Exercise session 5

Aalto University
School of Business

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Oct 16, 2020

1 a – Government intervention…

In order to help the producers, a minimum price may be set for the market.

Can a minimum price above the competitive equilibrium price increase total producers' surplus in the market?

Does it always increase producers' surplus?

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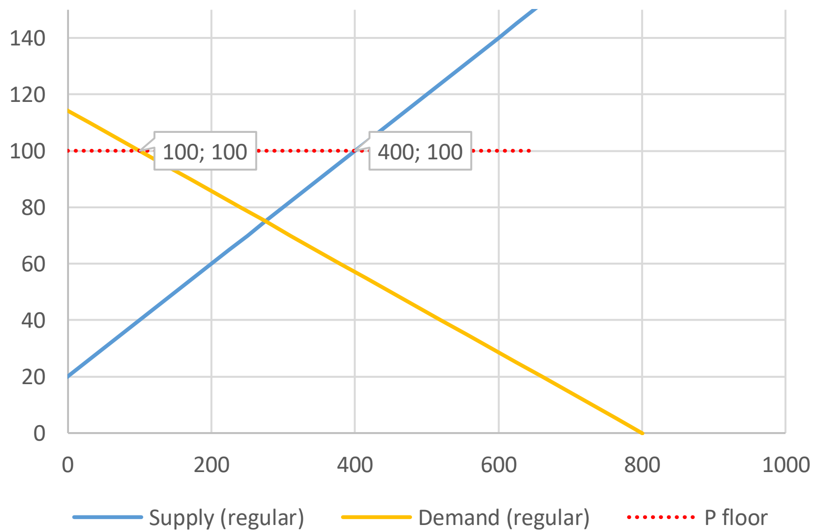
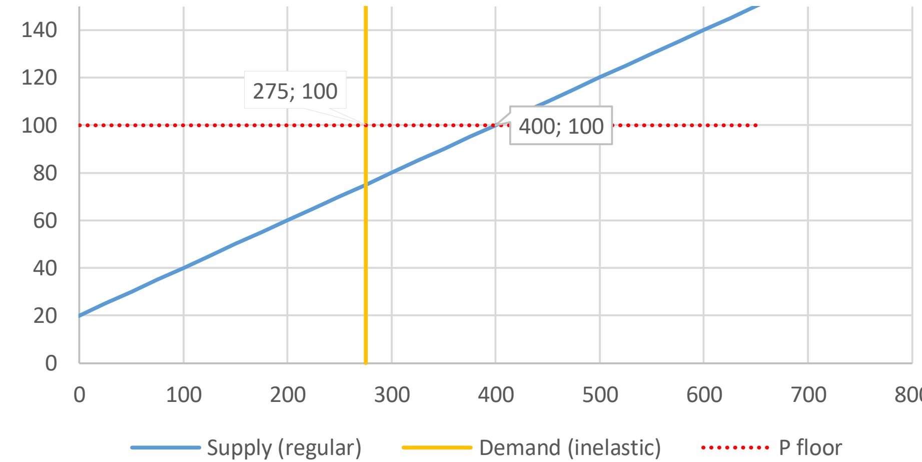
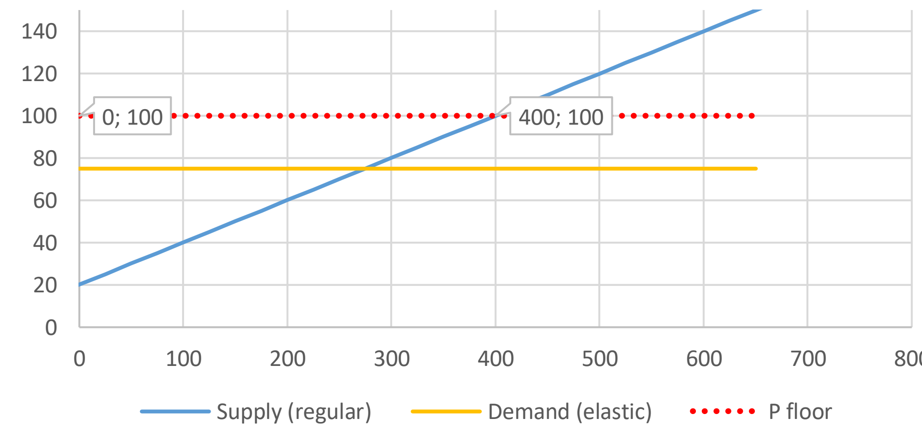
Does it always increase producers' surplus?

It can, but only if demand elasticity is low enough.
CS, PS and DWL shown in class.







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1 b – Government intervention…

A price cap or a price ceiling (or a maximum price) is often meant to help the consumers in a competitive market.

Does a price cap below market price always help the buyers?

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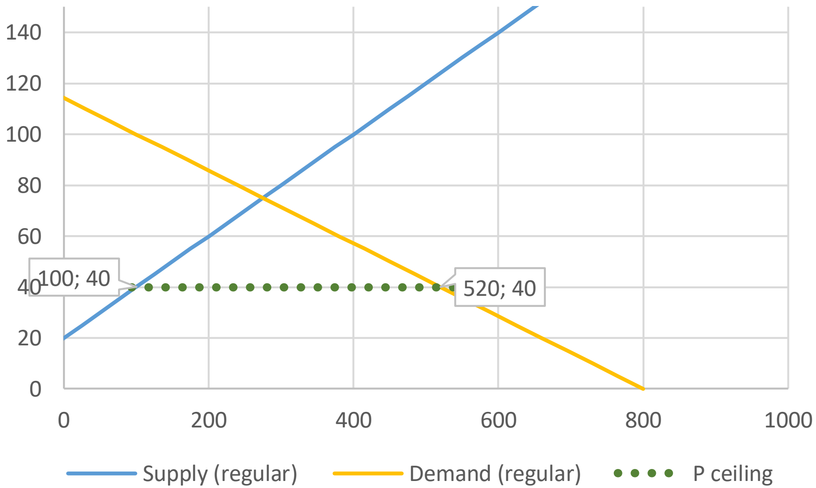

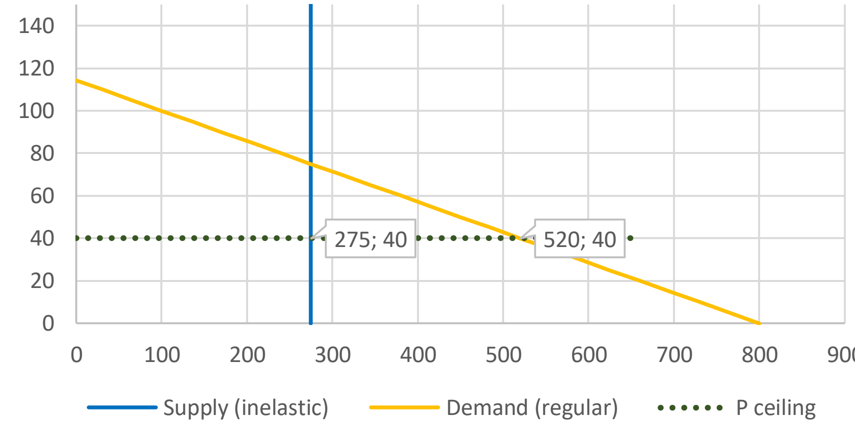

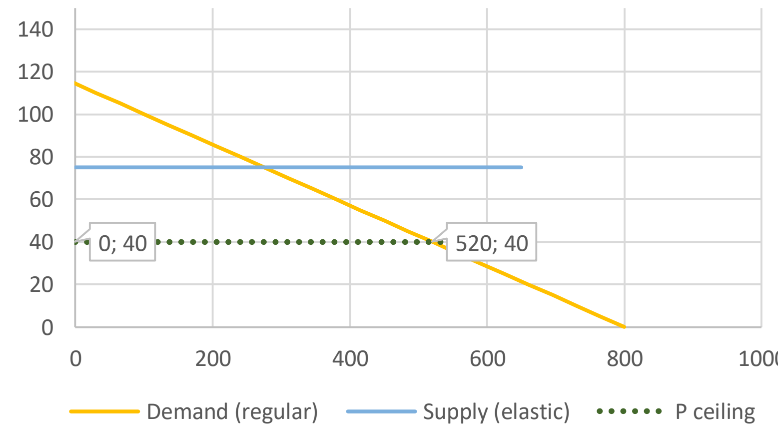

1 c – Government intervention…

Suppose that in the absence of international trade, the domestic competitive equilibrium price for a good is EUR 60 per unit.
The good is also available in the world market at price EUR 40 with a perfectly elastic (horizontal) supply curve.

Draw the diagram for changes in domestic consumer and producer surplus after allowing free trade with the world market (assume no transportation costs).

How do the surpluses change if a 10 EUR per unit import tariff is set for foreign production?

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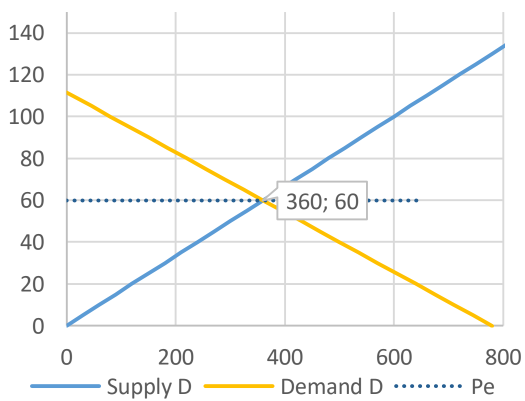
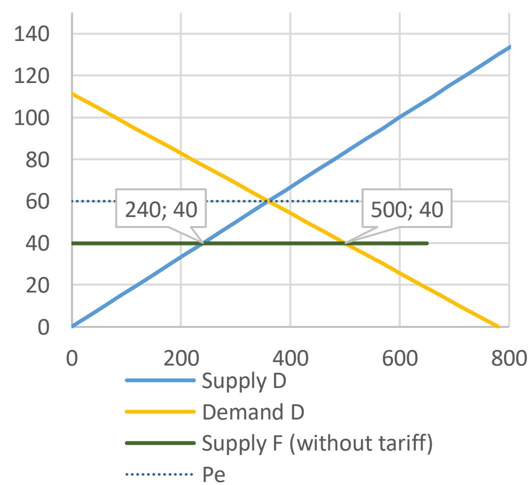
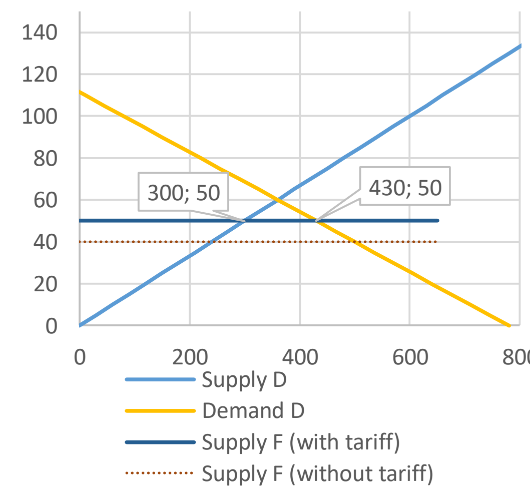






1 d – Government intervention…

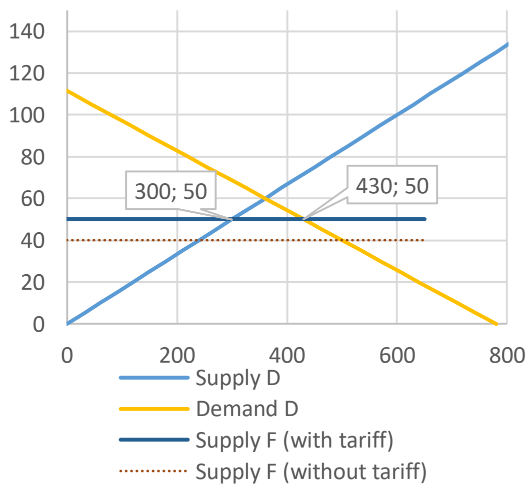
Instead of imposing a tariff, an import quota can be set for products produced in foreign countries. A quota just sets an upper bound for imports of the good in question. The goods within the quota are sold in the market together with domestic products.
Assume that consumers view foreign and domestic products as perfect substitutes.

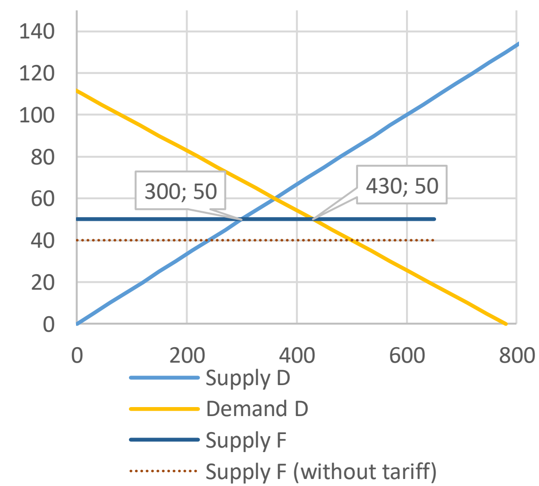
Which of the two methods for restricting imports would you use? (Hint: for a tariff of x EUR per unit of import, consider a quota of y units in such a way that the total quantity sold in the market is equalized. Compare the outcomes).

1 d – Government intervention

Which of the two methods for restricting imports would you use? (Hint: for a tariff of x EUR per unit of import, consider a quota of y units in such a way that the total quantity sold in the market is equalized. Compare the outcomes).

A tariff brings revenues to the government (the rectangle between (300;50), (430;50), (300;40), (430;40)), and the DWL is only the small triangles below the supply curve (to the left of the rectangle) and below the demand curve (to the right of the rectangle).
With the import quota, the deadweight loss is much larger (the whole trapezoid).





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2 – Trade

Consider a model of trade between two countries, Domestic (D) and Foreign (F).

Manufacturing labor is cheaper in F than in domestic and as a result, the equilibrium price of large appliances is EUR 90 lower in F than in D if there is no foreign trade.

All appliances regardless of the country where they are produced are considered to be equally good by all buyers (no home bias).

2 a – Trade

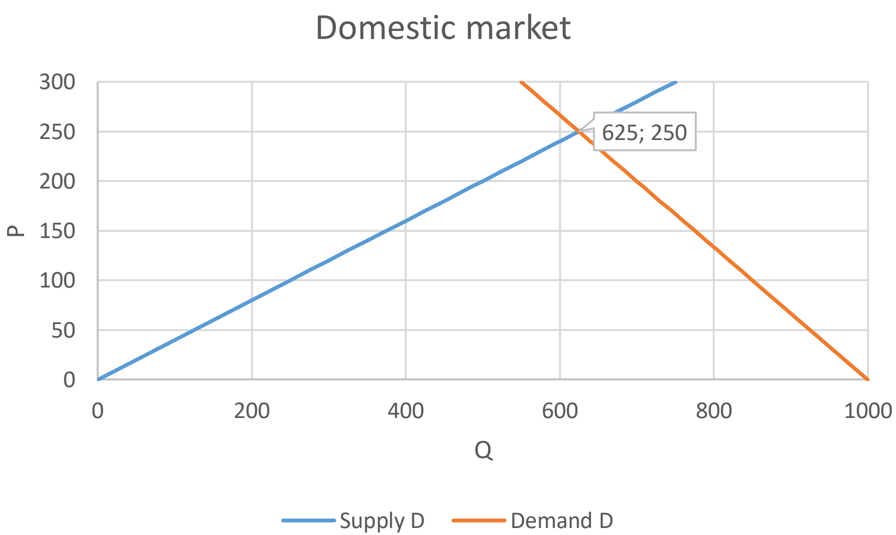
Draw the demand and supply diagrams for the two countries in two graphs that allows you to compare the price levels.

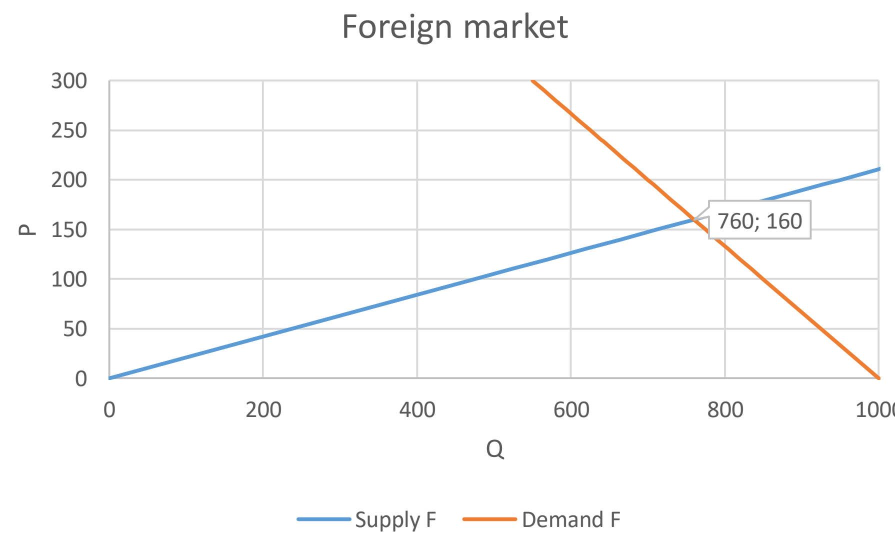
Assume that the two countries start trading, but the cost of transporting goods is EUR 60 per appliance. Consider the resulting equilibrium prices in the two countries after allowing free trade. Explain how the prices are different if the buyers in D pay the transportation cost versus if the producers pay the cost to get to the market in D.

2 a – Trade

$$Q_{DF} = 1000 - 1.5P_F$$
$$Q_{SF} = 4.75P_F$$
$$Q_{DD} = 1000 - 1.5P_D$$
$$Q_{SD} = 2.5P_D$$

Draw the demand and supply diagrams for the two countries in two graphs that allows you to compare the price levels.





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2 a – Trade

$$Q_{DF} = 1000 - 1.5P_F$$
$$Q_{SF} = 4.75P_F$$
$$Q_{DD} = 1000 - 1.5P_D$$
$$Q_{SD} = 2.5P_D$$

- If there is a transportation cost of 60, it must be that the equilibrium domestic price is 60 larger than the foreign price:

$$P_D = P_F + 60$$

- In equilibrium, it must be that the amount of demand in the domestic country is equal to the supply in the domestic country plus the imports (exports from the foreign country).
  - The amount of exports is the difference between foreign supply and demand at the foreign price:

$$X = Q_{SF} - Q_{DF} = 4.75P_F - (1000 - 1.5P_F) = 6.25P_F - 1000$$

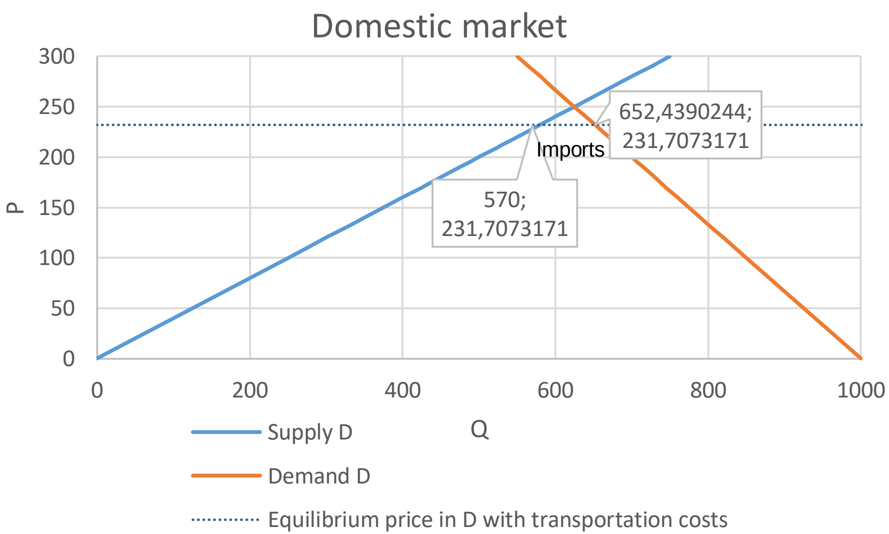
$$Q_{DD} = Q_{SD} + X \Rightarrow$$
$$1000 - 1.5P_D = 2.5P_D + 6.25P_F - 1000$$
$$1000 - 1.5(P_F + 60) = 2.5(P_F + 60) + 6.25P_F - 1000$$

- From this we can derive the price in the foreign country and then the domestic price:

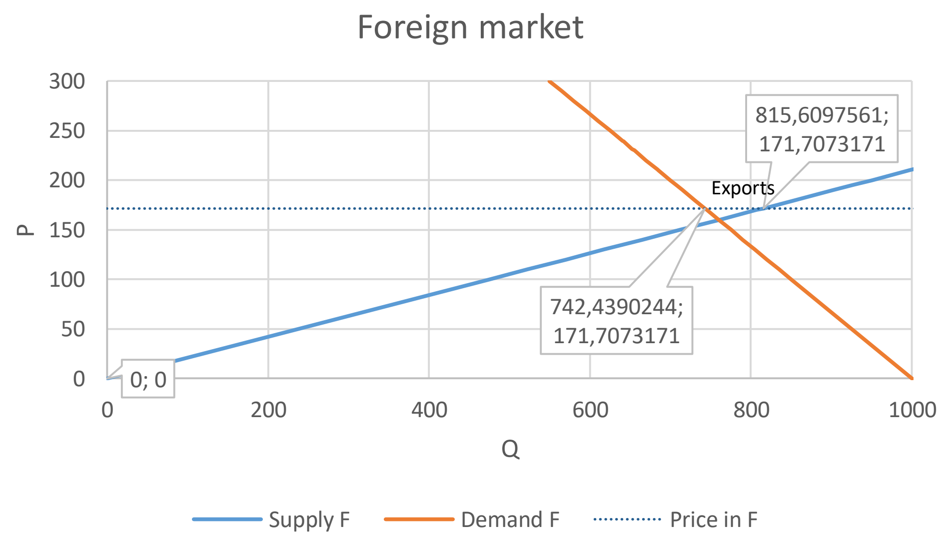
$$P_F = 171.71$$
$$P_D = 231.71$$

Prices are the same, regardless of who pays transportation costs.

2 a – Trade



Domestic market
300
250
200
150
100
50
0
P
0
200
400
600
800
1000
Q
652,4390244; 231,7073171
Imports
570; 231,7073171
Supply D
Demand D
Equilibrium price in D with transportation costs



Foreign market
300
250
200
150
100
50
0
P
0
200
400
600
800
1000
Q
815,6097561; 171,7073171
Exports
742,4390244; 171,7073171
0; 0
Supply F
Demand F
Price in F

2 b – Trade

Suppose another country (S) exactly similar to D joins in the free trade area.
The cost of transportation between any two countries is EUR 60.
What happens to equilibrium prices?

What can you say about the producer and consumer surplus in D as a result of S joining the free trade area?

2 b – Trade

$$Q_{DF} = 1000 - 1.5P_F$$
$$Q_{SF} = 4.75P_F$$
$$Q_{DD} = 1000 - 1.5P_D$$
$$Q_{SD} = 2.5P_D$$
$$Q_{DS} = 1000 - 1.5P_S$$
$$Q_{SS} = 2.5P_S$$

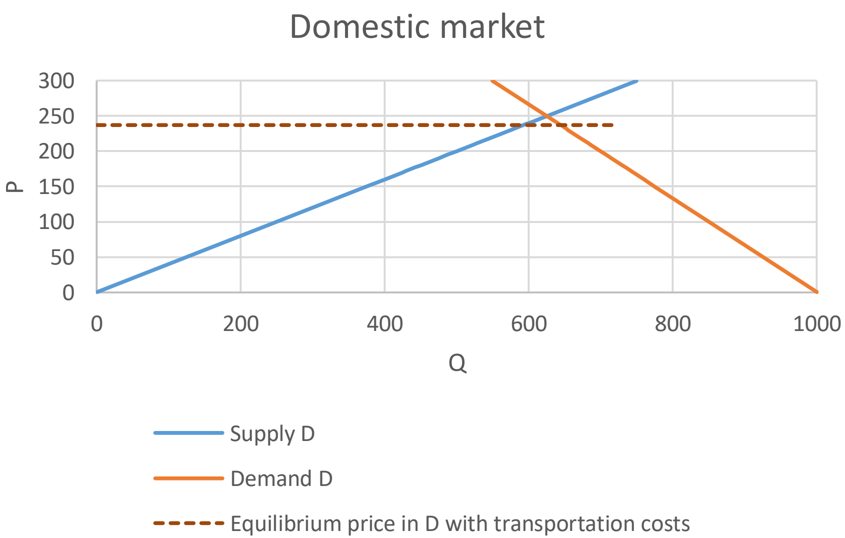
$$P_D = P_S = P_F + 60$$

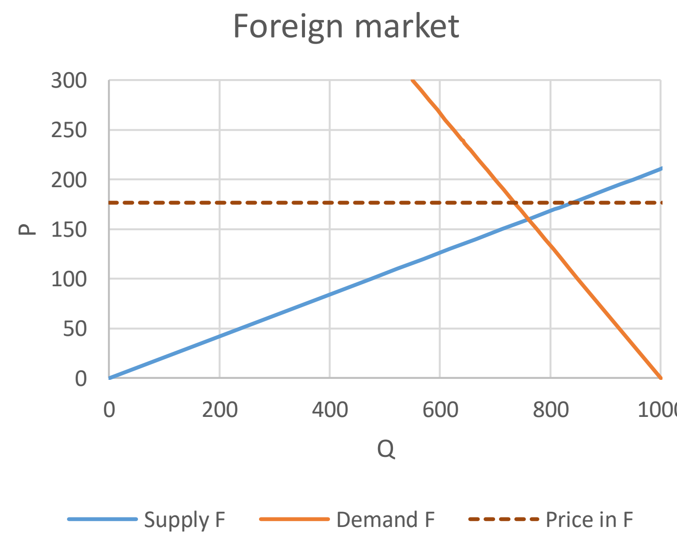
- In equilibrium, it must be that the amount of demands in country D and S are equal to the supply in country D and S plus the imports.
  - The amount of exports is still $X = 6.25P_F - 1000$

$$Q_{DD} + Q_{DS} = Q_{SD} + Q_{SS} + X \Rightarrow$$
$$2(1000 - 1.5P_D) = 2 \cdot 2.5P_D + 6.25P_F - 1000$$

- From this we can derive the price in the foreign country and then the price in D and S:

$$P_F = 176.84$$
$$P_D = P_S = 236.84$$





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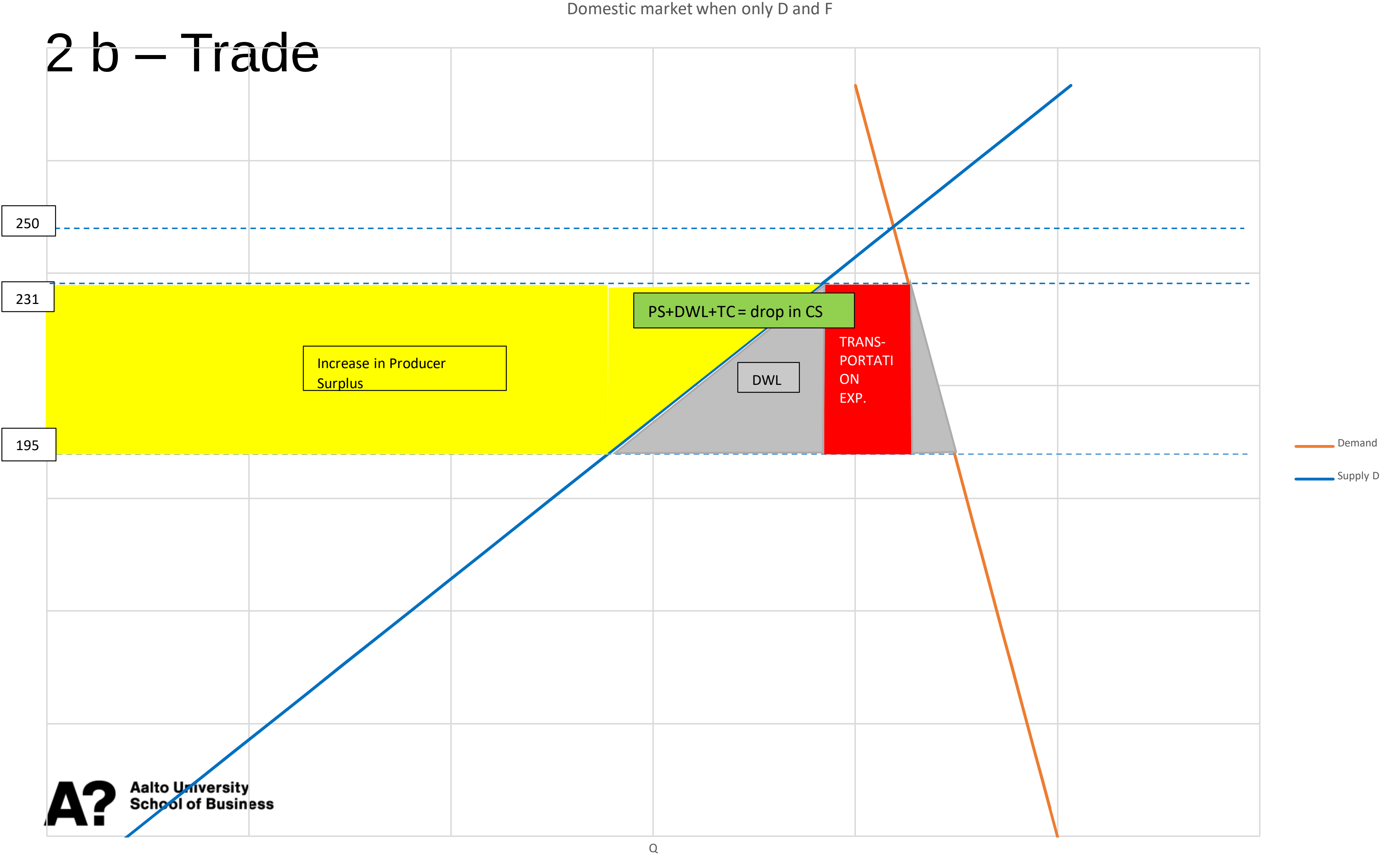
2 b – Trade



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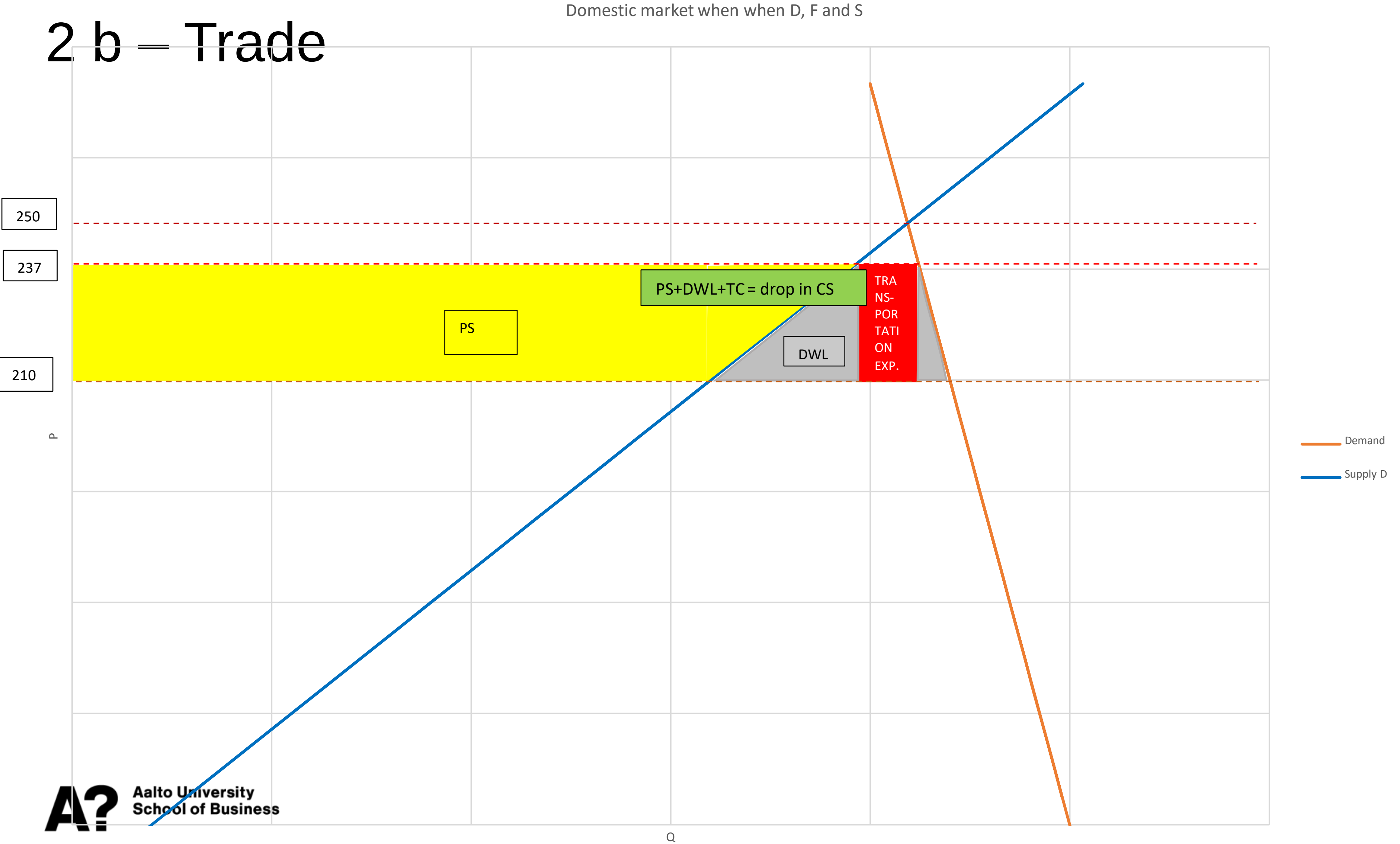
2 b – Trade



Domestic market when when D, F and S
250
237
210
P
Q
PS
PS+DWL+TC = drop in CS
DWL
TRA NS- POR TATI ON EXP.
Demand
Supply D

2 b – Trade

$P = 250$	$P = 231.71$	$P = 195.12$
$D = 625$	$D = 652.44$	$D = 707.32$
$S = 625$	$S = 579.27$	$S = 487.8$
	$X = 73.19$	

$$\Delta PS = (231.71 - 195.12) * 487.8 + (231.71 - 195.12) * \frac{579.27 - 487.8}{2} = 19522$$

$$TC = 73.19 * (231.71 - 195.12) = 2678$$

$$DWL = (231.71 - 195.12) * \frac{579.27 - 487.8}{2} + (231.71 - 195.12) * \frac{707.32 - 652.44}{2} = 2677.47$$

$$\Delta CS = -(\Delta PS + TC + DWL) = -24877.5$$

2 b – Trade

$P = 250$	$P = 236.84$	$P = 210.53$
$D = 625$	$D = 644.74$	$D = 684.21$
$S = 625$	$S = 592.1$	$S = 526.32$
	$X = 52.64$	

$$PS = (236.84 - 210.53) * 526.32 + (236.84 - 210.53) * \frac{592.1 - 526.32}{2} = 14712.8$$

$$TS = 52.64 * (236.84 - 210.53) = 1385$$

$$DWL = (236.84 - 210.53) * \frac{592.1 - 526.32}{2} + (236.84 - 210.53) * \frac{684.21 - 644.74}{2} = 1384.56$$

$$\Delta CS = -(\Delta PS + TC + DWL) = -17482.36$$

2 b – Trade

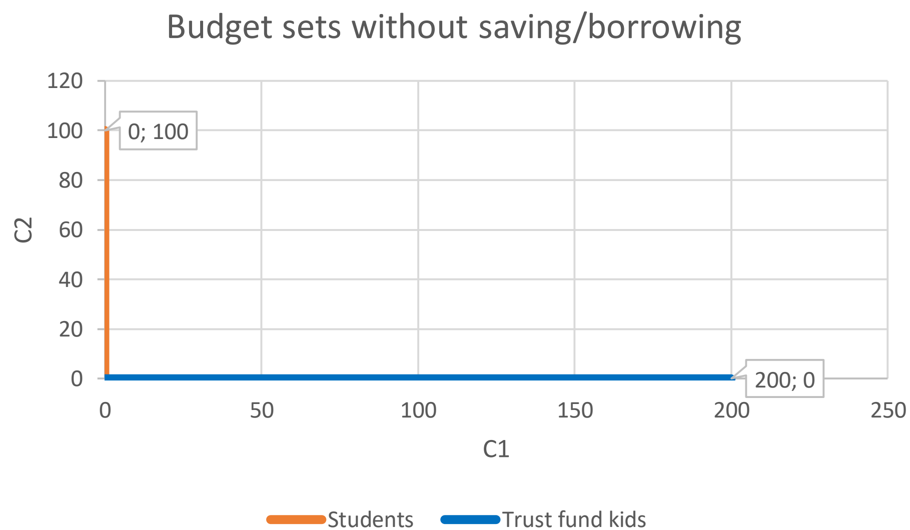
	D and F	D, S and F
ΔCS	-24877.5	-17482.36
ΔPS	19522	14712.8
TC	2678	1385
DWL	2677.47	1384.56

3 – Consumption and saving

There are two types of individuals: students and trust fund kids.

- Students work hard and earn 100 in period 2 when they are old. Unfortunately since they study in period 1, they have no income in that period.
- Trust fund kids get an inheritance of 200 and they conclude that they do not have to study. As a result, they have no labor income in period 2.

Denote consumptions in the two periods by c1 and c2.



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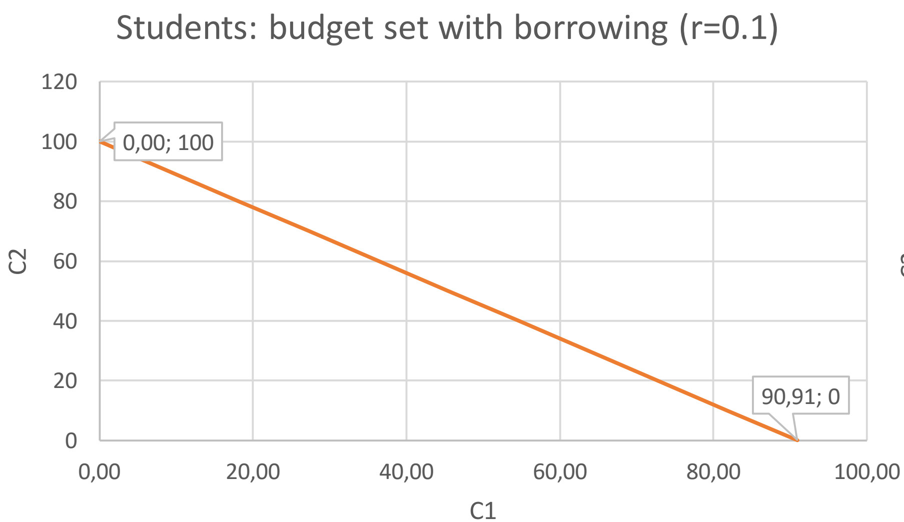
3 a – Consumption and saving

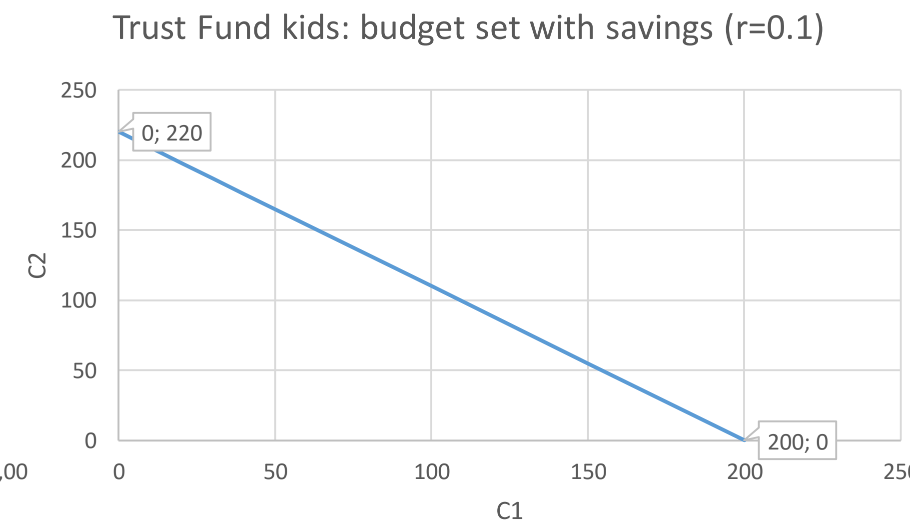
Since both types of individuals like to consume on both periods, they realize that a market for borrowing and loans might be a good idea.

Suppose that there is a market rate for lending and borrowing at r so students can borrow $c1$ for consumption when young in exchange of paying $(1 + r)c_1$ back when old. We require that $(1 + r)c_1 \leq c_2$so that any amount borrowed can be paid back.
Similarly the trust fund kids may save s when young to get back $(1 + r)s$ when old.

Draw the budget sets for the two types of individuals.

3 a – Consumption and saving





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3 b – Consumption and saving

- Draw indifference curves to the two types of buyers that reflect the fact that the MRS between consumption in period 1, c1 and consumption in period 2, c2 is given by the ratio of the two consumptions:

$$MRS = \frac{c_2}{c_1}$$

(Actually you can graph such indifference curves explicitly as $c_2(c_1) = \frac{u}{c_1}$ and the indifference curves corresponding to higher u give consumption pairs that are better than consumption pairs on indifference curves with lower u).

- Find the optimal savings s for the trust fund kids and optimal borrowing c_1 for the students in the graphs.

3 b – Consumption and saving

Draw indifference curves to the two types of buyers that reflect the fact that the MRS between consumption in period 1, c1 and consumption in period 2, c2 is given by the ratio of the two consumptions:

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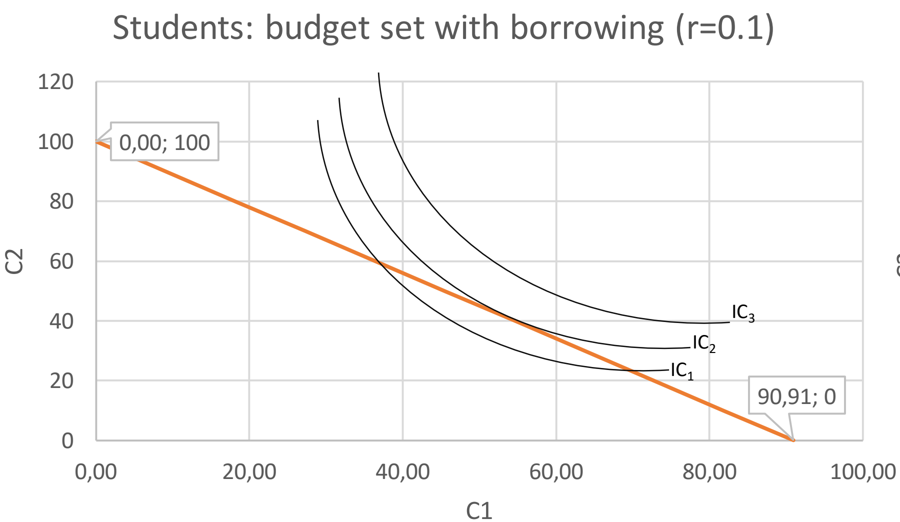
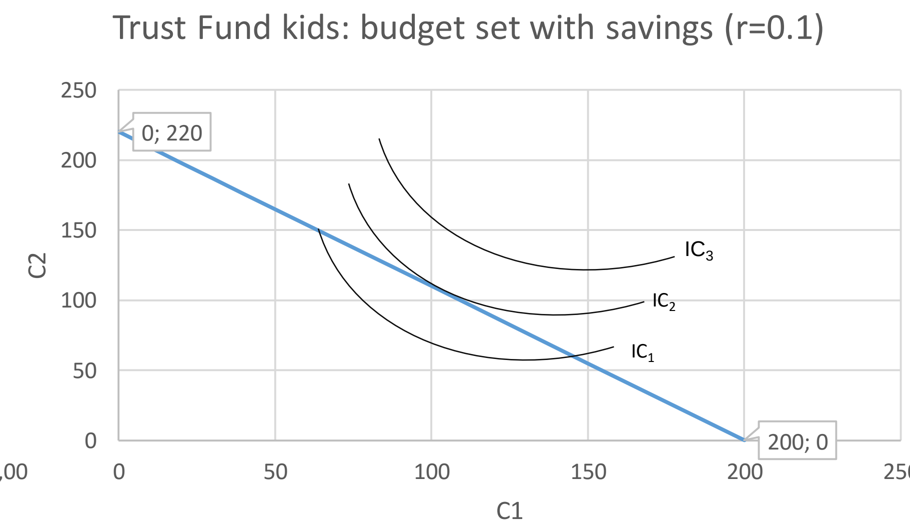
Find the optimal savings s for the trust fund kids and optimal borrowing c_1 for the students in the graphs.





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3 c – Consumption and saving

Use the budget constraint and the requirement that $MRS = MRT$ to solve algebraically the optimal savings and borrowings.

3 c – Consumption and saving

The intertemporal budget constraint tells us that the present value of the current and future consumption cannot exceed the present value of the current income and future income.

$$\sum_{t=1}^{T} \frac{c_t}{(1+r)^{t-1}} \leq \sum_{t=1}^{T} \frac{w_t}{(1+r)^{t-1}}$$

In this case:

$$\frac{c_1}{(1+r)^0} + \frac{c_2}{(1+r)^1} = \frac{w_1}{(1+r)^0} + \frac{w_2}{(1+r)^1}$$

So for students:

$$c_{S1} + \frac{c_{S2}}{1+r} = \frac{100}{1+r} \Leftrightarrow c_{S2} = 100 - (1+r)c_{S1}$$

$$\boldsymbol{MRT_S} = |-(1+r)| = \mathbf{1} + \boldsymbol{r}$$

And for trust fund kids:

$$c_{T1} + \frac{c_{T2}}{1+r} = 200 \Leftrightarrow c_{T2} = (200 - c_{T1})(1+r)$$

$$\boldsymbol{MRT_T} = |-(1+r)| = \mathbf{1} + \boldsymbol{r}$$

The MRS was given already as:

$$MRS = \frac{c_2}{c_1}$$

3 c – Consumption and saving

For optimum, set $MRT = MRS \Longrightarrow 1 + r = \frac{c_2}{c_1} \Leftrightarrow \boldsymbol{c_2 = c_1(1 + r)}$

Then plug it into the intertemporal budget constraint.

Students:

$$MRT = MRS\colon\ c_{S2} = c_{S1}(1 + r)$$
$$BC\colon c_{S2} = w_{S2} - (1 + r)c_{S1}$$

$$c_{S1}(1 + r) = w_{S2} - (1 + r)c_{S1}$$
$$2c_{S1}(1 + r) = w_{S2}$$
$$c_{S1} = \frac{w_{S2}}{2(1 + r)}$$
$$c_{S1} = \frac{100}{2.2} = 45.45$$
$$\boldsymbol{b_S = c_{S1} = 45.45}$$

Trust fund kids:

$$MRT = MRS\colon\ c_{T2} = c_{T1}(1 + r)$$
$$BC\colon\ c_{T2} = (W_{T1} - c_{T1})(1 + r)$$

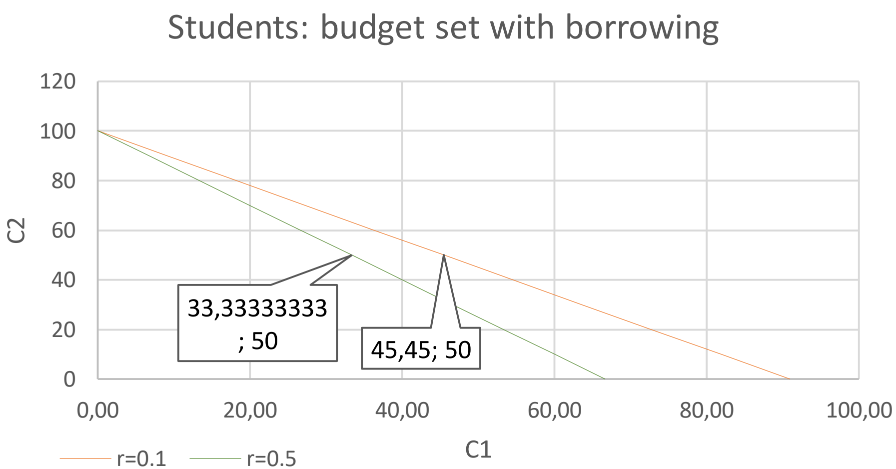
$$c_{T1}(1 + r) = (w_{T1} - c_{T1})(1 + r)$$
$$c_{T1}(1 + r) = w_{T1}(1 + r) - (1 + r)c_{T1}$$
$$2c_{T1}(1 + r) = w_{T1}(1 + r)$$
$$c_{T1} = \frac{w_{T1}(1 + r)}{2(1 + r)} = \frac{w_{T1}}{2}$$
$$c_{T1} = \frac{200}{2} = 100$$
$$\boldsymbol{s_T = w_{T1} - c_{T1} = 200 - 100 = 100}$$

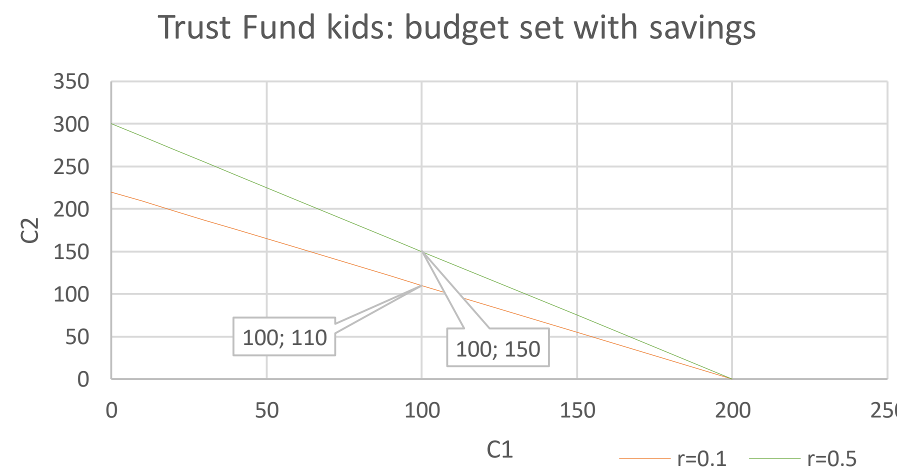
3 d – Consumption and saving

Determine the effect of an increase in r on the optimal savings and borrowings graphically.
Show the income and substitution effects in the graphs.

3 d – Consumption and saving

Determine the effect of an increase in r on the optimal savings and borrowings graphically.
Show the income and substitution effects in the graphs. (done in class)





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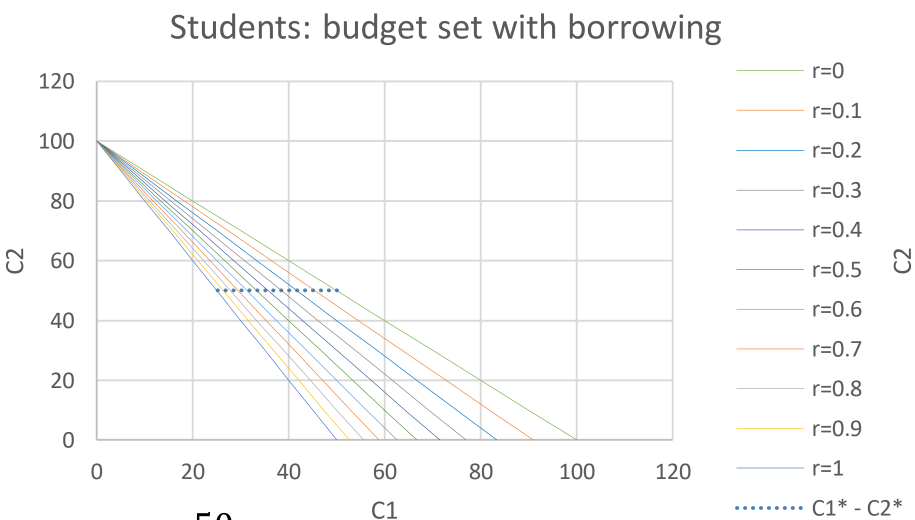
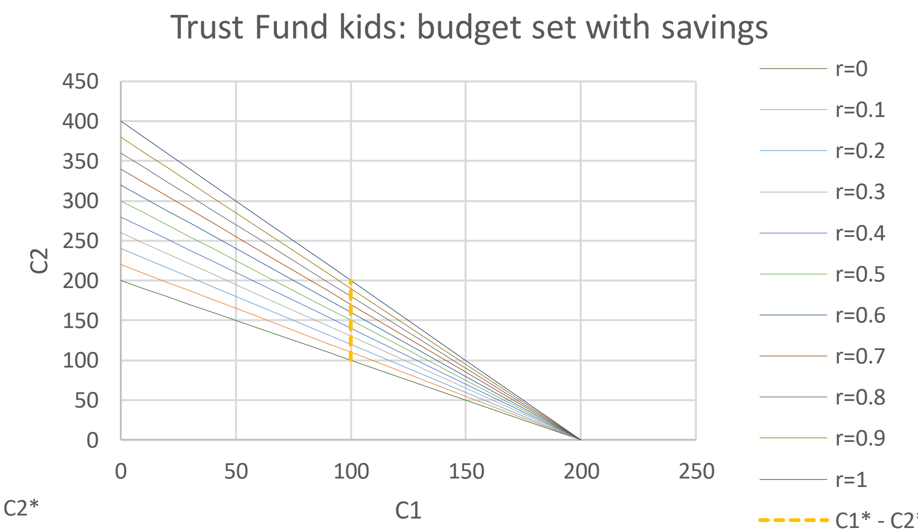
3 d – Consumption and saving

Determine the effect of an increase in r on the optimal savings and borrowings graphically.
Show the income and substitution effects in the graphs.



$$c_{S1}^* = \frac{50}{1+r}$$
$$c_{S2}^* = (1+r)c_{S1}^* = 50$$



$$c_{T1}^* = 100$$
$$c_{T2}^* = c_{T1}^*(1+r) = 100(1+r)$$

3 e – Consumption and saving

In any credit market, borrowing must equal lending since each transaction has these two sides. For our model, this means that the borrowing by students must equal lending by trust fund kids.

Using the algebraic solutions found in part c, determine the equilibrium rate r that makes borrowing equal to lending when 10% of the population are trust fund kids.
How does the equilibrium rate vary as we change the fraction x of trust fund kids in the model and what are the implications of this to the welfare of the two types of individuals?

3 e – Consumption and saving

Using the algebraic solutions that you found in part c, determine the equilibrium rate r that makes borrowing equal to lending whet 10% of the population are trust fund kids.

$$b_S = \frac{50}{(1+r)}$$

$$s_T = 100$$

Assume 1 trust fund kid and 9 students.

Then total borrowing is $Tb_S = 9 \cdot \frac{50}{(1+r)} = \frac{450}{(1+r)}$

And total lending is $Ts_T = 100$

Equating the two: $\frac{450}{(1+r)} = 100 \Leftrightarrow 450 = 100(1+r) \Leftrightarrow \boldsymbol{r = 3.5}$

3 e – Consumption and saving

How does the equilibrium rate vary as we change the fraction x of trust fund kids in the model and what are the implications of this to the welfare of the two types of individuals?

$$x = [0,1]$$

$$Tb_S = (1-x) \cdot \frac{50}{(1+r)} = \frac{50-50x}{(1+r)}$$

$$Ts_T = x \cdot 100$$

Equating the two: $\frac{50-50x}{(1+r)} = x \cdot 100 \Leftrightarrow r = \frac{0.5}{x} - 1.5$

The larger x, the smaller r, the larger the welfare of students.

$$x = 0.2 \Leftrightarrow r = 1$$

$$x = 0.3 \Leftrightarrow r = 0.167$$

$$x = 0.40 \Leftrightarrow r = -0.25$$

$$x = 0.333 \Leftrightarrow r = 0$$

4 – Electricity

There are five main sources of supply for electricity in the Nordic market.
Wind plants, nuclear plants and combined heat and electricity production account together for 40% of actual generation.
Hydro power accounts for about 55% of generation,
and the remainder (between 5 and 10% in most years) comes from fossil fuel thermal plants.

4 a – Electricity

Ignore for the moment hydro power generation.

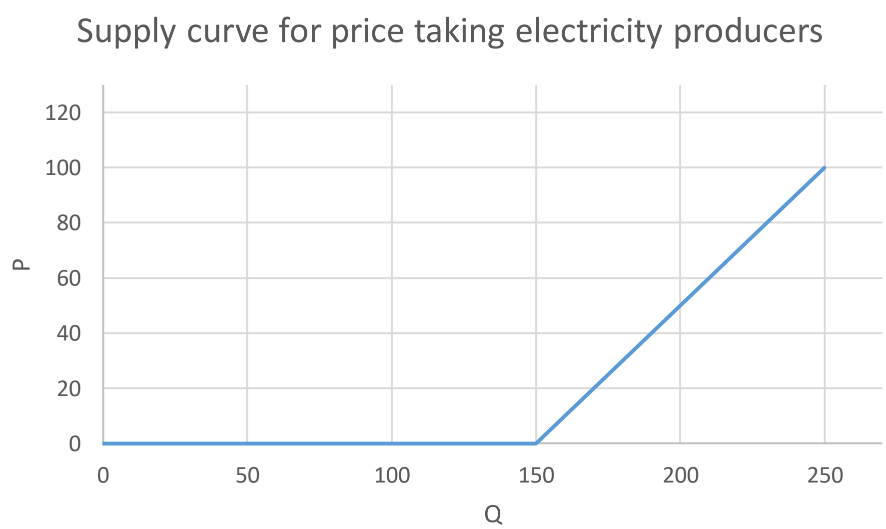
Construct the supply curve for the electricity market where nuclear generation accounts for 80 TWh per year, wind accounts for 30 TWh and combined production accounts for 40 TWh.
(You may assume that the marginal cost of production for these is zero even though for nuclear, the marginal cost for short periods is negative).

The rest of the supply comes from thermal plants of fixed size. Assume that these plants vary in efficiency of production, but not in size.
There are 100 plants each with capacity 1 TWh per year and cost of production that varies between 1 and 100 by plant (so that at each integer P between 1 and 100, there is one plant with average cost at P).

Draw the resulting supply curve for price taking electricity producers.

4 a – Electricity

$$N = 80TWh$$
$$W = 30\ TWh$$
$$C = 40TWh$$
$$MC_N = MC_W = MC_C = 0$$
$$T_{i}{}_{i=1}^{i=100} = 1TWh$$
$$MC_{T}{}_{i=1}^{i=100} = i$$



4 b – Electricity

Suppose that the demand is completely inelastic at 170 TWh per year.
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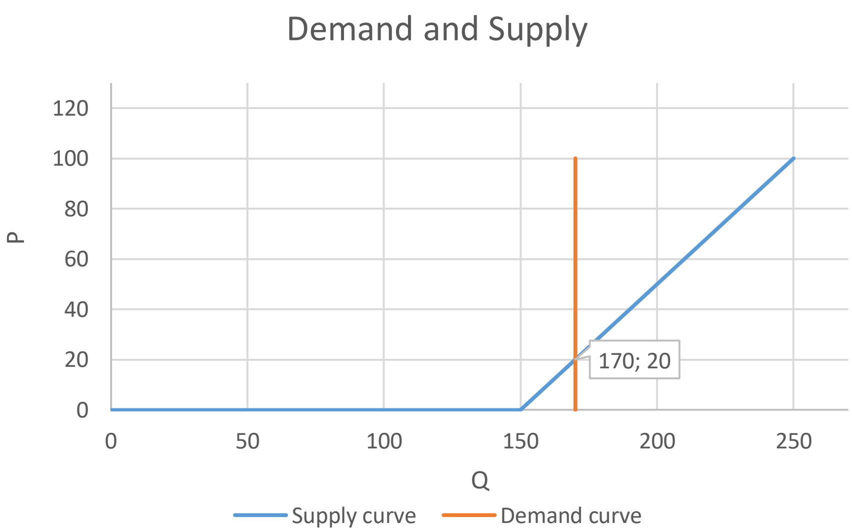

$$S = 150 + P$$
$$D = 170$$
$$S = D: 150 + P^e = 170 \Longrightarrow$$
$$P^e = 20$$
$$Q^e = 170$$

$$\Pi_N = 20 \cdot 80 = 1600$$
$$\Pi_W = 20 \cdot 30 = 600$$
$$\Pi_C = 20 \cdot 40 = 800$$

$$\Pi_{T_{i=1}^{i=20}} = \left(20 - MC_{T_{i=1}^{i=20}}\right) \cdot 1 = 20 - i$$
$$T\Pi_{T_{i=1}^{i=20}} = \sum_{i=1}^{1=20} \left(20 - MC_{T_{i=1}^{i=20}}\right) \cdot 1 = \sum_{i=1}^{1=20} 20 - i$$
$$= 19 + 18 + 17 + \cdots + 1 + 0 = 190$$

4 c – Electricity

Assume now that we go to the actual case of hourly pricing of supplies and demands. We keep on using the same numbers (just not measured in TWh but 1/8760 parts of TWh).

Wind production varies between 0 and 60 based on the wind conditions.
Let W denote the potential wind production in a given hour.
What is the equilibrium price as a function of W?

4 c – Electricity

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Wind production varies between 0 and 60 based on the wind conditions.
Let W denote the potential wind production in a given hour.
What is the equilibrium price as a function of W?

$$S = N + C + T + W = 80 + 40 + P + W$$
$$D = 170$$
$$S = D: 120 + W + P = 170$$

$$\Longrightarrow P = 50 - W$$
$$P(kWh) = \frac{50 - W}{8760} = 0.0057 - \frac{W}{8760}$$

$P(kWh) = P(TWh)/8760$

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School of Business

4 d – Electricity

Add some further realism to the model by assuming that demand in winter is 190 per hour and in summer 160 per hour.

What are the prices for the different seasons (depending on wind conditions)?

4 d – Electricity

In winter:

$$S_W = N + C + T + W = 80 + 40 + P_W + W$$
$$D_W = 190$$
$$S_W = D_W: 120 + P_W + W = 190$$

$$\Longrightarrow P_W = 70 - W$$

$$P_W(kWh) = \frac{70 - W}{8760} = 0.008 - \frac{W}{8760}$$

In summer:

$$S_S = N + C + T + W = 80 + 40 + P_S + W$$
$$D_S = 160$$
$$S_S = D_S: 120 + P_S + W = 160$$
$$\Longrightarrow P_S = 40 - W$$

$$P_S(kWh) = \frac{40 - W}{8760} = 0.00457 - \frac{W}{8760}$$

4 e – Electricity

Finally add some hydro power into the consideration.

How does hydro power production differ from the other sources? (Hint: the marginal cost of operating the plant is minuscule, but what is the opportunity cost of producing electricity for a given hour?)

Is there any natural variability in hydro power production over the year?

How would you supply electricity in the market if you were the manager of a profit maximizing small hydro plant?

4 e – Electricity

Finally add some hydro power into the consideration.

How does hydro power production differ from the other sources? (Hint: the marginal cost of operating the plant is minuscule, but what is the opportunity cost of producing electricity for a given hour?)

- Producing electricity now means I cannot generate it later (I give up potentially higher profits if price increases later)

Is there any natural variability in hydro power production over the year?

- Larger when snow melts, or during rainy season.

How would you supply electricity in the market if you were the manager of a profit maximizing small hydro plant?

- Produce electricity at peak times when prices are at the highest. (pump water back up when prices are at the lowest)