Economics graphs

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Abstract

This paper aims to show the different graphs that can be created using LaTeXpackages `tikz` and `pgfplots` (see some documentation here and there) for Economic theory graphs. Many of these graphs being used extensively when teaching Economics, I wanted to share the ones I made in order to show how versatile these packages are. The graphs shown are as detailed as possible, so that the user can see how to customize different parts. They are built using functions which details are given at the beginning of each graph in comments.[1]

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[1] This is a work in progress. Hence, many lines are commented to show possible options.

List of Figures

1 Introduction

The graphs shown above always follow the same code structure: the `axis` environment is first used to define the axes limits (`xmin`, `ymin`, `xmax` and `ymax`), the type of legend to display (with `legend style`), axes labels and their position (with `xlabel` and `ylabel`), axes marks (with `xtick` and `xticklabels`), as well as the number of points to use to draw the graphs (with `sample`). An example of `axis` is shown below, taken from the first graph in section 3:

```
% Graph for surpluses with a negative consumption externality.
% SMC = 0.5Q
% PMB = 60 - 0.5Q
% SED = 20
% SMB = 40 - 0.5Q
% Market equilibrium: (60, 30)
% Socially efficient level: (40, 20)
\begin{axis}[
xlabel={$Q$},
ylabel={$P$},
```

```
axis lines= middle,
samples = 41,
xmin = 0, xmax = 90,
ymin = 0, ymax = 70,
xtick = {0, 40, 60} ,
xticklabels={$0$, $Q^*$, $Q^M$},
ytick = {20, 30},
yticklabels={$P^*$, $P^M$  },
legend pos = outer north east,
legend style={draw=none},   % If we don't want borders around the legend
xlabel style={below},
ylabel style={left}]
```

The second part of the code consists in creating the function to be plotted using `addplot`. Several arguments can be provided (thickness, color, reference name, domain) before declaring the function (`y` as a function of `x`). Vertical lines can also be created using `addplot`, before declaring the coordinates between which to draw the lines. The `node` command allows to position a node on the graph by declaring its coordinates. Different shapes as well as pieces of text can be represented. Besides, `addplot+` can sometimes be seen instead of `addplot`. Using `addplot` without options makes the package choose a style in a pre-defined ordered list of styles (hence, two `addplot` in a row will return two different colors etc without having to precise that). The options declared by the user will **replace** the pre-defined style to be selected. When declaring options within `addplot+`, these options are **appended** to the style that is selected.

Personally, I prefer declaring all the options myself so I know what to expect, hence I prefer my options to replace the pre-defined style, and I use `addplot`. The example below shows different curves for an externalities graph:

```
% Social marginal benefit
\addplot[ thick, name path = SMB, blue, domain = 0:80] {40- 0.5*x};
% Private marginal benefit
\addplot[thick, name path = PMB, blue, domain = 0:80] {40 + 20 - 0.5*x};
% Social marginal cost
\addplot[thick, name path = SMC, red, domain = 0:80] {0.5*x};
 % Market Equilibrium price
\addplot[dashed, name path = pm, domain = 0:60] {30};
 % Socially efficient price
\addplot[dashed, name path = pstar, domain = 0:40, black ] {20};
 % Market Equilibrium quantity
\addplot[dashed, black] coordinates {(60, 0) (60, 30)};
% Socially efficient quantity
\addplot[dashed, black] coordinates {(40, 0) (40, 20)};
```

Many Economic theory graphs display surpluses, which can be represented using the `fillbetween` package. The `addplot` command is first used to declare colors, thickness etc, then `fill between` is used by declaring between which functions and on what domain areas have to appear. Hence, `name path` can be very useful inside the `addplot` command when declaring a function, in order to reference it easily when needed. The code below declares surpluses in the first graph in section 3:

```
% Filling areas under the functions now
% Consumer surplus
\addplot [
thick,
color=cyan,
fill=cyan,
fill opacity=0.5
]
```

```
fill between[
of=SMB and pstar,
soft clip={domain=0:60},
];

% Producer surplus
\addplot [
thick,
color=red,
fill=red,
fill opacity=0.5
]
fill between[
of=pstar and SMC,
soft clip={domain=0:60},
];

% Deadweight loss
\addplot [
thick,
color=green,
fill=green,
fill opacity=0.5
]
fill between[
of=SMC and SMB,
soft clip={domain=40:60},
];
```

The `legend` command allows to make a legend that will report all the functions declared with `addplot` in order. So if one only wants the third and fifth functions to appear in the legend, one needs to include commas in between. The code below is taken from the first graph in section 3:

```
% The legend lists all the curves created before.
% So many entries are empty as not needed to appear in the legend
\legend{,
        ,
        ,
        ,
        ,
        ,
        ,
        Consumer surplus,
        Producer surplus,
        Deadweight loss
}
```

Note that throughout this document, the `figure` environment is used around the graphs in order to reference them in the list of figures and caption them.

2 Monopoly and price discrimination

In this section are displayed graphs for monopoly as well as first degree price discrimination outcomes. Note that to make graphs appear side by side, `begin{tikzpicture}` has to be added immediately after `end{tikzpicture}`, without any line jump.

2.1 Monopoly

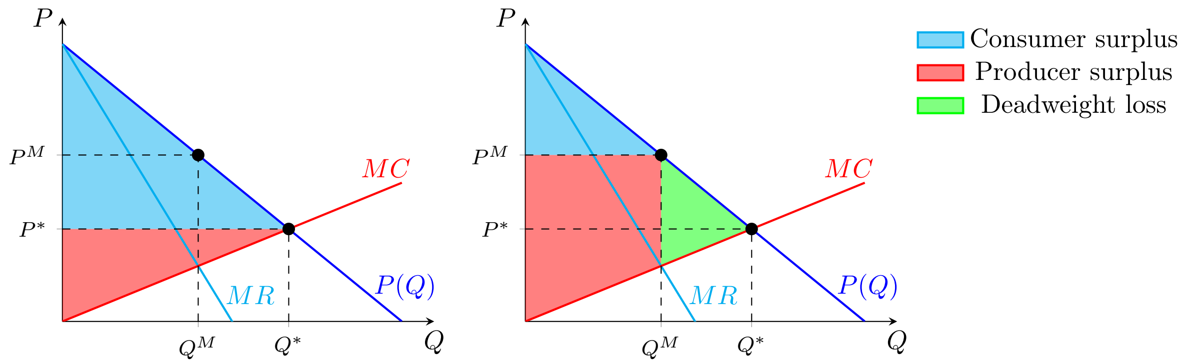

Figure 1: Surpluses under perfect competition (left) and uniform monopoly pricing (right)

2.2 Price discrimination: First degree

The following graphs show the monopoly outcome under uniform pricing versus first degree price discrimination. Under the latter, the monopolist is able to extract all the consumer surplus, leaving no blue area in the left graph.

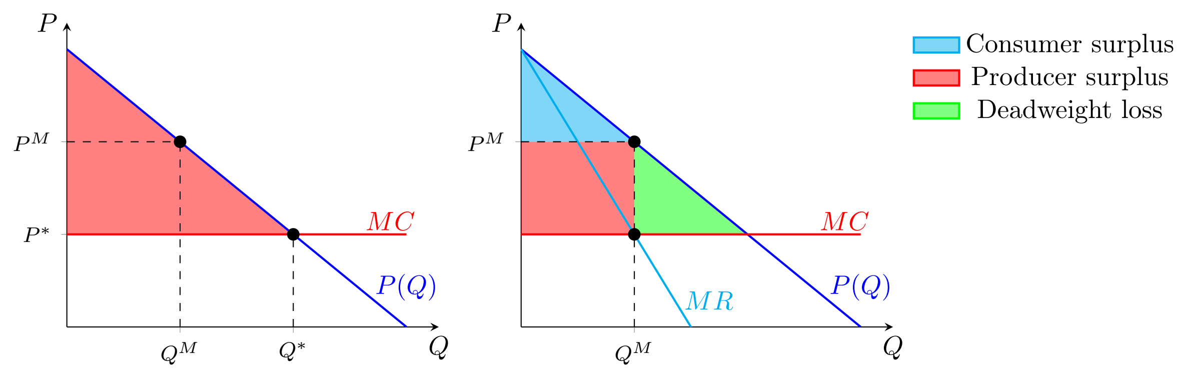

Figure 2: Monopoly outcome under first degree price discrimination (left) vs uniform pricing (right).

3 Externalities

This section displays the different impacts of positive/negative externalities in the case of production/consumption. Note the use of `fill between` to display the different surpluses and deadweight losses.

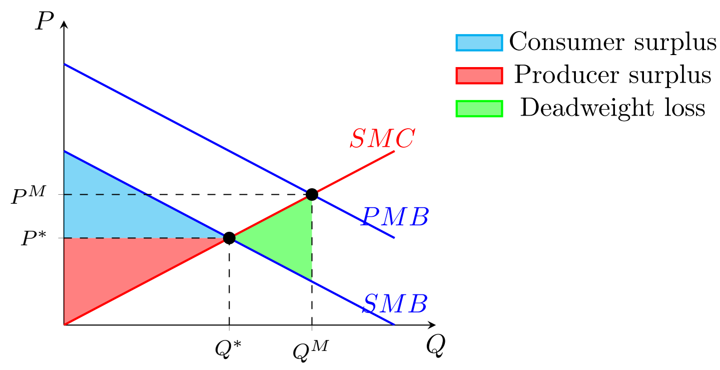

Figure 3: Negative consumption externality

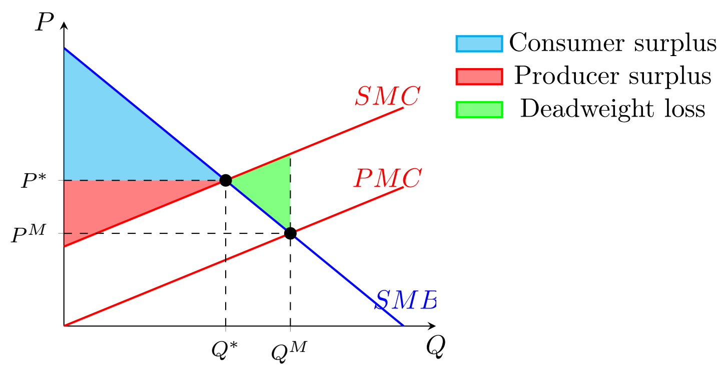

Figure 4: Negative production externality

This last graph shows the design of a **Pigouvian tax** in the case where there is a negative production externality. Note that the marginal external cost is not constant here.

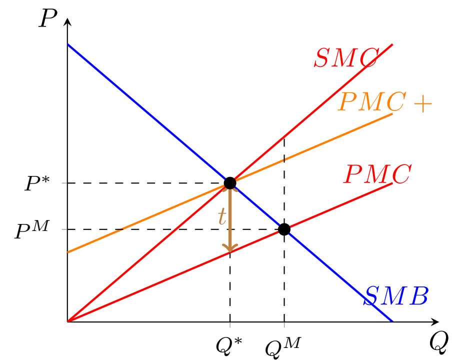

Figure 5: Pigouvian tax for a negative production externality

4 Taxation

This section show various graphs among which are found:

- The Lorenz curve
- The impact of a tax/subsidy on consumer surplus, producer surplus, government revenue/cost and the resulting deadweight loss.
- Tax incidence, shown through graphs displaying a more inelastic demand than supply

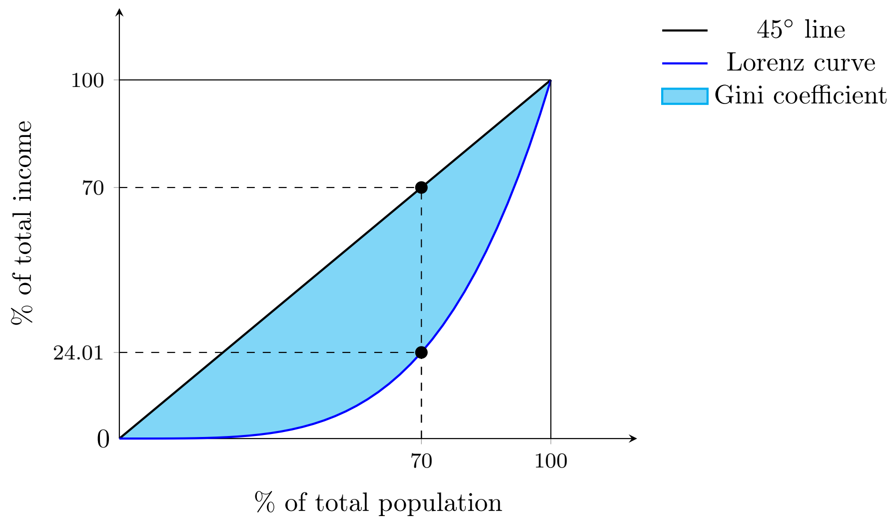

Figure 6: Lorenz curve and Gini coefficient

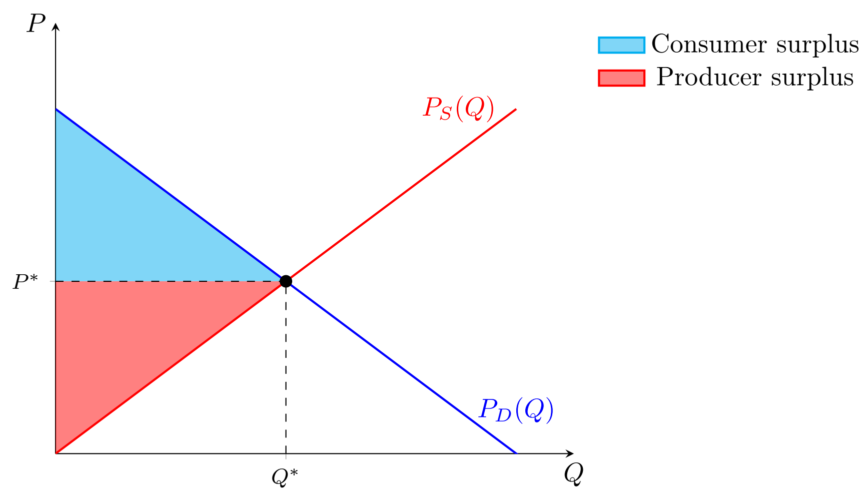

Figure 7: Surpluses under perfect competition

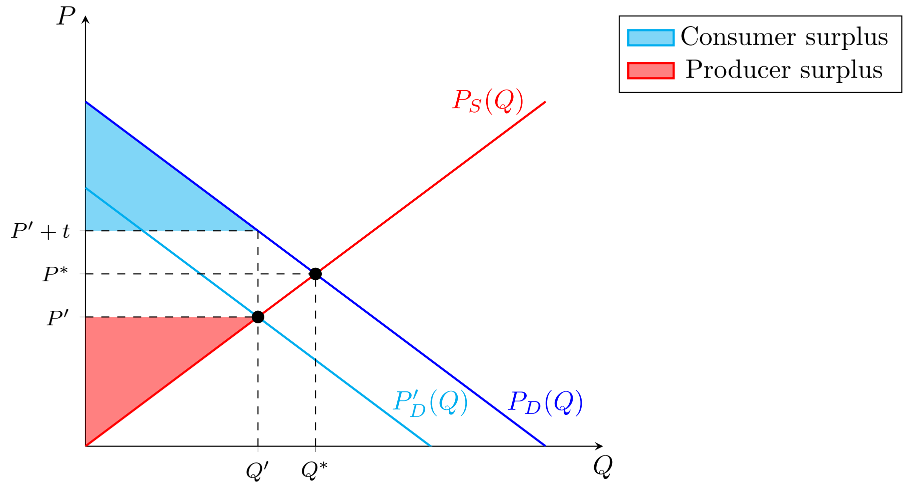

Figure 8: Effect of a quantity tax on demand

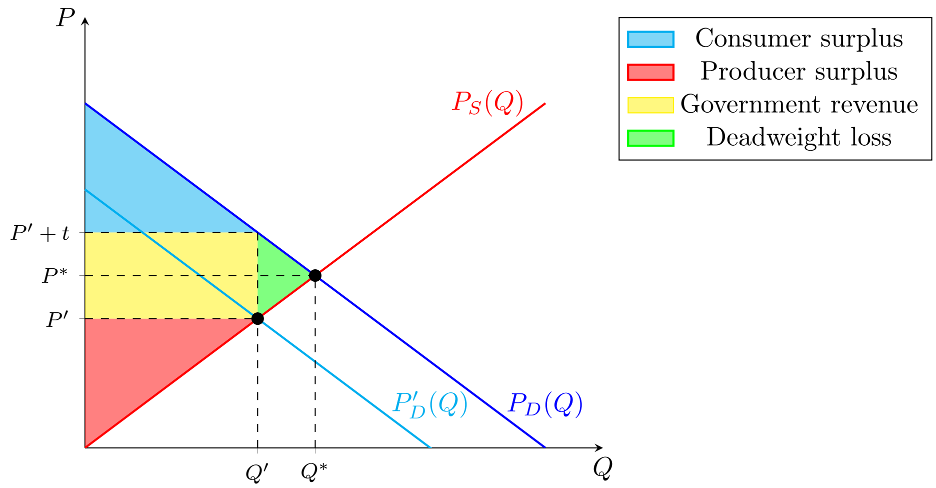

Figure 9: Surpluses and deadweight loss under a quantity tax on consumers

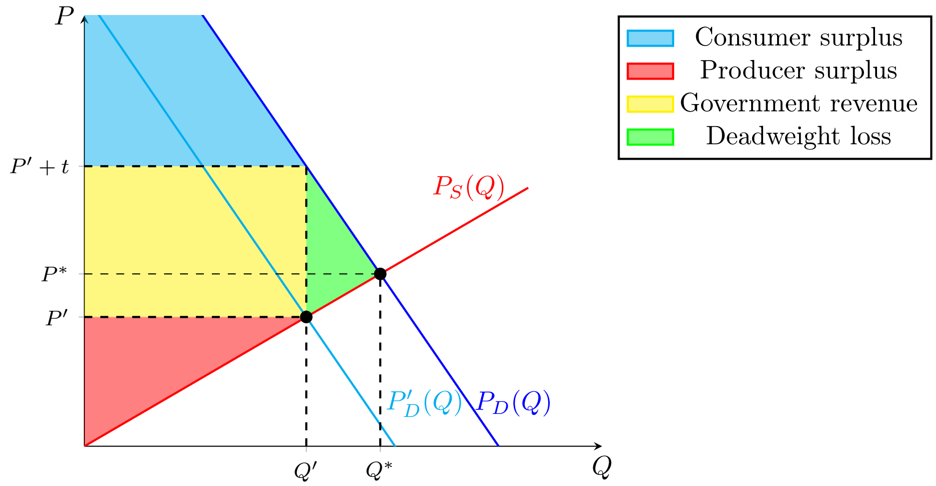

Figure 10: Surpluses and deadweight loss under a quantity tax on an inelastic demand

5 Labour Economics

This section shows labor supply decisions in a leisure/consumption graph. A Cobb-Douglas utility function is used. Note that in the graph below, `legend` is not declared , rather `addlegendentry` is used immediately after declaring the function. It is another way to declare the legend, although I prefer to dedicate a whole environment to it using `legend`.

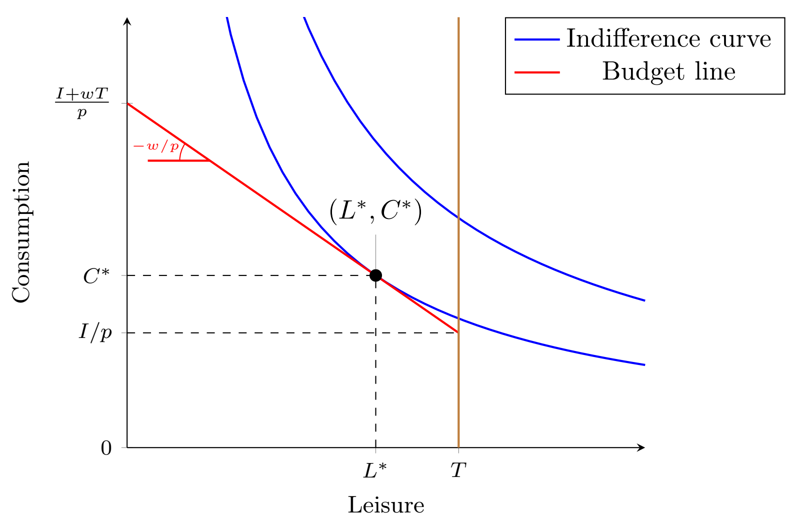

Figure 11: Optimal consumption-leisure decision

The graph below shows the impact of a wage tax on labor supply (in the example shown here, the new optimal labor supply is lower as the **substitution effect** dominates the **income effect**).

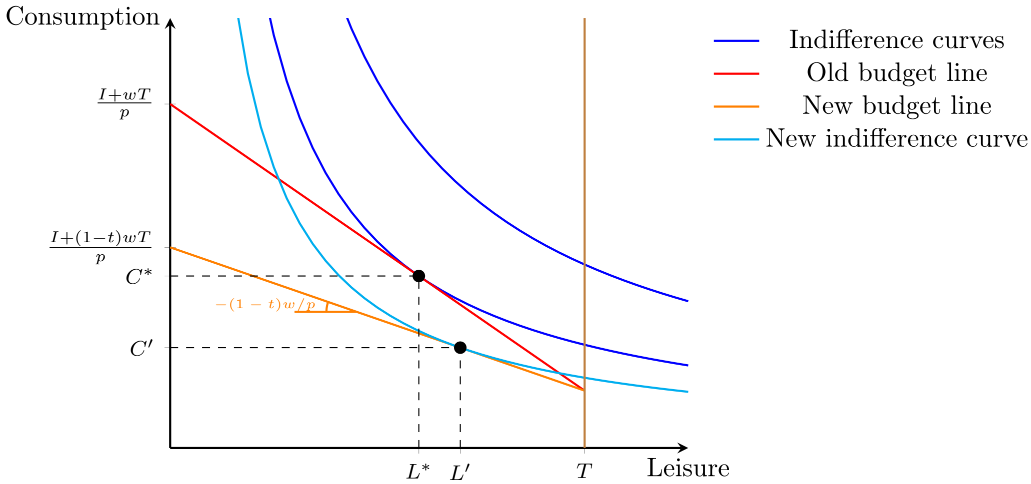

Figure 12: Effect of a wage tax on labor supply decisions

6 International trade

This section contains graphs of the impact of import tariffs and export subsidies.

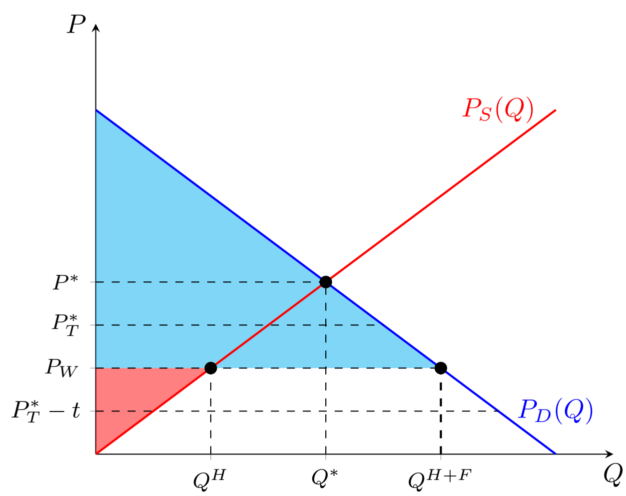

Figure 13: Consumer and producer surpluses after an import tariff in a large economy

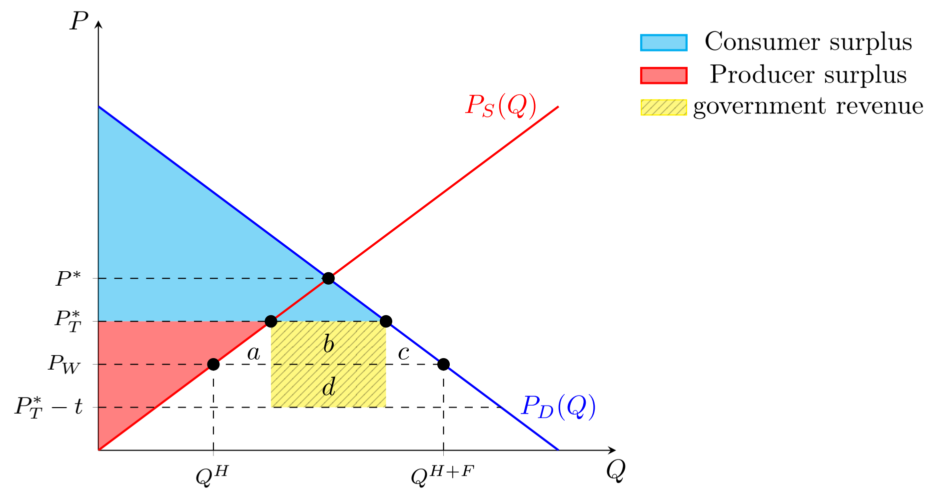

Figure 14: The impact of an import tariff in a large economy

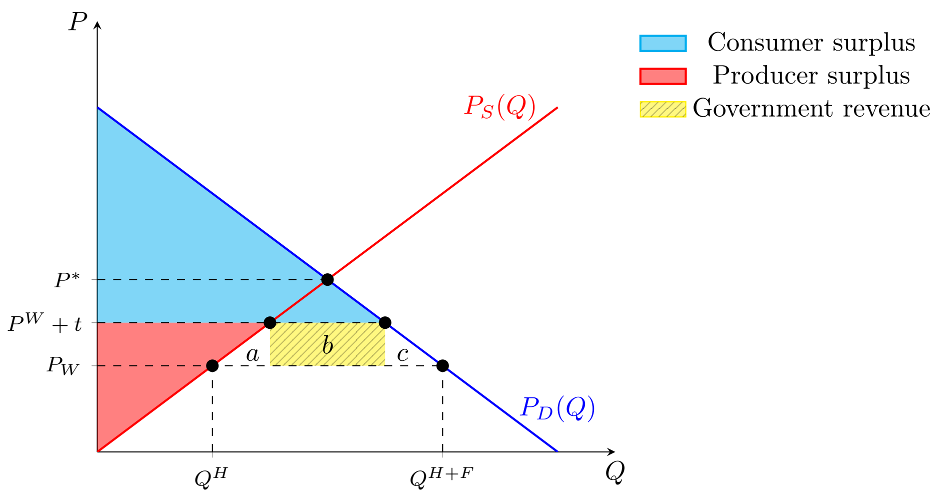

Figure 15: Surpluses after an import tariff in a small economy

7 Insurance

In this section is exposed the optimal insurance decision of a risk averse agent facing a probability $1 - \alpha$ of incurring a loss L and a probability α of not incurring any loss. The agent's utility is concave, and the insurance policy rates are actuarially fair (the coverage per dollar π equals $1 - \alpha$, the probability of the loss occurring). Therefore, full insurance is optimal (point B) as opposed to no insurance (point A).

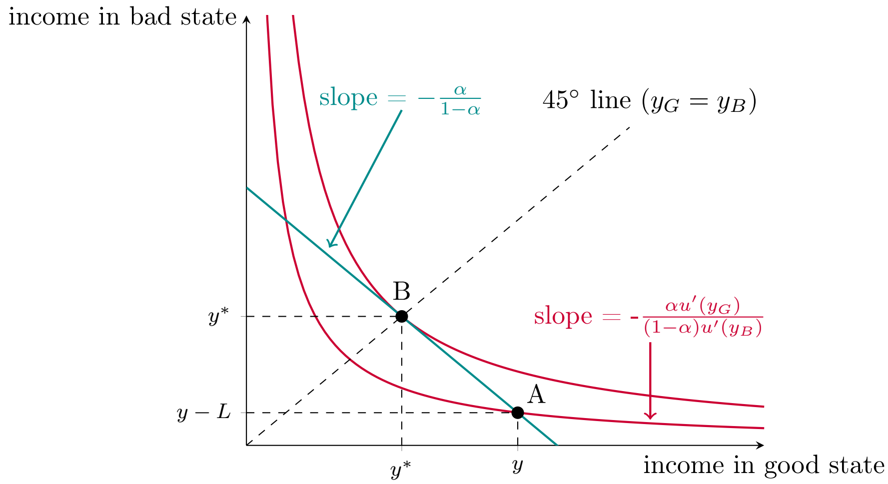

Figure 16: Optimal insurance decision

8 Game theory

This section contains graphs for Nash equilibria in simultaneous moves games, as well as normal and extensive form games. The first graph shows the Nash equilibrium in mixed strategies in the "matching pennies" game.

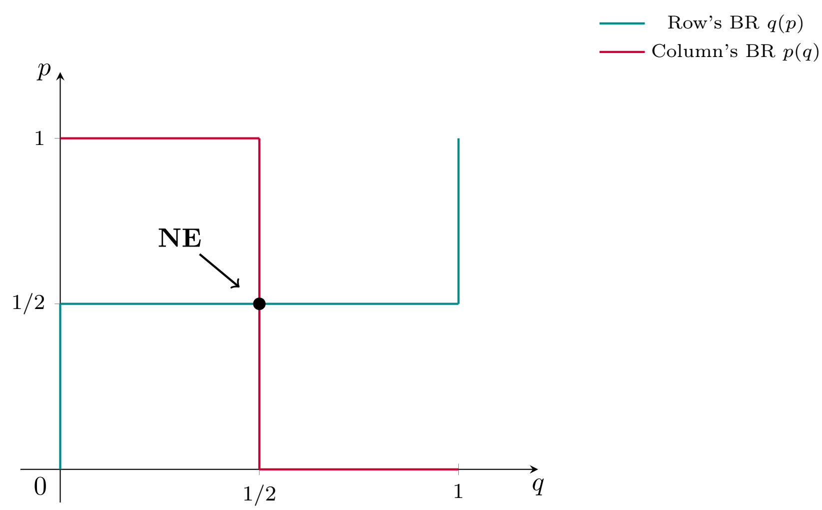

Figure 17: Mixed strategies Nash equilibrium in the Chicken game

The next graph shows the Nash equilibria in a "chicken game". There are 2 Nash equilibria in pure strategies, and 1 in mixed strategies.

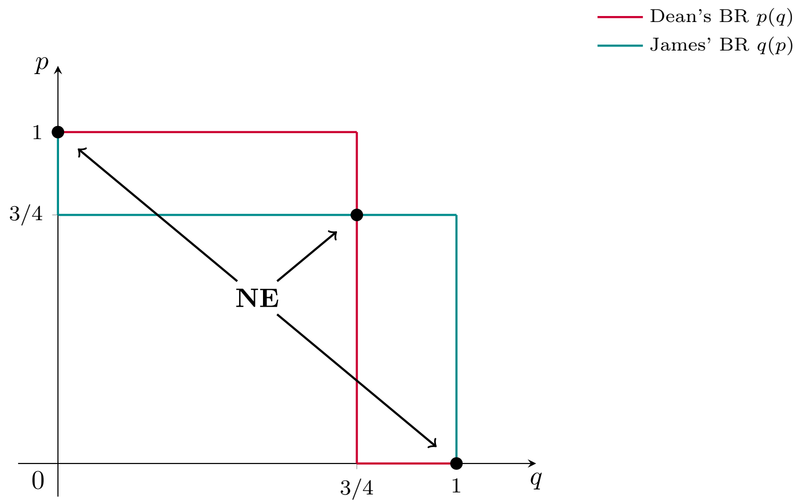

Figure 18: Nash equilibria in the chicken game

Consider the following simultaneous moves game:

		Sanji: Party 1	Sanji: Party 2
Girl	Party 1	5, 15	20, 10
	Party 2	15, 5	0, 20

Avoiding Sanji

The following tree shows a version of the game played sequentially. Here the girl gets to make the first move:

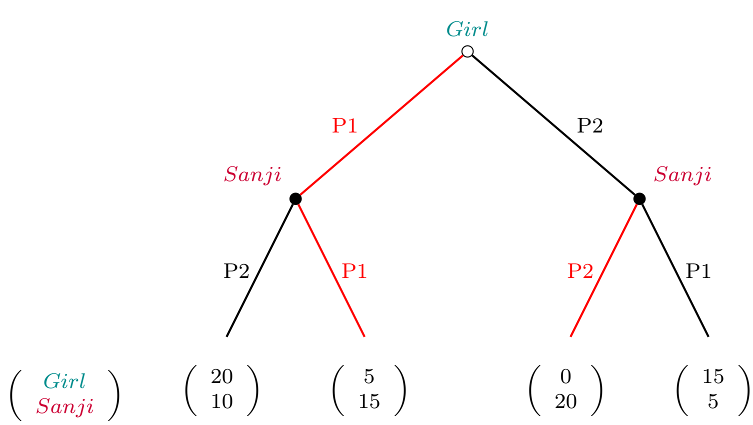

Figure 19: A sequential game tree

The notorious centipede game is in the following tree:

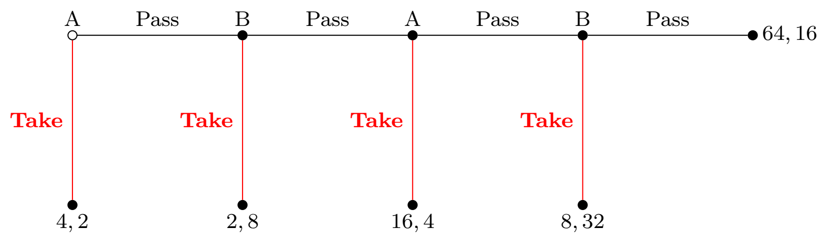

Figure 20: The centipede game

9 Program evaluation methods

Program evaluation methods aim at estimating the causal impact of some intervention (or treatment) labelled D_i on some outcome variable Y_i. Depending on the design of the intervention, different methods will be employed. For 2 methods in particular, a graphic illustration helps understand the mechanics of the method.

9.1 Difference-in-differences (Did)

When randomized control trials are not feasible, natural experiment can be used to estimate the average treatment effect on the treated (ATT). Because Selection into the treatment is not random in a natural experiment, one can rely on the comparison in the time variation for treatment and control group. Under the **parallel tends assumption** (in the absence of treatment, the control and treatment groups would have evolved the same way over time), the difference in the time variation delivers a consistent estimate of the ATT. It can be estimated via the following equation:

$$Y_{i,t} = \beta_0 + \tau D_i + \lambda D_t + \delta \left(D_i \times D_t\right) + X'_{i,t}\beta_1 + \varepsilon_{i,t}$$

where D_t is a dummy variable equal to 1 if observation i occurs after the treatment, and equal to 0 if it occurs before, D_i is the treatment dummy variable, and $X_{i,t}$ is a set of additional covariates. The ATT is given by δ, and all the coefficients can be represented in the following graph (the treatment group is represented in blue, the treatment group in red):

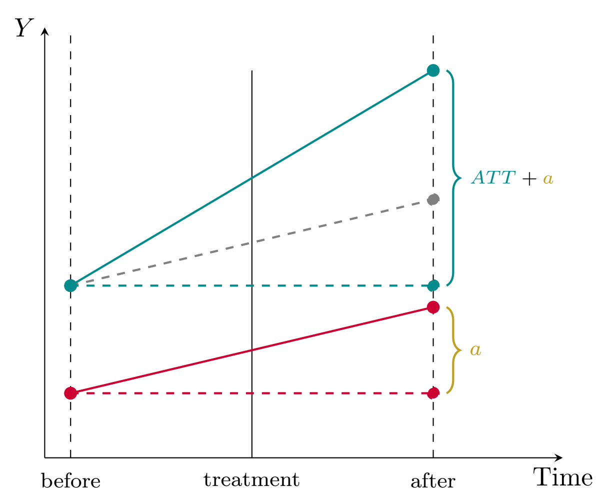

Figure 21: Difference-in-differences estimation decomposition

Note the presence of curly brackets using the command

```
\draw [darkcyan, thick, decorate, decoration={brace, raise = 5pt, amplitude = 5pt, mirror}]
(85, 40) -- (85, 90)node [black, midway, right=10pt]
```

9.2 Regression Discontinuity Designs (RDD)

There are instances where the assignment to treatment is a deterministic function of some variable. Crossing such a threshold can define a discontinuity in the outcome variable, and under the **continuity assumption**, the cause of that jump is due to the treatment only. Observations on either side of the threshold can be considered comparable, if not for their treatment status. Hence, such designs help estimate a **Local Average Treatment Effect (LATE)**. The design is explained best with a graph around the cutoff point:

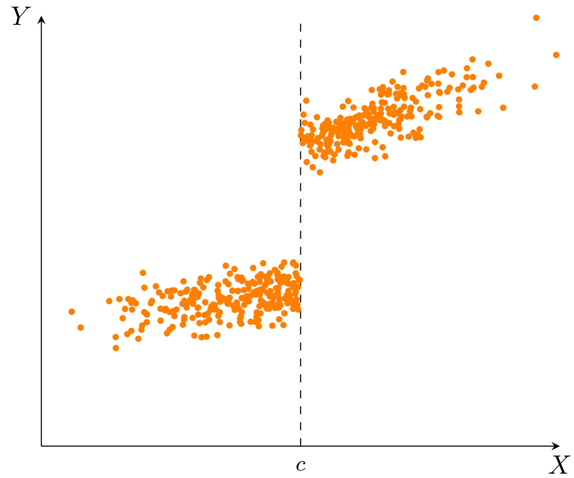

Figure 22: Regression Discontinuity Design

This graph was produced using data generated in **Rstudio**, converted into the .dat format (other statistical software such as Matlab or Stata can also be used for that purpose). The data were loaded in Latex using

```
\pgfplotstableread{RDD.dat}{\table}
```

The data will automatically appear in the graph, what is left to do is design the format of the graph itself (axes range, cutoff point, lables, etc)