

Assignment Project Exam Help

Week 1: Overview and Math Review

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Monetary Economics

ECOS3010

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- Textbook: Bruce Champ, Scott Freeman and Joseph Haslag, Modeling Monetary Economics, 5th edition, Cambridge University Press.

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- Assessment

- Assignment 1 (10%): Available Friday August 26, 5 pm. Due Friday September 16, 11:59 pm.
- Assignment 2 (10%): Available Friday October 7, 5 pm. Due Friday October 28, 11:59 pm.
- Midterm exam (30%): Monday, Sep 19, 11 am.
- Final exam (50%): during exam period.

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- Lecture topics

- Money
- Inflation
- Price surpluses and the Phillips curve
- International monetary system
- Money and capital
- Liquidity and financial intermediation
- Bank risks, liquidity risks and bank panics
- Crisis

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Important Mathematical Concepts

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Differentiation and chain rule:

Consider three functions $F(x, y)$, $x(a)$, and $y(a)$.

Q: what's the derivative of F w.r.t to a

A: using chain rule,

$$\frac{\partial F(x, y)}{\partial a} = \frac{\partial F(x, y)}{\partial x} \frac{\partial x(a)}{\partial a} + \frac{\partial F(x, y)}{\partial y} \frac{\partial y(a)}{\partial a}$$

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- Example:

problem: suppose firm's profit function is $\Pi(y) = -y^4 + 6y^2 - 5$ where Π is the firm's profit and y is the amount of output. Assume firm's production function is $y = 5L^{2/3}$, where L is the amount of labour input. Apply the Chain Rule to compute the derivative of Π with respect to L .

- solution:

$$\begin{aligned}\frac{d}{dL}(\Pi(y(L))) &= \Pi'(y) \cdot y'(L) \\ &= [-4(y)^3 + 12y] \cdot \left(\frac{10}{3}L^{-1/3}\right) \\ &= [-4(5L^{2/3})^3 + 12(5L^{2/3})] \cdot \left(\frac{10}{3}L^{-1/3}\right)\end{aligned}$$

Chain rule, log and exponential functions III

which after simplifying equals

$$(-4 \cdot 125L^2 + 60L^{2/3}) \cdot \left(\frac{10}{3}L^{-1/3}\right) = -\frac{5000}{3}L^{5/3} + 200L^{1/3}.$$

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- **Properties of log functions:**

$$\ln(ab) = \ln(a) + \ln(b)$$

$$\ln\left(\frac{a}{b}\right) = \ln(a) - \ln(b)$$

$$\ln(a^b) = b \ln(a)$$

$$\frac{d \ln(x)}{dx} = \frac{1}{x}$$

$$\ln(1+x) \approx x, \text{ if } x \text{ is small}$$

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- **Exponential function:**

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$$e^{\ln(a)} = a$$

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- consider a function $y = f(x)$. Necessary (first-order) condition for optimization of this function:

$$\frac{dy}{dx} = \frac{df(x)}{dx} = 0$$

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- it's a maximum if $\frac{d^2f(x)}{dx^2} \leq 0$ (a **concave** function), a minimum if $\frac{d^2f(x)}{dx^2} \geq 0$ (a **convex** function).
- example 1 (concave):

$$\begin{aligned} y &= f(x) \\ &= x^\alpha - x + 1, \text{ where } 0 < \alpha < 1 \end{aligned}$$

figure:

- example 2 (convex):

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$$y = f(x) = x^\beta - x + 1, \text{ where } \beta > 1$$

figure: ...
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- the value of x that maximizes y is called

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$x^* = \arg \max_x f(x)$
 $y^* = f(x^*)$ is the maximum value of the function.

- **Example 1:**

• *problem*

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$$\text{Max}_{x,y} f(x,y) = xy$$

$$\text{s.t.} \quad 3x + 4y = 16$$

• *solution:*

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- Example 1:

- consider the following utility maximization problem of a consumer/household

$$\max_{x,y} U = U(x,y)$$

$$s.t. \quad p_x x + p_y y \leq M$$

- solution:

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Constrained optimization (Lagrangian method) I

- It is not always possible to express x as a function of y explicitly. In that case, we can apply the Lagrangian method.

- Example 1:

- *problem:*

$$\begin{aligned} \max_{x,y} \quad & f(x,y) = xy \\ \text{s.t.} \quad & 3x + 4y = 16 \end{aligned}$$

- *solution:*

- first, form a Lagrangian with Lagrange multiplier λ

$$L = xy + \lambda [16 - 3x - 4y]$$

Constrained optimization (Lagrangian method) II

- next, take the derivatives w.r.t. x , y , and λ yielding

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$$0 = y - 3\lambda$$

$$0 = x - 4\lambda$$

$$0 = 16 - 3x - 4y$$

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- last, solve for three values using the system of equations above, yielding

$$x = \frac{8}{3}$$

$$y = \frac{8}{3}$$

$$\lambda = \frac{2}{3}$$

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• Example 2:

- consider the following utility maximization problem of a consumer/household

$$\begin{aligned} \max_{x,y} U &= U(x,y) \\ \text{s.t. } p_x x + p_y y &\leq M \end{aligned}$$

- we can solve this problem using the Lagrangian method
- solving the problem:
 - form the Lagrangian function (**note the way the constraint is written!**)

$$L = U(x, y) + \lambda[M - p_x x - p_y y]$$

Constrained optimization (Lagrangian method) IV

- first-order conditions (FOC)

$$\frac{\partial L}{\partial x} = U_x(x, y) - \lambda p_x = 0$$

$$\frac{\partial L}{\partial y} = U_y(x, y) - \lambda p_y = 0$$

$$\frac{\partial L}{\partial \lambda} = M - p_x x - p_y y = 0$$

- **the solution:** combining the first two FOCs to eliminate λ , we have (the maximum utility, subject to the budget constraint, must satisfy these conditions)

$$\frac{U_x}{U_y} = \frac{p_x}{p_y}$$

and

$$p_x x + p_y y = M$$

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$$\begin{aligned} \max \quad & f(x, y, z) = (1+x)yz \\ \text{s.t.} \quad & x + y + z \leq 1 \end{aligned}$$

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