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 Qi is household i's quantity demanded, Ai and Bi are demand parameters for household i, Mi is household i's income, and prd is the buyer price of the good. In case you're interested, this is a demand equation derived from a Stone-Geary utility function.

```
Qi = (Ai*Mi)/prd - Bi
```

The market supply of the good is given by the equation below, where Qs is total market supply and prs is the seller price of the good:

```
Qs = 5000*prs
```

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

```
prs = prd - 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.csv**. 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, Mi, [3] parameter Ai in the household's demand equation, and [4] parameter Bi in the demand equation. The demographic type is reserved for use in a subsequent assignment 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 `csv`
2. Imports `scipy.optimize` as `opt`.
3. Defines a function called `read_households()` that takes `filename` as an argument. Use `str` as the type hint for `filename` and `list` as the type hint for the function's return value. The function should:
    1. Create an empty list called `households`.
    2. Open `filename` for reading using `fh` as the file handle.
    3. Create an object called `reader` to read the file by calling `csv.DictReader()` with `fh` as its argument.
    4. Use a `for` loop to iterate over `reader` using `hh` (short for household) as the loop variable. The loop should use `float()` calls to make the values stored under the following three keys numeric: `inc`, `a`, and `b`. The loop should then append `hh` to `households`.

5. After all lines in the file have been read the function should print a message saying `"Lines read:"` and the value of `len(households)`. If all has gone well, the length should be 1000. After the print statement the function should return `households`.

4. Defines a function called `ind_demand()` that takes two arguments: `prd` (the buyer price, use hint `float`) and `hhlist` (a list of households, hint `list`). It should return a `list` (remember to include the hint) consisting of the quantities demanded by each of the households.

   Build the list in the same way you've built several previous lists. Start with an empty list and then use variable `hh` to loop through the items in `hhlist`. Within the loop use the individual demand equation to compute the quantity demanded by the household stored in `hh` and then append that value to the list you're building. Be sure to return the finished list.

5. Defines a function called `mkt_demand()` that takes the same two arguments as `ind_demand()`: `prd` (hint `float`) and `hhlist` (hint `list`). The hint for the return value should be `float`. The first line should compute a list of individual quantities, `qlist`, by using `ind_demand()`. The next line should use the `sum()` function to add up the demand values in `qlist`. The function should then return the sum.

6. Defines a function called `mkt_supply()` that takes one argument, `prs`, the seller price (hint `float`), and returns the market supply (hint `float`) computed using the equation above.

7. Defines a function called `excess_d()` that takes three arguments: `prd` (hint `float`), `tax` (hint `float`), and `hhlist` (hint `list`) and returns the excess demand at that price (hint `float`). The excess demand is the difference between the total demand and total supply in the market. The first line of the function should compute `prs` using the accounting rule above. The second and third lines should compute the market demand, `qd`, and maket supply, `qs`, using `mkt_demand()` and `mkt_supply()`. The function should then return the difference: `qd-qs`.

8. After all the functions have been defined, use `read_households()` to read the input file into a variable called `hhlist`.

9. Create a variable called `guess` for the initial guess of the price `prd` and set it to 20.

10. Solve for the base case (equilibrium 1) by doing the following:

    1. Set variable `tax` to 0.

    2. Calculate the initial value of the buyer price, `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` as the arguments.

    4. Print a message giving `prd1` and `qd1`. Include some text to indicate which equilibrium is being printed.

11. Then 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.

12. Calculate and print total tax revenue under the policy case.
13. Calculate and report the percentages of the tax burden that fall on the buyers as a group and the seller. Round the percentages to integers so that, for example, 12.345% is printed as 12%.

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. We'll do that in a subsequent exercise.
- You may want to check each equilibrium by computing `mkt_supply()` to make sure it's equal to the market demand.