Teaching "Externalities" with Dynamic Graphs in Microsoft Excel

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INTRODUCTION

While we are sometimes discouraged that our students may not be reading the textbook, our lessons and concepts are driven home most completely through the use of graphs. Even if our students are reading the textbook, the textbook only presents static graphs. While modern textbooks often have electronic ancillaries, the examples and graphs tend to be pre-programmed: the learner only has access to a relatively small number of examples, i.e., those examples for which the textbook authors and programmers have explicitly provided, most commonly with Adobe Flash objects.

Microsoft Excel spreadsheet application allows us to parameterize examples with Excel programming so that student-learners have access to a huge inventory of examples. By using simple "Form Controls" from the Developer tab (Excel 2007) and linking the values of these controls to graphs that update automatically, we can create rich interactive examples so that our students can explore important, but sometimes complex economic concepts. We are applying this teaching strategy to the concept of externalities.

EXCEL MODULE

A module is programmed in Microsoft Excel to show each of the following as linear curves:

1. marginal private cost (production, or supply side);
2. marginal private benefit (consumption, or demand side);
3. marginal external cost or benefit in consumption;
4. marginal external cost or benefit in production;
5. marginal social cost (production, or supply side) ; and
6. marginal social benefit (consumption, or demand side).

For each of the six curves, the slope and intercept values are controlled by means of “spin buttons.” This, we believe, is a significant source of the value of this teaching strategy: the user can repeatedly click on a single spin button and track in the graph how the changing value of one of the parameters affects the private market equilibrium and/or the social optimum. The Excel programming also solves for the private market equilibrium and the social optimum and the points associated with these optima are identified in the graph.

To prevent visual clutter or visual overload, each curve is associated with a pair of option buttons to “Show” or “Hide” the associated curve.

Demand: MPB = 150 – Q

Intercept	150	◉ SHOW
Slope	1	○ HIDE

Consumption externality: MEC = 20

Constant	20	○ SHOW
Slope	0	◉ HIDE

Supply: MPC = 50 + Q

Constant	50	◉ SHOW
Slope	1	○ HIDE

Production externality: MEC = 20

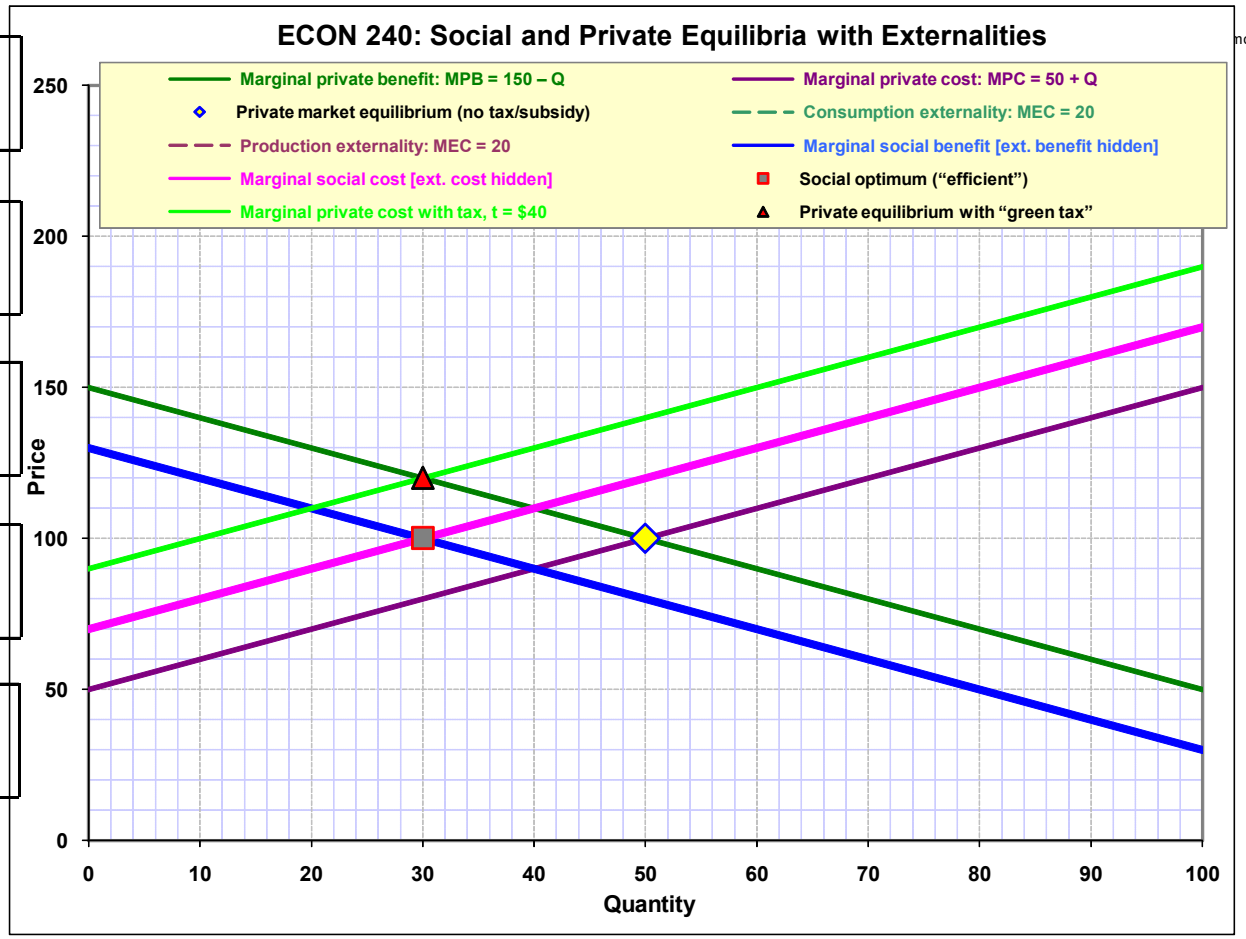
Constant	20	○ SHOW
Slope	0	◉ HIDE

Net unit tax (a "green tax")
t = 40

t =	40	◉ SHOW
		○ HIDE

Marginal social benefit
◉ SHOW ○ HIDE

Marginal social cost
◉ SHOW ○ HIDE



Private market equilibrium (no tax/subsidy)

*Q** =	50
*P** =	100

Social optimum ("efficient")

*Q** =	30
*P** =	100

Private equilibrium with "green tax"

*Q** =	30
*P** =	120

By clicking on the up and down arrows for consumption or production externalities, students can visualize:

- Negative consumption externalities
- Positive consumption externalities
- Negative production externalities
- Positive production externalities.

The students can observe the effect of each externality on:

- Marginal social cost
- Marginal social benefit
- Socially optimal quantity.

For each externality the students can choose a tax/subsidy and note its effect on the private equilibrium with tax/subsidy.

The students can set the tax/subsidy to achieve the socially optimal quantity and can note how this tax/subsidy compares with the marginal external cost/benefit.

STUDENT ACTIVITIES

Activity 1

a. Note the location of the Marginal Private Benefit (MPB) & Marginal Private Cost (MPC) curves. Also, note the price and quantity in the box titled "Private market equilibrium."

b. Click "Show" for Marginal Social Cost (MSC).

c. Note the location of the MSC curve. Why does it overlap the MPC curve?

d. Click "Show" for Marginal Social Benefit (MSB).

e. Note the location of the MSB curve. Why does it overlap the MPB curve?

Demand: MPB = 150 – Q

Intercept	150	◉ SHOW	
Slope	1	○ HIDE	

[No externality in consumption]

Constant	0	○ SHOW	
Slope	0	◉ HIDE	

Supply: MPC = 50 + Q

Constant	50	◉ SHOW	
Slope	1	○ HIDE	

[No externality in production]

Constant	0	○ SHOW	
Slope	0	◉ HIDE	

Net unit tax (t > 0) or subsidy (t < 0)

No unit tax or subsidy

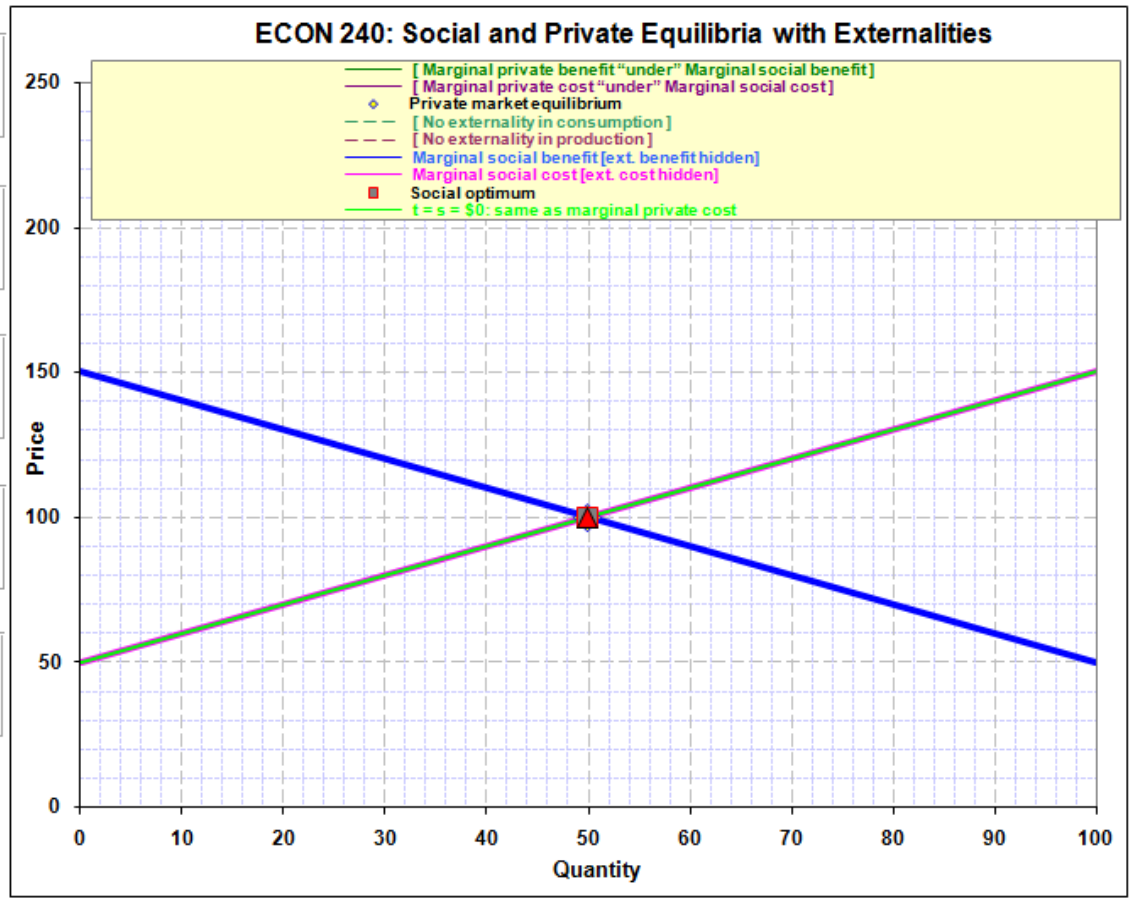
t =	0	◉ SHOW	
		○ HIDE	

Marginal social benefit

◉ SHOW ○ HIDE

Marginal social cost

◉ SHOW ○ HIDE



Private market equilibrium

*Q** =	50
*P** =	100

Social optimum

*Q** =	50
*P** =	100

Private equilibrium with $0 tax or subsid

*Q** =	50
*P** =	100

Activity 2

a. In the box titled "No externality in production," increase the MEC to 20 by clicking on the up arrow for Constant.

b. Note the location of the MSC curve. Why does it not overlap the MPC curve? What is the vertical difference between the two curves?

c. Note the price and quantity in the box titled "Social optimum."

d. In the box titled "Net unit tax," click "Show." Note the price and quantity in the box titled "Private equilibrium with tax/subsidy."

e. Set the tax by clicking on the up arrow until the quantity becomes equal to the quantity in the box titled "Social optimum." What is the value of the tax at this point? How does it compare to the value of the Marginal External Cost (MEC)?

Demand: MPB = 150 – Q

Intercept	150	◉ SHOW
Slope	1	○ HIDE

[No externality in consumption]

Constant	0	○ SHOW
Slope	0	◉ HIDE

Supply: MPC = 50 + Q

Constant	50	◉ SHOW
Slope	1	○ HIDE

Production externality: MEC = 20

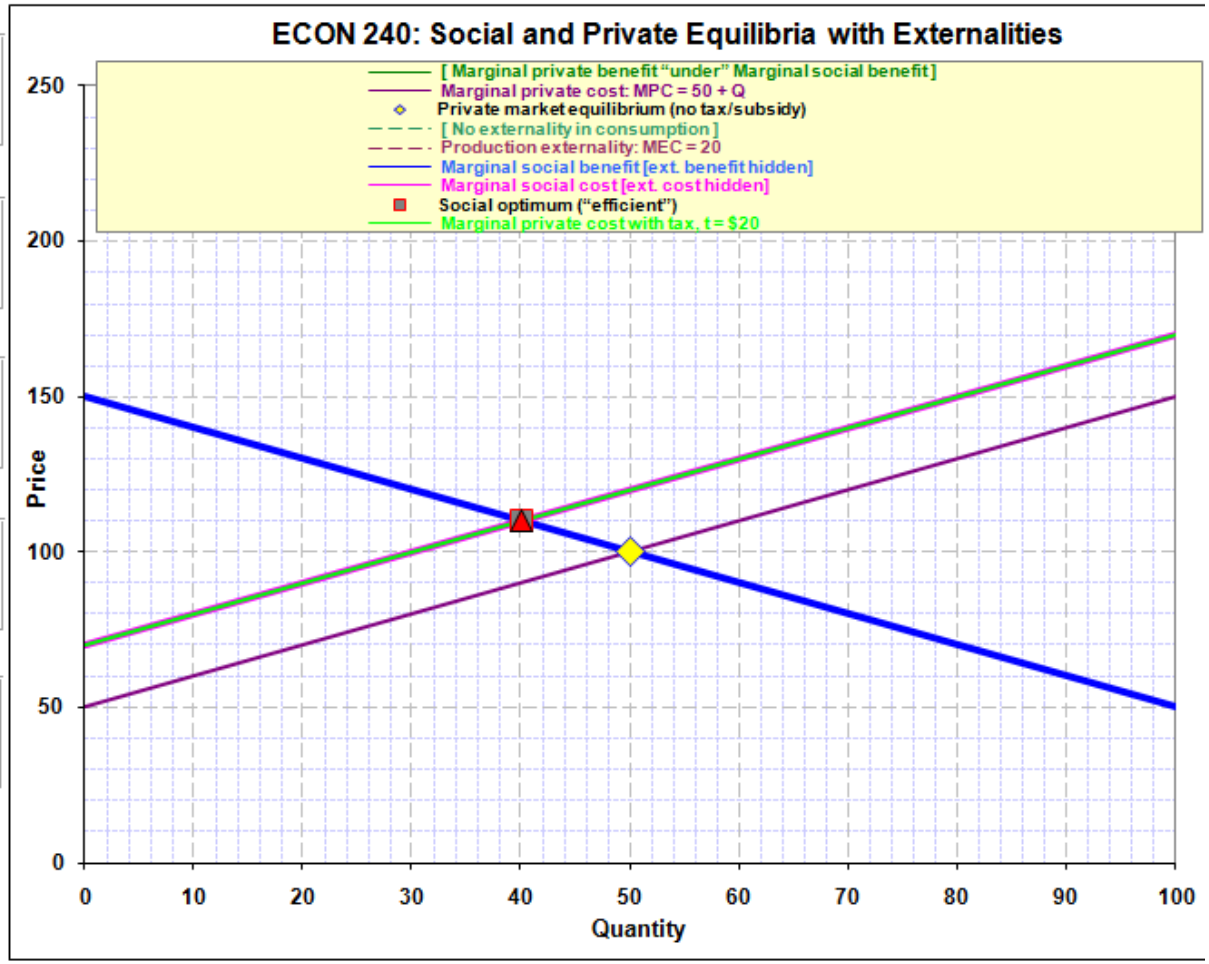
Constant	20	○ SHOW
Slope	0	◉ HIDE

Net unit tax (a "green tax")
t = 20

t =	20	◉ SHOW
		○ HIDE

Marginal social benefit
◉ SHOW ○ HIDE

Marginal social cost
◉ SHOW ○ HIDE



Private market equilibrium (no tax/subsidy)

*Q** =	50
*P** =	100

Social optimum ("efficient")

*Q** =	40
*P** =	110

Private equilibrium with "green tax"

*Q** =	40
*P** =	110

Activity 3

a. In the box titled "No externality in consumption," increase the MEC to 20 by clicking on the up arrow for Constant.

b. Note the location of the MSB curve. Why does it not overlap the MPB curve? What is the vertical difference between the two curves?

c. Note the price and quantity in the box titled "Social optimum."

d. In the box titled "Net unit tax," click "Show." Note the price and quantity in the box titled "Private equilibrium with tax/subsidy."

e. Set the tax by clicking on the up arrow until the quantity becomes equal to the quantity in the box titled "Social optimum." What is the value of the tax at this point? How does it compare to the value of the MEC?

Demand: MPB = 150 – Q

Intercept	150	◉ SHOW
Slope	1	○ HIDE

Consumption externality: MEC = 20

Constant	20	○ SHOW
Slope	0	◉ HIDE

Supply: MPC = 50 + Q

Constant	50	◉ SHOW
Slope	1	○ HIDE

[No externality in production]

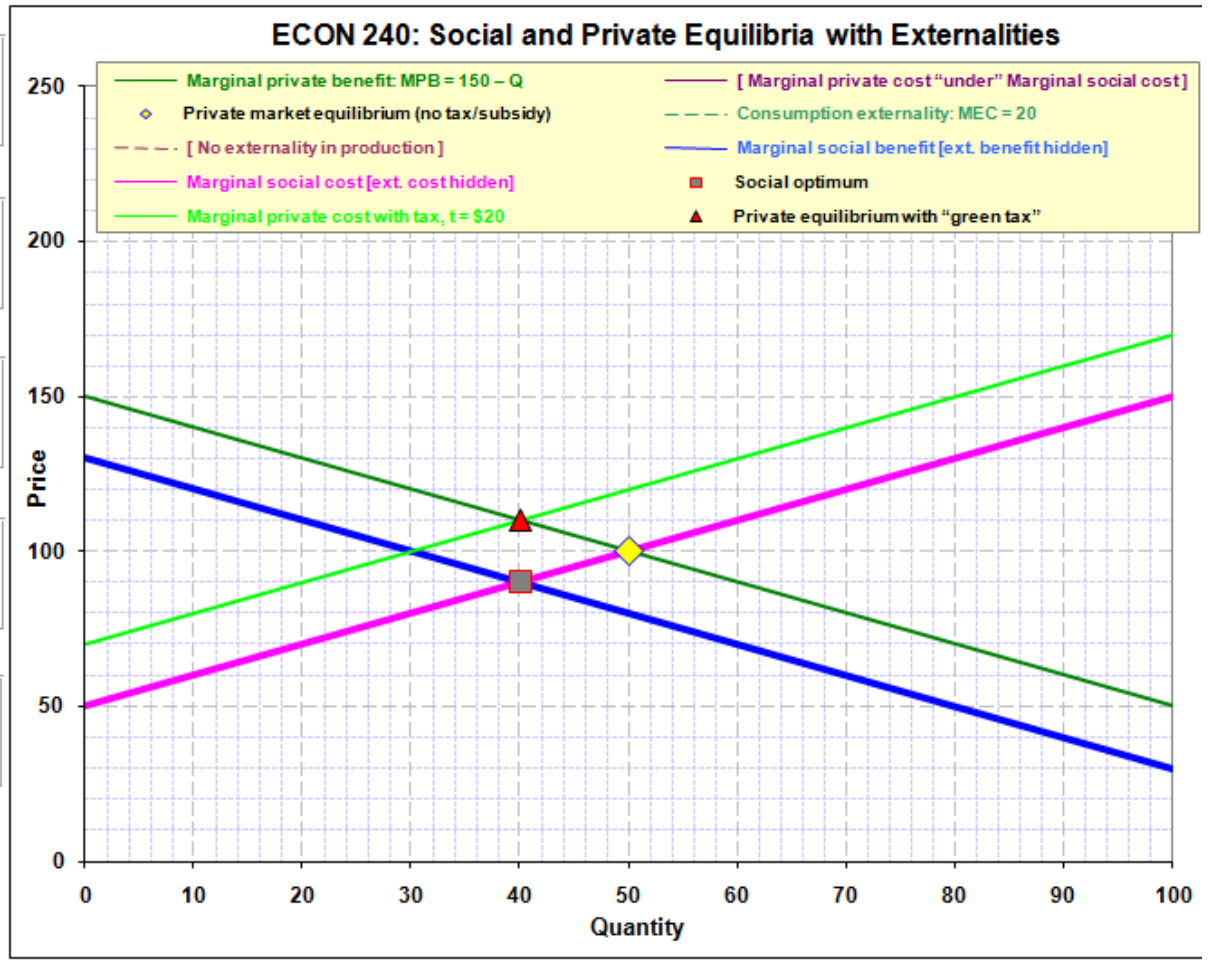
Constant	0	○ SHOW
Slope	0	◉ HIDE

Net unit tax (a "green tax")
t = 20

t =	20	◉ SHOW
		○ HIDE

Marginal social benefit
◉ SHOW ○ HIDE

Marginal social cost
◉ SHOW ○ HIDE



Private market equilibrium (no tax/subsidy)

Q^* =	50
P^* =	100

Social optimum

Q^* =	40
P^* =	90

Private equilibrium with "green tax"

Q^* =	40
P^* =	110

Activity 4

a. In the box titled "No externality in production," click on the down arrow for Constant until MEB is –20.

b. Note the location of the MSC curve. Why does it not overlap the MPC curve? What is the vertical difference between the two curves?

c. Note the price and quantity in the box titled "Social optimum."

d. In the box titled "Net unit tax," click "Show." Note the price and quantity in the box titled "Private equilibrium with tax/subsidy."

e. Set the subsidy by clicking on the down arrow until the quantity becomes equal to the quantity in the box titled "Social optimum." What is the value of the subsidy at this point? How does it compare to the value of the MEB?

Demand: MPB = 150 – Q

Intercept	150	◉ SHOW
Slope	1	○ HIDE

[No externality in consumption]

Constant	0	○ SHOW
Slope	0	◉ HIDE

Supply: MPC = 50 + Q

Constant	50	◉ SHOW
Slope	1	○ HIDE

Production externality: MEB = –20

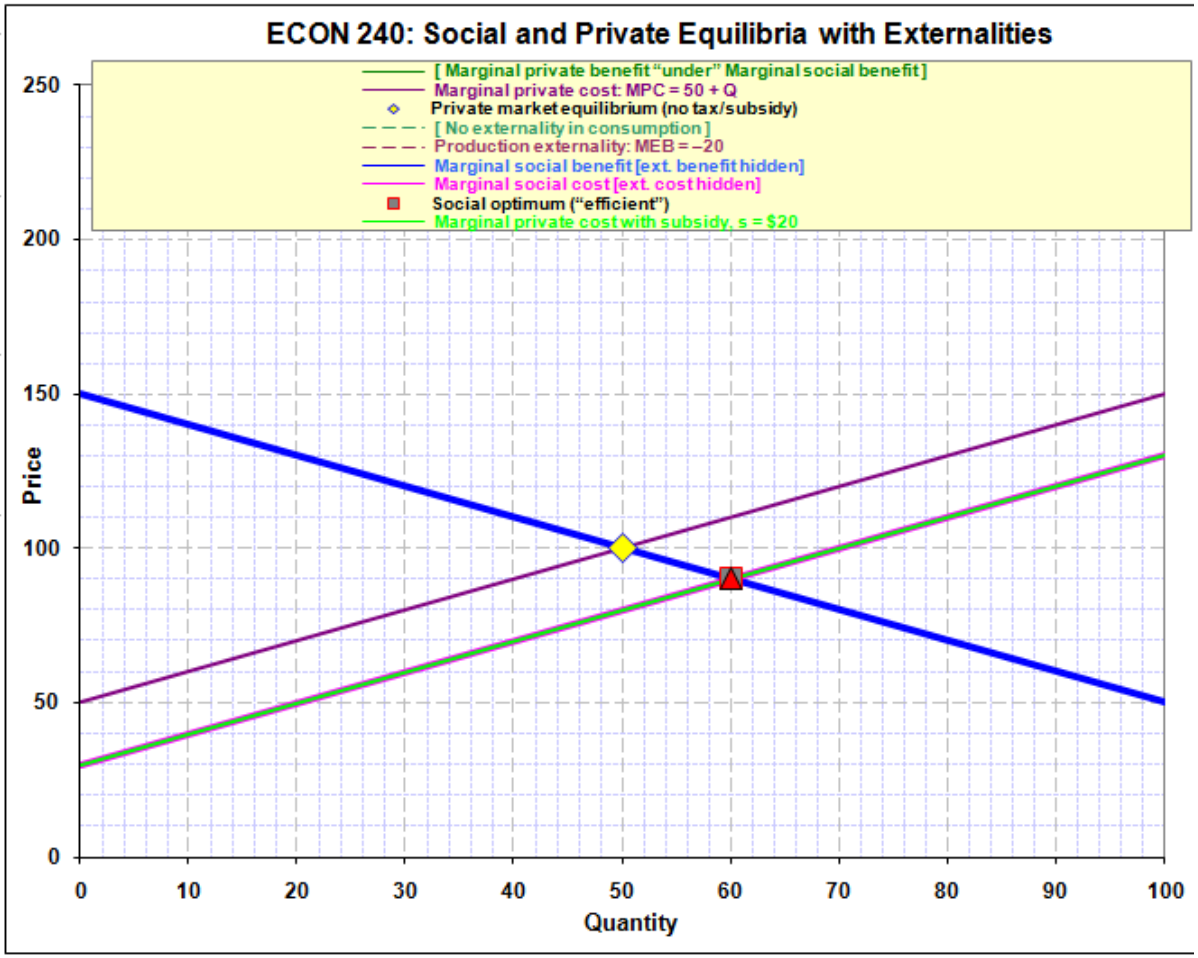
Constant	–20	○ SHOW
Slope	0	◉ HIDE

Net unit subsidy (a "green subsidy")
s = 20 (i.e., t = –20)

t =	–20	◉ SHOW
		○ HIDE

Marginal social benefit
◉ SHOW ○ HIDE

Marginal social cost
◉ SHOW ○ HIDE



Private market equilibrium (no tax/subsidy)

*Q** =	50
*P** =	100

Social optimum ("efficient")

*Q** =	60
*P** =	90

Private equilibrium with "green subsidy"

*Q** =	60
*P** =	90

Activity 5

a. In the box titled "No externality in consumption," click on the down arrow for Constant until MEB is –20.

b. Note the location of the MSB curve. Why does it not overlap the MPB curve? What is the vertical difference between the two curves?

c. Note the price and quantity in the box titled "Social optimum."

d. In the box titled "Net unit tax," click "Show." Note the price and quantity in the box titled "Private equilibrium with tax/subsidy."

e. Set the subsidy by clicking on the up arrow until the quantity becomes equal to the quantity in the box titled "Social optimum." What is the value of the subsidy at this point? How does it compare to the value of the MEB?

Demand: MPB = 150 – Q

Intercept	150	◉ SHOW
Slope	1	○ HIDE

Consumption externality: MEB = –20

Constant	–20	○ SHOW
Slope	0	◉ HIDE

Supply: MPC = 50 + Q

Constant	50	◉ SHOW
Slope	1	○ HIDE

[No externality in production]

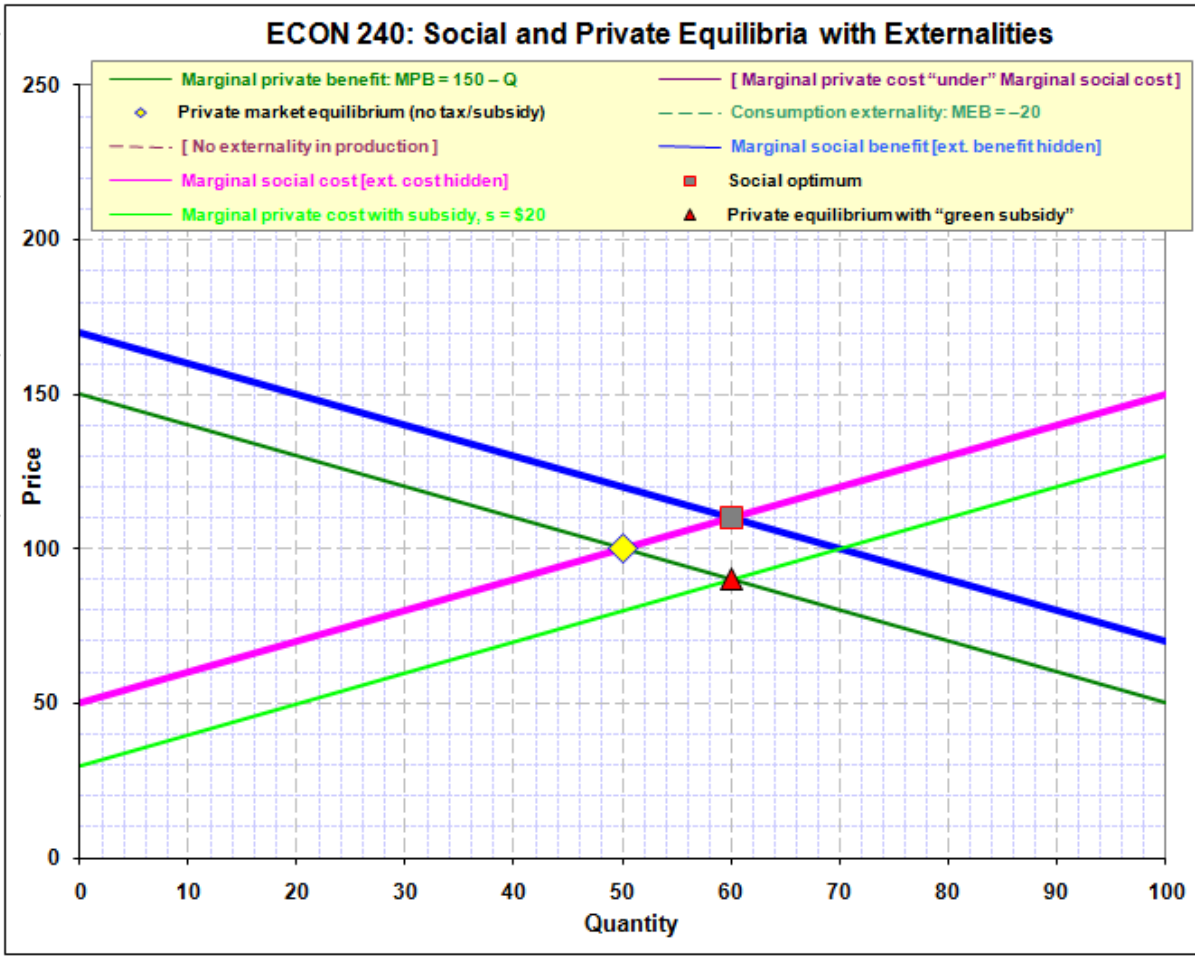
Constant	0	○ SHOW
Slope	0	◉ HIDE

Net unit subsidy (a "green subsidy")
s = 20 (i.e., t = –20)

t =	–20	◉ SHOW / ○ HIDE

Marginal social benefit
◉ SHOW ○ HIDE

Marginal social cost
◉ SHOW ○ HIDE



Private market equilibrium (no tax/subsidy)

Q^* =	50
P^* =	100

Social optimum

Q^* =	60
P^* =	110

Private equilibrium with "green subsidy"

Q^* =	60
P^* =	90

LEARNING OUTCOMES

The assignment was used in an intermediate-level introductory course in environmental economics. 100 percent of the students correctly understood the effect of externalities on marginal social cost and marginal social benefit. 95 percent of the students correctly understood the relationship between the size and nature of externality and the tax/subsidy for achieving the socially optimal quantity. 100 percent of the students indicated that the assignment provided them an opportunity to better understand the concepts.