

Reforming Subsidies

A Tool-kit for Policy Simulations

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Abstract

The paper provides basic guidelines and tools for simulating subsidy reforms with Stata using a single cross-section survey. Simulations are discussed under a partial equilibrium and medium-term framework using a marginal approach. The paper distinguishes between *single priced products*, such as fuel or bread, and *multiple*

priced products, such as household utilities. Part I provides basic instructions for carrying out subsidy analyses. Part II outlines economic theory and formulae for the two types of products considered. Part III illustrates the use of the Stata codes, which are downloadable from the Internet.

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Reforming Subsidies: A Tool-kit for Policy Simulations¹

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Preface

The objective of this tool-kit is to provide a relatively simple and efficient tool to simulate the impact of price reforms on household welfare and government revenues.

The work is motivated by a combination of factors. First, there is currently a large demand on the part of governments in the MENA region and elsewhere in developing and emerging economies to reform consumption subsidies and reduce budget expenditure on these subsidies. This is due to the increasing fiscal pressure generated by the global increase in commodity and food prices and by the volatility of changes in these prices. In the presence of subsidies on imported food and commodity items, governments have difficulties in predicting budget needs and often find themselves financially uncovered when prices increase. The tool-kit should allow analysts to provide timely responses to governments wishing to understand the economic implications of price changes.

Second, simulating the impact of subsidies reforms on household welfare and government revenues is time consuming. The gathering of data, the preparation of the simulation model and the preparation of a report are all time consuming activities that require months on end to be completed. Because of the volatility of global food and commodity prices, by the time a subsidies report is ready either the government has lost interest in the issue or the data on which the report is based is out of date. The tool-kit proposed should help analysts to significantly improve on speed of analysis.

Third, there is little consistency across existing studies on subsidies in terms of methods to evaluate the impact of price changes on household welfare and government revenues. Some studies use simple incidence analyses, others make an effort to consider behavioral changes and demand elasticities and others are simply silent on the underlying methodology used. The tool-kit proposed outlines in detail assumptions, economic theory, formulae and empirical issues related to the model so that estimations can be replicated with the same methodology for different products and in different countries.

This first version of the tool-kit aims at being simple and focused. The focus is on selected data, products, assumptions, inputs, outputs. The intention is to provide answers for standard cases and data settings. The only data required is one cross-section household survey. Products are stylized into two prototypes described as singled priced goods (such as bread or sugar where prices are fixed irrespective of quantities consumed) and multiple priced goods (such as utilities where prices change according to quantities consumed). Assumptions are limited to the medium-term scenario where we consider inflation and behavioral changes but not savings and investments. The inputs of the model are the price change, inflation and elasticities and the outputs are changes in household welfare and government revenues.

The work complements other efforts carried out by the World Bank on micro-simulations such as the package ADePT and should eventually be integrated into ADePT in a second stage of the work. During the first stage of the work, we expanded on the treatment of inflation, elasticities and multiple priced goods. There is an explicit treatment of inflation as a separate effect from the price shock simulated. An effort is made to provide guidelines for the estimation of demand elasticities for different types of goods. For the first time, we distinguish between single priced and multiple priced goods and provide tools for the analysis of both types of goods. In particular, the case of multiple priced goods is treated in detail with the support of economic theory and estimation formulae for household welfare and government revenues.

We also show how the restructuring of utilities' tariffs has great potential benefits for both equity and efficiency of public spending.

The tool-kit has been designed to be user friendly. All estimation commands have been programmed in Stata. This is the most popular statistical package in the World Bank and also the most popular for distributional analysis worldwide. Users can run Stata modules interactively with windows or by embedding commands in programming codes. This should allow different types of users to take full advantage of the tool-kit.

This is an initial product that is expected to be tested, improved and expanded during the next fiscal year. At present, we are expecting to conduct tests in Morocco, Tunisia and Egypt where governments are currently asking to the World Bank for support in subsidies reforms. To expand on the possible users of the tool-kit, we are planning to create an add-on package for Stata and a new module for ADePT. We will also explore how to extend the work in various directions such as the use of savings to simulate alternative household responses to price changes or the simulations of alternative reforms that include the reform of social assistance benefits. In essence, this is the first stage of a work in progress and we very much hope to receive comments and feedback from readers and users. Please send your views and comments to pverme@worldbank.org and Araar.Abdelkrim@ecn.ulaval.ca.

Part I – Framework

Introduction

The objective of this work is to analyze the distributional implications of subsidies and to simulate the impact of subsidies reforms on household welfare and on the government budget. Our intention is not to provide all possible means of analysis and simulation but to restrict choice to a selected number of tools that require a minimum amount of data and are relatively simple to understand and to implement. The manual wants to serve policy analysts who, as often is the case, need to react quickly to governments' requests. Time and quality of outputs are two dimensions that are normally inversely related. Given that the time given by politicians to analysts is typically short, we try to improve on the quality of outputs by designing standard and data parsimonious routines.⁴

Definitions

Different texts often refer to the same concepts with different names. Here we clarify the jargon that will be used throughout the manual.

It is important to distinguish first the category of subsidized good. We distinguish between **primary, intermediate and final subsidized goods** depending on where the product enters the production chain. This distinction is instrumental in understanding from the start whether we need to look into effects that reach households through other agents. For example, fuel may be considered as a primary product given that is an input for most production processes, although it is also a product that can be consumed by households. Electricity is typically an intermediate product as it needs some form of energy to be produced and is also a production input for other productions, although is also a final product consumed by households. A product like bread instead is a final product as it does not usually enters other processes of production and is directly consumed by households. The categorization in these three types of products helps us to immediately identify some of the boundaries of the analysis as it points to the number of intermediaries and the price-shift mechanisms that we need to consider.

We distinguish between **direct and indirect subsidies** with respect to households. In tax theory, direct taxes are taxes that are paid directly to the government by the tax payer such as the Personal Income Tax (PIT) while indirect taxes are taxes that are first collected by intermediaries such as the Value Added Tax (VAT). Analogously, we can define direct subsidies as subsidies that are provided directly to the beneficiaries such as subsidies on bread or electricity and as indirect subsidies as subsidies that are provided to intermediaries such as enterprises.

Following from the above definition, we can distinguish between **direct and indirect effects** of subsidies on household welfare.

⁴ The manual was inspired by an analysis of electricity subsidies conducted in Jordan in November 2011: Verme, P. (2012) "Electricity Subsidies and Household Welfare: Can Household Afford to pay for the Budget Crisis?" mimeo, World Bank.

Direct effects are the price and quantity changes that apply to the final consumer when subsidies on final products are changed. These include the short-term crude change in prices (also called first-round effects) and the medium-term behavioral response of the final consumer in terms of quantities consumed (also called second-round effects, behavioral changes or **demand responses** to price changes).

Indirect effects are those that measure the “trickle down” effect on the final consumers of subsidies applied to intermediaries. The “trickle-down” effects evidently depend on the behavior of the intermediary and on what proportion of subsidies are transferred onto the final consumer. Thus, indirect effects can be considered as the **supply responses** to price changes.

To simplify the exposition, we will consider **partial equilibrium effects** those that consider only direct effects of price reforms and **general equilibrium effects** those that consider both direct and indirect effects on the whole economy.

Focus of the work

Subsidies cover a wide array of products and services and, in very broad terms, one could argue that all government expenditures can be considered as a form of subsidy. Analysis of subsidies and simulations of subsidies reforms can also cover a wide array of technical issues and become extremely complex exercises. This section delimits the boundaries of the manual.

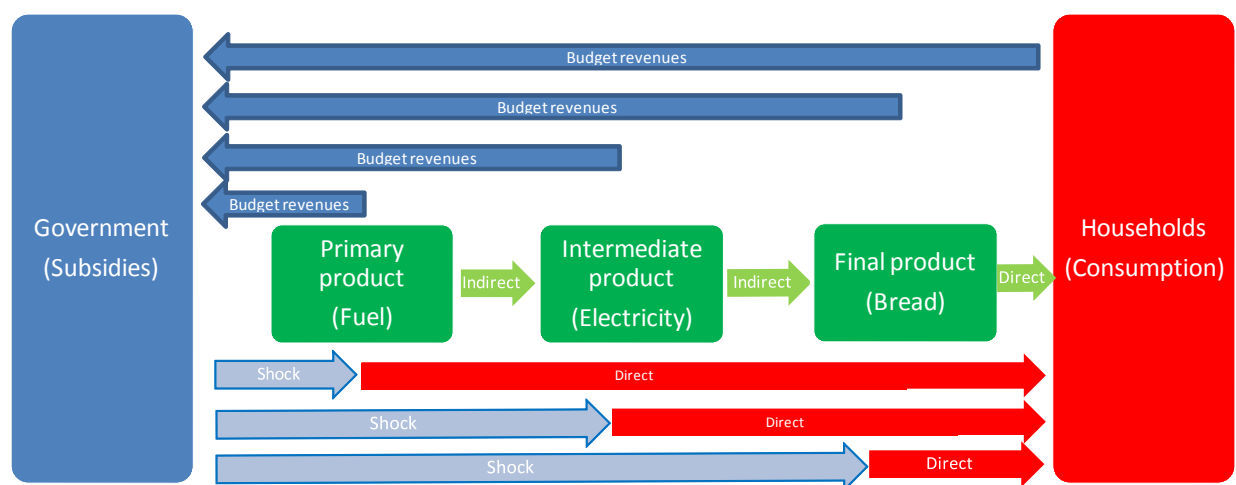
The following restrictions will apply:

- Two agents are considered, the government and consumers represented by households. The government sets the prices of subsidized commodities and households react to changes in prices. If more detailed information on production is available the analyst will be enabled to use some of this information in order to refine the estimation of the impact of reforms.
- Products considered will be those that are consumed by households and subsidized by the government. This typically restricts the range of products to a few items in any given country.
- The analysis is restricted to two prototype products that cover most typologies of subsidized products. The distinction is between single-priced products and multiple-priced products. By single priced-products we mean consumers’ products for which the government fixes the unit price irrespective of quantities consumed. Examples are set prices for bread or sugar. By multiple-priced products we mean products for which the government fixes different prices according to different levels of consumption. Examples are set prices for electricity or water.
- The data requirement is restricted to only one household consumption survey. Users will be enabled to import into the analysis estimations made through other means such as input-output tables or computable general equilibrium models but the assumption is that the analyst has access to only one cross-section household survey. This is the most likely scenario faced by analysts when they first visit a country to carry out a subsidies analysis.
- The focus will be on the medium-term effects as defined further as opposed to short-term and long-term effects.

- The model will treat partial equilibrium effects as opposed to general equilibrium effects. However, general equilibrium effects on prices can be imported into the model to adjust household expenditure for changes in the consumer price index generated by changes in price of the subsidized product.

The figure below summarizes the agents and parameters of the model. The government changes prices of primary, intermediary or final products (shock). Depending on these choices, effects on final consumers will be direct, indirect or both. Final consumers (households) will face direct and indirect effects and will react by changing household behavior. This will result in changes in household expenditure and government revenues.

Subsidies scheme



Process

The process of analysis of subsidies typically implies three main phases. The **first** phase is the **incidence analysis** of subsidies on household welfare. This will include a collection of information on the functioning of the specific subsidy treated, a quantification of the cost of subsidies for the government and a distributional analysis of the incidence of subsidies on household welfare. Governments usually want to know first the total cost of subsidies, who benefits from the existing subsidies and to what extent.

The **second** phase will be the **price shock simulation**. This is when the government wishes to change subsidies by changing the set price of subsidized products or by changing the budget allocations for subsidies. The analyst is asked to study the impact of a set of simulations of the effects of these changes on the budget and on household welfare. For example, the government wishes to increase the price of electricity and would like to know the impact on the government's finances and on household welfare. In this case, the analyst needs to take a number of critical decisions on the exogenous and endogenous parameters to be used, decide the time horizon of the analysis and estimate the relevant elasticities to run the model.

The **third** phase is the **impact analysis** when the model is run, the output is analyzed and different alternative scenarios are compared. The table below summarizes the steps.

Table 1 - Process summary

Phase	Step	Action
A - Incidence analysis	1	Product analysis
	2	Budget analysis
	3	Distributional incidence analysis
B - Price shock model	4	Identify the price shock(s)
	5	Define the assumptions
	6	Estimate elasticities
C - Impact analysis	7	Estimate household welfare changes
	8	Estimate budget changes
	9	Compare different scenarios

In what follows, we describe more in detail each step of each phase.

A - Incidence analysis

Step 1 – Product analysis

The first step of Phase A is to study the functioning of the subsidized product. This is perhaps the most time consuming exercise. One needs to understand the entire production and consumption process of the subsidized product to see where subsidies enter the process and then understand how subsidies are administered. In some cases, subsidies are administered on production inputs but the beneficiaries are households via controlled prices. For example, subsidies on wheat or flour are combined with controlled prices on bread so that the final beneficiaries of subsidies are households. The aim of this exercise is to understand whether the subsidized product is a primary, intermediary or final product so as to prepare the setting for the analysis that follows. This manual does not provide any guideline on this step and it is assumed that the analyst is already familiar with the product.

Step 2 – Budget analysis

The objective here is to estimate the total envelope of subsidies in local currency and for the product of interest. This step requires a thorough investigation of the cost of subsidies. In some cases, subsidies are clearly visible in the government budget and the total amounts can simply be taken from the budget. This is the case for example of transfers made to economic agents (public or private) to cover the difference in price of imported goods versus set government prices. In other cases, the evaluation is more subtle and requires estimations of subsidies by means of comparison of set prices with a benchmark international price. This is the case for example of locally produced goods for which the cost of production or the market price in the absence of subsidies is not known. Also, the true cost for the government may include hidden costs such as foregone revenues for the government that would accrue from the elimination of

subsidies in addition to the value of subsidies. This may be the case for example of spill-over effects due to improved market functioning of the subsidized product. The total envelope of subsidies in local currency for the product of interest represents the benchmark for assessing changes in budget revenues further in the process. It is also the monetary value that is used to allocate subsidies to households in the incidence analysis that follows.

Step 3 – Distributional incidence analysis

This step implies a standard welfare distributional analysis. This is a static incidence analysis. There is no “change” to consider but only the existing distribution of subsidies across households. The purpose is to understand whether subsidies are pro-poor or pro-rich and whether subsidies affect the level of poverty and inequality or not. This is an analysis that existing packages like DASP⁵ or ADePT⁶ are perfectly capable of handling but that will be useful to carry out with the tools provided in this manual so that this step will represent the benchmark scenario for the shock and impact analysis. The output of this step will typically be tables and graphs illustrating the distribution of subsidies across households and welfare statistics such as poverty and inequality.

The only data requirement for an incidence analysis is a cross-section household survey that contains information on household expenditure on the subsidized product and the total amount of estimated subsidies on the product or, alternatively, the amount of subsidies as a share of the subsidized price. With this information, the analyst can spread the total amount of subsidies on households according to the share of household expenditure on the overall expenditure on the subsidized product. Or, equivalently, household expenditure on the subsidized good can be multiplied by the amount of subsidies as a share of the subsidized price.

Note that this step is often mistaken for a policy simulation reform that amounts to the elimination of subsidies where the impact of the reform is measured in terms of the difference between the distribution of income with and without subsidies. This is not the case as changes in subsidies imply household behavioral effects on the demand side (in terms of substitution of the subsidized product with other consumption products and in terms of changes in the quantities consumed) and on the supply side (in terms of price-shift behavior of supply agents). This is the reason why we clearly distinguish in this manual between incidence analysis and impact analysis. Under some specific assumptions, the impact analysis of the elimination of subsidies is equivalent to an incidence analysis of the elimination of subsidies but it is important to clearly distinguish between the two exercises. An impact analysis requires a set of preliminary assumptions on household behavior and can result in very different outcomes as compared to an incidence analysis.

⁵ <http://dasp.ecn.ulaval.ca/>.

⁶ <http://www.worldbank.org/adept>.

B – Price shock model

Step 4 – Identify the price shock

There are two main forms of subsidies reforms simulations that have slightly different implications for modeling. These two forms can be regarded as looking at the same problem from two different angles.

The first form is an increase in prices of the subsidized product. The government has an idea of the price increase it wants to apply to the subsidized product and wants to know what this implies for household welfare and government revenues. From a modeling perspective, this is a simple increase in the price of the subsidized product that can be modeled by changing the product price in the household expenditure data.

The second form of subsidies reform simulation is a budget cut that affects agents that manage the subsidized products. For example, the subsidized product may be produced by a public or private company that receives subsidies directly from the government so as to sell the product at regulated prices. In this case, we know the intended budget cut but not the corresponding increase in prices.

To model such change, we can follow one of at least two options. The first option is to spread the budget cut on households proportionally to the share of subsidized product consumed. In this case, households will bear the budget cut in a proportion that is equivalent to the share of subsidized product consumed over total household consumption of that product. This is what we described for the incidence analysis but it is unsatisfactory because amounts to an incidence evaluation where we cannot model elasticities. The second option is to simulate increases in prices that would result in an increase in revenues for the government equivalent to the budget cut. This is a more accurate approach because the final change in government revenues will result from simulations that can take into account price-quantity and cross-price elasticities and other factors that may affect demand. This is the approach followed in this manual.

Step 5 – Define the assumptions

Before modeling changes in subsidies, the analyst needs to make a number of critical decisions on assumptions regarding sequencing of events, deflators, budget constraints and elasticities. To simplify these choices we can think of choosing between modeling short-term, medium-term and long-term effects. As a rule of thumb, we can think of these three time-horizons as described in terms of days, months and years respectively.

Short-term effects (days) include the change in price determined by the government but no inflation adjustments, no behavioral effects and no life-cycle effects. The assumption here is that when the price of a subsidized product increases, in the very short-term, households will simply respond by keeping quantities consumed unaltered and, as a consequence, by increasing expenditure. That is because most households can afford to buy at least once the subsidized product at increased prices and because it is unlikely that households would re-assess their income and budget priorities in a matter of days. Economically speaking, this amounts to assume that households can draw temporarily on savings to increase current expenditure and, by doing so, they lift the budget constraint. The odd effect of this assumption is that, with an increase in price and no inflation adjustments, households will increase

expenditure in real terms. In terms of utility, the household will continue to consume the same quantity of the subsidized good, which means that household utility remains unaltered. To reflect this effect when we measure poverty, the poverty line should also be adjusted by an equivalent amount and this would result in no change in poverty when the price of the subsidized good increase. This is a counterintuitive result that we consider valid only within the boundaries of the short-term assumptions.

Medium-term effects (months) include the change in price, inflation adjustments and consumers' behavioral effects but not life-cycle effects. The assumption here is that the household budget constraint is fixed and that households do not dig into savings to face increased prices but also that households will adapt their behavior to the new prices by substituting the subsidized product with other products and/or by changing the consumed quantities of the subsidized product. In this case, household real expenditure would decrease and poverty may increase. We expect this to be the typical effect that occurs within one-two months from the introduction of the price shock as households reassess their priorities and fully understand the impact of the price change on the household budget.

Long-term effects (years) include the change in price, inflation adjustments, behavioral effects and life-cycle effects (changes in savings and investments over the long-term). In this case, the household budget constraint is not fixed and will depend on the household savings and investment behavior. Depending on the importance of the subsidized product for the household and the size of savings, the household will decide whether to substitute future consumption with current consumption or not. Simulations of long-term effects will imply knowledge of the household savings vector and life-cycle theory assumptions.

In this manual, we will **focus on medium-term effects** as we defined them for various reasons. First, governments are generally uninterested in the short-term effects and little interested in the long-term effects. Medium-term effects are those that are most likely to affect the political cycle and social instability. Second, life-cycle effects require life-cycle assumptions and knowledge about current savings and long-term behavioral attitudes to savings which complicate the model a great deal and increase data requirements and computational complexities. Further, in developing countries, and especially in the poorest among them, the saving component can be neglected because of the low disposable income of the bulk part of the population, which makes the short-term and long-term scenarios less realistic.

Table 2 – Assumptions according to the time horizon

Time horizon	Inflation	Elasticities	Savings
Short-term (days)	No	No	No
Medium-term (months)	Yes	Yes	No
Long-term (years)	Yes	Yes	Yes

Step 6 – Estimate elasticities

We consider here two types of elasticities. The first is the price-quantity elasticity of demand. The question addressed here is of how much quantities demanded by households will change subject to a

change in the price of the subsidized product. The second type of elasticity is cross-price elasticity of demand. The question addressed here is to what extent households will substitute the consumption of the subsidized product for other substitute products subject to an increase in the price of the subsidized product. For example, we try to assess the increase in household consumption of pasta when the price of rice increases.

The estimation of **demand elasticities** is the subject of a rich literature and is product specific. There are at least three types of settings we can consider. Under the first setting, the analyst can draw on the specific literature and borrow demand elasticities estimated elsewhere. For example, in certain countries and for certain products there exist a large literature on the estimation of demand elasticities which can then be used “off the shelves” for modeling. The demand elasticity for electricity in the US is one example. In this case, our manual will simply allow practitioners to input these values into the model.

Under the second setting, the analyst has longitudinal panel data and price shocks of the subsidized product along the period. This is the ideal scenario where demand elasticities can be estimated and then used in the simulation model. In reality, this setting is rare either because panel data are rarely available or because no significant change in prices has occurred.

More often the analyst has only one cross-section household survey, which is the reason why we have chosen to focus on this data setting. With one cross-section survey it is still possible to estimate demand elasticities but this requires price variability in the data. For example, we have representative data by region or district where the subsidized product price changes. Or, alternatively, we have a product with multiple prices across the nation according to quantities consumed (such as utilities prices). In these cases, we can exploit this variability to estimate demand elasticities based on the assumption of homogeneous behavior across households. We can also improve on this assumption by controlling for household characteristics. As compared to the first two options, this is a less appealing option but one that improves on ignoring behavioral effects altogether. Also, in multiple price settings, it is rare to have enough variation in prices to model the impact of the marginal price on consumption.

Cross-price elasticities are typically less important than own-price elasticity of demand to an extent that they are rarely modeled in subsidies reforms. That is because subsidized products tend to be essential items such basic food items or utilities, which are difficult to substitute or do not have natural substitutes. However, it is plausible that for some products and in some countries substitutes exist. For example, in some countries it is possible to partly substitute electricity consumption with gas consumption by using gas heaters as opposed to electricity heaters. The product analysis of Phase I should also have uncovered this type of issues and when substitution is likely to occur to an important extent it is advisable to estimate cross-price elasticities. In fact, given that cross-price elasticities will have an impact on demand elasticities, the two elasticities should be modeled in the same demand equation by controlling for the substitute product consumption.

C – Impact analysis

In this phase we run the model based on the choices made in Phase II and estimate changes in household welfare and the budget revenues subject to the price change. This is the focus of this manual. Part II will describe the economic fundamentals and the formulae derived from theory and assumptions made while Part III will illustrate the application of these tools in Stata. In this section we simply sketch these final steps of the analysis.

Step 7 – Estimate changes in household welfare

Changes in social welfare can be estimated using any distributional measure. In general, governments would be interested in popular measures such as those of poverty or inequality. However, outputs may include other analyses, which may focus on the entire distribution, the middle-class, the relation between the very rich and the very poor, the progressivity of the reform, etc. We can perform dominance tests for the robust ordinal ranking of the distributions before and after the reform simulation. In essence, the output of this step is a typical distributional analysis that compares the benchmark scenario of the initial welfare distribution with the scenario determined by the price shock. Our simulation model will produce two household welfare distributions, one before the price shock and the other after the price shock. The analyst can then compare these two distributions as desired, comparing means, poverty rates, inequality or the entire distributions with stochastic dominance analysis.

This step will also estimate changes in total expenditure on the subsidized good. This is normally the sum of changes in household expenditure across the distribution, which amounts to the total estimated impact on household welfare.

Step 8 – Estimate changes in government revenues

Changes in government revenues are estimated starting from the total changes in household expenditure. However, these two measures do not coincide in our model. That is because of the different deflators used for household expenditure and government revenues. This difference will be explained in detail in Part II. The output of this exercise is a single number which is interpreted as the change in budget revenues due to the price shock determined by the government.

Step 9 – Compare different scenarios

The final product and main objective of the analysis is to provide the government with a short, concise and clear menu of policy options. The principal client of the analysis should be thought as being a Minister with very limited time to dedicate to the issue. The final report on the subsidies analysis may include all of the steps described above but the final product for policy purposes has to be constrained to a few concise pages to be operational.

The final policy note should include the set of assumptions, the budget changes and the welfare changes under different scenarios where scenarios are mainly determined by different price changes and different ranges of elasticities. In essence, this part will focus on determining the sensible lower and upper bounds of the analysis. For example, we may want to run the model with a range of elasticities centered on the estimated elasticity. We may also want to model a range of price changes rather than a single price change.

The example below for electricity subsidies in Jordan illustrates a simple table for presenting results. Estimates of elasticities for the demand of electricity in countries similar to Jordan vary around values of -0.4/-0.5 while our own estimate of elasticity provided a value of -0.55. To make sure of including these estimates and also to allow for a certain margin of error we modeled a lower bound of -0.3 and an upper bound of -0.6. Following discussions with the client about possible reforms in prices, it was finally decided to model a range of price increases in between 30% and 60% which we took as lower and upper bounds. We also agreed with the client on the parameters of interest that were identified in changes in the poverty rate and changes in government revenues. We then presented results on changes in poverty and government revenues by quintiles of electricity consumers using lower and upper bounds of elasticities and two different price increases. It is noticeable how the increase in elasticity can actually outweigh the effect of price increases in terms of budget revenues.

Table 3 – Electricity subsidies reform simulation in Jordan

	Quintiles	Poverty increase (%)		Revenues Increase	
		+30% tariffs	+60% tariffs	+30% tariffs	+60% tariffs
e=-0.3	1	0.0000	0.0000	297,352	506,961
	2	0.0001	0.0003	476,101	811,713
	3	0.0008	0.0022	684,948	1,167,779
	4	0.0006	0.0019	970,770	1,655,084
	5	0.0000	0.0021	1,806,516	3,079,962
	Total	0.0003	0.0014	4,235,687	7,221,499
e=-0.6	1	0.0000	0.0017	107,242	38,997
	2	0.0003	0.0028	171,709	62,439
	3	0.0022	0.0054	247,030	89,829
	4	0.0019	0.0058	350,114	127,314
	5	0.0021	0.0031	651,530	236,920
	Total	0.0014	0.0038	1,527,625	555,500

Source: Verme (2011). (*) Quintiles of electricity consumption.

Part II – Theory and formulae

Introduction

This section is devoted to presenting the theoretical framework for the estimation of the impact of changes in the price of the subsidized goods on household welfare and on government revenues. The basic framework is what we will refer to as the “marginal approach”. The marginal approach refers to the first order approximation of the true impact of the reform. It assumes that, except for the price change, all other determinants of welfare or government revenues remain constant. Thus, implicitly, this approach assumes a constant nominal budget constraint for households and a reduction in real welfare proportional to the price increase.

This Part is divided into two main sections, one dedicated to single priced goods and the second dedicated to multiple priced goods. As already discussed in Part I, single priced goods are subsidized goods where the government set the sale price and this price is the same for any quantity sold on the market. This may be the case of consumption products such as flour or sugar where the government imposes a fixed market price irrespective of the quantities consumed. Multiple priced goods are instead subsidized goods where the government sets different prices for different quantities consumed. This is typically the case of utilities such as water and electricity where different tariffs are set for different consumption blocks.

In terms of modeling price changes, single and multiple priced goods require different frameworks. In the case of single priced goods, modeling is quite straightforward in that an increase in price is simply reflected in a correspondent decrease in quantity consumed and a proportional decrease in real household welfare. In what follows, we will review the estimation of household total expenditure, household expenditure on the subsidized good and government revenues. We will see that the key elements of modeling single priced goods are the estimation of price/quantities elasticities and the treatment of inflation.

In the case of multiple priced goods modeling is more complicated but also more versatile in terms of simulations of price reforms. The main complication derives from the fact that the supply curve – the price schedule – is nonlinear, to different quantities consumed correspond different prices. This brings about an important distinction between average and marginal price that has implications for the estimation of the main outputs considered. For example, estimating price-quantities elasticities with multiple priced goods is more complicated than with single priced good as the modeler is faced with several choices regarding the use of average or marginal prices in the estimation of the demand equation. This part discusses some of these issues and proposes some possible solutions.

Multiple priced goods are also more versatile than single priced goods as they allow for at least three additional types of simulations. The first type is the possibility of simulating different price increases for different consumption blocks. For example, one can assume a price increase of 20% for the first block, 30% for the second block and 40% for the third block in the case of a three blocks’ structure. The second is the possibility to change the structure of the blocks. For example, one could increase or decrease the number of blocks, say an increase from five to ten blocks. And the third is the possibility to change the margins of each block. For example, one could increase or decrease the size of each block to increase or

decrease the number of consumers in each block. The combination of these different options offers a great deal of flexibility to the modeler.

As for the case of single priced goods, in what follows we will discuss for multiple priced goods the estimation of household expenditure, household expenditure on the subsidized goods, government revenues and the treatment of inflation. In addition, we will provide the formulae to estimate the quantities consumed starting from expenditure on the subsidized good and also a discussion on the estimation of elasticities. It should be noted that the estimation of price-quantities elasticities is product specific. For example, there is a vast literature on the estimation of the price-quantities elasticities of electricity consumption, some of which we review in this part of the work. A detailed discussion will be also devoted to changes in the tariff structure of utilities such as electricity. This is perhaps the most promising route of subsidies reforms in terms of equity considerations and one of the main innovations of our model as compared to similar other models.

Notation and economic framework

Let h =households; p =prices; q =quantities; $k \in \{1,2\}$ = the consumer's choice bundle limited to two goods; $t \in \{0,1\}$ = time with time '0' indicating the period before reforms and time '1' indicating the post-reform period. Then, $q_{k,h}^t$ = quantity consumed of good k in time t ; $e_{k,h}^t$ = household expenditure on good k in time t ; and y_h^t = a monetary indicator of household income in time t . For simplicity, we will use as a measure of welfare household expenditure e_h^t , as it is standard practice in welfare analyses.⁷ Given our initial assumptions of fixed nominal budget constraint and no savings, household income will equal household expenditure ($e_h^t = y_h^t$). Δp and Δq will refer to absolute changes and dp and dq will refer to relative changes in prices and quantities respectively so that $dp = \Delta p/p$ and $dq = \Delta q/q$. This also implies that the own-price elasticity of demand can be described as $\mathcal{E} = (\Delta q/q)/(\Delta p/p) = dq/dp$.

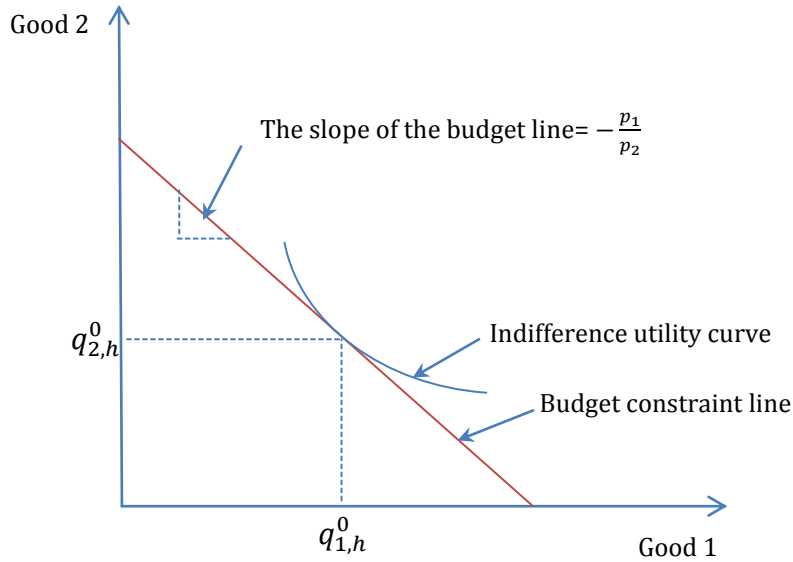
The basic economic framework follows the standard consumer's choice model with two goods and a budget constraint. For simplicity, we will consider good 1 as the subsidized good and good 2 as the bundle of the rest of goods consumed by the household. To simplify the exposition of the marginal approach we will normalize prices to one. The same increase (decrease) in quantities of the two goods buys the same value of the two goods. As an example, we could think of quantities of bread and saffron where one quantity of bread costs 1 USD and is expressed in kilograms and one quantity of saffron costs 1 USD but is expressed in grams. Both quantity units of bread and saffron cost 1 USD but the weight scale is different. This a simple stratagem that allows the budget line to be a 45 degrees line irrespective of changes in relative prices and the Marginal Rate of Substitution (MRS) of the two goods to be equal to one. Therefore, in equilibrium, the marginal rate of substitution (MRS) will be equal to the ratio of prices such that:

$$MRS_{1,2} = \frac{MU_1}{MU_2} = \frac{p_1}{p_2} = 1$$

A graphical representation of the consumer equilibrium is shown in Figure 1.

⁷ For the purpose of this manual, it is irrelevant whether household expenditure is adjusted per capita or per adult equivalent.

Figure 1: Consumer equilibrium



In such framework, a change in price of a given good will reduce the purchasing power of the household and will reduce quantities consumed. If we assume that the reduction in real income is one monetary unit, the household will reduce consumption by one unit, whether the reduction of consumption relates to good 1, good 2 or both. Given that the marginal utility of the two units when we are near equilibrium is equal, any partition of the reduction in consumption will generate a decrease in real income by one unit. In graphical terms, this is equivalent to an inward movement of the budget line when the price of good 1 increases. Depending on how the household splits the reduction in quantity consumed between the two goods, the equilibrium will shift along the budget line. In all cases, the budget line remains a 45 degrees line due to the normalization applied to prices.

To illustrate this again, assume that the basket of goods of a given consumer with an income of 120\$, is composed of two goods, which are flour and oranges. For simplicity, also assume that one kilogram is equal to two pounds. The price of oranges is \$2 per Kg, while that of flour is 1\$ per Kg. At consumer equilibrium, the bought quantities are 10 Kg of oranges and 100 Kg of flour. Equivalently, we can say that the consumer buys 20 pounds of oranges with a price of \$1 per pound. This makes all prices normalized to 1\$. If the price of flour increases by 1%, the consumer can reduce by 1 Kg the quantity of flour (-1%) or by one pound the quantity of oranges. Any combination of reduction in expenditures by, for instance, f in flour and o in oranges such that, $(f + o) = \$1$ respects the budget constraint. Further, this will generate the same decrease in the monetary welfare of the consumer, evaluated at \$1.

Starting from this, the objective is to simulate a price shock occurring to a subsidized good k . Recall that we are working in the framework of a medium-term scenario where we assume that households will adjust the consumed quantities, the nominal budget constraint is fixed, there are no savings (income equals expenditure) and that we can have partial and general equilibrium inflation effects. Formally, the basic notation that we will use is as follow:

$dp_k = \Delta p_k / p_k^0$ = The relative price change of the subsidized item k . This is the partial equilibrium price change and is an input defined by the researcher.

π_k = The inflation or general equilibrium price change due to a change in price of the subsidized good k .

$\epsilon_{k,h} = \frac{\Delta q_{k,h} / q_{k,h}^0}{\Delta p_k / p_k^0}$ = The non-compensated own-price elasticity of demand of good k . This is a parameter to be estimated by the researcher or simply a known parameter to be used in the model.

$dq_k = dp_k \epsilon_{k,h}$ = The change in consumed quantity of good k . This is an output measured on the basis of the first two parameters.

$1/(1 + \pi_k)$ = The general equilibrium deflator.

Δy_h = The change in household real expenditure. This is the first final output of interest.

Δr = The change in government revenues. This is the second final output of interest.

Based on these premises, we will now consider two cases representing two types of goods. The case of single pricing and the case of multiple pricing as described in Part I.

Single pricing

We define single priced goods as the goods for which the government sets the price and the set price does not vary with quantities consumed. This is the case for example of the set price for subsidized bread, sugar or fuel if the unit price is the same irrespective of the quantities consumed by households. We model a price shock and we discuss separately partial equilibrium effects and general equilibrium effects.

Household expenditure

In our current framework, we have assumed that the nominal budget constraint is fixed for all households. When the price of good 1 increases by dp_1 , the consumer faces a reduced real budget constraint and must therefore reduce the consumed quantity. Assume that the consumer can decrease only the quantities of good 1. In such case, the change in quantity of good 1 is $\Delta q_{1,h}^* = -q_{1,h}^0 dp_1$. Of course, the household can select any combination of decrease in quantities of the two goods, but the change in welfare will be $-q_{1,h}^0 dp_1$. In essence, the decrease in welfare (real values) implied by the increase in price of good k is

$$\Delta e_h = \Delta y_h = -e_{k,h}^0 dp_k$$

This means that all we need to know to estimate the change in welfare is the change in price, which is decided by the researcher or indicated by the government, and the expenditure on the subsidized good at

time `0`, which is information available in household consumption surveys. Note that this approach leads to the same result as the Laspeyres measure of welfare change and is consistent with the approach proposed by Coady (2006).

Household expenditure on the subsidized good

Let us start by expressing the nominal expenditure in period 1 of the household h after the increase in price of good k by:

$$\tilde{e}_{k,h}^1 = q_{k,h}^1 p_k^1$$

We need therefore to know the new price and the new purchased quantities.

For the change in price, we assume that this applies instantly so that:

$$\begin{aligned} p_k^1 &= p_k^0 + dp_k \\ &= 1 + dp_k \end{aligned}$$

For the change in quantities, the adjustment may depend on several factors. However, for simplicity, we assume that the consumer adjusts quantities based on its preferences, and subsequently, on the elasticity of demand of the good with respect to its price. Recall that the non-compensated elasticity of demand of good k with respect to its own price is

$$\epsilon_{k,h} = \frac{\Delta q_{k,h}/q_{k,h}^0}{\Delta p_k/p_k^0} \text{ and that } p_k^0 = 1.$$

Then, the new quantity at time 1 can be described as:

$$\begin{aligned} q_{k,h}^1 &= q_{k,h}^0 + \Delta q_{k,h} \\ &= q_{k,h}^0 + q_{k,h}^0 \epsilon_{k,h} dp_k \\ &= q_{k,h}^0 (1 + \epsilon_{k,h} dp_k) \end{aligned}$$

Subsequently, the new household nominal expenditure on good k can be expressed as

$$\tilde{e}_{k,h}^1 = q_{k,h}^0 (1 + \epsilon_{k,h} dp_k) (1 + dp_k);$$

the change in household nominal expenditure on good k is

$$\begin{aligned} \Delta \tilde{e}_{k,h} &= e_{k,h}^0 (1 + \epsilon_{k,h} dp_k) (1 + dp_k) - e_{k,h}^0 \\ &= e_{k,h}^0 dp_k (1 + \epsilon_{k,h} (1 + dp_k)) \end{aligned} ;$$

and the change in household real expenditure on good k is

$$\Delta e_{k,h} = e_{k,h}^0 (1 + \epsilon_{k,h} dp_k) - e_{k,h}^0$$

$$\Delta e_{k,h} = e_{k,h}^0 \epsilon_{k,h} dp_k.$$

When $\epsilon_{k,h} = 0$, the household continues to buy the same quantity of good k and expenditure on good k increases. However, given the fixed budget constraint, the household must reduce expenditure on the rest of goods.

When $\epsilon_{k,h} = -1$, the consumer reduces the quantity of good k by the proportion dp_k . In this case, the reduction in real household expenditure is $de_h = -e_{k,h}^0 dp_k$ and there is no need for the household to reduce expenditure on other goods.

Finally, the total change in household real expenditure on good k is

$$\Delta e_k = \sum_{h=1}^H e_{k,h}^0 \epsilon_{k,h} dp_k$$

And the final household real expenditure on good k is

$$e_k^1 = e_k^0 + \Delta e_k$$

Government revenues

We now turn to estimate the change in the nominal government revenues. Formally, the change in nominal revenue is the same as the nominal change in household expenditure:⁸

$$\begin{aligned} \Delta \tilde{r}_h &= \tilde{e}_{k,h}^1 - e_{k,h}^0 \\ &= e_{k,h}^0 (1 + \epsilon_{k,h} dp_k)(1 + dp_k) - e_{k,h}^0 \\ &= e_{k,h}^0 dp_k (1 + \epsilon_{k,h} (1 + dp_k)) \end{aligned}$$

However and unlike household expenditure, the change in nominal government revenues can be considered as a proxy of the change in real government revenues. That is because the inflation effect of the increased revenues for the government is negligible.⁹ With this assumption, the total change in government nominal and real government revenues will be

$$\Delta \tilde{r}_h \cong \Delta r_h = \sum_{h=1}^H e_{k,h}^0 dp_k (1 + \epsilon_{k,h} (1 + dp_k))$$

and the final government revenue will be

⁸ If we consider that the change in price is small (say 2-3%), then the term $e_{k,h}^0 \epsilon_{k,h} (dp_k)^2$ can be neglected and $d\tilde{r}_h = e_{k,h}^0 dp_k (1 + \epsilon_{k,h})$.

⁹ For example, with an increase in price of 1% and with an average share of expenditures on the good of 1% the increase in inflation will be only of about 0.01%.

$$r_h^1 = r_h^0 + \Delta r_h$$

Inflation adjustments

As already discussed, we are working on the assumption that the researcher has only one cross-section survey and that simulations are conducted only with this survey. We cannot therefore model general equilibrium effects considering all agents and all markets. We can, however, make price adjustments using changes in the Consumer Price Index (CPI) generated by changes in price of the subsidized good.

Changes in the CPI that imply only the change in price of the subsidized good can be estimated using any price index. For instance, using the Laspeyres price index, we find that:

$$\begin{aligned} 1 + \pi_k &= \prod_{j=1}^K (1 + dp_j)^{\alpha_j} \\ &= (1 + dp_k)^{\alpha_k} \end{aligned}$$

where α_k is the average share of expenditure on the good k . In our case, the average level of prices is 1 in the initial period and the increase in average prices is π_k . To be noted here, when α_k is relatively small, π_k tends to zero and its impact can be neglected. This would be the case of most subsidized products that occupy a relatively small share of the CPI basket.

Note that, when the elasticity is the same for all households, we find that:

$$\Delta r = \tau_k r^0$$

$$\text{with } \tau_k = \left[\frac{dp_k (1 + \epsilon_k (1 + dp_k))}{1 + \pi_k} \right].$$

This formula may help to find the appropriate increase in price to generate a predefined level of change in real revenues.

$$dp_k = \frac{-(1 + \epsilon_k) - \sqrt{(1 + \epsilon_k)^2 + 4\epsilon_{k,h}\tau_k(1 + \pi_k)}}{2\epsilon_{k,h}}$$

To be noted here that in the case where the interaction effect is neglected, the predefined level of change in real revenues is:

$$dp_k = \tau_k \left(\frac{1 + \pi_k}{1 + \epsilon_k} \right)$$

For many products such as primary or intermediate products (fuel or electricity for example), we should also expect that a change in price will result in changes in prices of other products. This effect can be simulated using input-output tables or general equilibrium models or this information may simply be available from previous studies. In these cases, we can simply import the CPI change into our model.

Whether we estimate the CPI change on the subsidized product or on all products, the general equilibrium case implies deflating household expenditure and government revenues by the inflation rate generated by the change in the price of the subsidized good. With inflation adjustments, the final government revenues are simply described as

$$r_h^1 = \frac{\tilde{r}_h^1}{1 + \pi_k}$$

Note that $\Delta e_k \neq \Delta r$.

Estimating elasticities

We have seen that to estimate changes in total revenues we need to know the demand elasticity of the subsidized good to changes in prices. This elasticity may be known for the particular good treated. For example, country and sector specialists may already know rather well demand elasticities for specific subsidized goods and, in this case, all we need to do is to use these known elasticities. However, in many cases, demand elasticity is not known in advance and will have to be estimated. The economic framework is simply the classic demand schedule where the slope of the demand and the elasticity is given by $-dq/dp$ or. With only a cross-section survey, we may have variation in price (say across regions or districts). In such case it is possible to estimate the demand elasticity with a simple equation as proposed by Deaton (1997):

$$\ln q_h = \alpha + \beta \ln e_h + \gamma \ln p_{1,h} + \varepsilon_h$$

where β is the expenditure (income) elasticity and γ is the own-price elasticity, which is our parameter of interest. This equation is a very general equation that can rarely be applied as such. Depending on the type of good considered, we may want to control for various factors such as substitutes goods or use fixed effects for spatial indicators such as urban or rural areas or municipalities. Moreover, with subsidized goods, it is rare to find variation in prices across regions or districts in cross-section surveys. Indeed, this would imply different subsidies across areas. Therefore, the equation above can only be considered as a broad baseline equation that need to be adjusted and tailored to the particular good and country treated.

The equation above also assumes that demand elasticity is equal for all consumers while we may want to consider different elasticities for different types of consumers such as the poor and the non-poor or people living in urban or rural areas. This can be easily done by estimating different equations that may also be adjusted for the specific conditions of the different groups by adding specific control variables. However, the important point to retain here is that there is no universal model to estimate demand elasticities and researchers will have to find the most appropriate model case by case.

Multiple pricing

For some goods, pricing is not homogeneous across quantities consumed, a case often referred to as non-linear pricing. The generic term *nonlinear pricing* refers to any case in which the tariff is not strictly

proportional to the quantity purchased. This applies to regulated and non-regulated prices for goods where, to different levels of consumption, correspond different levels of prices. This is typically the case of utilities such as electricity or water where the price is set according to the consumed quantity.

For simplicity, assume that we have two goods, electricity, which we call good 1, and the rest of goods which we call good 2. Further, assume that the price of electricity is defined by two blocks of consumed quantities as follows:

The price schedule

Block	Price
1: $[0 - Q_1]$	$p_{1,1}$
2: $[Q_1 \text{ and more}]$	$p_{1,2}$

In this case, the *marginal price* for a given consumer refers to the price of the last block of consumption. In what follows we will also consider the most common case where consumers pay the marginal price for each block for the quantities consumed in each block and not the marginal price of the last block on the whole consumption. This is similar to progressive taxation on income where tax payers pay the lowest tax rate for the first block of income and increasingly higher tax rates for subsequent blocks of income as income increases.

It should be noted here that, in the case of goods characterized by block tariffs such as utilities, at least two different types of tariffs exist. Similar to Komives et al. (2006) we call the first type *Increase Block Tariffs* (IBT). This is where the household pays the price for the block of consumption in which it falls for all consumed units. The second type is *Volume Differentiated Tariff* (VDT). In this case, the household pays different prices on their consumed units for each block covered by consumption. To be noted here that, when the number of blocks increases, this makes the VDT type converging towards the IBT type. In this paper, we focus only on the VDT type. This is justified by the fact that this structure is the most common type of tariff structure used in developing countries.

Estimation of consumed quantities

With multiple pricing, the estimation of the quantities consumed by the household is also a little more complicated given that household surveys typically contain information on expenditure but not on quantities consumed of a good such as electricity. Households report expenditure as shown on the electricity bill but not the kWh consumed. However, the quantities consumed can be easily estimated.

Let B = the number of tariff blocks with $b = (1, \dots, B)$ and $B > 1$; Q_b the upper kWh consumption within block b and \bar{e}_b the upper expenditure threshold in block b . Then, consumption of electricity in kWh for each household belonging to each bracket can be calculated as follows:

$$kWh_{h,b} = \begin{cases} \frac{e_{h,1}}{p_1} & \text{for } b = 1 \\ \sum_{j=1}^{b-1} Q_j + \frac{e_{hb} - \bar{e}_{b-1}}{p_b} & \text{for } b > 1 \end{cases}$$

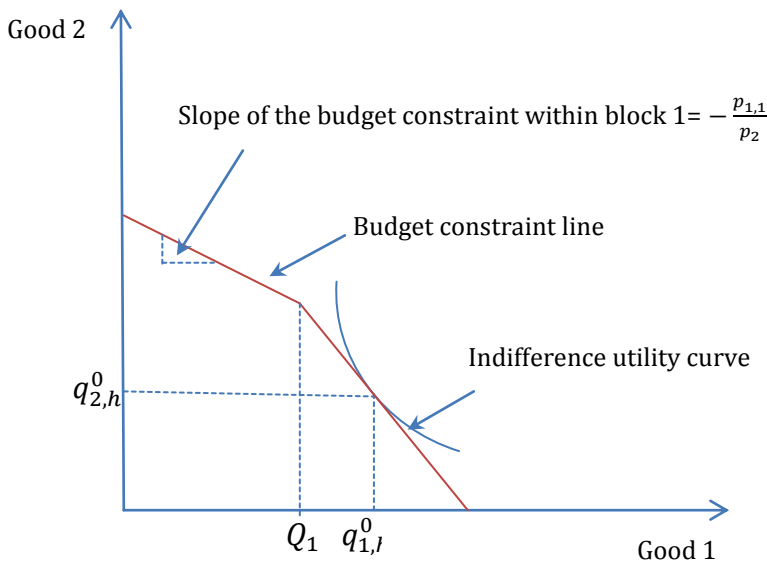
It is important to keep in mind that, in the case of multiple priced goods such as utilities, households may report expenditure on more than one period or they may not report or report only in part expenditure if they are late with payments (arrears). This will affect the total expenditure on the subsidized utility and, by consequence, the estimate of the quantities consumed and the estimate of the welfare impact. It is important therefore to collect information from the utilities companies on payments and arrears to have a sense of the scale of the problem. By comparing the utility company revenues by tariff block with the revenues by block calculated from the household surveys one can see how good the survey is in capturing expenditure on utilities. Also, by using the company information on arrears by tariff block, one can use this information to impute the missing expenditure into the survey data in an effort to correct the bias caused by arrears.

Household expenditure

In figure 2, we show the equilibrium of a consumer when we assume the case of an increasing marginal price schedule with $p_{1,1} < p_{1,2}$. The budget constraint is the inflected line. We assume also that the consumer prefers to consume a quantity of electricity which is higher than Q_1 . In equilibrium:

$$MRS_{1,2} = \frac{MU_1}{MU_2} = \frac{p_{1,2}}{p_2}$$

Figure 2: Consumer equilibrium



As before, we normalize all prices to one. In the case of electricity with two prices, the normalization applies to the last price block as follows:

The price schedule

Block	Price
1: $[0 - Q_1]$	$p_{1,1}/p_{1,2}$
2: $]Q_1 \text{ and more}]$	1

With non-linear pricing the analysis is basically the same as before at the margin, or in the block tariff where the household consumption is actually located. In the last tariff block, we apply the same approach as illustrated for single priced goods.

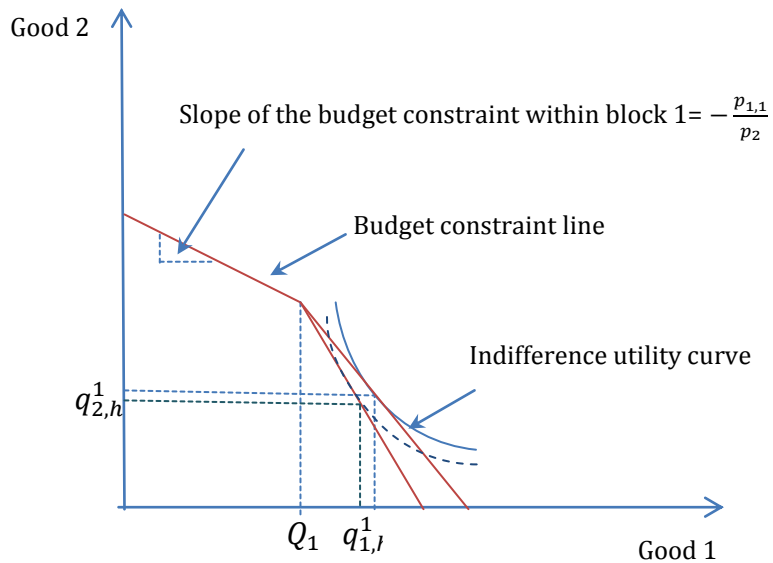
With multiple pricing, the government may decide to increase (decrease) tariffs for one block, multiple blocks or all blocks. It may also decide to apply different increases in tariffs to different blocks.

Let us consider first the case of an increase in price in only one block, say the second block in a two blocks' structure. In figure 3, we show the new consumer equilibrium when we assume an increase in its marginal price of block 2 by $p_{1,2}$. As before, the change in welfare can be estimated with the marginal approach. If we denote the total expenditure of household h within each block b by $e_{1,h,b}^0$, the change in welfare equals to:

$$\Delta e_h = \Delta y_h = -e_{1,h,2}^0 dp_{1,2}$$

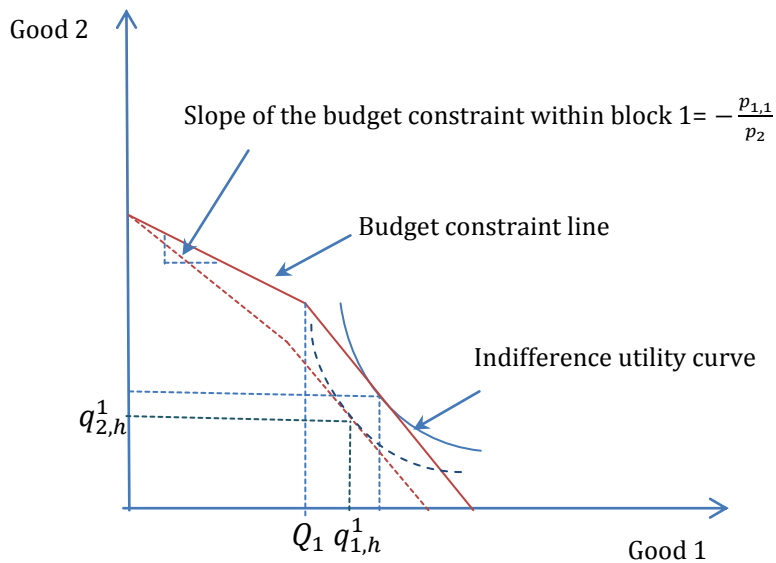
Thus, the reduction in the purchasing power of the household will depend on the consumed quantity of the last block and on the amplitude of the price change in this block.

Figure 3: Consumer equilibrium with schedule price change (case 1)



Now, assume that the change of price occurs in the first block only ($dp_{1,1}$), as shown in figure 4 below. If the decrease in the consumed quantities will concern only electricity, the consumer must decrease the quantity consumed by a number of units within block 2 for an amount equal to $e_{1,h,1}^0 dp_{1,1}$.

Figure 4: Consumer equilibrium with schedule price change (case 2)

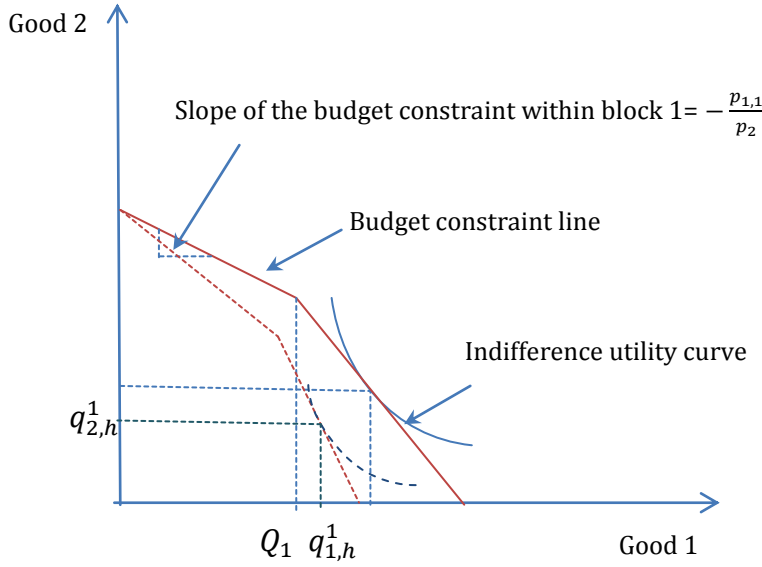


Starting from this, we can now write a general formula, in which we assess the change in welfare implied by the change in the prices of the B blocks:

$$\Delta y_h = - \sum_{b=1}^B e_{1,h,b}^0 dp_{1,b}$$

Note that this simple formula can accommodate any form of price increase, in one block, multiple blocks and with different price changes in different blocks. For example, in figure 5, we show the case of change in the price of the two blocks. Thus, the consumer will adjust bought quantities to the new budget constraint.

Figure 5: Consumer equilibrium with schedule price change (case 3)



In addition to price changes, the number of blocks may also change. For instance, assume that initially, we have two blocks such as:

$$\text{Block}_1 : [0, Q_1^0] \rightarrow p_{1,1}^0$$

$$\text{Block}_2 :]Q_1^0, \text{more}] \rightarrow p_{1,2}^0$$

Assume also that the price schedule after the reform takes the following form:

$$\text{Block}_1 : [0, Q_1^1] \rightarrow p_1^1$$

$$\text{Block}_2 :]Q_1^1, Q_2^1] \rightarrow p_2^1$$

$$\text{Block}_3 :]Q_2^1, \text{more}] \rightarrow p_3^1$$

To assess the change in welfare, we begin by representing each of the two price schedules in an appropriate common price schedule. For example, assume simply that $Q_1^2 < Q_1^0$ and $Q_2^1 > Q_1^0$, the two price schedules can be represented as follows:

Block	Initial	Final
$[0, Q_1^1]$	p_1^0	p_1^1
$[Q_1^1, Q_1^0]$	p_1^0	p_2^1
$[Q_1^0, Q_2^1]$	p_2^0	p_2^1
$[Q_2^1, \text{more}]$	p_2^0	p_3^1

Household expenditure on the subsidized good

We derive the nominal change in household expenditure on good k. First, assume that we have two blocks and the change in prices occurs only in the second block. Thus, we have:

$$\widetilde{\Delta e}_{k,h} = \widetilde{\Delta e}_{k,h,2} = e_{k,h,2}^0 dp_{k,2} (1 + \epsilon_{k,h}(1 + dp_{k,2}))$$

When the interaction effect of change in quantity and price is omitted we find that:¹⁰

$$\widetilde{\Delta e}_{k,h} = e_{k,h,2}^0 dp_{k,2} (1 + \epsilon_{k,h})$$

Now, assume the inverse case, in which only the price of the first block changes. The change in nominal expenditure is then:

$$\Delta \widetilde{e}_{k,h} = \Delta \widetilde{e}_{k,h,1} = e_{k,h,1}^0 dp_{k,1} (1 + \epsilon_{k,h})$$

For those consuming in the second block, the reduction in quantities will be relatively low by assuming that $p_{k,1} + dp_{k,1} < p_{k,2}$. For instance, if the consumer buys 100 units in each of the two blocks and the price in the second is twice that of the first block, an increase of 10% in the first block is perceived by the consumer like an increase of 5% in the second block. In general, we can say that the equivalent increase in price of the second block is: $dp_{k,2} = \frac{e_{k,h,1}^0}{e_{k,h,2}^0} dp_{k,1}$. Thus for those who consume in block 2, the increase in price of block 1 will generate a change in real income equivalent to:

$$\begin{aligned} \widetilde{\Delta e}_{k,h} &= e_{k,h,2}^0 \frac{e_{k,h,1}^0}{e_{k,h,2}^0} dp_{k,1} (1 + \epsilon_{k,h}) \\ &= e_{k,h,1}^0 dp_{k,1} (1 + \epsilon_{k,h}) \end{aligned}$$

We can then write the general formula of change in nominal expenditure on good k as follows:

$$\widetilde{\Delta e}_{k,h} = \sum_{r=1}^B e_{k,h,b}^0 dp_{k,b} (1 + \epsilon_{k,h})$$

¹⁰ It is worth noting that the interaction should be neglected using the first order approximation rule. Further, this term converges to zero when the change in price is relatively small.

Government revenues

This, in summary, the nominal change in revenue of the producer is:

$$\Delta \tilde{r} = \sum_{h=1}^H \sum_{b=1}^B e_{k,h,b}^0 dp_{k,b} (1 + \epsilon_{k,h})$$

In the case when we take into account the interaction between the change in quantity and that in price, the nominal change in revenue of the producer is:

$$\Delta \tilde{r} = \sum_{h=1}^H \sum_{b=1}^B e_{k,h,b}^0 dp_{k,b} (1 + \epsilon_{k,h} (1 + dp_{k,b}))$$

Inflation adjustments

The discussion on inflation adjustments applied to single priced good can also be applied here so that the government revenues can be deflated by $1/(1 + \pi)$ where π is the CPI change estimated with the change of all affected prices.

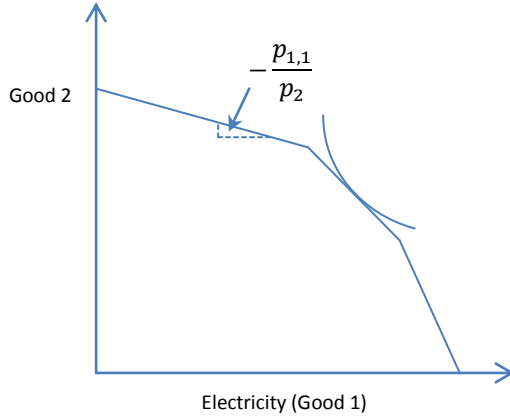
Estimating elasticity

We treat here the estimation of price elasticity for non-linear price goods. As an example, we focus on the case of electricity. As already mentioned, we cannot find a consensus about the relevant model to estimate this elasticity. Indeed, estimation models that fit all types of electricity systems would be hard to find and, different countries would probably want to follow a different estimation strategy.

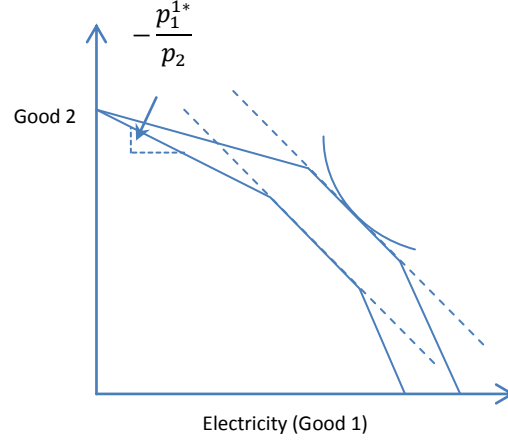
Consider for example a price schedule broken into three blocks with the marginal price of electricity increasing from the lowest to the highest block. We denote the marginal price of electricity (good 1) in block b by $p_{1,b=1}$ and the price of good 2 by p_2 . In Figure 6, we show an example of the consumer equilibrium where we assume the existence of three marginal electricity prices. Among the implications of increasing marginal prices is the nonexistence of multi-equilibrium, like what we can find in the case of decreasing marginal prices (see Taylor 1976).

Figure 6: Non-linear pricing structure

Consumer equilibrium



Intra-marginal prices and income effect



Taylor (1975) has reviewed a number of studies that estimated the elasticity of demand to changes in prices for electricity. The models presented are estimated longitudinally with time data or cross-section with data on states or provinces. These models share some essential elements that can be summarized in the following equation

$$\log(q_i) = \alpha + \beta \log(y_i) + \gamma \log(E_i) + \theta \log(P_i) + \vartheta(X_i) + \epsilon_i$$

Where the subscript i =unit of observation; q_i = quantity consumed of electricity; y_i = household income; E_i = electricity expenditure; P_i = Price of electricity where this price can be alternatively the marginal price or the average price; X = vector of control variables; θ = price elasticity and β = income elasticity. These models can control for various factors such as substitutes products, household white goods, climate conditions, household size and other factors specific to the case-study.

In our case, we assumed that the researcher has only one cross-section survey which means that the unit of observation is the household and the number of observations relative to the marginal price will be the number of price blocks present in the electricity system. This may be a problem for the estimation of elasticity if the number of blocks is small. In principle, one could use average price instead of marginal price to overcome such problem. However, the use of average price may cause endogeneity. This is because we use the quantity to compute the average price and this will make the average price correlated with the error term. Alternatively, as reported by Taylor (1975), we can use the per capita expenditure on electricity (up to the block before the last so as to exclude the block of the marginal price) together with the marginal price of the last block of consumption as follows:

$$\log(q_h) = \alpha + \beta \log(y_h) + \gamma \log(E_{h,b-1}) + \theta \log(P_h) + \vartheta(X_h) + \epsilon_h$$

Where P_h = marginal price and $E_{h,b-1}$ = expenditure on electricity up to block b-1 of household h .

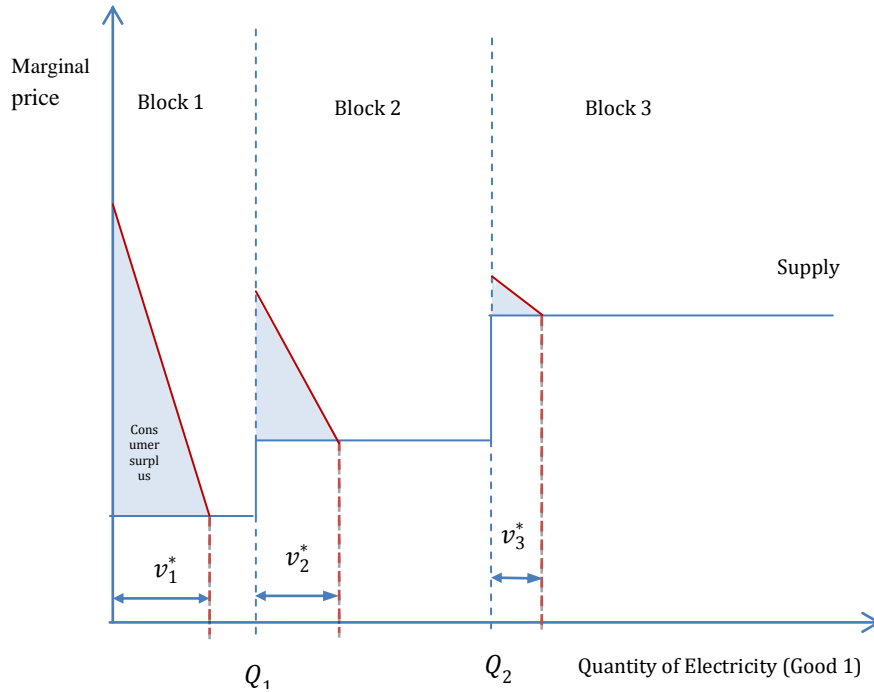
Changes in tariff structures and the consumer's surplus

Let us revert to theory and consider some implications of the nonlinear price schedule in terms of consumer surplus and deadweight loss.

As shown in Figure 7, in block 1, the provider can offer to each household any quantity until the maximum of block 1 with the first applied marginal price. In the case where all households buy the maximum quantity, the maximum supplied quantity can be denoted by \bar{Q}_1 . However, since poor households consume less than the maximum of block 1, the demand of quantity within the first block is $v_1^* < \bar{Q}_1$. With increasing marginal price in consumption, the elasticity of demand within the first block is expected to be low. This is because the marginal utility of the first electricity units is higher than the marginal utility of subsequent units. In other words, the elasticity of demand with respect to the marginal price of the first block must be lower than the elasticity of subsequent blocks. And the partial demand curve must be steeper in the first block.

In block 2, all those who consume in block 3 will buy the maximum quantity allowed in block 2. Other consumers can buy only a given quantity in block 2, and this is depending on the applied marginal price. The partial demand curve is more flat compared to that of the first block. This is because of the declining marginal utility of the units in block 2 compared to those bought in the first block. Finally, in block 3 and analogously to the discussion for block 2, we find that the demand curve is more flat than in the previous two blocks.

Figure 7: Demand and supply of electricity with the increasing marginal price



Based on this schedule of prices, the total exchanged quantity in this market will equal to

$$V = \sum_{b=1}^B v_b^*.$$

with v_b^* = quantity consumed in block k .

From a social planner perspective, we can now see the benefits of increasing the number of tariffs (blocks). Consider for example shifting from a three blocks' tariff structure as the one described to a smooth and linear supply function that correspond to the same price increases of the three original blocks. This is like passing from a three blocks' structure to an infinitesimal blocks structure as depicted in Figure 8 below. The advantage of this move is that it is possible to reduce the consumer's surplus, although this will also induce some deadweight loss. This is shown in Figure 8 by the blue areas (consumer's surplus) and by the orange areas (deadweight loss).

Note that such supply schedule is not only theoretical but could in principle be applied in real life. For example, in the case of electricity, it would be sufficient to establish a marginal price increase for each kWh consumed where the marginal price increase could be linear but also concave or convex. If all households in the country had a meter, then the calculation of the electricity bill would be straightforward. The meter provides the exact quantity consumed by each household in kWh and, based on this quantity and the marginal price per each kWh, the bill could be easily calculated. Moreover, if electricity consumption is proportional to household income, then such system would be progressive in that richer households would face higher marginal prices. The drawback of such system is that it is more difficult to discriminate between poor and non-poor people and that it would be necessary for all households to have a meter.

Even if tariff restructuring does not imply shifting to a linear supply curve, it is clear from the illustration below that it is possible to reduce the consumer's surplus in a more progressive way, and increase government revenues by increasing the number of tariff blocks. Therefore, as a rule of thumb, increasing the number of blocks is a good approach to subsidies reforms related to multiple priced products.

The graph illustrates the decomposition of a linear demand curve into three blocks (Block 1, Block 2, Block 3) and the corresponding marginal price and quantity of electricity (Good 1). The vertical axis is labeled "Marginal price" and the horizontal axis is labeled "Quantity of Electricity (Good 1)". The demand curve is a downward-sloping line, and the supply curve is an upward-sloping line. The area under the demand curve is divided into three blocks by vertical dashed lines at quantities Q_1 and Q_2 . The marginal price is shown as a horizontal line segment for each block, with the corresponding quantity of electricity (Good 1) labeled as v_1^* , v_2^* , and v_3^* .

Deaton (1997) *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*, World Bank Publications

Taylor, L. D. (1976) The Demand for Electricity: A Survey. The Bell Journal of Economics, Vol. 6, No. 1, pp. 74-110

Part III – SUBSIM - The Subsidies simulation Stata Toolkit

Introduction

The main aim of this Stata toolkit is to help studying the impact of price reforms on household wellbeing and on the government revenues. As discussed in Part II, we can have the case of **single pricing**, where we have one price that applies to all quantities consumed and **multiple pricing**, where different prices apply to different quantities consumed. In this part, we focus on multiple pricing given that single pricing will be a straightforward simplification of the multiple pricing case. Recall that products with multiple pricing imply that consumers will pay the price set for each block only to the quantities consumed in that particular block. This is typically the case of utilities such as water, electricity or gas. As before, we assume that the analyst has at least one household survey containing information on income or consumption and that the price structure of the subsidized good is known.

Summary of commands

This preliminary version of the tool-kit includes nine Stata commands. Let IM = Impact; R = Revenues; W = Welfare; SCH = Schedule; TR = Transform; EX = Expenditure; QUA = Quantity; P = Price. Then the STATA commands of the tool-kit are described as follows:

- **pschset - Sets the price schedule**

With pschset, we can initialize the price schedule of a given good in order to perform other estimations. For instance, we can initialize the price schedule before the reform and that after the reform, then we can estimate the impact of the price reform on household welfare or budget revenues.

- **pschsetv - Sets the price schedule using the Stata variables**

With pschsetv, we can initialize the price schedule of a given good using directly the Stata variables. We must use this module instead of the pschset when the number of blocks is higher than 10.

- **pschdes - Describes the price schedule**

The command produces the description of a given price schedule which has been previously set by the command 'pschset'.

- **trexqua - Transforms expenditure into consumption for multiple priced products**

The command can transform household total expenditure on a given item with a predefined price schedule into consumed quantities. Some descriptive results by population sub-groups are also produced. The population sub-groups can be defined by consumption blocks or by any other partition of the population such as urban and rural areas.

- **imwref – Estimates the impact of price changes on household welfare**

This command estimates the impact of price changes on household welfare. Some descriptive results by population sub-groups are also produced. By default, the population groups are defined by deciles, but the user can indicate any other partition of the population, for instance, by urban and rural areas.

- **imrref – Estimates the impact of price changes on budget revenues**

This command can be used to estimate the impact of price changes on household welfare. Further, some descriptive results by population sub-groups are produced. By default, the population groups are defined by deciles, but the user can indicate any other partition of the population, for instance, by urban and rural areas.

- **imrrefpr - Estimates the impact of price schedule reform on budget revenues comparing sets of price increases.**

This command extends imrref to take into account a range of possible price changes.

- **imrrefel - Estimates the impact of price schedule reform on budget revenues comparing sets of price elasticities.**

This command extends imrref to take into account a range of possible price elasticities.

- **spriceref – Seeking the requested increase in prices in order to increase the revenue by a given percentage**

This module enables to compute the requested increase in prices in order to increase the real revenue by a given percentage, and this, by taking into account the price elasticity and inflation.

Package installation

The installation of the SUBSIM Stata package can be done by one among the two following ways:

- A) Net installation: while connected to the internet, the user should type the following two Stata command lines:

```
net from http://dasp.ecn.ulaval.ca/subsim/
```

```
net install subsim, force
```

- B) Local installation: if the user has already the zipped copy of the folder subsim (<http://dasp.ecn.ulaval.ca/subsim.zip>), the user should type the following two Stata command lines:

```
net from c:/subsim/
```

```
net install subsim, force
```

Initializing the price schedules (pschset)

The module **pschset** is used to initialize the price schedule, which can be used later for other computations. To illustrate how this module works, let us begin by presenting an example of the predefined schedule price of electricity:

	Blocks (quantities by kWh)	Tariffs
1:	0 – 160	0.033
2:	160 – 300	0.072
3:	300 – 500	0.086
4:	500 – 750	0.114
5:	750 – 1000	0.135
6:	1000 and more	0.174

In this example, we have six blocks. For instance, if the household consumes 200 kWh, the amount of the bill is: $(160 \times 0.33 + 40 \times 0.072) = 55.68$. As is the case for all modules of this toolkit, the user can execute the commands by using the dialog boxes, the command windows, or also, by executing the Stata command lines through the do file.

Panel A

Panel B

To open the dialogue box and to initialize the price schedule, in the Stata window command, type the command:

db pschset

Once the dialogue box is opened, as shown in Panel A, indicate the number of blocks and the rest of information, as shown in Panel B.

Remarks:

- The user can initialize more than one price schedule. For instance, the user can initialize a number of potential price schedule reforms.
- Information about price schedules will remain in memory until the end of the Stata session.

Initializing the price schedules using the Stata variables (pschsetv)

The module `pschsetv` must be used to initialize the price schedule when the number of blocks exceeds 10. To show how this module function, let us returning to the last example and where the price schedule takes the form:

Stata variables			
Blocks	Blocks	max	Tariff
1	0 – 160	160	0.033
2	160 – 300	300	0.072
3	300 – 500	500	0.086
4	500 – 750	750	0.114
5	750 – 1000	1000	0.135
6	1000 and more	.	0.174

```
. clear
. input max tr
      max      tr
1. 160    0.033
2. 300    0.072
3. 500    0.086
4. 750    0.114
5. 1000   0.135
6. .      0.174
7. end
. pschsetv pschl, tr(tr) mxb(max) nblock(6)
. pschdes pschl
```

Description of the price schedule: pschl

Block	Tariff
0 - 160	0.033000
160 - 300	0.072000
300 - 500	0.086000
500 - 750	0.114000
750 - 1000	0.135000
1000 and more	0.174000

Describing the price schedules (pschdes)

Assume that the user has defined different price schedules, the module **pschdes** can serve to display the description of one or a given list of price schedules. The following example illustrates this:

```
. pschset pschl, nblock(3)  mxbl(160)  mxbl(300)   tr1(0.033) tr2(0.072) tr3(0.086)

. pschset psch2, nblock(4)  mxbl(160)  mxbl(300)  mxbl(500)   tr1(0.033) tr2(0.072) tr3(0.086) tr4(0.114)

. pschdes pschl psch2
```

Description of the price schedule: pschl

Block	Tariff
0 - 160	0.033000
160 - 300	0.072000
300 and more	0.086000

Description of the price schedule: psch2

Block	Tariff
0 - 160	0.033000
160 - 300	0.072000
300 - 500	0.086000
500 and more	0.114000

Further, the user may need to perform a graphical representation of one or of the different price schedules. To this end, the user will have only to add the option `dgra(1)` to display the graph. The following example illustrates this.

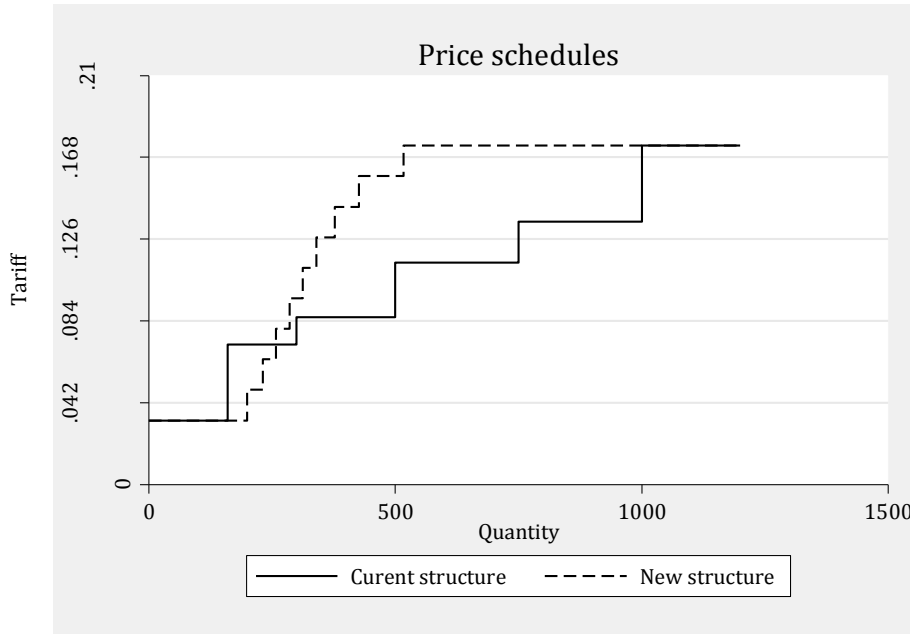
```
. pschdes pschl psch2 , dgra(1) legend(order(1 "Curent structure" 2 "New structure")) ;
```

Description of the price schedule: pschl

Block	Tariff
0 - 160	0.033000
160 - 300	0.072000
300 - 500	0.086000
500 - 750	0.114000
750 - 1000	0.135000
1000 and more	0.174000

Description of the price schedule: psch2

Block	Tariff
0 - 200	0.033000
200 - 231	0.048667
231 - 258	0.064333
258 - 286	0.080000
286 - 312	0.095667
312 - 340	0.111333
340 - 377	0.127000
377 - 426	0.142667
426 - 517	0.158333
517 and more	0.174000



Estimating the consumed quantities (trexqua)

We may need to estimate the consumed quantities of the good with the price schedule at the household level. That is because household surveys typically include information on expenditure but not on quantities consumed. Further, we may need to show some basic descriptive statistics on the distribution of these consumed quantities. The module **trexqua** is designed to respond to such requirements. As before, we assume that the user has a single household survey in which we can find total expenditure of the concerned good. Further, we assume that the user has the data to initialize the price schedule of the good. The first step can be the following Stata command line in order to initialize the price schedule:

```
pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) tr1(0.033)
tr2(0.072) tr3(0.086) /// tr4(0.114) tr5(0.135) tr6(0.174)
```

After that, one can open the household survey data and set the sampling design (strata, clusters, weights, etc. For more details, see the annex B. Finally, one can type the command line *db trexqua* to open the dialog box. Note that the survey sampling structure can also be set using the *trexqua* window as shown in the window below.

To be noted here that, in addition to the generated statistics, after clicking on the “OK” button or SUBMIT, a new variable, with the name “*Elec_KWh*” in our example, is generated. This variable contains the household consumed quantity of the good.

```
. trexqua elec all_exp, hsize(hsize) name(Elec_KWh) psch(psch1)
```

Price schedule and household consumption
Sampling weight : wts_exp

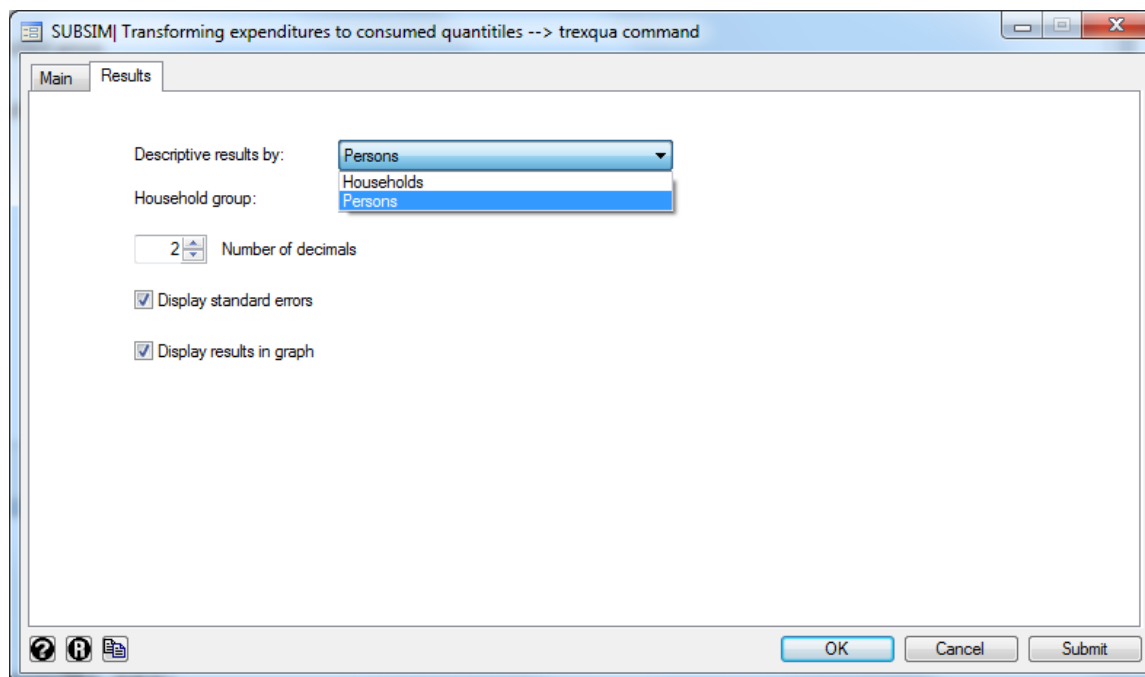
Population groups	Average household expenditures	Average consumed quantities	Proportion of households (in %)
0 - 160	4.479	135.728	1.951
160 - 300	11.036	239.946	40.177
300 - 500	21.795	374.828	45.088
500 - 750	41.787	580.937	10.842
750 - 1000	73.230	840.145	1.560
1000 and more	128.017	1190.846	0.382
All	20.510	348.691	100.000

As we can observe, the module estimates by default the following results by consumption blocks:

- The average household expenditure;
- The average household consumed quantity;
- The proportion of households.

The user can also select to display the standard errors of these statistics, and this, by taking into account the full information about the sampling design of the survey. Instead of carrying these descriptive results by group, defined by the consumption blocks, the user can select other partitions of groups (for instance, by area: rural/urban) and this, by indicating the group variable. Further, the user can generate these

statistics at the individual level. The following figure shows an example of selecting different other options:

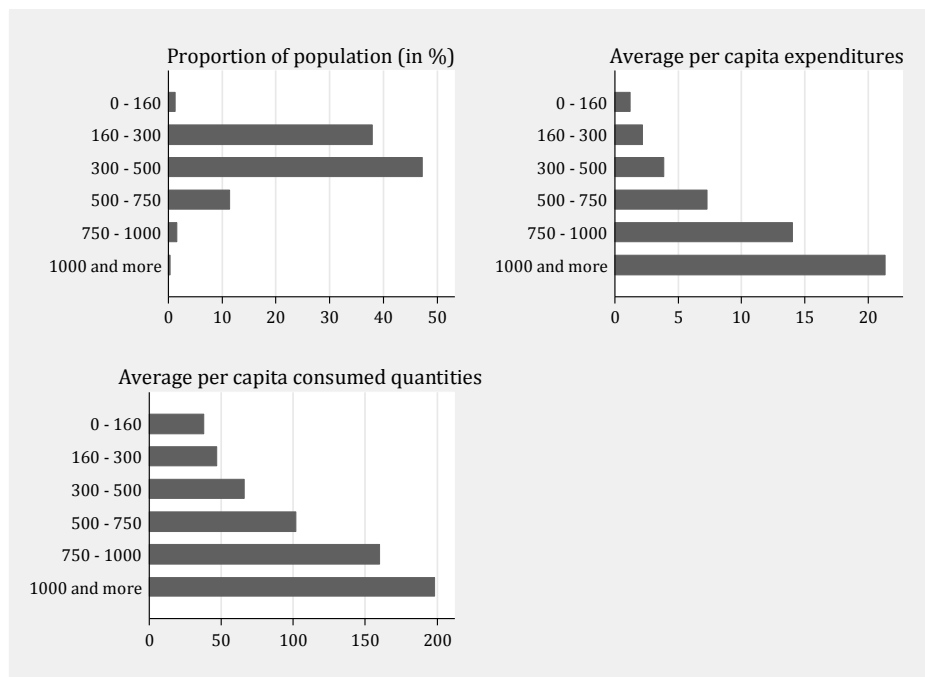


The displayed results are:

```
. trexqua elec all_exp, hsize(hhsize) name(Elec_KWh) psch(psch1) dec(2) result(per) dste(1) dgra(1)

Price schedule and household consumption
Household size : hhsize
Sampling weight : wts_exp
```

Population groups	Average per capita expenditures	Average per capita consumed quantities	Proportion of population (in %)
0 - 160	1.27	38.46	1.28
	0.06	1.80	0.13
160 - 300	2.17	47.11	37.98
	0.02	0.40	0.63
300 - 500	3.85	66.23	47.36
	0.03	0.50	0.66
500 - 750	7.34	102.07	11.45
	0.12	1.55	0.45
750 - 1000	13.99	160.55	1.51
	0.55	6.05	0.16
1000 and more	21.34	198.52	0.42
	2.37	23.78	0.11
All	3.81	64.71	100.00
	0.03	0.43	0.00



The price schedule reform and household wellbeing (imwref)

Multiple priced goods

We aim to estimate the impact of a given price schedule reform on household wellbeing. We assume beforehand that the user has a household survey in which we can find the monetary indicator of household wellbeing (for instance, household total expenditure) and the total expenditure on the good concerned by the reform (total expenditure on electricity for instance). In addition, we assume that we have two price schedules, those of the before and after the reform respectively. The first stage consists of initializing the two price schedules. For instance:

```
pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) ///
tr1(0.033) tr2(0.072) tr3(0.086) tr4(0.114) tr5(0.135) tr6(0.174)

pschset psch2, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) ///
tr1(0.0363) tr2(0.0792) tr3(0.0946) tr4(0.1254) tr5(0.1485) tr6(0.1914)
```

As we can observe, starting from the last Stata command lines, in this example we assume that the tariffs and the number of blocks change simultaneously with the reform. After initializing the two price schedules, we have to use the module **imwref** in order to estimate the impact of the reform on wellbeing:

`db imwref`

This module will generate several statistics on the impact of the reform on household wellbeing. Further, we can indicate the name of the variable to be generated, which will contain the impact of the reform on household wellbeing. The displayed results are:

```
. imwref all_exp elec, hsize(hsize) name(imp_well) ipsch(psch1) fpsch(psch2)
```

```
Impact on household wellbeing
Sampling weight : wts_exp
```

Deciles	Total impact on wellbeing	Average impact on wellbeing	Proportion of the impact (in %)
Decile 1	-134077.531	-1.187	5.79
Decile 2	-156369.484	-1.386	6.76
Decile 3	-172069.938	-1.524	7.43
Decile 4	-185747.891	-1.646	8.03
Decile 5	-191565.188	-1.698	8.28
Decile 6	-214324.609	-1.901	9.26
Decile 7	-234390.188	-2.074	10.13
Decile 8	-268500.156	-2.380	11.60
Decile 9	-302998.375	-2.687	13.09
Decile 10	-454539.938	-4.025	19.64
Population	-2314583.250	-2.051	100.00

By default, the statistics are estimated at household level and by deciles. However, the user can estimate them at the individual level (per capita) as shown in the window below.

SUBSIM| Impact of price schedule reform on household wellbeing --> imwref command

Main Results

Descriptive results by: Households

Household group: Households
Persons

2 Number of decimals

☒ Display standard errors

☒ Display results in graph

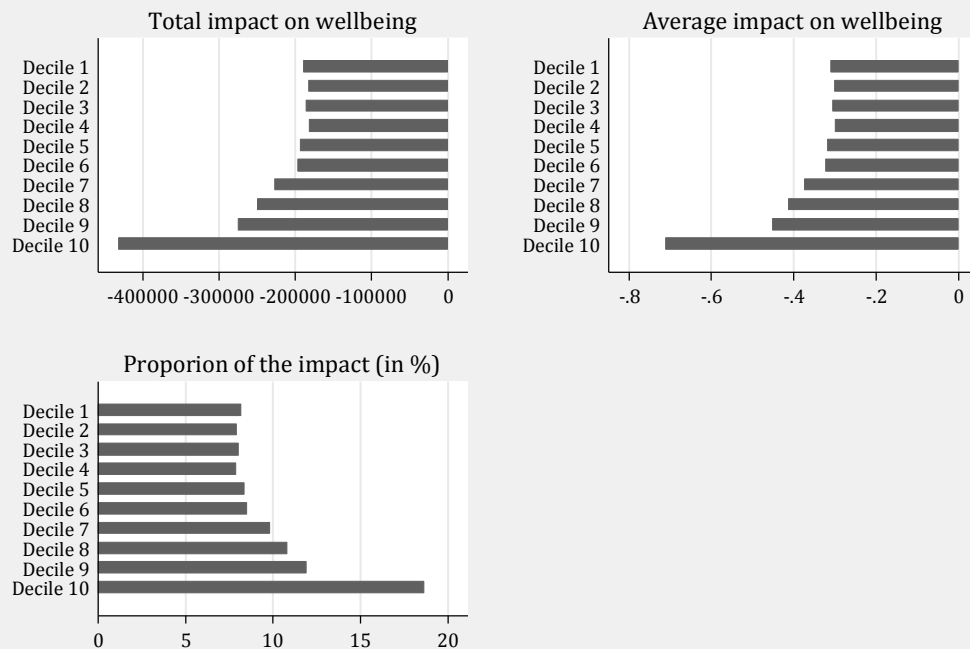
OK Cancel Submit

```
. imwref all_exp elec, hsize(hhsize) name(imp_well) ipsch(psch1) fpsch(psch2) dec(2) result(per) dste(1) dgra(1)

Impact on per capita wellbeing
Household size : hhsize
Sampling weight : wts_exp
```

Deciles	Total impact on wellbeing	Average impact on wellbeing	Proportion of the impact (in %)
Decile 1	-188918.23 7530.62	-0.31 0.01	8.16 0.33
Decile 2	-182940.14 6882.63	-0.30 0.01	7.90 0.31
Decile 3	-185734.45 7885.15	-0.31 0.01	8.02 0.34
Decile 4	-181962.69 7225.66	-0.30 0.01	7.86 0.32
Decile 5	-193457.47 8645.62	-0.32 0.01	8.36 0.37
Decile 6	-196948.23 7901.36	-0.32 0.01	8.51 0.34
Decile 7	-227451.91 10514.11	-0.37 0.01	9.83 0.44
Decile 8	-249773.25 12627.99	-0.41 0.01	10.79 0.52
Decile 9	-275058.09 12845.99	-0.45 0.01	11.88 0.53
Decile 10	-432338.84 18715.55	-0.71 0.02	18.68 0.71
Population	-2314583.25 26759.39	-0.38 0.00	100.00 0.00

Impact on wellbeing at the individual level



Based on these results, we can say that the population of the first decile has an average reduction in wellbeing of about -0.31 (real per capita expenditure decreases by about 0.31). Also, we can say that 18.68% of the total impact will fall on the richest decile.

To be noted here that, in addition to these basic statistics on the impact of the reform, the user can compute the total household expenditure after the reform, and then continue to produce other results with other Stata modules (DASP, ADePT, etc.). For instance, we may be interested to assess the impact of the reform on poverty, inequality or to show the progressivity of the impact.

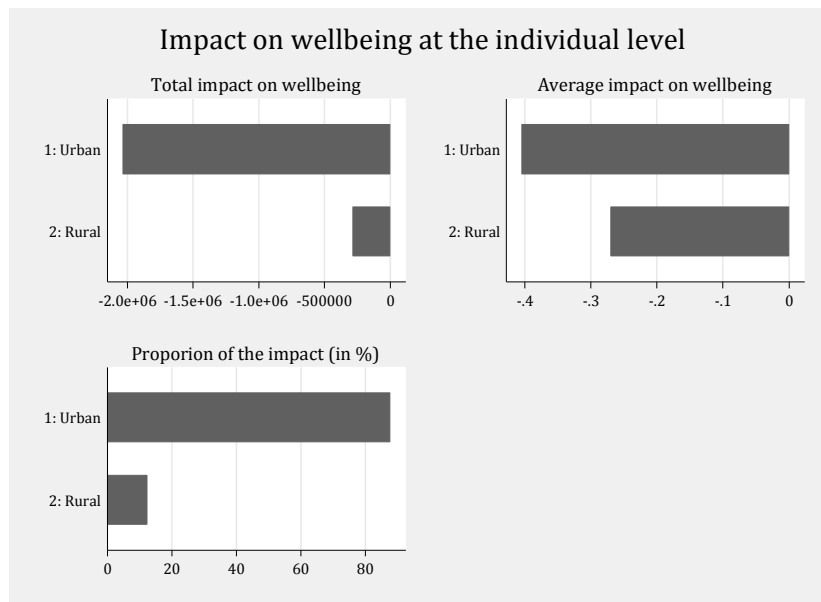
Now, assume that we aim to produce the results by another partition of groups instead of that by deciles (for instance, by rural and urban areas). To this end, the user has to indicate the group variable as follows:

The displayed results are:

```
. imwref all_exp elec, hsize(hhsize) name(imp_well) ipsch(psch1) fpsch(psch2) hgroup

Impact on per capita wellbeing
Household size : hhsize
Sampling weight : wts_exp
```

Population groups	Total impact on wellbeing	Average impact on wellbeing	Proportion of the impact (in %)
1: Urban	-2030917.63 27443.36	-0.40 0.00	87.74 0.37
2: Rural	-283665.63 8099.98	-0.27 0.00	12.26 0.37
Population	-2314583.25 26759.39	-0.38 0.00	100.00 0.00



Single priced goods

As explained in section II, the developed theoretical framework as well as the Stata Toolkit can be used in order to assess the impact of price change on wellbeing in the case of single priced goods. To illustrate this, we use the Namibian household expenditure survey for the period of 2003/2004. In addition to the total expenditures of the household, we have also information about the expenditures on the main consumption items, like food, clothing, housing, etc. For instance, assume that we would like to assess the impact of a proportional increase of 10% in the price of clothing. The first stage is to initialize the initial and final prices, and then to use the `imwref` module. In essence, the `imwref` command can be used with one price block instead of multiple blocks as was the case with multiple priced goods. The example below illustrates this:

```
. pschset psch1, nblock(1) tr1(1)
. pschset psch2, nblock(1) tr1(1.1)
. imwref hexp_total hexp_cloth, hsize(hsize) name(impact) ipsch(psch1) fpsch(psch2)
```

Impact on household wellbeing
Sampling weight : fw

Deciles	Total impact on wellbeing	Average impact on wellbeing	Proportion of the impact (in %)
Decile 1	-476706.906	-2.606	1.14
Decile 2	-919261.813	-5.024	2.20
Decile 3	-1428258.125	-7.814	3.42
Decile 4	-1854219.500	-10.114	4.44
Decile 5	-2201495.000	-12.038	5.27
Decile 6	-2762798.250	-15.106	6.61
Decile 7	-3967645.000	-21.691	9.49
Decile 8	-5370601.500	-29.324	12.85
Decile 9	-8564168.000	-46.840	20.49
Decile 10	-14258888.000	-77.776	34.11
Population	-41804044.000	-22.844	100.00

The price schedule reform and the government revenue (imrref)

We aim to estimate the nominal or real change in the government revenue implied by the price schedule reform. As before, the first stage consists of initializing the two price schedules:

```
pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) ///
tr1(0.033) tr2(0.072) tr3(0.086) tr4(0.114) tr5(0.135) tr6(0.174)
```

```
pschset psch2, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) ///
tr1(0.0363) tr2(0.0792) tr3(0.0946) tr4(0.1254) tr5(0.1485) tr6(0.1914)
```

After initializing the two price schedules, we have to use the module **imrref** in order to estimate the change in government revenue. Among the other information that can be used optionally are:

- The non-compensated demand elasticity of the good with respect to its price. By default, this elasticity is set to zero. However, the user can use a variable which contains the elasticity at household level (the elasticity may be the same for all households).
- The price inflation (in %) implied by the reform.

db imrref

In this first example, we assume that the inflation and the elasticity of demand of electricity are nil.

```
. imrref all_exp elec, hsize(hhsz) name(Imp_exp_elec) ipsch(psch1) fpsch(psch2)

Change in household expenditures on elec
Sampling weight : wts_exp
```

Deciles	Total change in expenditures	Average change	Proportion of the change (in %)
Decile 1	134077.531	1.187	5.79
Decile 2	156369.484	1.386	6.76
Decile 3	172069.938	1.524	7.43
Decile 4	185747.875	1.646	8.03
Decile 5	191565.188	1.698	8.28
Decile 6	214324.609	1.901	9.26
Decile 7	234390.188	2.074	10.13
Decile 8	268500.156	2.380	11.60
Decile 9	302998.375	2.687	13.09
Decile 10	454539.938	4.025	19.64
Population	2314583.250	2.051	100.00

Based on the results above, the producer revenue will increase by about 2 314 583.25 monetary unit. In what follow, we assume that the elasticity is equal to -0.3 and inflation increases by 1.2% (the estimated change in expenditures will be deflated –divided- by 1.012). Further, we aim to produce the results at the individual level.

gen elas=-0.3

db immref

The screenshot shows the 'Main' tab of a software window titled 'SUBSIM| Impact of price schedule reform on the producer revenue --> immref command'. The window has two tabs: 'Main' and 'Results'. The 'Main' tab contains several input fields and a 'Survey settings...' button.

Variables of interest:

- Total household expenditures:
- Household expenditures on the item:
- Household size:

Generate the variable of the impact on household expenditures on the item:

Name of the variable:

Price schedule names and optional parameters:

- Initial price schedule:
- Final price schedule:
- Elasticity:
- Inflation (in %):

Estimation method

Approximation:

At the bottom are buttons for 'OK', 'Cancel', and 'Submit'.

The screenshot shows the 'Results' tab of the same software window. It contains options for how to display the results.

Descriptive results by:

Household group:

Number of decimals

☒ Display standard errors

☒ Display results in graph

At the bottom are buttons for 'OK', 'Cancel', and 'Submit'.

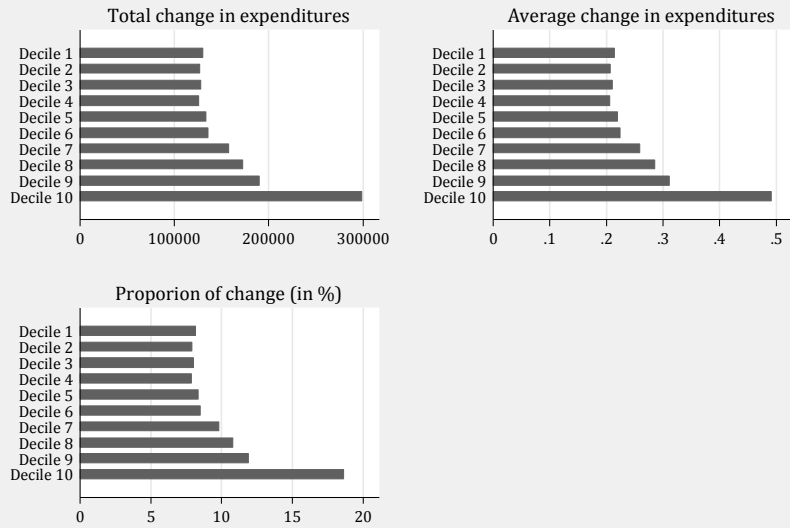
The displayed results are:

```
. imrref all_exp elec, hsize(hhsize) elas(elas) name(imp_exp_elec) ipsch(psch1) fpsch(psch2) dec(2) inf(1.2) result(per) dste(1) dgra(1)
```

Change in per capita expenditures on elec
Household size : hhsize
Sampling weight : wts_exp

Deciles	Total change in expenditures	Average change	Proportion of the change (in %)
Decile 1	130674.66	0.21	8.16
	5208.93	0.01	0.33
Decile 2	126539.62	0.21	7.90
	4760.71	0.00	0.31
Decile 3	128472.45	0.21	8.02
	5454.16	0.00	0.34
Decile 4	125863.52	0.21	7.86
	4997.99	0.00	0.32
Decile 5	133814.45	0.22	8.36
	5980.17	0.01	0.37
Decile 6	136229.02	0.22	8.51
	5465.37	0.01	0.34
Decile 7	157328.39	0.26	9.83
	7272.60	0.01	0.44
Decile 8	172768.05	0.29	10.79
	8734.78	0.01	0.52
Decile 9	190257.58	0.31	11.88
	8885.56	0.01	0.53
Decile 10	299048.59	0.49	18.68
	12945.54	0.01	0.71
Population	1600996.25	0.26	100.00
	18509.46	0.00	0.00

Impact on expenditures at individual level



The price schedule reform and the government revenue according to price change (imrrefpr)

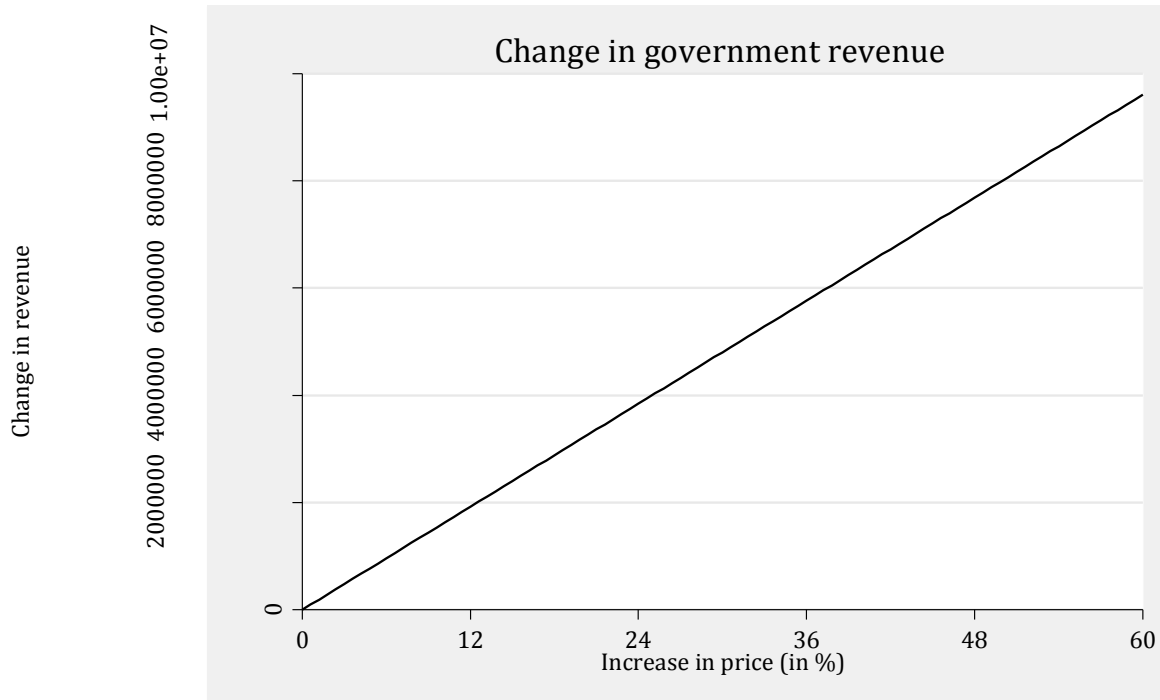
Now, we can be interested to have an idea about the link between the same proportional increase in prices of all blocks and the government revenue. To this end, we can use the module **imrrefpr**. As we can remark looking at the dialog box of this module, the main difference from that of the **imrref** concerns simply the reform scheme. More precisely, the user must indicate a range of the proportion of increase in prices.

db imrrefpr

The screenshot shows a software window titled "SUBSIM| Impact of price schedule reform on the government revenue --> imrrefpr command". The window has a tabbed interface with "Main" selected. The "Main" tab contains several input fields and a "Survey settings..." button. The "Variables of interest:" section has "Household expenditures on the item:" set to "elec" and "Household size:" set to "hhsz". The "Estimation method:" section has "Approximation" set to "Ignore the interaction effect (dp*dq)". The "Price schedule names and optional parameters:" section has "Initial price schedule:" set to "psch1", "Range of price change in %:" with "Minimum:" set to 0 and "Maximum:" set to 60, "Elasticity:" set to "elas", and "Inflation (in%):" set to 1.2. At the bottom, there are "OK", "Cancel", and "Submit" buttons.

Section	Field	Value
Variables of interest:	Household expenditures on the item:	elec
	Household size:	hhsz
Price schedule names and optional parameters:	Initial price schedule:	psch1
	Range of price change in %:	Minimum: 0, Maximum: 60
	Elasticity:	elas
	Inflation (in%):	1.2
	Estimation method:	Approximation: Ignore the interaction effect (dp*dq)

After clicking on the OK button, the following graph is plotted.



In this example, we find that increasing all prices by 60% will increase the producer revenue by about 14 millions.

The price schedule reform and the government revenue according to price elasticity (**imrrefel**)

In another case, we can be interested in having an idea about the link between the price elasticity and the government revenue. To this end, we can use the module **imrrefel**. As we can remark looking at the dialog box of this module, the main difference from **imrref** concerns simply the level of elasticity and the user must indicate a range of elasticities.

db imrrefel

SUBSIM| Impact of price schedule reform on the government revenue according to pri-elasticity --> immrefel command

Variables of interest:

Household expenditures on the item:

Household size:

Estimation method

Approximation:

Price schedule names and optional parameters:

Initial price schedule:

Final price schedule:

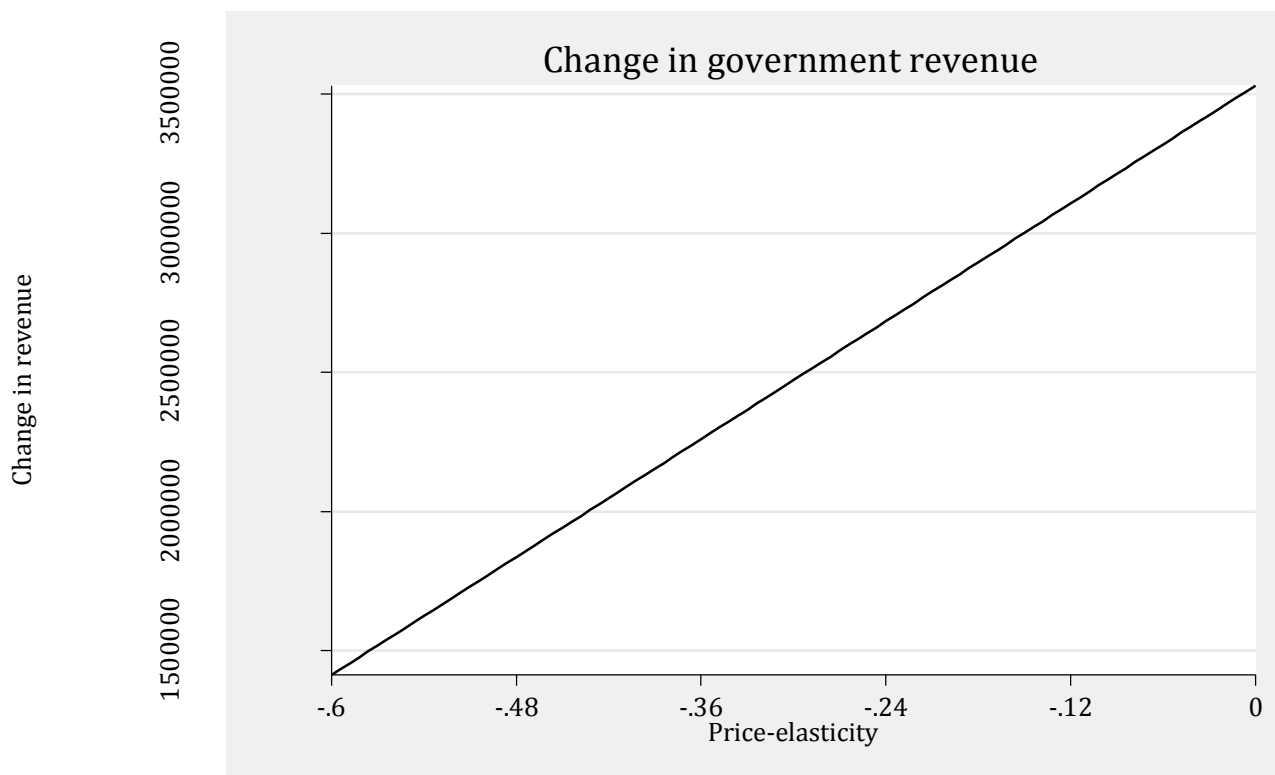
Range of elasticity: Minimum: Maximum:

Inflation (in%):

Survey settings...

OK Cancel Submit

After clicking on the OK button, the following graph is plotted.



The required increase in prices for a given increase in government revenue (spriceref)

We aim to know the required increase in prices in order to have a given real change in the government revenue. Thus, for this exercise, we assume that the increase in the price of each block is the same and also that the price elasticity is the same for all households.

The screenshot shows the SUBSIM software window titled "SUBSIM| Seeking the required propotion of increase in prices --> spriceref command". The interface is divided into three main sections: "Variables of interest:", "Options and parameters:", and "Estimation method".

- Variables of interest:** Contains two dropdown menus. "Household expenditures on the item:" is set to "elec", and "Household size:" is set to "hsize".
- Options and parameters:** Contains three text input fields. "Targeted increase in revenue (in %):" is set to "10", "Elasticity:" is set to "-0.2", and "Inflation (in %):" is set to "1.2".
- Estimation method:** Contains a dropdown menu for "Approximation" set to "Estimate with the interaction effect (dp*da)".

At the bottom right of the main panel is a button labeled "Survey settings...". At the bottom of the window are three buttons: "OK", "Cancel", and "Submit".

In the example above, we have an increase in real government revenue of 10%. We assume that the expected inflation will increase by 1.2% and that the price elasticity is equal to -0.2. The question that we want to address is: What is the required increase in prices to increase the revenue by 10%?

```
. spriceref elec, hsize(hsize) elas(-0.2) inf(1.2) pirev(10) appr(2)
The required change in price (in %): 13.0776
```

ANNEX A: Working with do files

As explained, SUBSIM modules can be used interactively using the Stata command box, with windows as shown in the manual and by embedding the various commands into a do file. A summary do-file of the main steps considered in this manual is shown below.

```
clear all
```

```
set mem 1000m
```

```
cd "C:\Users\Stata\"
```

```
use elec1, clear
```

```
*Set survey setting
```

```
svyset _n [pweight=wts_exp], vce(linearized) singleunit(missing)
```

```
*Set the price schedule
```

```
pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) tr1(0.033)  
tr2(0.072) tr3(0.086) tr4(0.114) tr5(0.135) tr6(0.174)
```

```
*Describe the price schedule
```

```
pschdes psch1
```

```
*Estimate quantities consumed
```

```
trexqua elec all_exp, hsize(hhsize) name(Elec_KWh) psch(psch1) dec(2) result(per) dste(1) dgra(1)
```

```
*Set pre and post reform price schedules
```

```
pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) ///  
tr1(0.033) tr2(0.072) tr3(0.086) tr4(0.114) tr5(0.135) tr6(0.174)
```

```
pschset psch2, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) ///  
tr1(0.0363) tr2(0.0792) tr3(0.0946) tr4(0.1254) tr5(0.1485) tr6(0.1914)
```

```
*Results on household wellbeing by decile (default)
```

```
imwref all_exp elec, hsize(hhsize) name(imp_well) ipsch(psch1) fpsch(psch2)
```

```
imwref all_exp elec, hsize(hhsize) name(imp_well) ipsch(psch1) fpsch(psch2) dec(2) dste(1) dgra(1)
```

```
*Results on household wellbeing by urban and rural areas
```

```
imwref all_exp elec, hsize(hhsize) name(imp_well) ipsch(psch1) fpsch(psch2) dec(2) dste(1) dgra(1)  
hgroup(ur_rl)
```

*Estimate of budget revenues

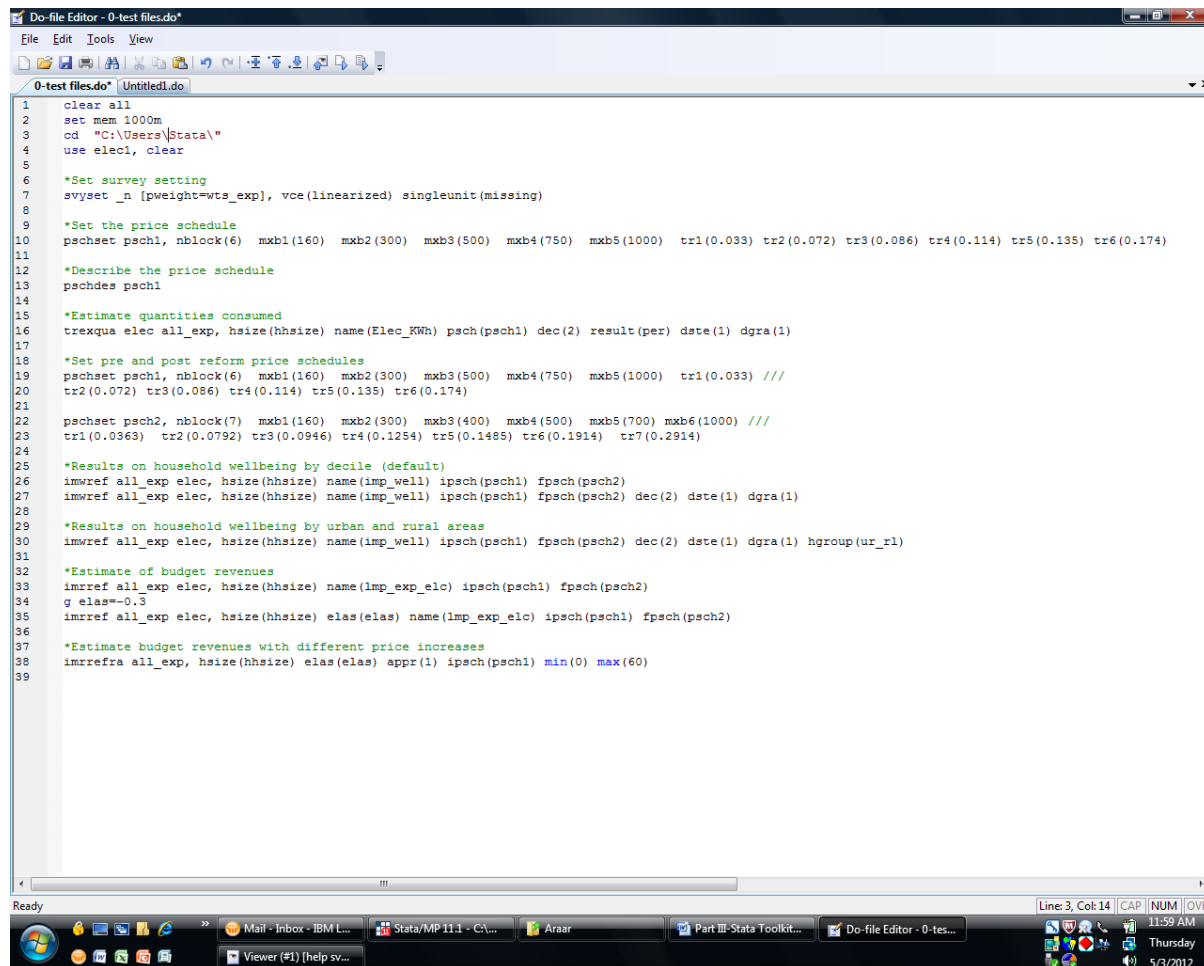
```
imrref all_exp elec, hsize(hhsize) name(lmp_exp_elc) ipsch(psch1) fpsch(psch2)
```

```
g elas=-0.3
```

```
imrref all_exp elec, hsize(hhsize) elas(elas) name(lmp_exp_elc) ipsch(psch1) fpsch(psch2)
```

*Estimate budget revenues with different price increases

```
imrrefpr all_exp, hsize(hhsize) elas(elas) appr(1) ipsch(psch1) min(0) max(60)
```



The screenshot shows a Do-file Editor window titled "Do-file Editor - 0-test files.do". The code is as follows:

```
1 clear all
2 set mem 1000m
3 cd "C:\Users\Stata\"
4 use elec1, clear
5
6 *Set survey setting
7 svyset _n [pweight=wts_exp], vce(linearized) singleunit(missing)
8
9 *Set the price schedule
10 pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) tr1(0.033) tr2(0.072) tr3(0.086) tr4(0.114) tr5(0.135) tr6(0.174)
11
12 *Describe the price schedule
13 pschdes psch1
14
15 *Estimate quantities consumed
16 trexqua elec all_exp, hsize(hhsize) name(Elec_KWh) psch(psch1) dec(2) result(per) dste(1) dgra(1)
17
18 *Set pre and post reform price schedules
19 pschset psch1, nblock(6) mxb1(160) mxb2(300) mxb3(500) mxb4(750) mxb5(1000) tr1(0.033) ///
20 tr2(0.072) tr3(0.086) tr4(0.114) tr5(0.135) tr6(0.174)
21
22 pschset psch2, nblock(7) mxb1(160) mxb2(300) mxb3(400) mxb4(500) mxb5(700) mxb6(1000) ///
23 tr1(0.0363) tr2(0.0792) tr3(0.0946) tr4(0.1254) tr5(0.1485) tr6(0.1914) tr7(0.2914)
24
25 *Results on household wellbeing by decile (default)
26 imwref all_exp elec, hsize(hhsize) name(lmp_well) ipsch(psch1) fpsch(psch2)
27 imwref all_exp elec, hsize(hhsize) name(lmp_well) ipsch(psch1) fpsch(psch2) dec(2) dste(1) dgra(1)
28
29 *Results on household wellbeing by urban and rural areas
30 imwref all_exp elec, hsize(hhsize) name(lmp_well) ipsch(psch1) fpsch(psch2) dec(2) dste(1) dgra(1) hgroup(ur_r1)
31
32 *Estimate of budget revenues
33 imrref all_exp elec, hsize(hhsize) name(lmp_exp_elc) ipsch(psch1) fpsch(psch2)
34 g elas=-0.3
35 imrref all_exp elec, hsize(hhsize) elas(elas) name(lmp_exp_elc) ipsch(psch1) fpsch(psch2)
36
37 *Estimate budget revenues with different price increases
38 imrrefpr all_exp, hsize(hhsize) elas(elas) appr(1) ipsch(psch1) min(0) max(60)
39
```

ANNEX B: Sampling design and Stata

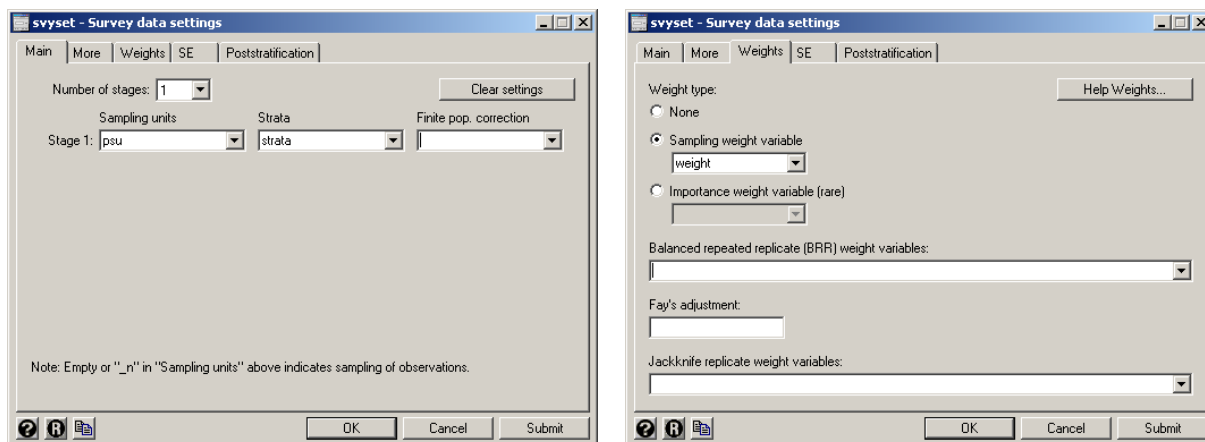
Data from surveys usually display four important characteristics:

1. they come with sampling weights (SW), also called inverse probability weights;
2. they are stratified;
3. they are clustered;
4. sample observations provide information aggregated over households, such as: Total household expenditures;
5. Number of “statistical units” (such as number of individuals).

We have different types of sampling designs. The SRS (simple random sampling) is rarely used to generate household surveys. Instead, a country is usually first divided into geographical or administrative zones and areas, called strata. A first level of random selection takes place within the Primary Sampling Units (denoted as PSUs) of a survey design, usually for each stratum. PSU's are often provinces, departments, villages, etc. Within each PSU, there may then be other levels of random selection. For instance, within each province, a number of villages may be randomly selected, and within every selected village, a number of households may then be randomly selected. The final sample observations constitute the Last Sampling Units (LSUs). Each sample observation may then provide aggregate information (such as total household expenditures) on all of the individuals found within that LSU.

Households within the same stratum typically share to a greater extent than in the entire population some socio-economic characteristics, such as geographical locations, climatic conditions, and demographic characteristics; these characteristics are determinants of the living standards of these households. Stratification generally decreases the sampling variance of estimators by ensuring that information is gathered across all strata. Generally, variables of interest (such as household income) vary less within a cluster than between clusters. Hence, multi-stage selection reduces the “quantity” of information generated by sampling since it does not draw from as many clusters as SRS would. The impact of clustering sample observations is therefore to tend to decrease the precision of populations estimators, and thus to increase their sampling variance.

In the window command of STATA, write the command `db svyset`, and type enter to open the following dialog box:



To be noted here that the main sampling design variables are:

- **Strata:** Provides the name of the variable (in an integer format) that contains the Stratum identifiers.
- **PSU:** Gives the name of the variable (in an integer format) that contains the Primary Sampling Units identifiers.
- **SAMPLING WEIGHT:** Specifies the name of the Sampling Weights variable.