

## Exercise: Solving for Market Equilibria

### Summary

This exercise analyzes the impact of a sales tax on a market with 1000 buyers. Each buyer has a demand equation of the form below, where  $Q_i$  is household  $i$ 's quantity demanded,  $A_i$  and  $B_i$  are demand parameters for household  $i$ ,  $M_i$  is household  $i$ 's income, and  $pr_d$  is the buyer price of the good. In case you're interested, this is a demand equation derived from a Stone-Geary utility function.

$$Q_i = (A_i * M_i) / pr_d - B_i$$

The market supply of the good is given by the equation below, where  $Q_s$  is total market supply and  $pr_s$  is the seller price of the good:

$$Q_s = 5000 * pr_s$$

Finally, the buyer and seller prices are related by a tax as shown below. Note that the tax may be zero.

$$pr_s = pr_d - tax$$

The exercise focuses on analyzing the impact of a policy that raises the tax from its base case value of 0 to a proposed policy case value of \$5.

### Input Data

All of the input data is contained in the file **households.txt**. It includes information about 1000 households, each on one line of the file. Using Python's zero-based subscript convention, the fields are as follows: (0) an identification number for the household, (1) the household's demographic type, (2) the household's income,  $M_i$ , (3) parameter  $A_i$  in the household's demand equation, and (4) parameter  $B_i$  in the demand equation. The demographic type is reserved for future use and is not used in this exercise.

### Deliverables

A script called **market.py** that computes the market equilibrium in both the base case (equilibrium 1) and policy case where the tax is set to \$5 (equilibrium 2), and then evaluates a couple of aspects of the policy.

### Instructions

Please prepare a script called `market.py` that does each of the following steps:

1. Imports `scipy.optimize` as `opt`.
2. Defines a function called `read_households()` that takes a variable called `filename` as an argument, reads the file, and returns a list of household objects (dictionaries) representing its contents. Each household object should have five keys, `id`, `type`, `inc`, `a`, and `b` corresponding to the five fields in the file. Conceptually, the function should be similar to the one from `npv.py` except that the fields are different.
3. Defines a function called `ind_demand()` that takes two arguments: `pr_d`, a buyer price, and `hhlist`, a list of households. It should return a list consisting of the quantities demanded by each of the households. Build the list by looping through the items in `hhlist` and using the individual demand equation to compute the corresponding quantity.
4. Defines a function called `mkt_demand()` that takes the same two arguments as `ind_demand()`: `pr_d` and `hhlist`. The first line should compute a list of individual quantities, `qlist`, by using `ind_demand`. The remainder of the function should sum the values in `qlist` and return the result.
5. Defines a function called `mkt_supply` that takes one argument, `pr_s`, the seller price, and returns the market supply using the equation above.
6. Defines a function called `excess_d` that takes three arguments: `pr_d`, `tax`, and `hhlist` and returns the excess demand at that price: that is, the difference between the total demand and total supply in the market.

The first line should compute `prs` using the accounting rule above. The second and third lines should compute the market demand, `qd`, and market supply, `qs`, using `mkt_demand` and `mkt_supply`. It should then return the difference: `qd-qs`.

7. The script should then use `read_households()` to read the input file into a variable called `hhlist`.
8. Then, create a variable called `guess` for the initial guess of the price `prd` and set it to 20.
9. Solve for the base case (equilibrium 1) by doing the following:
  1. Set variable `tax` to 0.
  2. Calculate the initial value of `prd`, `prd1`, by calling `opt.newton()` using `excess_d` as the first argument, `guess` as the second argument, `maxiter=20` as the third argument, and `args=[tax, hhlist]` as the fourth argument.
  3. Calculate the initial market quantity, `qd1`, by calling `mkt_demand()` using `prd1` and `hhlist`.
  4. Print a message giving `prd1` and `qd1`. Include some text to indicate which equilibrium is being printed.
10. Solve for the policy case (equilibrium 2) by doing the following:
  1. Set variable `tax` to 5.
  2. Calculate the policy-case value of `prd`, `prd2`, using `opt.newton()` again. The call will be the same as before except the tax will now be 5 instead of 0.
  3. Calculate the new market equilibrium by calling `mkt_demand()`.
  4. Print a message giving `prd2` and `qd2`. As before, include some descriptive text.
11. Calculate and print total tax revenue under the policy case.
12. Calculate and report the percentages of the tax burden that fall on the buyers as a group and the seller.

## Submitting

Once you're happy with everything and have committed all of the changes to your local repository, please push the changes to GitHub. At that point, you're done: you have submitted your answer.

## Tips

- This is a type of analysis known as “microsimulation”. It allows very fine-grained analysis of the impacts of policies. In this case, the analysis could pick up differences across demographic groups, or across income deciles, or both, although those steps are beyond the scope of this exercise.
- You may want to check each equilibrium by computing `mkt_supply()` to make sure it's equal to the market demand.