janvry, 1995); ii) calibrating parameters using estimated income and price elasticities (Creedy, 2001); iii) using a Frisch parameters from the literature and the estimated income elasticity to compute the minimum subsistence level (Savard, 2003; Kriström, 2006; Dervis, 1982); in the ELES case is sufficient to have an estimate of income elasticity to derive all the other parameters (Burniaux and Van der Mensbrugghe, 1991).

This paper focuses on the first approach. The ELES is estimated for Indonesia using the Indonesia Family Life Survey4 (IFLS4), reconciled with the Social Accounting Matrix (SAM) of Indonesia for 2007. The IFLS is a longitudinal panel started in 1993 (IFLS1) and carried out by Rand Corporation, collecting information at individual, household and community levels from November 2007 to May 2008. The fourth wave IFLS4 surveys 13,995 households (Strauss et al., 2009).

The reconciliation of expenditure and income sides, including transfers and savings, is performed using the Cross Entropy method as described in Chapter 3. Considering the reconciled household survey and therefore creating a direct link with the ENV-Linkages model (Burniaux & Château, 2008) allows including the price information in the analysis. The lack of price detail in the household data is compensated considering the relative prices coming from the model, where the considered numéraire is the index of OECD manufacturing exports prices (Burniaux & Château, 2008).

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**Zero values (%)**
Agriculture	0.6183	0.6081	0.0000	11.0872	4
Food	1.1227	0.9487	0.0000	30.2866	0
Fuel	0.1456	0.1838	0.0000	7.7186	12
Electricity	0.0776	0.1038	0.0000	5.6140	14
Transport	0.3213	0.5852	0.0000	13.5866	27
Manufacturing	1.0796	1.5453	0.0000	25.1061	0
Services	3.0144	3.2284	0.0566	32.6978	0
Construction	0.0001	0.0002	0.0000	0.0017	0

Table 12 descriptive statistics for expenditure (million USD)

The direct estimation of parameters starts from equations (1) and (2) rearranged and expressed in a stochastic formulation (Howe, 1975):

$$E_{i,j} = ({\theta_j}^* - {\beta_j}^* \sum_j {\theta_j}^*) + {\beta_j}^*(Y_i^d) + \varepsilon_j$$

$$s = (-\mu_s \sum_j {\theta_j}^*) + \mu_s(Y_i^d) + \varepsilon_{j+1}$$

The system includes J demand equations for commodities: Agriculture, Food, Fuel, Electricity, Transport, Manufacturing, Services and Construction, and one additional for savings. The underlying budget constraint that guarantees the coherence of the system determines also the independence of error terms (Pollak & Wales, 1969). The system is a nonlinear seemingly unrelated regression model where the sum of error components is equal to zero and therefore implies a singular variance covariance matrix. Therefore, in order to solve this problem is necessary to run the estimation on J equations, excluding savings demand; the parameters to be estimated are $\theta_j^*$and β_j^*, where $\theta_j^* = \theta_j p_j$.

The system can be handled using a seemingly unrelated regression (SUR) procedure (Zellner, 1962) through generalised non-linear least squares. The SUR approach allows considering jointly the J equations capturing the correlation in the error component and therefore providing a more efficient fit. The estimation procedure is performed both with nonlinear least squares and with iterative feasible generalised least squares (IFGNLS). The latter method allows iteratively updating the matrix of residuals and using it to reestimate the parameters more efficiently; in this way the estimators converge to the maximum likelihood result with an error term normally distributed. In both cases the sample weights coming from the household survey and robust standard errors are considered.

	Agriculture	**Food**	**Fuel**	**Electricity**	**Transport**	**Manufacturing**	**Services**	**Total**
$\boldsymbol{\beta_j}^*$	0.0356	0.0639	0.0059	0.0052	0.0335	0.1332	0.3541	0.6314
	(0.0013)	(0.0025)	(0.0003)	(0.0003)	(0.0017)	(0.0046)	(0.0055)	
$\boldsymbol{\theta_j}^*$	0.2646	0.4876	0.0869	0.0262	- 0.0112	- 0.2439	- 0.5039	0.1063
	(0.0112)	(0.0207)	(0.0027)	(0.0022)	(0.0136)	(0.0387)	(0.0509)	
$\boldsymbol{\beta_j}$	0.0564	0.1012	0.0094	0.0082	0.0530	0.2110	0.5608	1.0000

*Robust standard errors are reported in parenthesis.

**Estimates for the Construction commodity are not reported in the table because they are negligible but are considered in the estimation procedure.

Table 13 Estimate of partial marginal budget shares and average subsistence expenditure (in 1000 USD PPP)

Table 13 presents estimates of β_j^* and $\theta_j^*$with their standard errors; the partial marginal budget shares are all highly significant (1%) as well as the subsistence expenditures, except in the case of

Transport[4]. Summing up the partial marginal budget shares is possible to compute the marginal propensity to consume for Indonesia: $\sum_j \beta_j^* = \sum_j \beta_j \mu_c = \mu_c = 0.63$; using the same relation, it is also derived the marginal budget share β_j[5].

It worth to notice that the subsistence expenditures, θ_j^*, are negative for Transport, Manufacturing, Service and Construction: the negative signs are symptoms of the non-essentiality of these commodities that are purchased only above a certain amount of income (corner solution). Instead positive subsistence expenditure for energy and food highlights that they are necessary commodities (Powell &Wales, 1969). The average household devotes 43% of the expenditure to purchase the subsistence quantity of Food and Agricultural products, the 59% for Fuel and 33% for Electricity. Using the estimated expenditure for subsistence consumption, it is easy to derive the value of Frisch parameter that is -1.01. This value is low due to the negative component characterising subsistence expenditure; the range of estimates from the literature goes from -0.1 for rich countries and -10 for very poor countries according to Frisch (1975).

The Breusch-Pagan test and the correlation matrix confirm the presence of contemporaneous correlation among the equations of the system and support the decision to jointly estimate them (see Annex II).

Table **14** describes the responsiveness of demand to expenditure and income derived from ELES estimated parameters and evaluated for the average household: expenditure elasticities for Agricultural products, Food and Fuel are below the 0.6 threshold, showing that these commodities are considered necessary; instead Manufacturing, Services and Construction have elasticity well above 1 revealing that these are luxury commodities for the average household. These results are in line with recent cross country empirical analysis performed on Global Trade Analysis Project (GTAP) and International Comparison Programme (ICP) data using an AIDADS demand system (Reimer & Hertel, 2004).

[4] In order to check the consistency of the subsistence expenditure for Transport a seemingly unrelated linear regression was performed: $E_j = \alpha + \beta_j^*(Y^d) + \varepsilon_j$, where $\alpha = (\theta_j^* - \beta_j^* \sum_j \theta_j^*)$. In this case, all coefficients result highly significant and the subsistence expenditure in Transport coincides with the value from IFGNLS. The results are reported in Appendix II (Table 20).

[5] The marginal budget shares estimates using the LES equation (3), performed with IFGNLS leads to estimates of β_j consistent with the ELES results, differing at most of 2%.

	Income elasticity	Expenditure elasticity	Own price elasticity
Agriculture	0.367	0.582	-0.596
Food	0.363	0.575	- 0.610
Fuel	0.258	0.412	- 0.409
Electricity	0.428	0.674	-0.665
Transport	0.665	1.052	- 1.033
Manufacturing	0.787	1.247	-1.178
Services	0.749	1.187	- 1.073

Table 14 Income, expenditure and price elasticities for the SURE estimation

Commodity prices are not included in the household survey therefore in order to compute the own price elasticities the relative prices coming from ENV-Linkages are used[6]. Own price elasticities follow a similar pattern and an elastic response characterises Transport, Manufacturing and Services demand, completely inelastic is instead the demand for Fuel.

4.5 Zero expenditure bias correction

In household surveys is quite common to observe zero expenditure values for some items. This phenomenon is evident looking at Table 12 for expenditure in Fuel, Electricity and Transportation where the zero values are respectively 12%, 14% and 27%. The reason behind this pattern can be: a too short time frame for the measurement of purchasing habit (the above mentioned expenditures are relative to the consumption in the previous month); the result of household preferences; the unavailability of the commodity in the area; and the unaffordability. It is not convenient to represent a variable characterised by non-negligible zero values using a continuous distribution. Expenditure for some items can be characterised as censored by the presence of a latent variable and not considering this phenomenon determines bias in the estimation of demand system parameters.

Several studies have addressed the censoring issue using limited dependent variable models. In a one equation case, the most common approach is performing the maximum-likelihood estimation of a Tobit model (Tobin, 1958). When a system of equations is involved the procedure required is more complex because it is necessary to taking in account the correlation of errors across equation and the common parameter restrictions. In the case of censored simultaneous equation models,

[6] In ENV-Linkages the considered numéraire is the index of OECD manufacturing exports prices.

Heien and Wessells (1990) propose a two-step estimation procedure: the first step consists in a probit regression describing the probability for a household to purchase or not to purchase a certain commodity, then the fitted model is used to compute the inverse Mills' ratio; in the second step, a seemingly unrelated regression (SUR) procedure is performed including among the covariates the estimated inverse Mills' ratio. Shonkwiler and Yen (1999) propose an alternative two-steps procedure that corrects for the inconsistencies in the expenditure conditional mean and produces consistent estimates (Tauchmann, 2010).

The two-steps model can be characterised by the following equations:

$$\widetilde{E_{\iota,J}} = (\theta_j{}^* - \beta_j{}^* \textstyle\sum_j \theta_j{}^*) + \beta_j{}^*\left(Y_i^d\right) + \varepsilon_j \qquad \tilde{d}_{i,j} = f(Y_i^d, x_i)$$

$$d_{i,j} = \begin{cases} 1 & if\ \tilde{d}_{i,j} > 0 \\ 0 & if\ \tilde{d}_{i,j} = 0 \end{cases} \qquad E_{i,j} = d_{i,j} * \widetilde{E_{\iota,J}}$$

The observable dependent variables are household expenditure, $E_{i,j}$, and the choice of purchasing or not purchasing, $d_{i,j}$; this latter depends on the latent variable $\tilde{d}_{i,j}$, the dependent in the probit model, which in turn is function of the disposable income and other demographics, x_i, such as: household size, age and education of the head, rural/urban area, province, job of the head in the last year, electric appliances available in the house and type of stove used. The observed expenditure is therefore function of the dichotomous choice, $d_{i,j}$, and of the latent expenditure, $\widetilde{E_{\iota,J}}$.

Distinct probit models are estimated using this pool of explanatory variables in order to characterise the probability of purchasing Agricultural products, Fuel, Electricity and Transport. Performing single equation estimates instead of a multivariate model implies an underlying assumption that the correlation of errors across equations is null; this hypothesis determines a small loss of efficiency compared to the multivariate case, but does not affect consistency of estimates. All explanatory variables result highly significant and the pseudo R^2 range between 0.12 and 0.2.

Instead of using the inverse Mills ratio to account for the censored data, it is used the Shonkwiler and Yen (1999) procedure that introduce directly in the expenditure system the density function, $\varphi\left(Y_i^d, x_i\right)$, and the cumulative distribution function, $\Phi\left(Y_i^d, x_i\right)$, computed in the first step.

Therefore the expenditure equations for Agricultural products, Fuel, Electricity and Transport can be written in the following way:

$$E_{i,j} = (\theta_j^{*} - \beta_j^{*} \sum_j \theta_j^{*})\, \Phi(Y_i^d, x_i) + \beta_j^{*}\, \Phi(Y_i^d, x_i)\, Y_i^d + \alpha_j \varphi(Y_i^d, x_i) + \varepsilon_j$$

All the other equations that have not censored data maintain the original formulation. The number of parameters to be estimated increases from 9 to 13, with the introduction of α_j coefficient, and the estimation procedure is IFGNLS as before, with robust standard errors.

Taking into account the censoring phenomena determines small changes on the estimates of relative marginal budget shares and the marginal propensity to consume slightly decrease implying a higher propensity to save at country level (Table 15). The subsistence expenditure level is instead largely affected by reducing the bias due to null expenditure observations. For agriculture, Fuel and Electricity the value slightly double, and for Transport even change sign. Therefore the increased committed expenditure introduces more rigidity in the demand of poor households and conditions their utility level because the consumption below the subsistence threshold does not determine any increase of utility.

	Agriculture	**Food**	**Fuel**	**Electricity**	**Transport**	**Manufacturing**	**Services**	**Total**
$\boldsymbol{\beta_j}^{*}$	0.0362	0.0640	0.0051	0.0050	0.0289	0.1332	0.3540	0.6263
	(0.0014)	(0.0025)	(0.0003)	(0.0003)	(0.0030)	(0.0046)	(0.0055)	
$\boldsymbol{\theta_j}^{*}$	0.2802	0.5267	0.1454	0.0418	0.1777	-0.1600	-0.2810	0.7308
	(0.0134)	(0.0224)	(0.0045)	(0.0038)	(0.0677)	(0.0442)	(0.0828)	
$\boldsymbol{\alpha_j}$	0.2967		0.0051	-0.0029	-0.0896			
	(0.0323)		(0.0003)	(0.0072)	(0.0870)			
$\boldsymbol{\beta_j}$	0.0577	0.1022	0.0081	0.0079	0.0462	0.2126	0.5653	1.0000

*Robust standard errors are reported in parenthesis.

**Estimates for the Construction commodity are not reported in the table because they are negligible but are considered in the estimation procedure.

Table 15 Two-step model: probit models and SURE estimation (1000 USD)

Accounting for bias for zero expenditure and introducing the two-step procedure increases the fit of the system of equations whose R^2 ranges between 0.4 and 0.9.

Table 16 presents the elasticity derived from the estimated parameters. The elasticity computation considers the correction for censored data coming from the probit models; the expenditure elasticity can be rewritten as: $\varepsilon_E = \beta_j{}^{*}\Phi\left(Y_i^d, x_i\right) / w_j$ and the own price elasticity is: $\varepsilon_{j,j} = \frac{\theta_j \Phi\left(Y_i^d, x_i\right)(1-\beta_j)}{x_j} - 1$.

	Expenditure elasticity	Own price elasticity
Agriculture	0.571	- 0.591
Food	0.581	- 0.579
Fuel	0.312	- 0.129
Electricity	0.563	-0.538
Transport	0.652	-0.625
Manufacturing	1.256	- 1.117
Services	1.196	-1.041

Table 16 Income, expenditure and price elasticities for the Two-step model

The two step procedure implies also some changes in elasticity especially for commodities with relevant number of zero expenditure observations. In particular, this is true for expenditure elasticity of Fuel and Electricity whose demand results less elastic; Transport elasticity halves passing from being a luxury to being considered necessary. The other commodities become slightly more elastic. The demand response to own price changes is more inelastic for all goods.

4.6 Group-specific expenditure and aggregation problem

Deriving a system of demand equations at household or group level consistent with the representative household framework implies dealing with the aggregation issue. If aggregating demand across goods is a common procedure in the LES case and is guaranteed by the condition on expenditure propensity, deriving a representative demand function from group behaviours is a more problematic theme. The general rule is that identical and homothetic preferences guarantee the aggregation of multiple demand functions; the same conclusion can be extended to homothetic (not identical) preferences, with proportional income. When preferences are quasi-homothetic, an individual demand function of the form: $x_i(p,y) = a_i(p) + b_i(p)y_i$ can be aggregated into the total demand function, $x(p,y) = a(p) + b(p)y$, if two conditions have to be satisfied: $b_i(p) = b(p)$ and $E(a_i(p)) = a(p)$. As it is explained by Gorman, a slight deviation from homotheticity can be compensated by identical marginal propensity to consume of single agents, leading to perfect aggregation (Blundell and Stocker, 2007; Chipman, 2006). Graphically this condition is represented by parallel Engel curves.

In the case of LES and ELES demand systems, the adding-up condition is satisfied assuming constant marginal budget shares across household types. The introduction of probability and distribution functions to correct for latent variable bias affects the slope of the expenditure functions therefore to guarantee the consistency of household-specific demand response with the aggregate one it is necessary to keep constant at the country average level also the probability and distributional functions derived in the two-steps procedure. The differentiation of demand response across household types will be evaluated focusing on the changes in subsistence level consumption and own price elasticities.

For the non-censored equations, the SUR procedure is performed assuming β_j^*constant across typologies, instead the censored equations in the ELES system presents the following form:

$$E_{i,j} = \theta_j^* \, \overline{\Phi}\big(Y_i^d, x_i\big) + \beta_j^* \, \overline{\Phi}\big(Y_i^d, x_i\big)\big({Y^d}_i - \textstyle\sum_j \theta_{i,j} p_j\big) + \alpha_j \overline{\varphi}\big(Y_i^d, x_i\big) + \varepsilon_j$$

The next section will focus on rural/urban location as source of heterogeneity for household expenditure.

Urban and rural households

The difference in household's expenditure behaviour in rural and urban areas is evident looking at the survey data. Urban families have on average higher income than rural ones (+38%) and spend more money for buying commodities, in particular Manufacturing, Services and Electricity (respectively 48%, 48% and 60% more than rural households). This pattern emerges also estimating the subsistence consumption levels for the two categories (Table 17**)**. As expected, the committed consumption is consistent in urban areas because, given the higher average income, households perceive a higher consumption of certain commodities as necessary; this is true for Food, Fuel, Electricity and Transport. The urban class includes both poor and rich households, for this reason the negative signs for the subsistence level of Manufacturing and Services persists.

	θ_j^*		$\varepsilon_{i,i}$	
	Urban	**Rural**	**Urban**	**Rural**
Agriculture	0.2697	0.3096	-0.6276	-0.5231
Food	0.5544	0.5188	-0.5998	-0.5400
Fuel	0.1680	0.1297	-0.1400	-0.0808
Electricity	0.0597	0.0327	-0.4701	-0.5355
Transport	0.2509	0.2003	-0.5433	-0.5039
Manufacturing	-0.1352	-0.1480	-1.0816	-1.1321
Services	-0.1837	-0.2781	-1.0220	-1.0493

Table 17 Average subsistence expenditure (in 1000 USD PPP) and own-price elasticities, urban and rural

Table 17 presents also the own price elasticity values; as predicted by demand theory, the consumption of all goods shrinks after a price increase. Moreover rural and urban households react differently depending on the commodities interested by the price shock. Agriculture, Food, Fuel, Electricity and Transport demand is relatively inelastic and the phenomenon is more pronounced in rural areas. Electricity is considered instead a necessary good especially in urban areas. Manufacturing and Services demand response is elastic for both household types, whether rural families perceive more than the urban ones these as luxury commodities.

Policy simulation and effect on consumption

It is interesting to test the heterogeneous response of the two household types after a simple reform envisioning a fuel and electricity price increase. The focus on fuels and electricity is connected with the current debate on fossil fuel subsidies phase-out and will shed some light on the direct effect of this intervention in rural and urban areas. Clearly, estimating a complete expenditure system and computing price elasticities allow assessing only the direct impact of the policy on consumption of the targeted commodities and the effect on the price and consumption of the other goods; the indirect consequences on income generation and distribution cannot be assessed and need to be handled in a general equilibrium context.

The method used to evaluate the magnitude of subsidies in Indonesia in 2013 is the price-gap approach (IEA, 2006) that measures subsidies as the gap between the international price and the national consumer's price for tradable commodities and the long run marginal cost of supply (Burniaux and Chateau, 2011). Indonesia is among the countries that mostly subsidise energy consumption; around 4% of GDP in 2008 was devoted for supporting energy consumption. The reform determines a 140% increase of fossil fuel price and 100% of electricity price. The direct effect is a contraction of quantity consumed, on average respectively -12% and -34% at country level. The change of consumption is more pronounced for electricity because the demand of this commodity is relatively more elastic than fuel one. The expenditure adjustment for other goods is minimal and in the range of 1%.

The shock has heterogeneous impacts in urban and rural areas. Whether the elimination of electricity subsidy affects slightly more the demand of urban households (- 35% compared with -32%), the rise of fuel price reduces consumption of 15% in urban areas and 9% in rural ones due to the higher demand rigidity of rural families that consider necessary the commodity. The consumption of other commodities shrinks on average of 1%, Manufacturing is slightly more affected (-2%).

Figure 6 describes the change in household consumption due to the policy implementation. The gap between the pre- and post policy consumption is widening as income increases: once satisfied the subsistence level, where the demand is rigid, the response to a price change is more elastic and determines for 10th decile rural households a -36% reduction of fuel consumption and -44% of electricity consumption.

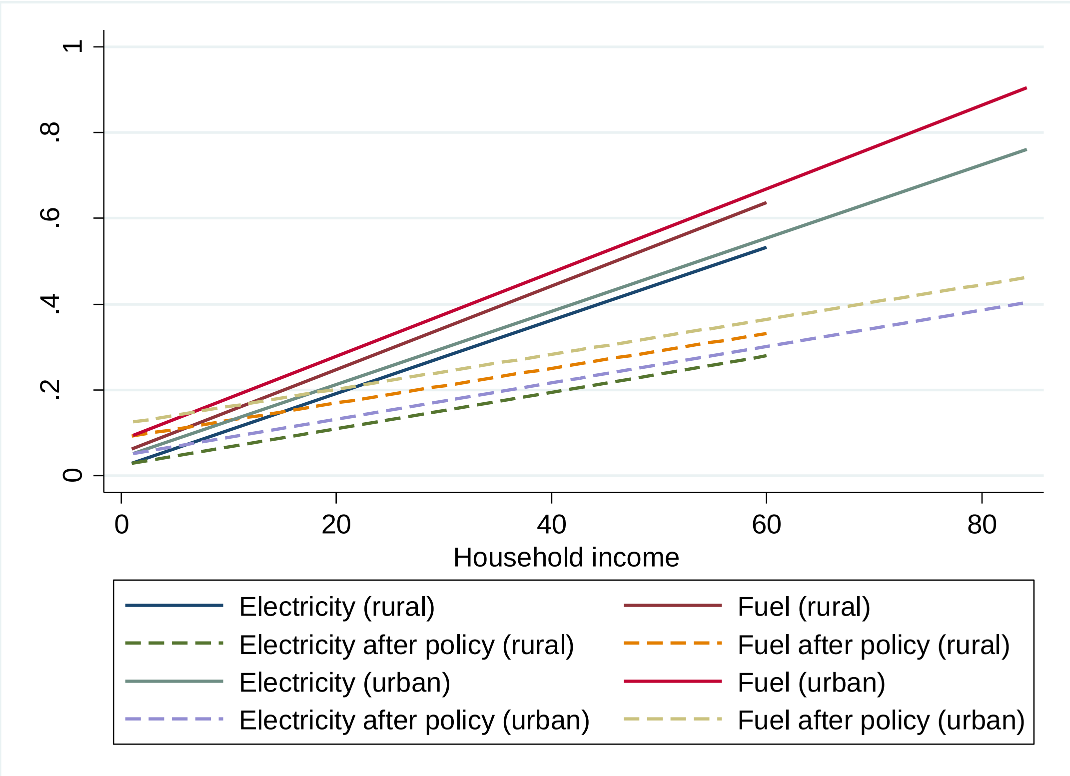

Figure 6 Household consumption of fuel and electricity, before and after policy

4.7 Conclusions

The paper illustrates the estimation procedure of an ELES demand system using Indonesian household survey (IFLS4) data, already reconciled with the base year macro variables, and correcting estimates for censoring bias. The procedure is not common in the macro modelling where usually demand parameters and elasticities derive from external sources. Most of the micro-macro modelling examples relay on externally computed Frisch parameters to downscale elasticities and other parameters for specific group of the population. Estimating demand parameters for several countries and subgroups, as it is required in most macro-models, is quite time consuming, but in this case the focus on only one country allows deriving a micro-rooted demand system.

The policy of fossil fuel subsidies phase out in Indonesia has a strong impact on fuel and electricity consumption that shrinks of 12% and 34 % respectively. Moreover, comparing estimation results at country and sub-group level highlights the heterogeneous response of different household types: the elimination of electricity subsidy affects slightly more the demand of urban households (- 35% compared with -32%), instead the rise of fuel price reduces consumption of 15% in urban areas and 9% in rural ones due to the higher demand rigidity of rural families that consider the commodity as necessary.

This work represents a first stage in better understanding demand system and the reliability of estimated parameters could be easily tested with different functional forms, also rank three demand functions. The final aim of this approach is to include the micro-rooted demand system in a CGE framework in order to capture not only the direct impact determined by a policy, but also all the indirect feedbacks. These arise from the consumption pattern change and affects profit generation in the targeted sectors and in all the economy, and income formation.

5 Conclusion

5.1 Main findings

A soft link between microdata and macro models is an effective way to represent heterogeneity in agent responses after a shock and can help shedding some light on distributional issues in income and consumption.

The presented exercise allows characterising about 10000 Indonesian different households which are heterogeneous with respect to income sources and expenditure choices, but perfectly consistent in aggregate with the national accounting. The ENV-Linkages model, a CGE framework, is used to simulate a policy scenario: a 1% reduction of fossil fuel subsidies in Indonesia for 2013. Two scenarios are built envisioning different recycling schemes of additional governmental revenues: one considering an unconditional lump-sum transfer to all households, and the other one, the increase of governmental expenditure. The deriving price shocks directly translate into expenditures and incomes variations in the microsimulation module and the welfare changes are assessed in terms of percentage loos and gain per capita.

At aggregate level, the scenario considering an unconditioned lump-sum compensation for the increase of energy prices is more efficient, determines a reduction of emissions and improves welfare. The other scenario, is again efficient and improves environmental performance, but determines a loss of welfare. Although in this second scenario the outcome has to be cautiously considered due to the incapability to account for the welfare change attributable to an increased quality of public service provisions, this result can be seen as a lower bound for welfare loss after a fuel subsidy reduction in Indonesia.

Looking at the intra-country effects, despite the limited decrease of fossil fuel subsidy, the reform has a non-negligible impact on welfare, especially for the lower deciles. The first scenario results strongly progressive and the second one is slightly regressive. A strong component in the final outcome is the initial level of distortion exerted by fuel subsidies: when subsidies represent a consistent share of governmental budget, as in the Indonesian case, the revenues originated by a reform of this system are consistent and in a lump-sum redistribution weight particularly on lower deciles.

The effect on expenditure of households is similar in the two scenarios, but shows a more pronounced inflationary phenomenon in absence of transfers. The effect on income is more diversified. Whether the labor remuneration rises due to the reallocation of this factor toward non-energy intensive sectors in both scenarios, the change of capital revenues due to the crowding-out effect increases the remuneration of capital in the “government expenditure” scenario. The price of natural resources decreases because this factor is directly affected by the drop of subsidy on energy commodities.

This modelling approach and the policy exercise shows that the regressive effect of the energy policy is limited and a simple neutral redistribution of fiscal revenues across household determines strongly progressive results that could be also improved with transfers targeting special groups of the population.

Chapter 4 represents a first step in investigating household behavioural response on the demand side. An Extended Expenditure Linear System (ELES) is derived to describe consumption choices of Indonesian households. The reference dataset is Indonesian household survey data (IFLS4), already reconciled with the base year macro variables. The ELES is estimated at country level using a seemingly unrelated regression approach; given the presence of a consistent number of zero expenditure observations, a two-step estimation procedure is implemented for correcting censoring bias and the resulting estimates are presented at country level and for rural/urban households. This procedure is not common in the macro modelling where usually demand parameters and elasticities derive from external sources.

The policy of fossil fuel subsidies phase out performed in Indonesia has a strong direct impact on fuel and electricity consumption. Moreover, comparing estimation results at country and sub-group level highlights the heterogeneous response of different household types: the elimination of electricity subsidy affects slightly more the demand of urban households, instead the rise of fuel price reduces more the consumption in urban areas than in rural ones due to the higher demand rigidity of rural families that consider the commodity as necessary.

5.2 Future developments

The review of micro-macro modelling literature offers interesting cause for reflection on the potentiality of this approach. Although a simple non-behavioural microsimulation shows interesting results in differentiating policy effects across households, it is able to capture only the heterogeneous response of agents induced by the base year discrepancies in consumption choices and income sources. Therefore modelling a behavioural response in expenditure and in labour market can guarantee the bias reduction in assessing distributional issue.

The microsimulation approach remains a preferable option compared to the Integrated Multiple Household model because it offers higher flexibility in introducing empirically derived relations to explain individual and household choices and it leaves open the possibility to exploit other heterogeneity dimensions available in household surveys. For example, education level can be used to enrich labour supply functions, health conditions can contribute to create qualitative indicators responsive to some policy implementation and demographic variables, such as age, gender and migration, are valuable information for describing individual behaviour in a dynamic context.

Whether a static analysis is sufficient to assess pre and after policy inequality and poverty conditions, the potentiality of a microsimulation with behavioural response can be fully exploited in a dynamic environment. To perform this step the CGE framework is essential. The population and labour market dynamics can follow fully exogenous path and be simply downscaled at individual level or their trend can be simulated using a population module.

The household demand specification is a key element especially when the envisioned policy targets directly market prices. The direct derivation of demand parameters appears a priority; using coefficients and elasticities coming from the literature and applying them to different countries is risky and careless of the information that can be extracted for the surveys. The Extended Linear Expenditure System estimated (ELES) in Chapter 4 is one of the possible specifications of demand, chosen in order to be consistent with the ENV-Linkages formulation. However, it will worth to estimate the demand using different functional formulations, also removing the linearity assumption of the ELES, in order to better fit the actual consumption behaviours; the only caveat in this development is the aggregation requirement that has to be met to guarantee the consistency between the household/individual level demand in the microsimulation module and the aggregate demand in the CGE framework.

Regarding the considered policy exercise, the fossil fuel subsidy phase-out is only one example of possible intervention, motivated by the country specific public debate and the economic conditions; in a microsimulation approach several different policies can be performed, as the recent literature can prove, and also the combined implementation of policies targeting different dimensions such poverty, environmental sustainability and trade liberalisation can be implemented.

In addition, the simulation exercises highlighted the importance of the revenue recycling mechanism determining in some cases the progressivity or regressivity of reforms; therefore, exploring different redistribution schemes of policy revenues expressly targeting determined population categories could offer interesting insights for a correct policy design.

References

Arze del Granado, F. J., Coady, C. and R. Gillingham (2012), The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries, *World Development* Vol. 40, No. 11, pp. 2234–2248

Annabi, N., Cockburn, J. And Decaluwé, B. (2006). Functional forms and parameterization of CGE models. *PEP MPIA Working Paper*, 2006.04. Poverty and Economic Policy Research Network.

Banks, James, Richard Blundell, and Arthur Lewbel. (1997). Quadratic Engel Curves and Consumer Demand. *Review of Economics and Statistics*, 79(4): 527–39.

Beaton C. and L. Lontoh (2010), *Lessons Learned from Indonesia's Attempts to Reform Fossil-Fuel Subsidies*, International Institute for Sustainable Development (iisd)

Blundell, R. and T.M. Stoker. (2007). Models of aggregate economic relationships that account for heterogeneity. Chapter 68 in *Handbook of Econometrics*, Volume 6A, 2007 Elsevier B.V.

Boccanfuso D, Decaluwé B, Savard L (2003) Poverty, Income Distribution and CGE Modeling: Does the Functional Form of Distribution Matter?. *Cahier de recherche/Working Paper 03-32.* Centre interuniversitaire sur le risque, les politiques économiques et l'emploi

Boccanfuso, D. and L. Savard (2007). Poverty and Inequality Impact Analysis Regarding Cotton Subsidies: A Mali-based CGE Micro-accounting Approach. *Journal of African Economies* (2007) 16 (4): 629-659. doi: 10.1093/jae/ejm001

Boccanfuso D, Estache A, Savard L (2011) The intra-country distributional impact of policies to fight climate change: a survey. *The Journal of Development Studies.* Volume 47, Issue 1, 2011

Bouet, A., Estrades, C., and D. Laborde (2013), "Households heterogeneity in a global CGE model: an illustration with the MIRAGE-HH" (MIRAGE-HouseHolds) model", LAREFI Working Paper, No. 1

Bourguignon, F., Robilliard, A. and S. Robinson (2003). Representative versus real households in the macro-economic modelling of inequality. *Document de travail. DT/2003-10, DIAL* (Devéloppement, Institutions & Analyses de Long terme)

Bourguignon, F. and A. Spadaro (2006) Microsimulation as a tool for evaluating redistribution policies. *Journal of Economic Inequality* 4:77–106. doi: 10.1007/s10888-005-9012-6

Burniaux, J. & J. Château.(2008). An overview of the OECD Env-linkages model. *OECD Economics Department Working Papers*, No. 653

Burniaux J-M, J. Chateau, J. Dellink, R. Duval and S. Jamet (2009), ―The Economics of Climate Change Mitigation: How to Build the Necessary Global Action in a Cost-effective Manner‖, *OECD Economics Department Working Papers*, No. 701, Paris.

Burniaux, J. and J. Chateau (2011), "Mitigation Potential of Removing Fossil Fuel Subsidies: A General Equilibrium Assessment", *OECD Economics Department Working Papers*, No. 853, OECD Publishing.

Bovenberg, A. Lans, Goulder and H. Lawrence (1996). Optimal environmental taxation in the presence of other taxes: general equilibrium analyses. *American Economic Review*. Vol. 86 no. 4, pp. 985–1000

Bulman, T., W. Fengler and M. Ikhsan (2008),. Indonesia's Oil Subsidy Opportunity. *Far Eastern Economic Review*, June.

Brenner M, Riddle M and Boyce J, (2007). A Chinese sky trust? Distributional impacts of carbon charges and revenue recycling in China. *Energy Policy*, vol. 35, 1771–1784.

Buddelmeyer H, Hérault N, Kalb G, Jong M van Z de (2008) Disaggregation of CGE results into household level results through micro-macro linkage: Analysing climate change mitigation policies from 2005 to 2030, *Melbourne Institute Report* 9.

Bussolo, M. and J. Lay (2003). Globalisation and poverty changes in Colombia. *OECD Working paper. No. 226*

Bussolo, M., Lay, J., Medvedev,D. and D. van der Mensbrugghe (2008b) Trade Options for Latin America: A Poverty Assessment Using a Top-Down Macro-Micro Modeling Framework. in *The impact of macroeconomic policies on poverty and income distribution*, François Bourguignon Maurizio Bussolo Luiz A. Pereira da Silva editors, Palgrave Macmillan and the World Bank, Washington, DC

Maurizio Bussolo & Rafael E De Hoyos & Denis Medvedev (2010). Economic growth and income distribution: linking macro-economic models with household survey data at the global level.

International Journal of Microsimulation, Interational Microsimulation Association, vol. 3(1), pages 92-103.

Chen S. and M. Ravallion (2010) The Developing World is Poorer than We Thought, But No Less Successful in the Fight Against Poverty*, The Quarterly Journal of Economics (2010) 125 (4): 1577-1625*.

Chipman, J. S. (2006). Aggregation and Estimation in the Theory of Demand. *History of Political Economy* 38 (annual suppl.) DOI 10.1215/00182702-2005-019

Cogneau, D. and Robilliard, A. (2000). Growth distribution and poverty in Madagascar: learning from a microsimulation model in a general equilibrium. *IFPRI TMD Discussion Paper* No. 61

Colombo G (2008) Linking CGE and microsimulation models: A comparison of different approaches. *International Journal of Microsimulation* 3:72–91.

Corong E (2007) Economic and Poverty Impacts of a Voluntary Carbon Reduction for a Small Liberalized Developing Economy: The Case of the Philippines. *Fondazione Eni Enrico Mattei Working Paper*, 2-9-2007

Chen, S. and M. Ravallion (2004) Welfare impacts of China's accession to the World Trade Organization. *World Bank Economic Review*. 18:29–57. doi: 10.1093/wber/lhhO3l

Clement, B., H.-S. Jung and S. Gupta (2007). "Real and Distributive Effects of Petroleum Price Liberalization: The Case of Indonesia," *Developing Economies*, Vol. 45(2), pp. 220-237

Colombo, G. (2010). Linking CGE and microsimulation models: A comparison of different approaches. *International Journal of microsimulation*, 3(1), 72–91.

Cranfield, J. A. L., Eales, J. S., Hertel, T. W., & Preckel, P. V. (2003). Empirical Model selection when estimating and predicting consumer demands using international, cross section data. *Agricultural Economics*, 353–364.

de Boer, P & Paap, R.(2009) Testing Non-nested Demand Relations: Linear Expenditure System versus Indirect Addilog, *Statistica Neerlandica*, Netherlands Society for Statistics and Operations Research, vol. 63(3), pages 368-384

Dartanto T., (2013) Reducing fuel subsidies and the implication on fiscal balance and poverty in Indonesia: A simulation analysis, *Energy Policy* 58(2013)117–134

Deaton A., (1997) *The analysis of household survey*, The International Bank for Reconstruction and Development, the World Bank

Decaluwé B, Dumont J-C and Savard L (1999). Measuring Poverty and Inequality in a Computable General Equilibrium Model. *Working paper 99-20, CREFA*, Université Laval, Quebec, Canada.

Dervis, K., de Melo, J., and Robinson, S. (1982). *General Equilibrium Models for Development Policy*. London: Cambridge University

Devarajan, S. and Go D.S. (2002) A macroeconomic framework for poverty reduction strategy papers. With an Application to Zambia. *Africa Region Working Paper Series* No. 38. October 2002

EC, (2010) The distributional impact of imputed rent in EU-SILC, *Eurostat Methodologies and Working Papers*

Ellis, J. (2010), "The Effect of Fossil-Fuel Subsidy Reform: A Review of Modelling and Empirical Studies", *Global Subsidies Initiative and International Institute for Sustainable Development Working Paper*, March.

Fan, S. Hazell, P. and S. Thorat (2000), Government Spending, Growth and Poverty in Rural India, *American Journal of Agricultural Economics*, vol. 82, no. 4 , pp. 1038-1051

Ferreira J and Horridge M (2006) „The Doha Round, Poverty and Regional Inequality in Brazil", Chapter 7 in Hertel T W and L A Winters (Eds.) *Putting Development Back into the Doha Agenda: Poverty Impacts of a WTO Agreement*, Washington, D.C.: Palgrave Macmillan and the World Bank.

Fofana, I. Lemelin, A. and J. Cockburn (2005), Balancing social accounting matrix: Theory and application, *CIRPEE Working Paper*

Golan, A. and G. Judge (1996). Recovering information in the case of underdetermined problems and incomplete economic data. *Journal of statistical planning and inference*, Vol. 49, No. 1, pp. 127-136, doi: http://dx.doi.org/10.1016/0378-3758(95)00033-X

Goulder, L. H. (2013) . Climate change policy's interactions with the tax system. *Energy Economics.* Volume 40, Supplement 1, December 2013, Pages S3–S11 http://dx.doi.org/10.1016/j.eneco.2013.09.017.

Gutierrez, R.G., Linhart,J. M. and J. S. Pitblado. (2003). From the help desk: Local polynomial regression and Stata plugins, *The Stata Journal* (2003), 3, Number 4, pp. 412–419

Heien D. and C.R. Wessells (1990), Demand Systems Estimation with Microdata: A Censored Regression Approach, *Journal of Business & Economic Statistics*, Vol. 8, No. 3. (Jul., 1990), pp. 365-371.

Hérault, N. (2006). Building and linking a microsimulation model to a CGE model for South Africa. South *African Journal of Economics.* Volume 74, Issue 1, pages 34–58, March 2006

Hérault N (2010) Sequential Linking of Computable General Equilibrium and Microsimulation Models: A Comparison of Behavioural and Reweighting Techniques. *International Journal of Microsimulation* 3:35–42.

Hertel, T. W and L. A. Winters (eds.) (2006), *Poverty and the WTO: Impacts of the Doha Development Agenda*, Palgrave Macmillan and the World Bank, Washington, DC

Howe, H. (1975). Development of the extended linear expenditure system from simple saving assumptions, *European Economic Review*, Volume 6, Issue 3, July 1975, Pages 305‑310

IEA, (1999) *World Energy Outlook 1999,* IEA/OECD Publishing.

IEA, (2006) *World Energy Outlook 2006,* IEA/OECD Publishing.

IEA, (2008) *Energy Policy Review of Indonesia,* OECD/IEA Publishing

IEA, (2010a) *World Energy Outlook 2010,* IEA/OECD Publishing

IEA, (2010b) Analysis of the scope of Energy Subsidies and Suggestions for the G-20 initiative, IEA, OPEC, OECD, World Bank Joint Report, Prepared for submission to the G-20 meeting, Toronto (Canada)

.IEA, (2011) *World Energy Outlook 2011*, IEA/OECD Publishing.

IEA, (2013) *World Energy Outlook 2013,* IEA/OECD Publishing.

Ivanic, M. (2004) Reconciliation of the GTAP and Household Survey Data, *GTAP Technical paper 31*

IISD (2012) "A citizen's guide to energy subsidies in Indonesia, 2012 update", International Institute for Sustainable Development, Report

http://www.iisd.org/gsi/sites/default/files/indonesia_czguide_eng_update_2012.pdf

Ju, J. (2011). Consumer Heterogeneity, Free Trade, and the Welfare Impact of Income Redistribution. *Review of International Economics, 19(2), 288–299. doi:10.1111/j.1467-9396.2011.00947.x*

Jung, H. and E. Thorbecke (2003), "The impact of public education expenditure on human capital, growth, and poverty in Tanzania and Zambia: a general equilibrium approach*", Journal of Policy Modeling*, vol. 25, no. 8, pp. 701-725.http://dx.doi.org/10.1016/S0161-8938(03)00060-7

Kriström, B. (2006), Framework for assessing the distribution of financial effects of environmental policy, in Eds, Ysé Serret and Nick Johnstone, *The Distributional Effects of Environmental Policy*, Edward Elgar, Cheltenham, UK.

Kullback, S. and R. Leibler (1951), «On information and sufficiency *», Annals of Mathematical Statistics*, vol. 22, no. 1, p p. 79-86

Lewbel, Arthur. (2008). *Engel Curve.* The New Palgrave Dictionary of Economics, 2nd edition, edited by Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan

Little, R. J. and D.B. Rubin, (2002) *Statistical Analysis with Missing Data*, Second edition, New York: Wiley

Lluch, C. & R. Williams. (1975). Cross Country Demand and Savings Patterns: An Application of the Extended Linear Expenditure System, *The Review of Economics and Statistics*, Vol. 57, No. 3 (Aug., 1975), pp. 320-328

Lofgren, H., Robinson, S. and M. El-said.(2003) Poverty and Inequality Analysis in a General Equilibrium Framework : The Representative Household Approach. pp 325-337 in eds. Bourguignon, F. And L.A. Pereira da Silva. *The Impact of Economic Policies on Poverty and Income Distribution: Evaluation Techniques and Tool*. World Bank and Oxford University Press, Washington, DC and New York

McDougall, Robert A., (1999) Entropy Theory and RAS are Friends, GTAP Working Papers. No300 http://docs.lib.purdue.edu/gtapwp/6

Metcalf , G. E. (1999), A Distributional Analysis of Green Tax Reforms. *National Tax Journal* 52 (1999):655-681. Available at: http://works.bepress.com/gilbert_metcalf/13

Miller, R.E. and P.D. Blair, (2009) *Input-Output Analysis. Foundations and Extensions*, Cambridge University Press

Miranti, R., et al. (2013), Trends in Poverty and Inequality in Decentralising Indonesia, *OECD Social, Employment and Migration Working Papers*, No. 148, OECD Publishing.doi: 10.1787/5k43bvt2dwjk-en

Mourougane, A. (2010), Phasing Out Energy Subsidies in Indonesia. *OECD Economics Department Working Papers*, No. 808, OECD Publishing.

Narayanan B.G. and T.L. Walmsley (2008). *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

OECD (2010), Phasing out energy subsidies, in *OECD Economic Surveys: Indonesia 2010*, OECD Publishing. http://dx.doi.org/10.1787/eco_surveys-idn-2010-5-en

OECD (2012), *OECD Economic surveys: Indonesia 2012*, OECD Publishing. http://dx.doi.org/10.1787/eco_surveys-idn-2012-en

OECD (2012b), *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD Publishing. doi: 10.1787/9789264122246-en

Pollak R. A. & Wales T. J. (1969). Estimation of the Linear Expenditure System. *Econometrica*, Vol. 37, No. 4 (Oct., 1969), pp. 611-628

Rausch, S. and T. F. Rutherford (2010), Computation of Equilibria in OLG Models with Many Heterogeneous Households, *Computational Economics* Vol. 36, No. 2, pp. 171-189,

Rausch, S., Metcalf, G. E. and J. M. Reilly (2011), Distributional impacts of carbon pricing: A general equilibrium approach with micro-data for households, *Energy Economics*, Vol. 33, Sup. 1, pp. S20-S33, doi: http://dx.doi.org/10.1016/j.eneco.2011.07.023

Ravallion, M. and M. Lokshin (2004) Gainers and losers from trade reform in Morocco. *World Bank Policy Research Working Paper* 3368, August 2004

Reimer, J. and T. Hertel , (2003) International Cross Section Estimates of Demand for Use in the GTAP Model, *GTAP Working Papers 1190*, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Reimer J, Hertel T (2004) Estimation of International Demand Behaviour for Use with Input-Output Based Data. *Economic Systems Research*,16:347–366. doi: 10.1080/0953531042000304245

Robilliard, A. and S. Robinson (2001). Reconciling household surveys and national accounts data using a cross entropy estimation method. *TMD Discussion Paper* No. 50. International Food Policy Research Institute.

Round, J. (2003). *Social Accounting Matrices and SAM-based Multiplier Analysis.* Washington DC: The World Bank.

Rutherford T, Tarr D, Bank TW (2005) Poverty Effects of Russia ' s WTO Accession : modelling "real " households and endogenous productivity effects By Household and Poverty Effects from Russia's Accession to the WTO. *World Bank Policy Research Working Paper 3473*, January 2005

Rutherford, T., Tarr, D., and O. Shepotylo (2006), "The Impact on Russia of WTO Accession and The Doha Agenda: The importance of liberalization of barriers against foreign direct investment in services for growth and poverty reduction" in, Hertel, T. W. and L. A. Winters, (eds.) (2006), Poverty and the WTO: Impacts of the Doha Development Agenda, Palgrave Macmillan and the World Bank, Washington DC

Sadoulet, E. & A. de Janvry (1995). *Quantitative Development Policy Analysis.* The Johon Hopkins University Press. Baltimore and London. 1995

Savard, L.(2005) . Poverty and Inequality Analysis within a CGE Framework: A Comparative Analysis of the Representative Agent and Microsimulation Approaches, *Development Policy Review*, 2005, 23 (3): 313-331

Shonkwiler, J.S. and S.T. Yen (1999), Two-steps estimation of a censored system of equations, *American Journal of Agricultural Economics 81, 972-982*

Spadaro, A. (2007). Microsimulation as a tool for the evaluation of public policies: methods and applications. *Fundacion BBVA*, 2007

Stone R. (1954): Linear expenditure system and demand analysis: an application to the pattern of British demand. *The Economic Journal 64 (255). 511-527.*

Strauss, J., F. Witoelar, B. Sikoki and A.M. Wattie. (2009) *The Fourth Wave of the Indonesian Family Life Survey (IFLS4): Overview and Field Report*. April 2009. WR-675/1-NIA/NICHD.

Tauchmann, H. (2010), Consistency of Heckman-type two-step estimators for the multivariate sample-selection model, *Applied Economics Volume 42, Issue 30, 2010*

Tobin, J. (1958).Estimation of Relationships for Limited Dependent Variables. *Econometrica*, Vol. 26, No. 1. (Jan., 1958), pp. 24-36.

UNECE (2011) *Canberra Group Handbook on Household Income Statistics*. United Nations Economic Commission for Europe, Geneva

United Nations and European Commission & International Monetary Fund & Organisation for Economic Co-operation and Development. & World Bank, (2009*) System of national accounts 2008*. New York: United Nations

UNSD, (2002) *International Standard Industrial Classification of All Economic Activities. ISIC Rev. 3.*, United Nations Statistic division, New York

WB, (2011) *Indonesia economic quarterly. 2008 again?*, The World Bank

WB, (2013*) Indonesia economic quarterly. Adjusting to pressure*, The World Bank

Widodo, T., G. A. Sahadewo, S. U, Setiastuti and M. Chaerriyah (2012), "Impact of Fuel Subsidy Removal on the Indoesian Economy ' in Wu, Y., X. Shi, and F. Kimura (eds.), *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies*, ERIA Research Project, Report 2011-17, Jakarta: ERIA, pp.173-206.

Yusuf AA, Resosudarmo BP (2007) On the Distributional Effect of Carbon Tax in Developing Countries: The Case of Indonesia, *Australian National University Economics and Environment Network Working Paper, EEN0706*

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association* 57: 348–368.

Data sources

IFLS4 http://www.rand.org/labor/FLS/IFLS/download.html

PovcalNet: the on-line tool for poverty measurement developed by the Development Research Group of the World Bank, retrievable at: http://iresearch.worldbank.org/PovcalNet/index.htm?3

World DataBank, Sustainable energy for all, retrievable at:

http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=sustainable-energy-for-all

Appendix I

Comparison between original and reconciled survey data

The reconciled expenditure differs for the original survey data. The original survey budget shares have been substantially modified. The changes reflect the discrepancies, seen on Table 6, between the sum of consumptions in the survey data and the SAM consumptions. More particularly, after reconciliation, the share of electricity in consumption divided by two (-50%) for all the defiles. The share of food and agricultural products decrease strongly, to the benefit of services and agricultural products.

Deciles	Transport	Fuels	Electricity	Agriculture	Services	Food products	Total manufacturing
1	2	0	-49	-32	42	-27	75
2	2	-1	-49	-33	38	-27	74
3	2	-1	-49	-33	37	-28	72
4	2	-1	-50	-34	36	-28	71
5	1	-1	-50	-34	32	-30	70
6	1	-1	-50	-34	29	-30	69
7	1	-1	-50	-35	26	-31	67
8	1	-1	-50	-35	23	-31	65
9	0	-2	-50	-36	17	-32	60
10	-1	-2	-50	-37	9	-34	55

Table 18: Percent increase (%) of survey data budget shares after reconciliation

deciles	Labour	Capital	Land	Natural resource	Transfers*
1	-29	-28	-27	156	1617
2	-17	-16	-15	208	1747
3	-13	-16	-12	197	1650
4	-10	-10	-16	175	1657
5	-8	-8	-11	192	1528
6	-10	0	-8	224	1583
7	-9	2	-11	215	1598
8	-9	8	-16	202	1547
9	-7	2	-6	230	1488
10	-4	2	-26	186	1234

**The transfers we adjusted before the entropy procedure based on their distribution in IFLS4 survey results

Table 19 Percent increase (%) of incomes shares after reconciliation

Appendix II

		Coef.	Std. Err.	z	P>z
Agriculture	$\boldsymbol{\beta}^*$	0.04	0.00	3,601.20	-
	$\boldsymbol{\alpha}$	260.84	0.13	2,039.13	-
Food	$\boldsymbol{\beta}^*$	0.06	0.00	4,360.60	-
	$\boldsymbol{\alpha}$	480.81	0.19	2,534.29	-
Fuel	$\boldsymbol{\beta}^*$	0.01	0.00	1,801.04	-
	$\boldsymbol{\alpha}$	86.26	0.04	2,031.34	-
Electricity	$\boldsymbol{\beta}^*$	0.01	0.00	2,945.58	-
	$\boldsymbol{\alpha}$	25.67	0.02	1,129.83	-
Transport	$\boldsymbol{\beta}^*$	0.03	0.00	3,494.12	-
	$\boldsymbol{\alpha}$	-14.75	0.12	- 118.98	-
Manufacturing	$\boldsymbol{\beta}^*$	0.13	0.00	6,558.00	-
	$\boldsymbol{\alpha}$	- 258.07	0.26	- 981.69	-
Services	$\boldsymbol{\beta}^*$	0.35	0.00	13,000.00	-
	$\boldsymbol{\alpha}$	- 541.51	0.34	- 1,573.46	-
Construction	$\boldsymbol{\beta}^*$	0.00	0.00	12,000.00	-
	$\boldsymbol{\alpha}$	- 0.05	0.00	- 2,410.40	-

Table 20 SURE estimation results, country level

	Agriculture	Food	Fuel	Electricity	Transport	Manufacturing	Services	Construction
Agriculture	1							
Food	0.212	1						
Fuel	0.1303	0.101	1					
Electricity	0.0158	-0.0036	0.0698	1				
Transport	-0.0657	-0.0689	-0.0172	0.0131	1			
Manufacturing	-0.1489	-0.1376	-0.0787	-0.0148	-0.031	1		
Services	-0.3511	-0.4398	-0.1539	-0.0548	-0.2686	-0.576	1	
Construction	-0.5102	-0.6015	-0.1979	-0.1096	-0.2454	-0.3274	0.9469	1

Breusch-Pagan test of independence: chi2(28) = 1.15e+08, Pr = 0.0000

Table 21 Correlation matrix of residuals and Breush-Pagan test

Estratto per riassunto della tesi di dottorato

L’estratto (max. 1000 battute) deve essere redatto sia in lingua italiana che in lingua inglese e nella lingua straniera eventualmente indicata dal Collegio dei docenti.

L’estratto va firmato e rilegato come ultimo foglio della tesi.

Studente: Campagnolo Lorenza matricola: 955700

Dottorato: Economia

Ciclo: 25

Titolo della tesi : Distributional effects of energy policy: a micro-macro perspective

Abstract:

This work analyses the profitability of enhancing a macroeconomic framework (Computable General Equilibrium model) using microdata from household surveys and assessing distributional effects on income and consumption induced by a simulated shock. On this purpose, the modelling options range from the fragmentation of the usual representative agent in a multi-household representation to the creation of a soft-link between the household data and the macro model. A focus is presented on inequality and poverty issues in the context of environmental and energy policies.

A non-behavioural microsimulation model is developed and it is used to evaluate the distributional impacts of a policy reducing fossil fuel subsidies in Indonesia. The creation of the microsimulation link begins analysing the 2007 Indonesian household survey (IFLS4, World Bank); it follows a reconciliation procedure with the Indonesian Social Accounting Matrix using the Cross-Entropy method. Around 10000 different households heterogeneous with respect to income sources and expenditure choices and consistent with the macroeconomic variables are represented in the microsimulation module. The policy scenario, implemented using ENV-Linkages model, determines a change of prices, factor remuneration and transfers. The impact of this reform on households’ welfare is analysed under two different revenue recycling schemes (unconditioned lump-sum transfer to all households and increased governmental expenditure) and highlights the heterogeneity of policy effects across households. In the first scenario the reform results strongly progressive and slightly regressive in the second one.

Furthermore, the behavioural response of household to energy policy is estimated using the Indonesian household survey data. An Extended Linear Expenditure System is fitted at county level and for urban/rural households taking in account the zero expenditure bias issue. A shock corresponding to a fossil fuel phase-out policy is imposed on consumer prices. The consumption behavioural response in the ELES system, evaluated at country level and for rural and urban

households, draws attention on heterogeneous demand response and on the value added by characterizing expenditure functions across agents.

Estratto:

Questo lavoro analizza la possibilità di introdurre in un modello macroeconomico (Computable General Equilibrium - CGE) dei dati microeconomici provenienti da sondaggi sulle famiglie e di valutare gli effetti redistributivi sul reddito e sul consumo generati dall'introduzione di uno shock esterno. A questo proposito, le possibilità modellistiche vanno dalla frammentazione dell'agente rappresentativo, caratteristico nell'approccio CGE, alla creazione di soft-link tra le variabili microeconomiche, a livello di famiglia e le macro variabili. Una sezione è incentrata sull'analisi della diseguaglianza e povertà nel caso di politiche ambientali ed energetiche.

Lo sviluppo di un modello microeconomico permette di valutare la distribuzione dell'impatto di una politica di riduzione dei sussidi sui combustibili fossili in Indonesia. Il modulo microeconomico si fonda sull'analisi di un sondaggio delle famiglie indonesiane nel 2007 (IFLS4, World Bank) e richiede una procedura di riconciliazione con i dati macroeconomici indonesiani. Il modulo microeconomico descrive 10000 famiglie, eterogenee per fonti di reddito e scelte di consumo, ma in linea con le statistiche macroeconomiche. Lo scenario di policy sviluppato con il modello ENV-Linkages, determina l'alterazione dei prezzi, della remunerazione dei fattori primari e dei trasferimenti. L'impatto della riforma è analizzato considerando due differenti opzioni redistributive delle entrate fiscali generate (trasferimento lump-sum a tutte le famiglie e aumento della spesa governativa) e sottolinea l'effetto eterogeneo della politica sulle differenti famiglie. Nel primo scenario la riforma risulta fortemente progressiva; è invece leggermente regressiva nel secondo caso.

Inoltre le variazioni del consumo delle famiglie in seguito ad una politica energetica vengono stimate con un Extended Linear Expenditure System, usando i dati microeconomici indonesiani. La stima, condotta a livello nazionale e per le categorie di famiglie urbane e rurali, prevede una correzione dell'errore dovuto alle molte osservazioni in cui la spesa risulta nulla. La variazione di prezzo, imposta da una riforma che prevede l'eliminazione dei sussidi sul consumo di combustibili fossili, determina differenti reazioni da parte delle famiglie e sottolinea l'importanza dell'integrazione di questa procedura in un contesto macroeconomico.