FIRMS IN THE TWO-PERIOD FRAMEWORK

MARCH 23, 2009

THE PLAN

- **First half of course: basic theory**
  - **Consumption-leisure framework**
  - **Consumption-savings framework**
  - **Infinite-period framework**
- **Second half of course**
  - **Round out details of the basic theory**
    - **Firms (Chapter 6)**
    - **Shocks (Chapter 9)**
    - **Putting together consumption-leisure with consumption-savings (Chapter 5)**

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    - How/why did macro theory and practice evolve the way it has?
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    - The Keynesian macroeconometric paradigm (1940's – 1970's)
    - The Real Business Cycle (RBC) revolution (1980's)
    - The divide in macro theory today: the effects of/role for monetary policy?

Chapter 11-13 and supplementary readings

Where Things Are Going

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  - Monetary economics
    - Monetary policy: the neutrality/non-neutrality debate (Chapter 14)
    - Interactions between monetary policy and fiscal policy (Chapter 15)
  - Link between financial markets and the macroeconomy ("accelerator")

Chapter 11-13 and supplementary readings

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BASICS

- **Embed firms in two-period (multi-period) economy**
- **In each period *t*, representative firm produces according to a production technology $A_t f(k_t, n_t)$**
  - n_t**: labor used for production**
  - k_t**: capital ("machines and equipment") used for production**
  - A_t**: total factor productivity**
    - **A catch-all measure for level of sophistication of technology**
    - **Real Business Cycle (RBC) view: the driving force behind the periodic ups and downs of macroeconomic activity (Chapter 13)**

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Introduction

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Can also think of education and other intangibles (i.e., experience, brand name) as "capital"

The function $f(k, n)$ describes how capital and labor combine with each other to yield output (goods)

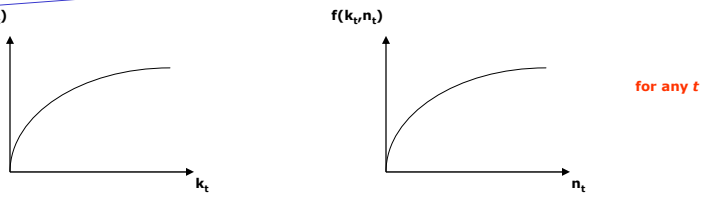
PRODUCTION FUNCTION

- **Production function $f(k_t, n_t)$ with all the "usual properties" of production functions**
  - **Strictly increasing in k_t and n_t**
  - **Diminishing marginal product in k_t and n_t**

Recall from intro micro

The extra output that results from using one additional unit of input

total output (i.e., GDP)



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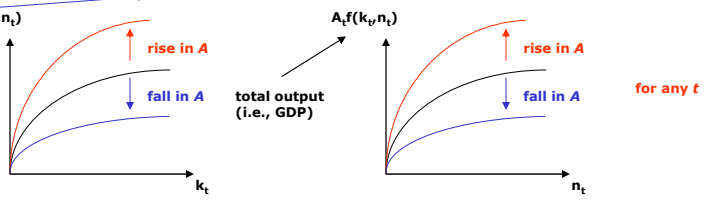

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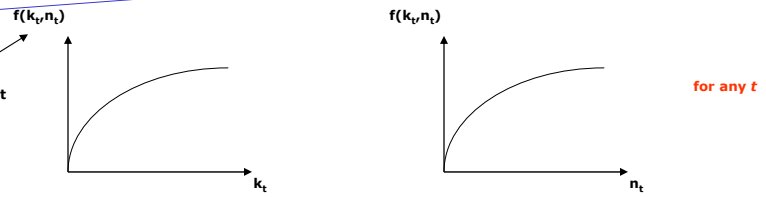

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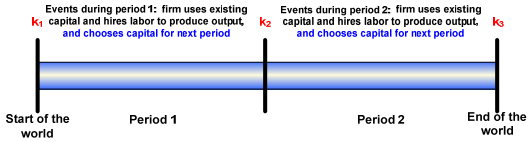
    - Except *k* cannot be negative (negative machines?...)
  - One of the components of GDP (= $C + I + G + NX$)
    - Investment comprises ≈ 15% of GDP in U.S.
    - Investment comprises ≈ 40% of GDP in China (high *I* drives rapid growth)

BASICS

- Timeline of events



- Notation
  - k_1: capital used for production in period 1 (decided upon in "period 0")
  - n_1: labor used for production in period 1
  - w_1: real wage rate for labor in period 1 ($w_1 = W_1/P_1$)
  - i: nominal interest rate
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BASICS

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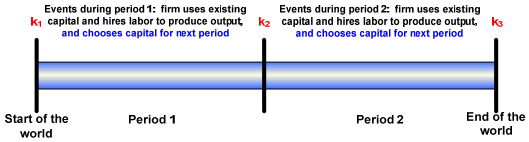

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    AND nominal price of one unit capital bought by the firm in period 1 for use in period 2 (recall time to build…)

    Underlying assumption/view of world: *capital goods* are not necessarily "distinct" from *consumption goods* (i.e., computers purchased by both firms and individual consumers)

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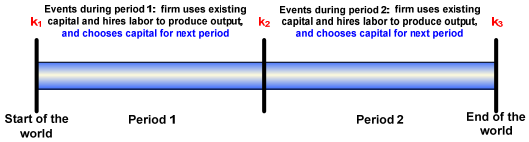

- **Notation**
  - k_2: capital used for production in period 2 (decided upon in period 1)
  - n_2: labor used for production in period 2
  - w_2: real wage rate for labor in period 2 ($w_2 = W_2/P_2$)
  - i: nominal interest rate
  - P_2: nominal price of output produced and sold by firm in period 2

    AND nominal price of one unit capital bought by the firm in period 2 for use in period 3 (recall time to build…)

    Underlying assumption/view of world: *capital goods* are not necessarily "distinct" from *consumption goods* (i.e., computers purchased by both firms and individual consumers)

FIRM PROFIT MAXIMIZATION

- A ***dynamic*** profit maximization problem
  - Because firm exists for both periods
  - All analysis conducted from the perspective of the very beginning of period 1
  - → Must consider present-discounted-value (PDV) of lifetime (i.e., two-period) profits

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- Dynamic profit function
  - (specified in nominal terms – could specify in real terms…)

Period-1 profits

$$P_1 f(k_1, n_1) + P_1 k_1 - P_1 w_1 n_1 - P_1 k_2$$

Total revenue in period 1 (price x output) | Value of pre-existing capital (an asset for firms) | Total labor cost in period 1 | Total cost of buying capital for period 2 (time to build → must purchase period-2 capital in period 1)

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Period-1 profits; (PDV of) period-2 profits

$$P_1 f(k_1,n_1) + P_1 k_1 - P_1 w_1 n_1 - P_1 k_2 + \frac{P_2 f(k_2,n_2)}{1+i} + \frac{P_2 k_2}{1+i} - \frac{P_2 w_2 n_2}{1+i} - \frac{P_2 k_3}{1+i}$$

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- Two-period model: k_3 = 0 (no machines needed in "period 3")

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with respect to n_1: $P_1 f_n(k_1, n_1) - P_1 w_1 = 0$ — Equation 1

with respect to n_2: $\frac{P_2 f_n(k_2, n_2)}{1+i} - \frac{P_2 w_2}{1+i} = 0$ — Equation 2

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These FOCs are foundation for:
1. Labor Demand
2. Capital/Investment Demand

COBB-DOUGLAS PRODUCTION FUNCTION

- **A commonly-used functional form in modern quantitative macroeconomic models**

$$f(k_t, n_t) = k_t^{\alpha} n_t^{1-\alpha}$$

(saw Cobb-Douglas utility function on Problem Set 1)

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Macro Fundamentals

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- **Cobb-Douglas form useful for illustrating factor demands**
  - $mpn_t = f_n(k_t, n_t) = (1-\alpha)k_t^{\alpha} n_t^{-\alpha}$
  - $mpk_t = f_k(k_t, n_t) = \alpha k_t^{\alpha-1} n_t^{1-\alpha}$

MICRO-LEVEL LABOR DEMAND

- **Firm-level demand for labor defined by the relation**

Follows from Equation 1 and Equation 2 $w_t = (1-\alpha)k_t^{\alpha} n_t^{-\alpha} (= mpn_t)$ for both $t = 1$ and $t = 2$

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Because exponent (-*a*) is a negative number, can move to denominator

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A NEGATIVE RELATIONSHIP BETWEEN w_t and n_t

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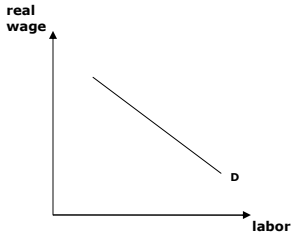

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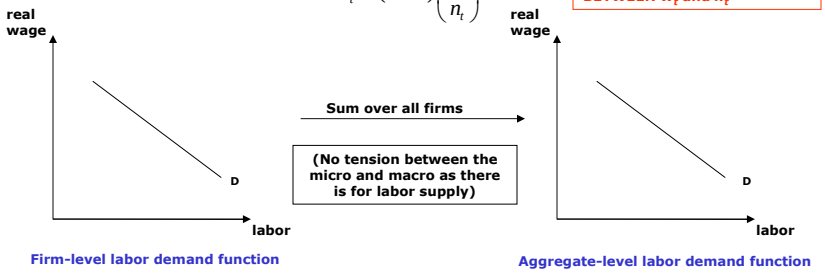

Firm-level labor demand function

Aggregate-level labor demand function

- **Completes picture of the aggregate labor market**

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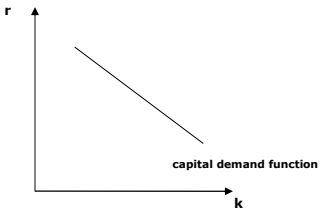

CAPITAL DEMAND

- **Firm-level demand for capital defined by the relation**

Follows from Equation 3 (will see it soon…)

$$r_t = \alpha k_t^{\alpha-1} n_t^{1-\alpha} (= mpk_t)$$

Because exponent ($\alpha - 1$) is a negative number, can move to denominator

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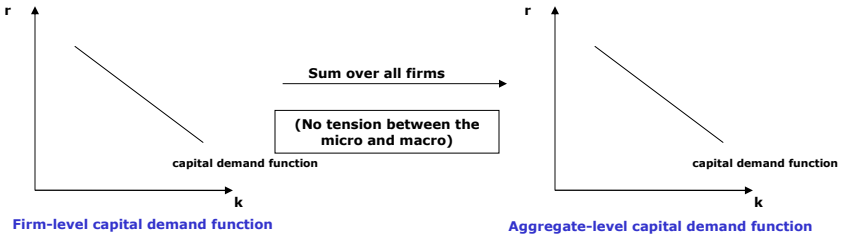


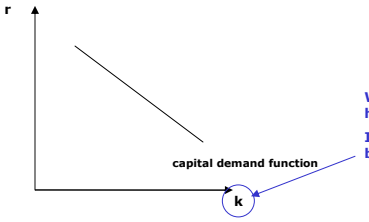
Firm-level capital demand function

Aggregate-level capital demand function

- **(Almost…) completes picture of the aggregate capital market**

FROM CAPITAL DEMAND TO INVESTMENT DEMAND

- **Capital is a stock variable**



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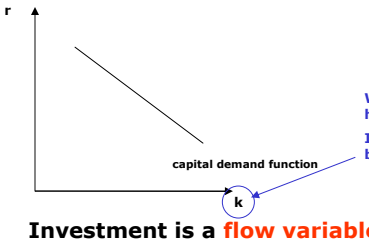

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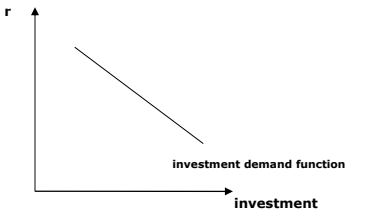


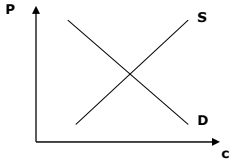
$inv_1 = k_2 - k_1$

At start of period 1, k_1 cannot be changed. Thus any rise in demand for k_2 is reflected one-for-one in a rise in inv_1.

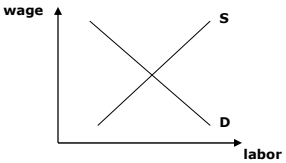
→ Capital demand and investment demand functions have same shape

THE THREE MACRO (AGGREGATE) MARKETS

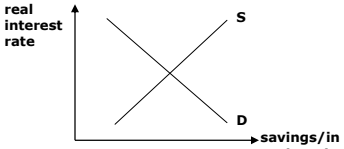
- **Goods Markets**
  - Demand derived from C-L framework (Supply follows from factor demand functions)



- **Labor Markets**
  - Supply derived from C-L framework
  - Demand derived from firm theory in C-S framework



- **Capital/Savings/Funds/Asset Markets (aka Financial Markets)**
  - Supply derived from C-S framework Demand derived from firm theory in C-S framework



REAL INTEREST RATE

- *r* a key variable for macroeconomic analysis
- Chapter 4: *r* measures the price of period-1 consumption in terms of period-2 consumption
- Chapter 8: *r* reflects degree of impatience
- Midterm Exam (Question 1b): *r* reflects rate of consumption growth between periods

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$$f_k(k_2, n_2) = r$$

When firms make optimal investment decisions → *r = mpk*