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Acknowledgements

The SEAS tool was developed by a team led by Babatunde Abidoye, Global Policy Adviser, from the UNDP Sustainable Development Goal Integration (SDGi) Unit, and Abdel Rahman El Lahga and Sami Bibi from the Partnership for Economic Policy (PEP). The contributors to the development of the tool included Alefa Banda (UNDP), Volodymyr Turbayevsky (UNDP), Leslie Alex (UNDP), Chedly Rdissi (PEP), John Cockburn (PEP) and Luca Tiberti (PEP).

UNDP operates in 170 countries and territories, helping to eradicate poverty, reduce inequalities and exclusion, and build resilience so countries can sustain progress. As the United Nations development agency, UNDP plays a critical role in helping countries achieve the Sustainable Development Goals (SDGs).

UNDP’s SDG Integration Team within the Global Policy Network aims to build a coherent and consolidated range of services (the SDG Integrator ‘offer’), emphasizing direct short-to medium-term engagements to provide rapid responses to requests from country offices for support the national implementation and monitoring of integrated policy solutions, qualitative and evidence-driven analysis for accelerated progress, and knowledge sharing and upscaling of innovative approaches to sustainable development. SEAS is one of the tools developed to support rapid analysis to understand the impact of various subsidies on welfare.

PEP is a Southern-led global organization dedicated to supporting development in the Global South through the provision high quality, locally generated evidence that informs better decisions in policy and practice. To achieve this, PEP supports the work, strengthens the capacity and promotes the findings of local researchers in developing countries; facilitates engagement and collaboration between researchers and policymakers; and creates a space for learning and knowledge-sharing between researchers throughout the globe.
Acronyms and abbreviations

HBS  Household Budget Survey  
IBT  Increasing block tariffs  
IO   Input-output  
PEP  Partnership for Economic Policy  
SDG  Sustainable Development Goal  
SEAS Socio-Economic Analysis of Subsidies  
UNDP United Nations Development Programme  
VDT  Volume differentiated tariffs
Introduction
In many developing countries, consumer and producer subsidies represent a high fiscal burden that threatens the stability of public finance equilibria. A large body of empirical literature shows the often inequitable distribution of subsidies and suggests that they no longer meet their intended objectives of reducing inequality and protecting the most vulnerable. These findings increasingly reinforce the voices calling for a reform of the current system of subsidies, not only for fiscal reasons, but also for better income redistribution.

Subsidy reforms can improve macroeconomic performance and help create the fiscal space needed for green investments, correcting environmental externalities, and enhancing social protection programmes, especially in the light of the impacts of the COVID-19 pandemic. The reallocation of subsidies could therefore deliver an important boost to achieving the Sustainable Development Goals (SDGs). However, the resultant price changes associated with subsidy reforms can generate direct and indirect negative effects on household welfare via commodity reforms price increases.

Describing the Socio-Economic Analysis of Subsidies tool
The Socio-Economic Analysis of Subsidies (SEAS) simulator aims to conduct a distributional analysis of consumers’ subsidies and simulations of subsidies reforms. It estimates the impact of subsidies reforms on household welfare, poverty and inequality, and the government budget with or without compensatory cash transfers. It can be applied to energy and food subsidies. SEAS can strengthen the administration’s capacity to design, implement and continuously update social protection programmes.

SEAS is written in Python and is completely free of charge. It is also web-based and is available on the UNDP Data futures platform (see Subsidy Reform Analysis – UNDP Data Futures Platform). It offers an intuitive and easy-to-use graphical interface for simulating subsidy reforms and their impact on the outcomes. The design of SEAS is strongly inspired by the SUBSIM tool.\(^1\) In addition, it contains an extension that allows users to model consumption behaviour based on a Stone-Geary utility function that is less restrictive than the Cobb-Douglas utility function (see Annex for the theoretical framework).

The importance of the SEAS tool
Hasty removal of subsidies triggered social unrest in the past, for example, in Ecuador in October 2019.\(^2\) Therefore, governments often need to simulate various reform

---


scenarios in changing socio-economic contexts. Hence, a prior assessment must be undertaken of the impact of the reform on household welfare, poverty and government revenue. The SEAS tool offers users the possibility to simulate reform scenarios and produce quick and easy-to-interpret results without needing considerable modelling experience or the use of proprietary statistical software such as Stata. Unlike other tools, it allows for simulations of subsidy reforms using micro-level data from household surveys as well as macro-level data from input-output tables. Thus, the tool can strengthen a government’s capacity to design, implement and continuously update developmental programmes such as social protection, and SDG financing programmes.
1. **How to use the SEAS tool in practice**

The tool can be accessed on the SEAS webpage at Subsidy Reform Analysis – UNDP Data Futures Platform. By default, the landing page loads the SEAS user interface (Figure 1). Also, it briefly describes the motivation behind the SEAS tool and what it can be used for. By clicking on the ‘Next’ button, the user proceeds to the next phase.

**Figure 1**: The Socio-Economic Analysis of Subsidies (SEAS) landing page

Running a simulation can be performed by completing five phases:

1. **Provide general information**
2. **Upload files**
3. **Select variables of interest**
4. **Selection Commodities of interest**
5. **Run the simulation.**

To move from one phase to another, a user needs to click on the ‘Next’ button. A user can return to previous phases to check or modify the inputs by using the ‘Back’ button.
The following sections describe the different phases when a user has their own database in .csv format. To avoid potential errors, we assume that the user has properly prepared the database by eliminating missing values using any statistical software.

Phase 1: General information
As presented in Figures 2 to 4, SEAS will require three pieces of information:

1. Dataset selection: Using the drop-down menu, the user can either choose to use ‘Demo dataset’, ‘an existing dataset’ or ‘own dataset’. In this case, select ‘Demo dataset’.

Figure 2: Dataset selection
Enter this information as shown in Figure 2. In this case, we told SEAS that we will use our own database on data from Tunisia for 2021.

Click on the ‘NEXT’ button to transition to Phase 2, as shown below.
Figure 5: Phase 1 completed

Phase 2: Upload the data files
SEAS requires users to choose the type of simulation to perform (direct or indirect effect). To choose a simulation, click on 'Direct Pricing Effect' or 'Indirect Pricing Effect', as shown in Figure 6; the choice made is highlighted by the dark blue colour in the left-hand graph.

To upload a data file from the user’s computer, the user chooses the file as shown in Figure 6. Here, we have a direct pricing effect simulation and the associated data file named 'direct.csv'. Figure 7 shows the required structure for the data to be used for direct effects simulations. The rows represent the unique observations in the dataset, and the columns contain the key and other variables of interest.
Figure 6: How to choose the type of pricing effect and upload file(s)

For the direct pricing effect, the user needs to upload a structured dataset created using Household Budget Survey (HBS). Among the key variables to include in the dataset include the following: per capita expenditure, poverty line, population, and the household size. It should be noted however, that even without the last two variables the simulation will still run. The remainder of the variables must be disaggregated per capita expenditures on commodities of interest. There should be no missing values for all the variables in the dataset.

Indirect pricing effects require at least one HBS and an Input-Output (I/O) matrix file. The I/O matrix should be expressed in local currency. Both the I/O data and the HBS data are expressed in the same currency, in nominal terms and for the same year. In general, it will be difficult to obtain I/O tables and HBS data for the same year. This implies that either the HBS, or the I/O data or both will need to be adjusted for prices to make data in nominal terms comparable and for the same reference year before use. Note that the last line of the I/O matrix should be the total value added also called total primary input (total output - total intermediate inputs).

Choose a pricing effect type and upload the necessary data for the simulation:

Direct Pricing Effect
- The impact of a price change on household well-being via the consumption of subsidised products

Example Dataset: direct.csv

Upload the Input Data for Simulation:
- (This is typically household income and expenditure survey data)

direct.csv

Figure 7: Data structure

<table>
<thead>
<tr>
<th>Abcd</th>
<th>efg</th>
<th>hijk</th>
<th>lmnop</th>
</tr>
</thead>
<tbody>
<tr>
<td>bigh</td>
<td>cd</td>
<td>ef</td>
<td>gh</td>
</tr>
<tr>
<td>hv</td>
<td>ij</td>
<td>km</td>
<td>ln</td>
</tr>
</tbody>
</table>

7
Phase 3: Enter variables of interest
Once the file is uploaded on the SEAS interface, the user can fill in the main parameters of the analysis. The mandatory variables are indicated by a red asterisk, as shown in Figure 8.

**Figure 8: Variable of interest**

In the left window, a user must provide the following, as shown in Figure 9:
- the per capita household expenditure;
- the per capita poverty line.

The survey weight of the household is set to a default of 1 (in the case of a self-weighted sample). The household size is also set to 1 by default (in the case of user using individual-level data).
In Figure 9, on the right of the screen, in the middle, the user must choose the variable used for displaying the results. By default, SEAS presents the results by expenditure quintile (automatically calculated from the user’s data). If the user wishes to use other variables (e.g. deciles, region, area of residence), s/he must click on the 'DATA VARIABLES' button and choose the variable in his/her database.

Finally, the user must choose the approach to model the price shock by choosing between 3 approaches: the marginal approach (default), Cobb-Douglas, or Stone-Geary. We recommend using the Cobb-Douglas approach, which often gives robust results. Advanced users can use the Stone-Geary approach, but this requires a prior analysis of consumption behaviour. By default, SEAS sets the parameters of the Stone-Geary utility function to 0.25 and 0 (see the theoretical framework in the Annex).

Phase 4: Select the commodities subject to the subsidy reform
This phase allows the user to choose the number of items subject to price changes. SEAS allows to choose up to 20 items.

Once the user has selected the items for which the simulation will run, the next phase is to choose the name of the variable for the good in question (by default SEAS uses the same name of the variable), the unit of measurement of the quantity consumed (litre, kg, unit, etc.), the linear (price equal for quantities of the items consumed) or non-linear pricing mode (price changes with the quantity of an item consumed, e.g.
electricity), the initial price, the unit subsidy, the final price (after shock) and the price elasticity. By default, the price elasticity is set to 0.5. The user can choose the most appropriate value according to the country context and the specificities of the goods (see the theoretical framework in the Annex for more details).

Figures 10 to 12 show the steps to complete. We have chosen a simulation for three commodities: baguette, oil and sugar, all subject to linear pricing.

**Figure 10**: Commodities of interest – indicating the number of commodities to analyse

**Figure 11**: Commodities of interest – selecting the commodities of interest
Phase 5: Run the simulation
In phase 5, the user is ready to run their simulation (Figure 13).

But before running the simulation, SEAS presents a summary of parameters of the simulation on the left side of the screen. Also, on the right side of the screen it offers the user, the possibility to simulate a lump sum monetary transfer to the population to mitigate the impact of the price change on the welfare of the population.

If the user checks the 'Apply lumpsum transfer' box, they will have to: (i) select whether the desired transfer will be applied per household or per individual; (ii) indicate the transfer rate applied (ranging from 0 to 1, i.e. if the user chooses the value 1, the government will use all of the savings generated by the price increase as a monetary transfer to the population); (iii) specify a binary variable, created using the survey data, that will indicate the population targeted by the transfer, by filling in the last box 'Targeting Form'. Click, then, on 'Run Simulation' box.

It may take several minutes for SEAS to complete its simulations. The waiting time depends on the size of the database, the number of goods considered, and the traffic on the server at the time of the simulation.
**Figure 13:** Run the simulation

![Run Simulation](image)

2. **Displaying results**

After successfully running the simulation, the results screen appears, as shown in Figure 14.

The user can export all the results (Excel file and graphs) in a zipped file by clicking on the 'export' button.

The user can also view the detailed results by clicking on the 'View All Results' button, or by category, as presented by the three results tabs.

If the user wants to modify the simulation by changing some parameters, they can click on the 'Modify Simulation' button and continue the navigation using the 'Back' and 'Next' buttons.

**Figure 14:** The initial screen of results

![Results Screen](image)

By clicking on the 'View All results' button, a screen opens similar to the one in Figure 15. The list of all result tables is presented on the left side of the screen. The user can also access the graphs by clicking on the 'Graphical Analysis' tab (Figure 16).
3. **Simulate the indirect effect of the price change**

To simulate the indirect impact of a change, let’s start the simulation process again from phase 2.

By clicking on the ‘Indirect Pricing Effect’ tab, SEAS prompts the user to provide two data files. The first is for the household expenditure categories, and the second is for...
the input-output (IO) tables reflecting the interactions between the different sectors of activity. In our example, the first file is 'indirect.csv', and the second file is 'iomv.csv' (see Figure 19). Figure 17 shows the structure of the data file containing household expenditure categories (columns G to O) arrived at after aggregating all expenditure items falling under these categories. Similarly, Figure 18 shows the structure for the IO data file, where the columns from A onwards represent different economic sectors (in the actual datasets, the columns must be labelled accordingly). These will be matched with the respective household expenditure categories.

**Figure 17**: Data structure for the household expenditure categories

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
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<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
<th>R</th>
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<td>hhsize</td>
<td>hhsize_new</td>
<td>region</td>
<td>place</td>
<td>hshweight</td>
<td>food</td>
<td>clothes</td>
<td>dir_eff</td>
<td>transport</td>
<td>electricity</td>
<td>travel_tourism</td>
<td>telecomunication</td>
<td>habits</td>
<td>education</td>
<td>nitrats</td>
<td>moth</td>
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<td>1800.482</td>
<td>575.46</td>
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<td>0.0715</td>
<td>52.754</td>
<td>37.4364</td>
<td>0</td>
<td>99.95697</td>
<td>974.056</td>
<td>610.056</td>
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</tr>
<tr>
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<td>2.7888</td>
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<td>480.7528</td>
<td>480.031</td>
<td>1800.482</td>
<td>575.46</td>
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<td>0.0715</td>
<td>52.754</td>
<td>37.4364</td>
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<td>575.46</td>
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<td>52.754</td>
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<td>0</td>
<td>99.95697</td>
<td>974.056</td>
<td>610.056</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 18**: Data structure for the Input-Output (IO) table
For the direct pricing effect, the user needs to upload a structured dataset created using Household Budget Survey (HBS). Among the key variables to include in the dataset include the following: per capita expenditure, poverty line, population weight, and the household size. It should be noted however, that even without the last two variables the simulation will still run. The remainder of the variables must be disaggregated per capita expenditures on commodities of interest. There should be no missing values for all the variables in the dataset.

Indirect pricing effects require at least one HBS and an Input-Output (I/O) matrix file. The I/O matrix should be expressed in local currency. Both the I/O data and the HBS data are expressed in the same currency, in nominal terms for the same year. In general, it will be difficult to obtain I/O tables and HBS data for the same year. This implies that either the HBS, or the I/O data or both will need to be adjusted for prices to make data in nominal terms comparable and for the same reference year before use. Note that the last line of the I/O matrix should be the total value added also called total primary input (total output total intermediate inputs).

Choose a pricing effect type and upload the necessary data for the simulation:

- **Direct Pricing Effect**
  - The impact of a price change on household well-being via the consumption of substituted products
  - Example Dataset: indirect.csv
  - Upload the Input Data for Simulation: * (This is typically household income and expenditure survey data)
  - indirect.csv

- **Indirect Pricing Effect**
  - The impact of a price change on household well-being via the consumption of products that are affected indirectly by the change in price of substituted products
  - Example Dataset: iomv.csv
  - Upload I/O Matrix Data File: * (The simulation of indirect effects requires at least one Household Income and Expenditure Survey Data and an Input Output (I/O) matrix file)
  - iomv.csv

In Phase 3, which fills in the main variable of interest, similar steps are taken as in the simulation of the direct effect of the price change. Figure 20 shows the key variables required.
In phase 4, the user fills in the goods consumed by the household and their respective correspondences in the IO table, shown in the column, 'Matching IO sectors'. In the example presented in Figure 21, the household consumes nine categories of goods, each of which corresponds to one or more sectors of the IO table. For example, the consumption of the category 'food' comes essentially from sectors 1 and 3 of the IO table. The third item 'dir_eff' or 'Energy' will be subject to price changes.
In the last step, the user specifies the good that is subject to the price change and the level of the change expressed in percentage.

The user can specify the number of items that are subject to price shocks (in this example, 1) and the item in question (in this example, 'dir_eff').

In the example shown in Figure 22, a 15 percent increase in the price of energy is simulated. The user can also specify the option to model the shock. By default, SEAS offers 'Cost push prices exogenous short term'.
Figure 22: Run the indirect price effects simulation

After clicking on “RUN SIMULATION”, a results screen opens, which is similar to that of the ‘direct effect’ simulation.

4. Non-linear pricing schemes
This section presents the simulation of a price shock for a good with non-linear pricing by first selecting the direct pricing effect and “direct.csv” data file under phase 2. Then, the user can proceed to complete phase 3, in the same way as for the direct pricing effect simulation above. In phase 4, the user can select the number of commodities to analyse. Here, we chose 1 item, ‘Electricity’. After choosing the non-linear pricing for the good ‘Electricity’, SEAS prompts the user to initialize the initial (pre-reform) and final (simulated) prices for the good.
Figure 23: Simulation for a good with non-linear pricing

By clicking on the ‘INITIALIZE’ button under the Initialize price tab, the user can fill in the initial tariff information, as shown in Figure 24.

Click on the ‘Save’ button once the required information is given. Then initialize the final price, as shown in Figure 25.
Figure 24: Initialize the pre-reform price
Once the prices are initialized, click the ‘SAVE’ and then the ‘Next’ buttons, and SEAS will prompt the user to run the simulation, as shown in Figure 26.

After clicking on ‘RUN SIMULATION’, a results screen opens, which is similar to that of the ‘direct effect’ simulation.
Annex 1. Theoretical background of the results produced by the Socio-Economic Analysis of Subsidies (SEAS)

This section, which draws on the original SUBSIM user manual, presents the theoretical background of the results produced by the Socio-Economic Analysis of Subsidies (SEAS). The framework is identical to that used by SUBSIM.

1. The process of the analysis
The analysis of subsidies typically follows three main phases. The first phase is the incidence analysis of subsidies on household welfare. This will involve the 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 the total cost of subsidies first, then who benefits from the existing subsidies and to what extent.

The second phase is the price shock simulation. This occurs 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. Here, the analyst needs to take several critical decisions on the exogenous and endogenous parameters to be used, decide on 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 analysed, and different alternative scenarios are compared. Table 1 summarizes the steps.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Step</th>
<th>Action</th>
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<tbody>
<tr>
<td>A - Incidence analysis</td>
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<td>Product analysis</td>
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<td></td>
<td>2</td>
<td>Budget analysis</td>
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<td>Distributional incidence analysis</td>
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<td>B - Price shock model</td>
<td>4</td>
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<td>C - Impact analysis</td>
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<td>Estimate household welfare changes</td>
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The following describes in greater 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, which may be the most time-consuming exercise. It is essential 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 in order to prepare the analysis that follows. This manual does not provide any guidance regarding 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 comparing set prices with an international benchmark price, 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, which 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 DASP\(^5\) or ADePT\(^6\) 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 on 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 out of the overall expenditure on the subsidized product. Alternatively, 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 because changes in subsidies imply household behavioural 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 behaviour of supply agents). This is the reason that there is a clear distinction 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 behaviour and can result in very different outcomes compared to an incidence analysis.

**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 modelling. These two forms approach 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 modelling perspective, this is a simple increase in the price of the subsidized product that can be modelled 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 to sell the product at regulated prices. Here, the intended budget cut is known but not the corresponding increase in prices.

To model such a change, one of at least two options can be followed. The first option is to spread the budget cut across households proportionally to the share of subsidized product consumed. Here, 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 consider 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 modelling changes in subsidies, the analyst needs to make several critical decisions on assumptions regarding sequencing of events, deflators, budget constraints and elasticities. To simplify these choices, a choice can be made between modelling short-, medium- 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 with no inflation adjustments, no behavioural 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, therefore, by increasing expenditure. This is because most households can afford to buy the subsidized product at increased prices at least once, and because it is unlikely that they would re-assess their income and budget priorities in a matter of days. Economically speaking, this assumes that households can draw temporarily on savings to increase current expenditure, hence lifting 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, i.e. 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 increases. 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’ behavioural 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 behaviour to the new prices by substituting the subsidized product with other products and/or by changing the consumed quantities of the subsidized product. Here, household real expenditure would decrease and poverty may increase. We expect this to be the typical effect that occurs within 1–2 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, behavioural effects and life-cycle effects (changes in savings and investments over the long term). Here, the household budget constraint is not fixed and will depend on the household savings and investment behaviour. 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.

This manual **focuses on medium-term effects** as defined here 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 behavioural attitudes to savings, which greatly complicate the model and increase data requirements and computational complexities. Further, in developing countries, and especially in the poorest, 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

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>Inflation</th>
<th>Elasticities</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term (days)</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Medium-term (months)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Long-term (years)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Step 6 – Estimate elasticities

Two types of elasticities are considered here. The first is the price-quantity elasticity of demand. The question addressed here is: To what extent will quantities demanded by households change when there is 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 will households 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 that 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 is a vast literature on the estimation of demand elasticities, which can be used ‘off the shelves’ for modelling; the demand elasticity for electricity in the United States of America is one example.

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

Usually, the analyst has only one cross-section household survey, which is 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 homogenous behaviour across households. We can also improve on this assumption by controlling for household characteristics. Compared to the first two options, this is a less appealing option but one that improves on ignoring behavioural 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 the extent that they are rarely modelled in subsidies reforms. This is because subsidized products tend to be essential items such basic food items or utilities, which are difficult to substitute or for which there are no 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 issue, 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 modelled 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 describes the economic fundamentals and the formulae derived from theory and assumptions made, while Part III illustrates the application of these tools in Stata. In this section, these final steps of the analysis are outlined.

**Step 6 – 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, i.e. 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 7 – 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. This 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 8 – Compare different scenarios
The final product and main objective of the analysis is to provide the government with a short, concise and clear range of policy options. The principal client of the analysis should be thought of as a minister with very limited time to dedicate to the issue. The final report on the subsidies analysis may include all the steps described above, but the final product for policy purposes must 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 centred on the estimated elasticity. We may also want to model a range of price changes rather than a single price change.

2. Notations
To predict the potential effects of price changes (through changes in indirect taxes or subsidies) on the level and the distribution of welfare across households, a definition of a welfare indicator must be agreed upon. In line with most other studies, we rely on total expenditure per capita to predict the potential distributional effects of price changes. To illustrate how this can be done, let the subscript (i) \( r \) refer to the reference situation that prevails prior to any subsidy reform; (ii) \( s \) refer to the post-reform situation; (iii) \( h \) refer to the household; and (iv) \( k \) refer to the commodity. In the same vein, let
1. \( Y = (Y_1, Y_2, \ldots, Y_{H}, \ldots, Y_H) \) be a vector of households’ total expenditure from a household survey of \( H \) households (observations). Thus \( Y_{r,h} \) and \( Y_{s,h} \) stand for the total expenditure of a household \( h \) in the reference situation \( r \) and in the post-reform situation \( s \), respectively.

2. \( W = (W_1, \ldots, W_{H}, \ldots, W_H) \) be a vector of households’ weight. Then, \( w_h = n_hW_h \) is the individual weight, and \( N = \sum_{h=1}^{H} n_hW_h \) is an estimate of the population size, where \( n_h \) is the size of the household \( h \). The households’ weight remains unchanged across the simulation reforms.

3. \( p(p_1, p_2, \ldots, p_{k}, \ldots, p_K) \) be a vector of \( K \) prices (related to \( K \) goods) so that \( p_{r,k} \) and \( p_{s,k} \) are the price in the reference situation \( r \) and in the post-reform situation \( s \), respectively.

4. \( \xi(\xi_1, \xi_2, \ldots, \xi_k, \ldots, \xi_K) \) be a vector of \( K \) unitary subsidies.

5. \( Q_h(Q_{h,1}, Q_{h,2}, \ldots, Q_{h,k}, \ldots, Q_{h,K}) \) be a vector of \( K \) quantities of commodities purchased by the household \( h \). Then, \( X_{h,k} = p_kQ_{h,k} \) is the expenditure of household \( h \) on the commodity \( k \).

6. \( C_s(C_{s,1}, C_{s,2}, \ldots, C_{s,h}, \ldots, C_{s,H}) \) be a vector of income changes related to the post-reform situation \( s \); so that \( C_{r,h} = 0 \) for all the households \( h \). \( C_{s,h} \) could either be negative (a rise in the annual fee of electricity, for instance), nil, or positive (a targeted or universal compensation that could be a part of the reform \( s \) package).

The living standards of a household \( h \) (in either the reference situation \( r \) or the post-reform one \( s \)) is then given by \( y_h \), the total expenditure per capita:

\[
y_h = \frac{Y_h}{n_h}
\]

such that \( y = (y_1, \ldots, y_H, \ldots, n_{H}, \ldots, n_H) \) denotes then the vector of total expenditure per capita. Thus \( y_{r,h} \) and \( y_{s,h} \) stand for the total expenditure per capita of a household \( h \) in the reference situation \( r \) and in the post-reform situation \( s \), respectively.

In the same vein, the per capita quantity of the commodity \( k \) consumed by the household \( h \) is defined as:

\[
q_{h,k} = \frac{Q_{h,k}}{n_h}
\]

We can also define \( x_{h,k} \) and \( C_{s,h} \) accordingly.

It is assumed within the micro-simulation framework that, in the reference situation \( r \) prevailing before the reform, each household \( h \) has welfare level per capita equal to \( y_{r,h} \) and faces the price system \( p_r \). Following the reform, which results in some price changes, each household faces a new vector of prices and total expenditure per capita \((p_s, y_{s,h})\) where:
Recall that $c_{s,h}$ could either be negative, nil, or positive (and $c_{r,h} = 0$ for all households $h$).

3. The potential effects of the reform: the marginal approach

3.1. The impact of the reform on the per capita household’s demand

Theoretically, the price changes resulting from a subsidy reform would be levied by both firms and consumers. A computable general equilibrium (CGE) model could be used to elicit the sharing of subsidy reform costs or benefits between firms and households. Most CGE models broadly assume that all production functions are homogeneous of degree one and that there is perfect competition. Under these assumptions, the supply curve of each commodity is horizontal so that consumers reaped the entire costs or benefits of the reform. For simplicity, we assume such a framework, although there is nothing in our approach that prevents the introduction of alternative hypotheses.

Given the above assumptions, the estimation of the households’ demand variation resulting from the subsidy reform is straightforward. If we assume that the own price elasticity ($e_k$) is known (from the literature or specific estimations) and given by:

$$e_k = \frac{q_{s,k} - q_{r,k}}{q_{h,r,k}} \frac{p_s - p_r}{p_r}$$

while the cross-price elasticities are nil ($e_{k,l} = 0$), then the post-reform demand could be computed as:

$$q_{h,s,k} = e_k q_{r,h,k} \left( \frac{p_s - p_r}{p_r} \right) + q_{r,h,k}$$

The common formulae to compute $e_k$ (given by equation 5a) is valid only when price changes are relatively small (marginal). Some subsidy reforms could provoke an increase in some pre-reform prices greater than 100 percent. Equation (6a) shows, for instance, that if the absolute value of $e_k$ is greater than 0.5 and $\left( \frac{p_s - p_r}{p_r} \right)$ is greater than 1, then $q_{h,s,k}$ would be negative. Such a result clearly could not be plausible. To address this issue, we introduced in the micro-simulation model the arc elasticity formulae. Arc elasticity measures elasticity at the midpoint between two selected points on the demand curve by using a midpoint between the two points. The arc elasticity of demand can be calculated as:

$$e_k = \frac{q_{s,h,k} - q_{r,h,k}}{\bar{q}_{h,k}} \frac{p_s - p_r}{p_r}$$
where $\bar{q}_{h,k} = \frac{q_{r,h,k} + q_{s,h,k}}{2}$ and $\bar{p}_k = \frac{p_{r,k} + p_{s,k}}{2}$. The post-reform demand could therefore be computed as:

$$q_{s,h,k} = \frac{2\bar{p}_k + (p_{s,k} - p_{r,k})e_k}{2\bar{p}_k - (p_{s,k} - p_{r,k})e_k}$$

(6b)

3.2. The impact of the reform on the per capita household’s welfare

To capture the effects of price changes on the distribution of real income, the easiest approach is to assume the uniformity of the impact of price changes all the households, regardless of their consumption pattern and socio-demographic characteristics. Let $n_s$ be the consumer price index (CPI), which indicates the average price change following the simulation $s$

$$\pi_r^s = \frac{\sum_{h=1}^{H} \sum_{k=1}^{K} n_{h} W_{h} p_{s,k} q_{r,h,k}}{\sum_{h=1}^{H} \sum_{k=1}^{K} n_{h} W_{h} p_{r,k} q_{r,h,k}}$$

(7)

By definition, $\pi_r = 1$ and $\pi_s$ may be lower or greater than 1 according to whether the subsidy reform results in an increase or a decrease in the consumer prices. The expected purchasing power per capita of each household at any given situation could then be approximated by:

$$\Gamma_{r,h} = \frac{y_{r,h}}{\pi_r^s} = \frac{y_{r,h}}{\pi_r^s}$$

$$\Gamma_{s,h} = \frac{y_{s,h}}{\pi_s^s} = \frac{y_{r,h} + c_{s,h}}{\pi_s^s}$$

(8)

$$\Delta\Gamma_{h} = \Gamma_{s,h} - \Gamma_{r,h} = y_{h,r} \left( \frac{1 - \pi_s^s}{\pi_s^s} \right) + \frac{c_{s,h}}{\pi_s^s}$$

Where $\Delta\Gamma_{h}$ is an approximation of the monetary-equivalent change in the welfare (per capita) of the household $h$.

Clearly, however, this is not the best approach due to the diversity in the households’ consumption pattern. The impact of any subsidy reform would not necessarily be proportional to the household welfare level. It is well known, for instance, that the poor devote a larger budget share to food than the non-poor. Hence, an increase in food prices, for instance, would hurt more the poor than the non-poor. To consider the variability in the effects of subsidy reforms, we can alternatively calculate consumer price indices that are specific to each household.

This is not, however, the route commonly followed in the literature, especially when the price changes resulting from subsidy reforms are marginal. When the price changes are marginal, we can approximate the monetary-equivalent change in the welfare of a household $h$ as:

$$\Delta\Gamma_{h}^{Marg.} = c_{s,h} - \sum_{k=1}^{K} q_{r,h,k} (p_{s,k} - p_{r,k})$$

(9)
As stated above, the approximation given by equation (9) is fine when price changes are relatively small (marginal). In the opposite case, \( \Delta \Gamma^M_{\text{Marg}} \) would overstate the effects of price changes on the households’ welfare. A better approximation of the monetary-equivalent change in the welfare of a household \( h \) could be obtained as:

\[
\Delta \Gamma^C_{\text{Crude-EV}} = c_{s,h} + \sum_{k=1}^{K} p_{r,k} (q_{s,h,k} - q_{r,h,k})
\]  

(10)

When the price changes are not marginal, the change in the households’ well-being per capita given by \( \Delta \Gamma^C_{\text{Crude-EV}} \) (equation 10) will be closer to the equivalent variation (EV) than \( \Delta \Gamma^M_{\text{Marg}} \) (equation 9). For this reason, we refer to this measure as a crude EV. Recall that the actual EV is an exact measure of households’ well-being changes associated with price changes, which we will use in Section 4 with the Cobb-Douglas approach.

### 3.3. The impact of the reform on poverty and inequality

To describe how poverty is affected by subsidy reforms, we must also obviously address the measurement of poverty. We use the popular Foster-Greer-Thorbecke (1984) (FGT) family of poverty indices. Let \( z \) be a real poverty line, that is, a line measured in terms of the reference prices \( p_r \). Let also \( y \) be a given distribution of per capita consumption (it could be equal to \( y_r, y_s \) or any alternative welfare distribution). The FGT family of poverty indices is then defined as

\[
P_{\alpha}(z, y) = \frac{1}{N} \sum_{h=1}^{H} n_h W_h \left( \frac{z - y_h}{z} \right)^\alpha \varphi(y_h < z)
\]  

(11)

Where \( N, n_h, \) and \( W_h \) are as defined above; \( \varphi(.) \) is an identification function taking the value of 1 when its argument is true and 0 otherwise, and \( \alpha \) is a poverty aversion parameter; it captures the sensitivity of the poverty index to changes in the distribution. As is well known, for \( \alpha = 0 \), \( P_0(z, y) \) is the incidence of poverty (the headcount ratio), yielding the proportion of the population living in poverty (i.e. with a per capita consumption level below the poverty line). For \( \alpha = 1 \), \( P_1(z, y) \) is the normalized average poverty gap measure (the `intensity" of poverty), and, for \( \alpha = 2 \), \( P_2(z, y) \) is often referred to as the severity of poverty. For \( \alpha > 1 \), \( P_\alpha(z, y) \) is sensitive to the distribution of welfare among the poor, and when \( \alpha \) becomes very large, \( P_\alpha(z, y) \) approaches a Rawlsian measure.

It is assumed within the micro-simulation framework that, in the reference situation \( r \) prevailing before the reform, each household \( h \) has welfare level per capita equal to \( y_{r,h} \) and faces the price system \( p_r \). Following any subsidy reform, the consumers face a new vector of prices and total expenditure per capita \( (p_s, y_{s,h}) \). These changes are equivalent to a change in their purchasing power equal to \( \Delta \Gamma_h \) where could be approximated using a marginal approach (see equation 9), a crude equivalent variation (see equation 10) or an exact measure of the equivalent variation as we shall see in section 4. Therefore, the impact of a subsidy reform on poverty could simply be computed as:

\[
\Delta P_\alpha(z, y) = P_\alpha(z, y_r + \Delta \Gamma) - P_\alpha(z, y_r)
\]  

(12)
Recall that \( \Delta \Gamma_h \) could be lower or greater than 0 according to whether the subsidy reform results in an increase or a decrease in the welfare level of the household \( h \). If, for instance, the reform \( s \) results in increases in some commodity prices and some compensations \( (c_{s,h} > 0) \) to a targeted group of the population (the rural households, for example), \( \Delta \Gamma_h \) will be negative for the non-targeted population and positive for some or all the households of the targeted population.

The impact of the subsidy reform on inequality could be calculated accordingly, where the Gini index at any situation could be estimated as:

\[
Gini(y) = \frac{\sum_{g=1}^{H} \sum_{h=1}^{n} n_g n_h W_g W_h |y_g - y_h|}{N^2 \bar{y}}
\]  
(13)

3.4. The impact of the reform on the government revenue

The impact of the reform on government revenue could be estimated using the following equation

\[
\Delta R = R(\xi_s) - R(\xi_r) = \sum_{h=1}^{H} \sum_{k=1}^{K} n_h W_h \xi_{s,k} q_{s,h,k} - \sum_{h=1}^{H} \sum_{k=1}^{K} n_h W_h \xi_{r,k} q_{r,h,k}
\]  
(14)

where \( R(\xi_r) \) and \( R(\xi_s) \) denote the government spending due to the subsidy scheme prevailing in the reference situation \( r \) and the post-reform situation \( s \), respectively.

4. The potential effects of the reform: the Cobb-Douglas/Stone-Geary approach

As mentioned in Section 3, the welfare measures \( \Delta \Gamma_h \) (of the impact of the reform) given by either equation (9) or equation (10) are a crude approximation of the exact welfare measure given by the equivalent variation (EV). To estimate the EV, we rely on the concept of equivalent income (see King, 1983). For a given budget constraint \( (p_s, y_{s,h}) \), the equivalent income is defined as the income level that, at the reference price system \( p_r \), yields the same utility level as that utility level reached under \( (p_s, y_{s,h}) \)

\[
v(p_r, \Gamma_h(p_r, p_s, y_{s,h})) = v(p_s, y_{s,h})
\]  
(15)

where \( p_r, p_s, \) and \( x_{s,h} \) are as defined above, \( v(\cdot) \) is the indirect utility function, and \( \Gamma_h(\cdot) \) is here the equivalent income function that is specific to the household \( h \). Since \( p_r \) is fixed across all households, \( \Gamma_h(\cdot) \) is an exact monetary metric of actual utility \( v(p_s, x_{s,h}) \) because \( \Gamma_h(\cdot) \) is an increasing monotonic transformation of \( v(\cdot) \). Thus, inverting the indirect utility function, the equivalent income, \( \Gamma_h(p_r, p_s, x_{s,h}) \) is obtained as:

\[
\begin{align*}
\Gamma_{r,h} &= \Gamma_h(p_r, p_r, y_{r,h}) = y_{r,h} \\
\Gamma_{s,h} &= \Gamma_h(p_r, p_s, y_{s,h}) = y_{r,h} + \Delta \Gamma_h
\end{align*}
\]  
(16)

where \( \Gamma_{r,h} \) and \( \Gamma_{s,h} \) stand henceforth for the equivalent income in the reference \( (r) \) and post-reform \( (s) \) situations, respectively and \( \Delta \Gamma_h \) is the exact equivalent variation of \( h \).

The subsidy reform that results in prices increase is then equivalent to taking from each
household an amount of income equal to their equivalent variation. Hence, $\Delta \Gamma_h$ is the sum of money per capita that the household $h$ would be willing to sacrifice in its initial position to avoid the reform.

To measure $\Delta \Gamma_h$, SUBSIM uses the commonly used Cobb–Douglas utility function. The main drawback of this utility function is that all own price elasticities are equal to -1. The empirical literature tends to show, however, that most subsidized goods are inelastic (i.e. the absolute value of own price elasticity is below 1). For this reason, SEAS offers the possibility to assume $K$-commodity Stone-Geary preferences with the utility function:

$$u_h(q_h) = \prod_{k=1}^{K}(q_{h,k} - y_{h,k})^{\beta_{h,k}} \quad \text{with} \quad \sum_{k=1}^{K} \beta_{h,k} = 1$$

(17)

and the resulting indirect utility function:

$$v_h(p, y_h) = \frac{y_h - \sum_{k=1}^{K} p_k y_{h,k}}{\prod_{k=1}^{K}(p_k)^{\beta_{h,k}}} \quad \text{with} \quad \sum_{k=1}^{K} \beta_{h,k} = 1$$

(18)

where $y_{h,k}$ is the minimum subsistence requirements (per capita) for the commodity $k$, and $\beta_{h,k}$ is the proportion of the residual household’s total expenditure per capita (i.e. $y_h - \sum_{k=1}^{K} p_k y_{h,k}$) allocated to the consumption of $k$ once the minimum subsistence requirements ($\sum_{k=1}^{K} p_k y_{h,k}$) are bought. Thus, the higher the value of $y_{h,k}$, the lower the absolute value of the own price elasticity of the commodity $k$ (i.e. the more inelastic is the demand for the commodity $k$).

To take into account of the heterogeneity in the households’ preferences, the key parameters of the Stone-Geary utility function ($y_{h,k}$ and $\beta_{h,k}$) are specific to each household $h$. They are calibrated by SEAS and, unlike the commodities demand $q_{h,k}$, assumed to be insensitive to subsidy reforms. For $y_{h,k} = 0$, the Stone-Geary utility function reduces to the well-known Cobb–Douglas utility function.

Relying on (15) to (18), the equivalent income for any household $h$ following s subsidy reform $s$ could be given by:

$$\Gamma_h(p_r, p_s, y_{s,h}) = \sum_{k=1}^{K} p_{r,k} y_{h,k} \quad \text{with} \quad \sum_{k=1}^{K} \beta_{h,k} = 1$$

(19)

When the households’ preferences are described by Stone-Geary utility function, the equivalent income function has a clear interpretation in terms of real income. If the $\sum_{k=1}^{K} p_{s,k} y_{h,k}$ represents the minimum subsistence requirements, only the residual income $y_{s,h} - \sum_{k=1}^{K} p_{s,k} y_{h,k}$ is available for discretionary allocation and this is deflated by the household’s specific consumer price index ($\prod_{k=1}^{K}(p_{s,k}/p_{r,k})^{\beta_{h,k}}$) to express it in the reference price system, $r$. Adding then the initial cost of minimum subsistence requirements to the real residual income yields the equivalent income. When the minimum subsistence requirements for all commodities $y_{h,k}$ are equal to 0, $\beta_{k,h}$ becomes
the budget share devoted by \( h \) to the commodity \( k \), and the equivalent income function reduces to that generated by the Cobb-Douglas preferences:

\[
\Gamma_h^r (p_r, p_s, y_{s,h}) = \frac{y_{s,h}}{\pi_{s,h}^r} \quad \text{where} \quad \pi_{s,h}^r = \prod_{k=1}^{K} (\frac{p_{s,k}}{p_{r,k}}) \beta_{h,k}
\]

(20)

One of the most striking features of the Cobb-Douglas preferences and, to lesser extent, of the Stone-Geary preferences is that the inference of the household’s specific (and exact) consumer price index \( \pi_{s,h}^r \) is straightforward. In the former case, \( \beta_{h,k} \) simply corresponds to the budget share devoted by \( h \) to the commodity \( k \). In the latter case, \( \beta_{h,k} \) cannot be computed in absence of any information about the level of \( y_{h,k} \). From the restrictions imposed by the consumer theory, however, we know that for any household \( h \), \( y_h \) should not be lower than \( \sum_{k=1}^{K} p_k y_{h,k} \) and that \( q_{h,k} \) should never be lower than \( y_{h,k} \) to ensure that the households’ demand functions are derived from constrained utility maximization. The easiest way to fulfill these conditions is to set \( y_{h,k} \) as a fraction \( \theta \) of the pre-reform households’ consumption of the commodity \( k \):

\[
y_{h,k} = \theta q_{r,h,k} \quad \text{with} \quad 0 \leq \theta < 1
\]

(21)

Finally, the values of the \( \beta_{h,k} \) can be calculated as:

\[
\beta_{h,k} = \frac{p_{r,k} (q_{r,h,k} - y_{h,k})}{y_{r,h} - \sum_{k=1}^{K} p_{r,k} y_{h,k}}
\]

(22)

Equations (21) and (22) allow to calibrate the key parameters the key parameters of the Stone-Geary utility function, namely \( y_{h,k} \) and \( \beta_{h,k} \), for each household \( h \). Once the value of these two parameters are calibrated, using equation (19) and given that \( y_{s,h} = y_{r,h} + c_{s,h} \), the computation of the exact equivalent variation could be deduced as:

\[
\Delta \Gamma_h^{Exact-EV} = \sum_{k=1}^{K} p_{r,k} y_{h,k} + \frac{(y_{r,h} + c_{s,h}) - \sum_{k=1}^{K} p_{s,k} y_{h,k}}{\prod_{k=1}^{K} (\frac{p_{s,k}}{p_{r,k}}) \beta_{h,k}} - y_{r,h}
\]

(23)

Once the effect of the subsidy reform on each household’s welfare \( \Delta \Gamma_h^{Exact-EV} \) is computed, we can use:

- equation (12) to estimate the impact of the reform on poverty;
- equation (13) to estimate the impact of the reform on Gini inequality; and

---

3 Ideally, the parameters \( y_k \) and \( \delta_{k,h} \) should be estimated econometrically. This requires, however, the use of panel data that record living standards information on the same sample of households observed over multiple time periods.

4 The value of \( \theta \) could be calibrated so that the own price elasticity of a commodity \( k \) for a representative household \( h \) is equal to a pre-determined value of the own price elasticity (given, for instance, by the empirical literature) of the commodity \( k \).
• equation (14) to estimate the impact of the reform on government revenue.

5. Nonlinear tariffs

The formulas presented above apply to the linear pricing of goods, i.e. each unit of purchased goods is paid at price $p$ regardless of the quantity purchased. However, several tariffs for subsidized goods such as water and electricity are organized in quantities blocks where a different tariff corresponds to each block of quantities. These prices can be ‘marginal’, i.e. they only apply to the block where the consumer is located, or ‘flat’, i.e. they apply to all quantities consumed up to the block where the consumer is located. The first type of tarification is called ‘increasing block tariffs’ (IBT) and the second type is called ‘volume differentiated tariffs’ (VDT).

The following presents the treatment of non-linear pricing, specifically, the estimation of quantity change. Once the impact on quantities is known, the formulas developed above are applied to estimate the impact on household welfare.

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

<table>
<thead>
<tr>
<th>Block</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[0 - Q_1]$</td>
<td>$p_{1,1}$</td>
</tr>
<tr>
<td>$[Q_1$ and more]</td>
<td>$p_{1,2}$</td>
</tr>
</tbody>
</table>

Here, the marginal price for a given consumer refers to the price of the last block of consumption. We will then 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 entire 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. Just as in Komives et al. (2006), we call the first type VDT. This occurs where the household pays the price for the block of consumption in which it falls for all consumed units. The second type is IBT. Here, the household pays different prices on their consumed units for each block covered by consumption. This documents focuses only on the IBT type. This is justified by the fact that this structure is the most common type of tariff structure used in developing countries.
5.1. 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 \( = (1, ..., B) \); \( Q_b \) 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:

\[
kw_{h,b} = e_{h,1} \frac{p_1}{p_1} \text{ for } b = 1
\]

\[
\sum_{j=1}^{b-1} Q_j + e_{h,b} - \bar{e}_{b-1} \frac{p_b}{p_1} \text{ for } b > 1
\]

It is important to note that, in the case of multiple priced goods such as utilities, households may report expenditure for more than one period, or they may not report expenditure i– or report only in part – 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, the company information on arrears by tariff block one can be used to impute the missing expenditure into the survey data to correct the bias caused by arrears.

5.2. Household expenditure

Figure 15 shows the equilibrium of a consumer when we assume the case of an increasing marginal price schedule. The budget constraint is the inflected line. We assume also that the consumer prefers to consume a quantity of electricity that is higher. In equilibrium

\[
MRS_{1,2} = \frac{MU_1}{MU_2} = \frac{p_{1,2}}{38}
\]
Figure 27: Consumer equilibrium

Just as before, here 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

<table>
<thead>
<tr>
<th>Block</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>([0 - Q_1])</td>
<td>(\frac{p_{1,1}}{p_{1,2}})</td>
</tr>
<tr>
<td>([Q_1 \text{ and more}])</td>
<td>1</td>
</tr>
</tbody>
</table>

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 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 or 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, e.g. the second block in the two blocks’ structure. In Figure 16, 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 \(X_{1,h,b}^0\), the change in welfare equals to:

\[
\Delta y_h = -X_{1,h,2}^0 \, dp_{1,2}
\]
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 28:** Consumer equilibrium with schedule price change (case 1)

Now, assume that the change of price occurs in the first block only $p_{1,1}$, as shown in Figure 17. If the decrease in the consumed quantities concerns electricity only, then the consumer must decrease the quantity consumed by several units within block 2 for an amount equal to $X_{1,h,1}^0 dp_{1,1}$.

**Figure 29:** Consumer equilibrium with schedule price change (case 2)

Based on 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:
\[ \Delta y_h = - \sum_{b=1}^{B} X_{1,h,b}^0 d p_{1,b} \]

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, Figure 18 shows the case of change in the price of the two blocks. Thus, the consumer will adjust bought quantities to the new budget constraint.

**Figure 30**: 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:

- Block 1: \([0, Q_1^0]) \rightarrow p_{1,1}^0\)
- Block 2: \(Q_1^0, more \] \( \rightarrow p_{1,2}^0\)

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

- Block 1: \([0, Q_1^1]) \rightarrow p_{1}^1\)
- Block 2: \([Q_1^1, Q_2^1] \rightarrow p_{2}^1\)
- Block 3: \([Q_2^1, more ] \rightarrow p_{3}^1\)

To assess the change in welfare, we begin by representing each of the two price schedules in an appropriate common price schedule. For example, assuming simply that \(Q_1^2 < Q_1^0\) and \(Q_2^2 > Q_1^0\), the two price schedules can be represented as follows:
<table>
<thead>
<tr>
<th>Block</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>([0, Q_1^1])</td>
<td>(p_1^0)</td>
<td>(p_1^1)</td>
</tr>
<tr>
<td>([Q_1^1, Q_0^0])</td>
<td>(p_1^0)</td>
<td>(p_2^1)</td>
</tr>
<tr>
<td>([Q_0^1, Q_1^1])</td>
<td>(p_2^0)</td>
<td>(p_2^1)</td>
</tr>
<tr>
<td>([Q_1^1, \text{more}])</td>
<td>(p_2^0)</td>
<td>(p_3^1)</td>
</tr>
</tbody>
</table>

For the estimation of the impact of the reform on household welfare, poverty and inequality all the formulas developed earlier remain valid.

6. Treatment of own price elasticity

The formula for the estimation of changes in quantities consumed uses the own-price uncompensated elasticity. One of the main challenges in subsidies simulations is to specify the value of this elasticity correctly. There are at least three major difficulties.

The first difficulty is that it is very hard to estimate elasticities when products are subsidized. When prices are subsidized and especially when only one price is applied nationally and on all quantities, it is not possible to estimate the own-price elasticity cross-section with a model based on household data (there is no price variation). Sometimes, the subsidized price changes over time and one may have available several household consumption surveys that cover the period when price changes occurred. However, this is rare, and it is very difficult to isolate the impact of the price change in the subsidized product from other effects on expenditure over time. Therefore, subsidies analysts can rarely estimate elasticities for the country of interest.

The second difficulty relates to the use of known elasticities from the literature and other countries. Sometimes, it is possible to derive elasticity parameters from the specific literature on products. For example, the own-price elasticity for gasoline is well known and has been estimated widely worldwide, and the user could simply use estimations made for similar countries to the country of interest. However, known elasticities are typically estimated at free market prices and they are point elasticities that apply to prices that are not subsidized. The point elasticities at subsidized prices may be very different and cannot be assumed to be the same. Therefore, it is very difficult for subsidies analysts to simply ‘borrow’ elasticities from elsewhere.

The third difficulty is that the formula presented in the previous section is designed for small price changes (marginal changes) and does not function well for large price changes. When the product between changes in prices and elasticity \((dp_1 \epsilon_1)\) is
greater than 1, the post-reform quantity can become negative using this formula. Unlike other simulations of price changes, changes in subsidized prices can be very large, especially when governments want to remove subsidies altogether. In these cases, it is not unusual to have price increases of several folds so that $d_{p1}$ can be very large. Therefore, subsidies analysts cannot simply use standard parameters for elasticities like -0.3 or -0.5 but must consider more specifically the relation between subsidized and unsubsidized prices before specifying elasticities.

To overcome these problems, SEAS has three main solutions. The first solution is that, by design, SEAS does not allow quantities to become negative ($-Q_0$) because the post-reform quantity has a lower bound of zero. However, one should be aware that when results on quantities in the Excel output file show zero values, it is most likely that the specified elasticities are too large. Subsidized products are usually essential consumption items, and it is unlikely that households stop consuming these products altogether if the price increases. It is more likely that our specification of elasticity is incorrect.

The second solution is to use the value of elasticity at unsubsidized prices from another country and derive from this elasticity the correct elasticity to use for the subsidized price. When the subsidized price is several times lower than the unsubsidized price, the subsidized price is extremely low. But if this price is extremely low and quantity is initially high, we should expect the own-price elasticity to be very low. If prices increase a little around the subsidized price, consumers will tend to reduce quantities by very small amounts. On the contrary, if the subsidized price is very close to the unsubsidized price, then it is more likely that increases in prices will lead to large decreases in quantities and that the elasticity will be large. Hence, either the elasticity $\varepsilon_1$ is large, or the relative change in price $d_{p1}$ is large, but they should not be both large at the same time. As a rule of thumb, if the new price is three times the current price and the known elasticity at unsubsidized prices is (say) -0.3, then the elasticity to use in the formula may be around a third of that value, say 0.1.

With the assumption of a straight linear demand function, it is also possible to precisely calculate the initial elasticity (i.e. the elasticity at the subsidized price) using the final elasticity (the elasticity at the unsubsidized price). The formula is as follows:

$$\varepsilon_1 = \frac{1}{1 - \frac{\varepsilon'_1 (p'_1 - p_1)}{p'_1}} - 1$$

where $p'_1$ is the subsidized price and $p_1$ is the unsubsidized price.
The third and perhaps the most sensible solution is to run SEAS with different assumptions about the elasticity and compare results. Here, it is useful to use zero as a lower bound and the expected value of elasticity at the unsubsidized price as an upper value. This is what we would recommend especially when price increases are very large.

7. SEAS indirect effects

The price reform of subsidized goods impacts household welfare through two channels. Households pay higher prices for the goods affected by the reform. This impact, called the ‘direct effect’, is assessed with the tools developed above, using the SEAS-DirectEffect module. In addition, the change in the price of some goods generates indirect effects on household welfare through the transmission of higher production costs to households. For example, the increase in the price of gasoline generates direct effects by paying higher prices at the pump and increases the cost of other services such as transportation, which affects the household budget. The additional cost passed on by producers to households is called the ‘indirect effect’. The magnitude of the indirect effect depends on the structure of the economy and the degree to which subsidized goods are used as inputs in the production of goods and services.

In practice, assessing the indirect effect requires detailed knowledge of the structure of household consumption and the technology of the economy as reflected in the input/output (I/O) table.

SEAS builds on the work of Coady and Newhouse (2006) to estimate the indirect effect of changing the price of certain goods. The following paragraphs present the general methodology of SEAS-IndirectEffect.

The main objective of SEAS-IndirectEffect is to estimate the direct and indirect effects of a price change on household welfare combining a Household Budget Survey (HBS) and I/O tables for a particular country. Note that SEAS-Indirect focuses only on the goods that are concerned by the exogenous price shocks. Thus, this version is more appropriate to assess the indirect effect rather than the full direct effect of the subsidy reform. Direct effects are better estimated with SEAS-DirectEffect.

A. Data and methodology

SEAS Indirect requires at least one Household Budget Survey (HBS) and an I/O matrix (file). The I/O matrix required is the output matrix expressed in local currency. It is important that the I/O data and the HBS data are expressed in the same currency, in nominal terms and for the same year. In general, it will be difficult to
obtain I/O tables and HBS data for the same year. This implies that either the HBS, or the I/O data or both will need to be adjusted for prices to make data in nominal terms comparable and for the same reference year. This work must be performed by users before using SEAS-Indirect Effect.

Note that the last line of the I/O matrix should be the total value, added also called ‘total primary input’ (total output-total intermediate inputs).

For SEAS to match HBS data with I/O data, users must prepare HBS consumption aggregates that mimic the I/O sectors in advance. Since HBS products are much more numerous than I/O sectors, sets of HBS products corresponding to I/O sectors should be grouped so that SEAS can perform a one-to-one matching of HBS aggregates of products with I/O sectors. In some cases, one HBS product may span across several I/O sectors. SEAS can also handle this last case. The user will simply indicate in the dialogue box multiple I/O sectors corresponding to a single aggregate of HBS products (or one product).

Suppose that we want to study the direct and indirect welfare effects of a price increase of gasoline. Since I/O tables are organized by sector, and it is very rare for researchers to have access to I/O tables by individual product, the study of indirect effects can only be done by sector and group of products, and not by individual product. In our example, there is one sector called ‘petroleum products’, which includes gasoline as well as other products. We can shock this sector with a price increase and study the direct and indirect effects on final consumers. If users have detailed information on the sector structure and want to study the effect of a price change of only one product, it is possible to make the price shock proportionate to the importance of the product within the sector. For example, if gasoline accounts for only 20 percent of the petroleum sector and we wish to increase only the price of gasoline by 10 percent, one can shock the petroleum sector by 2 percent (10 percent of 20 percent). This is a user’s choice and does not make any difference to how SEAS operates.
Continuing with the example above, suppose now that we shock the petroleum sector with a price increase. Users will have prepared in advance aggregates of consumption products that roughly correspond to I/O sectors. In the example below, we have \( n \) consumption items present in the HBS represented by the list on the left-hand side, and 12 sectors in the I/O matrix represented by the list on the right hand side. Users will aggregate all HBS consumption products that belong to the I/O petroleum sector (ex: gas, gasoline and kerosene) into one item and prepare similar aggregates for the other sectors. SEAS will first load the HBS and I/O data, and then match I/O economic sectors with HBS consumption products following the indications provided in the dialogue box.

**Note:** Some products (e.g. food in the example below) may belong to more than one I/O sectors, while in other cases (e.g. gas, gasoline and kerosene), several products belong to one sector. To accommodate simulations for both cases, it is important that users construct HBS aggregates for the products that belong to only one sector in advance. For example, the variable ‘gas, gasoline and kerosene’ is constructed by users in advance to allow SEAS to match products with sectors.
The price change of the HBS items is estimated in two steps. In the first step, the price change of the I/O sectors is estimated based on the selected I/O model. In the second step, by using the sectoral price changes, the price change of HBS items are estimated based on the matching information indicated by the user and the importance of each sector. For instance, assume that the price change in sector eight is \( dp_{S8} = 0.1 \) and the price change in sector ten is \( dp_{S10} = 0.2 \). Further, assume that the value of total product of the sector eight is \( S8 = 100 \) and that of sector ten is \( S10 = 400 \); then, a weighted price change of food is equal to:

\[
\frac{100}{500} \times 0.1 + \frac{400}{500} \times 0.2 = 0.18.
\]

SEAS-IndirectEffect has the same tabs as SEAS-DirectEffect.
• **M1: Cost-push prices.** The main assumption here is that producers ‘push’ the increase in prices onto consumers via the increase in prices of market products. SEAS Indirect offers two sets of options (exogenous/endogenous model and short-term/long-term).

  • *Endogenous and exogenous model:* This refers to the sector that is shocked. With the endogenous option, we allow for the price adjustment of the shocked sector after the shock period. With the exogenous option, we assume that the price of the shocked sector does not change after the introduction of the price shock. Clearly, the selection of the appropriate model will depend on the country context. For instance, if the country is a net importer of the shocked good, and we assume that the economy cannot truly influence the world price, it may be appropriate to select the exogenous model.

  • *Short-term or long-term:* This refers to the time horizon of the price effects measured in terms of successive rounds of price adjustments. The short-term option considers only the first round effects. The long-term option considers infinite rounds.

• **M2: Marginal profit-push prices.** The main assumption here is that markets are competitive and reach full price adjustments and producers maintain their marginal profits in the long-term. For the formulae corresponding to this choice, see Annex with formulae.

**B. Formulae for input-output simulations**

SUBSIM Indirect provides various options for the simulation of indirect effects with input-output tables. The two sets of choices for the **cost-push model** will select one of four options for the estimation of direct and indirect effects. The formulae of the four options are listed in Table 3.
Table 3. Exogenous versus Endogenous Models

<table>
<thead>
<tr>
<th></th>
<th>Short-term (t=1)</th>
<th>Long-term (t=∞)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exogenous model</strong></td>
<td>( dP_t = dP_0 + \begin{pmatrix} (dP_0' \bar{A})' \end{pmatrix} )</td>
<td>( \frac{d}{dP} = (I - \bar{A}^{-1})^{-1} dP_0 )</td>
</tr>
<tr>
<td><strong>Endogenous model</strong></td>
<td>( dP_t = dP_0 + \begin{pmatrix} (dP_0' A)' \end{pmatrix} )</td>
<td>( \frac{d}{dP} = (I - P A')^{-1} dP_0 )</td>
</tr>
</tbody>
</table>

Where \( I \) is the identity matrix, and the matrix \( \bar{A} \) is similar to \( A \) by replacing the elements of the \( i_{th} \) line and the \( i_{th} \) column of the shocked sector by zeroes. For example, with a three sectors’ matrix and a price shock to the second sector:

\[
A = \begin{bmatrix} 0.2 & 0.2 & 0.3 \\ 0.2 & 0.0 & 0.3 \\ 0.2 & 0.0 & 0.3 \end{bmatrix} \quad \text{and} \quad \bar{A} = \begin{bmatrix} 0.00 & 0.0 & 0.0 \\ 0.0 & 0.5 & 0.2 \\ 0.0 & 0.0 & 0.1 \end{bmatrix}
\]

If we have an increase of 10 percent in price of sector 2, then:

\[
S = \begin{bmatrix} 0.1 \\ 0 \\ 0 \end{bmatrix} \quad \text{and} \quad U = \begin{bmatrix} 0 & 0 \end{bmatrix}
\]

where \( S \) is the vector of initial price shocks and \( U \) is the identity matrix with zero in correspondence of the shocked sector. Assume now that \( dP_t \) denotes the vector of price changes after \( t \) lapses of time (years or months). Just after the introduction of the price shock, the initial reaction will generate a change in price that is equal to:

\[
dP_0 = (S' A' U) + S = [0.10]
\]

\[
\begin{bmatrix} 0.00 \\ 0.04 \end{bmatrix}
\]
The four cost-push options provide welfare impacts that are ranked in the following order: (1)<(2) & (3)<(4) & (1)<(3) & (2)<(4), so that option 1 is the lower bound, and option 4 is the upper bound (see also example in text). Note that the International Monetary Fund adopts the cost-push model and the option of choice for this institution is option (4). A good choice is also to model upper and lower bounds and report both bounds in empirical analyses.

The formula applied for the **marginal profit-push model** is the following:

\[ P_1 = (I - A \cdot T)^{-1}V \]

Where T is the diagonal matrix of price changes and V is the vector of added values. Example:

\[
T = \begin{bmatrix}
1 & 0 & 0 \\
0 & 1.1 & 0 \\
0 & 0 & 1
\end{bmatrix}
\]
References


