CHIPS
Climate Change Impacts and Policies in Heterogeneous Societies

WP3 CHIPS Microsimulation Tool

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CHIPS Microsimulation Tool

USER GUIDE

"This document describes the steps to use the microsimulation tool developed in Working Package 3 of the CHIPS project"

Introduction

We have developed an Excel tool to simulate price and /or income shocks. The Excel is composed by the eight following sheets:

Sheet 1. Data

This sheet contains the variables in the database necessary to conduct the simulations performed in other sheets of the tool. We can use any set of microeconomic information. It could be a survey, but the Excel file supports sources containing economic and demographic information not from a survey. For instance, we can set information containing income, prices, and the demographic structure of populations with two requirements: i) it is necessary to include among them those corresponding to the variables included in the estimated specification of the demand system (except if the user change the system and the functioning of this sheet), but it is always possible to a reduced number of parameters in the simulation step; ii) the simulations are done at the level of the variables included in the information set, i.e., household data, but all results can be aggregated to the desired level (deciles or quintiles of income or total expenditure or population aggregate), and the tool even can work with data for homogeneous households. The data in this sheet corresponds to wave 2018 of the Encuesta Nacional sobre Ingresos y Gastos de los Hogares (ENIGH) for Mexico as partially presented in Figure 1. We have also proved it on the wave 2019 of the Spanish Household Budget Survey (Encuesta de Presupuestos Familiares).

Figure 1. Data sheet

household	wfood	wgasoline	wlpg	welectricity	wothernondur	pfood	pgasoline	plgp	pelectric	pothenondur
1	0,195	0,443	0,000	0,023	0,339	1,002	1,047	1,048	0,997	1,025
2	0,555	0,243	0,000	0,041	0,161	1,002	1,047	1,048	0,997	1,021
3	0,279	0,579	0,000	0,057	0,085	1,002	1,047	1,048	0,997	1,019
4	0,524	0,000	0,000	0,026	0,449	1,002	1,047	1,048	0,997	1,027
5	0,408	0,105	0,162	0,030	0,295	1,002	1,047	1,048	0,997	1,024
6	0,428	0,430	0,000	0,007	0,135	1,002	1,047	1,048	0,997	1,024
7	0,669	0,000	0,055	0,075	0,201	1,002	1,047	1,048	0,997	1,027
8	0,285	0,332	0,000	0,002	0,380	1,009	1,019	0,998	1,001	1,018
9	0,667	0,093	0,000	0,005	0,234	1,009	1,019	0,998	1,001	0,998
10	0,434	0,000	0,000	0,100	0,466	1,009	1,020	0,998	1,001	1,017
11	0,568	0,200	0,000	0,007	0,225	1,009	1,019	0,998	1,001	1,003
12	0,441	0,254	0,187	0,043	0,074	1,007	1,034	1,052	0,995	1,047
13	0,608	0,125	0,000	0,045	0,222	1,007	1,034	1,052	0,995	1,023
14	0,482	0,081	0,045	0,019	0,374	1,007	1,034	1,052	0,995	1,033
15	0,353	0,328	0,000	0,005	0,314	1,007	1,034	1,052	0,995	1,035
16	0,583	0,110	0,068	0,024	0,215	1,007	1,034	1,052	0,995	1,033
17	0,308	0,184	0,059	0,025	0,424	1,007	1,034	1,052	0,995	1,029
18	0,683	0,000	0,070	0,002	0,246	1,007	1,035	1,052	0,995	1,033
19	0,300	0,000	0,000	0,041	0,659	1,007	1,035	1,052	0,995	1,018
20	0,610	0,182	0,045	0,023	0,140	1,007	1,034	1,052	0,995	1,036
21	0,562	0,000	0,244	0,076	0,118	1,023	1,048	0,981	1,002	1,023
22	0,628	0,000	0,000	0,071	0,302	1,023	1,048	0,981	1,002	1,026

Sheet 2. Parameters

Since we do behavioral simulations, we need the parameters of a demand system. This sheet contains the parameter estimates for the *k* number of equations contained in the system. There is no need to estimate a demand system, but we can take the parameters from a system previously estimated in the literature, which should be include in this sheet. For the tool to correctly do the simulations, the requirement is that the estimated model should be a Quadratic Almost Ideal Demand System (QAIDS) of Banks *et al*. (1997). Figure 2 reports a subset of the estimated parameters for a QUAIDS model with *k = 5* using pooled household cross-section data for the period 2006-2018 for Mexico.[1]

Figure 2. Parameter estimates sheet

PARAMETER ESTIMATES					
	wfood	wgasoline	wlpg	welectricity	wothenondur
gamma_lnpfood	-0,1088	-0,0106118	0,001575	-0,0476372	0,1654706
gamma_lnpgasoline	-0,01061	0,0427218	-0,01391	-0,0185386	0,0003363
gamma_lnplpg	0,001575	-0,0139077	0,022426	0,0029065	-0,0129994
gamma_lnpelectricity	-0,04764	-0,0185386	0,002907	0,013353	0,0499163
gamma_lnpothenondur	0,165471	0,0003363	-0,013	0,0499163	-0,2027239
beta_lnexpenditure	-0,16719	0,0852646	0,012292	-0,0657342	0,135368
lambda_lnexpendituresq	-0,0125	-0,0061322	-0,00587	0,0066297	0,0178718
rho_vgtnodur	0,247128	-0,0546089	-0,00628	0,0226307	-0,2088686
alpha_gender	-0,00781	-0,0128691	0,002355	0,0027696	0,0155517
alpha_age	0,002857	0,0001376	0,000118	0,0004434	-0,0035557
alpha_agesq	-2,6E-05	-2,27E-06	2,32E-06	-3,32E-06	0,0000291
alpha_#older	0,032744	-0,0113409	-0,00073	0,0020222	-0,0226965
alpha_#young	0,025173	-0,0087559	-0,00129	0,002157	-0,0172804
alpha_urban	0,02149	-0,021314	0,000656	0,0109834	-0,0118153
alpha_north	-0,09063	0,0253054	0,008494	0,0260688	0,0307595
alpha_center	-0,0078	-0,0045474	0,011904	-0,0016966	0,0021424
alpha_edu1	-0,00515	-0,0149836	0,000281	0,0004441	0,0194116
alpha_edu2	0,002582	-0,0202515	0,001333	0,0008817	0,0154546
alpha_edu3	0,011635	-0,0211643	0,000543	-0,000582	0,0095682
alpha_nhabit	-0,00045	0,0008584	0,000927	0,0012974	-0,0026286

[1] Details of the dataset and the system estimated are in Labandeira *et al*. (2022).

Sheet 3. Potential reforms (or shocks)

In this sheet we should enter the data for the reform under consideration. The form to enter new prices of the goods is in percent variation, which is the way to calculate the new prices to include in the equations estimated and predict the new shares of expenditures after the shock. Once changes in prices are filled in the adequate cells, new prices for each good are calculated and shown at the bottom-left of Figure 3.

It is also possible to introduce shocks to income, which are again in percent variation corresponding to deciles of income. The changes in income produce a new income variable for each household, which could be reported here, but we include it in the Auxiliary calculations sheet. Two further considerations should be done here: i) of course, the tool also allow household-specific variation in income; ii) variation in income could be computed using different variables instead of the distribution of income (location, for instance) or in addition to the distribution of income.[2]

Figure 3. Potential reforms (shocks) sheet

Reform. CO2 tax. 25$/tCO2 Variation in energy prices	
Gasoline	5,73%
LPG	10,5%
Electricity	10,0%

Reform. Energy prices			
household	pgasolinas_r1	pglp_r1	pele_r1
1	1,107	1,158	1,097
2	1,107	1,158	1,097
3	1,107	1,158	1,097
4	1,107	1,158	1,097
5	1,107	1,158	1,097

Reform. Income shock. % variation Variation in household income	
Decile 1	-10%
Decile 2	-10%
Decile 3	-10%
Decile 4	-10%
Decile 5	-10%
Decile 6	-10%
Decile 7	-10%
Decile 8	-10%
Decile 9	-10%
Decile 10	-10%

[2] We refer in an indistinguishable way to income and total expenditure. We always use as proxy for income total expenditure on the goods modelled in the system, which are normally an aggregate of household non-durable expenditure.

Sheet 4. Expenditure shares

This sheet shows, first, the predicted expenditure shares of the different goods in the demand model under consideration. The predictions are done using the formulae of this share equation, and we use the data in the Data sheet, the parameters in the Parameters sheet and the new prices and/or new total expenditure variables as calculated in the Potential reforms sheet, according to:[3]

$$\boldsymbol{w_i^h = \alpha_i^h + \sum_{j=1}^{k} \gamma_{ij}\, lnp_j + \beta_i ln\left[\frac{m^h}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{ln\left[\frac{m^h}{a(p)}\right]\right\}^2}$$

Where *i*, *j* refers to the good, *h* to the household; $\boldsymbol{\alpha_i^h}$ collects the product of demographic variables and parameters (so it depends on goods and households); p_j is the price of good *j*; $\boldsymbol{\alpha, \gamma, \beta}$ and $\boldsymbol{\lambda}$ are parameters and $\boldsymbol{m^h}$ is household's h income (total expenditure on non-durable goods).

$$\boldsymbol{a(p) = \alpha_0 + \sum_{i=1}^{k} \alpha_i lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \gamma_{ij} lnp_i lnp_j}$$

$$\boldsymbol{b(p) = \prod_{i=1}^{k} p_i^{\beta_i}}$$

$$\boldsymbol{\lambda(p) = \sum_{i=1}^{k} \lambda_i lnp_i}$$

Next, the expenditure shares because of the reform are shown, calculated from the expenditure shares predicted by the model, the estimated parameters (parameter sheet) and the new prices (or new income or both new prices and new income) because of the reform (Potential reform sheet), following the formula (we only include in this guide the case of price changes):

$$\boldsymbol{w_i^{R1} = w_i + \sum_{j=1}^{k} \gamma_{ij}\left(lnp_j^{R1} - lnp_j\right)}$$

Where p_j^{R1} is the price of good *j* after the reform (or shock) and p_j is the initial price (before the reform or the shock). We can calculate shares after and income shock in an equivalent way but using in the share equation the pre- and post-income.

[3] In the case of the last group (other non-durable goods), the expenditure share is adjusted so that the sum of all the expenditure shares equals 1. In economic terms, the household optimizes allocating all total expenditure to purchase the basket of goods.

Figure 4. Expenditure shares sheet

EXPENDITURE SHARES. PREDICTION

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2$$

household	wfood_p	wgasoline_p	wlpg_p	welect_p	wondur_p
1	0,535486	0,169470241	0,056172	0,0593733	0,1794986
2	0,619452	0,162000924	0,044493	0,0637563	0,1102976
3	0,601705	0,023941288	0,065176	0,07462	0,2345576
4	0,684944	0	0,065622	0,0738987	0,1755347
5	0,43657	0,193324051	0,061071	0,0337274	0,2753077
6	0,366421	0,243679015	0,043286	0,0040777	0,3425368
7	0,639306	0,012604475	0,052385	0,0599935	0,2357109
8	0,585138	0,149051132	0,053609	0,0667984	0,1454037
9	0,391345	0,196138265	0,056379	0,038832	0,3173057
10	0,781117	0	0,059252	0,1387918	0,0208391
11	0,46363	0,183695731	0,053762	0,0444493	0,2544631
12	0,6335	0,103423772	0,048573	0,062344	0,15216
13	0,440151	0,18286898	0,063294	0,0435651	0,2701211

EXPENDITURE SHARES. REFORM

$$w_i^{R1} = w_i + \sum_{k=1}^{n} \gamma_{ik} \left(\ln p_k^{R1} - \ln p_k\right)$$

household	wfood_p_r1	wgasoline_p_r1	wlpg_p_r1	welect_p_r1	wondu
1	0,530511497	0,168695694	0,057911776	0,059903186	0,182
2	0,614477749	0,161226376	0,046232736	0,06428624	0,113
3	0,596730849	0,023166741	0,06691568	0,075149878	0,238
4	0,679969994	0	0,067362078	0,074428548	0,178
5	0,431595632	0,192549504	0,062810614	0,034257264	0,278
6	0,361446366	0,242904468	0,045025485	0,004607587	0,346
7	0,634332123	0,011829927	0,054124415	0,060523387	0,239
8	0,580163689	0,148276584	0,055348531	0,06732825	0,148
9	0,386370887	0,195363718	0,058118501	0,03936191	0,320
10	0,776142841	0	0,060991698	0,13932168	0,02
11	0,458655545	0,182921184	0,055501749	0,044979165	0,257
12	0,628525149	0,102649225	0,050312563	0,062873852	0,155
13	0,435176539	0,182094433	0,065033731	0,044094973	0,273

Sheet 5. Tax payments

This sheet shows the revenue obtained from each household when prices, income or both change. We could be interested in reforms changing taxes, but the tool serves for each shock in prices and income we are interested. Price changes are commodity-dependent, but we could also think (and simulate) in the case of household-dependent prices changes. Tax payments are calculated by dividing the new expenditure on each good (the result of multiplying the new share of expenditure on the good by total expenditure on non-durable goods) by the new price of the product (multiplying its average price by 1 plus the increase in price) to obtain the new consumption, which is multiplied by the increase in price resulting from the reform to obtain the additional revenue.

Likewise, we calculate total revenue at population level (national or regional level) using the grossing-up factor, which is a variable within our information set and collects the number of households in the population represented by the corresponding household. Since Mexican data contains quarterly information, to obtain annual revenue (or annual additional revenue), the obtained figure is multiplied by 4.[4]

Figure 5. Tax payments sheet

REFORM. TOTAL REVENUE (million pesos)

	Quarterly	Annual
Gasoline	21,43	85,72
LPG	13,54	54,17
Electricity	11,69	46,75
TOTAL	46,66	186,64

Revenue per household (pesos)			
household	gasoline	lpg	electricity
1	148,7055419	89,46171	88,59163727
2	129,6277409	65,14163	86,71605999
3	13,01467576	65,87846	70,82985436
4	0	56,92605	60,21540409
5	202,9717623	116,0308	60,58505998
6	367,5067719	119,3811	11,69561469
7	5,223470456	41,88104	44,83528626
8	112,2525224	73,43055	85,51464769
9	251,1491747	130,9331	84,89530114
10	0	17,84119	39,01614976

Revenue per household (pesos) (grossed-up to the population)			
household	gasoline	lpg	electricity
1	26023,4698	15655,8	15503,53652
2	22684,8547	11399,78	15175,3105
3	2277,56826	11528,73	12395,22451
4	0	9962,059	10537,69572
5	38361,6631	21929,83	11450,57634
6	69458,7799	22563,02	2210,471175
7	987,235916	7915,516	8473,869102
8	20878,9692	13658,08	15905,72447
9	46713,7465	24353,55	15790,52601
10	0	3318,462	7257,003855

[4] We can also think that the is some sort of seasonality in consumption and make different corrections for all additional revenue or good-specific additional revenue.

Sheet 6. Welfare measures

We calculate and show in this sheet the equivalent gain (or equivalent loss) as a result of the price (income) shock and it is shown for each household both in monetary terms and as a percentage of total non-durable expenditure. Moreover, we also show it on average weighted by the grossing up factor at the population level. Equivalent loss (*EL*) is calculated according to formula (we show it for prices, but we can also calculate for changes in *m* -total expenditure-):

$$\boldsymbol{EL^h = c(u_0, p^0) - (u_0, p^1)}$$

where $\boldsymbol{u_0}$ is pre-reform utility, $\boldsymbol{p^0}$ and $\boldsymbol{p^1}$ are the vector of pre- and post-shock prices, respectively; $\boldsymbol{c(u_0, p^0)}$ is the observed pre-shock expenditure and $\boldsymbol{c(u_0, p^1)}$ the equivalent income, i.e., the expenditure level at pre-shock prices that is equivalent in utility terms to household expenditure at final prices. The cost function is $\boldsymbol{\ln c(u, p) = \ln a(p) + \frac{\ln u\, b(p)}{1-\lambda(p) \ln u}}$, while the initial utility level is calculated using the following formula:[5]

$$\boldsymbol{\ln u_0 = \left\{ \left[\frac{\ln m - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1}}$$

$\boldsymbol{a(p)}$, $\boldsymbol{b(p)}$ and $\boldsymbol{\lambda(p)}$ are the vector of prices previously defined and *m* is total expenditure.

[5] A discussion can be found in Banks *et al*. (1996).

Figure 6. Welfare measures sheet

EQUIVALENT LOSS (EL)

$$EL^h = c(u_0, \boldsymbol{p^0}) - c(u_0, \boldsymbol{p^1})$$

Reform		
	EL (pesos)	EL (%)
Average	-261,95	-1,62%
household		
1	-339,6582042	-2,09%
2	-292,2661254	-1,97%
3	-156,0070043	-1,50%
4	-119,9213615	-1,35%
5	-393,5196232	-2,02%
6	-513,0990875	-1,84%
7	-95,47470683	-1,17%
8	-282,056455	-2,02%
9	-483,8398435	-2,04%
10	-50,25367048	-1,63%
11	-405,2447782	-2,00%
12	-152,3262612	-1,67%

Sheet 7. Indexes and graphs

Here we calculate the Gini index before and after the shock using:[6]

$$GI = 1 + \frac{1}{n} - \frac{2}{n^2 y}\sum_h y_h(n + 1 - h)$$

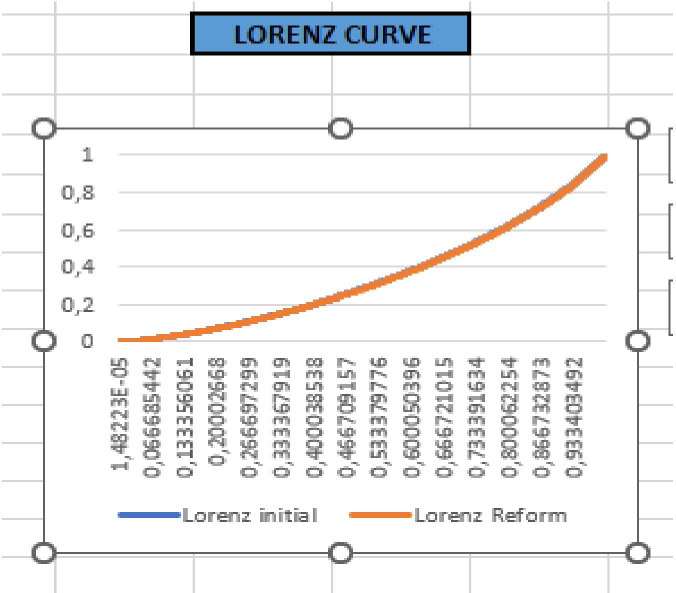
Where y is average household income and y_h income of household h; n is the number of households, and they are in ascending order of their income.

We also present a graph with the Lorenz curve, which any possible graph the reader interested could do here.

Figure 7. Indexes and graphs sheet

$$GI = 1 + \frac{1}{n} - \frac{2}{n^2 y}\sum_i y_i(n + 1 - i)$$

	GINI INDEX
Initial	0,310049403
Reform	0,310745149



[6] Of course, in this sheet we can include any measure of inequality or any other index.

Sheet 8. Auxiliary calculations

In this sheet all the intermediate calculations necessary to obtain the results of the previous sheets are performed, using the information contained in each of the sheets:

- Columns C-G: α_i for each household and product

- Columns I-L: $\sum_{j=1}^{k} \gamma_{ij}\, lnp_j$ for calculating predicted shares

- Columns N-V: Initial value of *a(p)*

- Column X: Initial value of *b(p)*

- Column Z: Initial value of *λ(p)*

- Columns AB-AF: Necessary expressions for calculating $c(u_0, p^0)$

-Columns AH-AL: After-shock value of *a(p)*

- Column AN: After-shock value of *b(p)*

- Column AP: After-shock value of *λ(p)*

- Columns AR-AT: Necessary expressions for calculating $c(u_0, p^1)$

- Columns AV-AX: All necessary expressions for the equivalent loss both at household and aggregate levels

- Columns AZ-BF: Initial Gini index

- Columns BH-BN: After-shock Gini index

- Columns BP-BR: Calculations to make the Lorenz curve

Sheet 9. Notes

This sheet contains explanatory notes to the previous sheets. All details about names of variables, construction of variables, parameters, etc. are in Labandeira *et al*. (2022).

References

Banks, J., R. Blundell and A. Lewbel (1996), "Tax reform and welfare measurement: Do we need demand system estimation", *The Economic Journal* 106, 1227-1241.

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