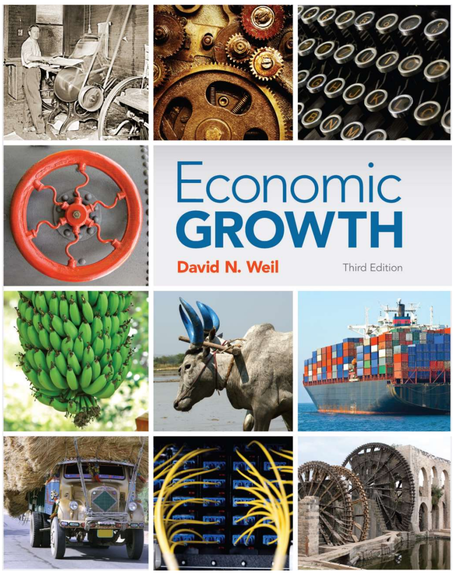
Chapter 3

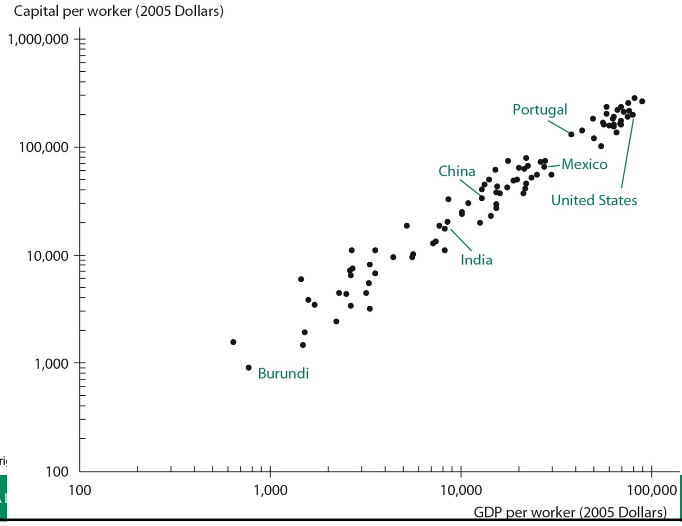
PHYSICAL CAPITAL



Nature of capital

- Capital is productive
- But it is has been produced itself…through investments. In other words capital is accumulated. Distinction between flows and stocks
- Capital depreciates
- Capital stock is made of machinery, tools, buildings, roads….
- It can private or public (mainly infrastructures)

An interesting stylised fact: GDP and Capital per Worker, 2009



Source: Calculations based on Heston et al. (2010).

PEARSON

Early models of economic growth

Harrod-Domar model

Solow model

ALWAYS LEARNING PEARSON

Harrod-Domar Model

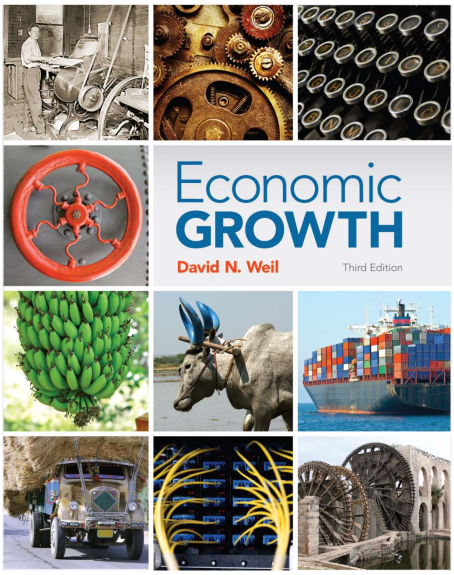
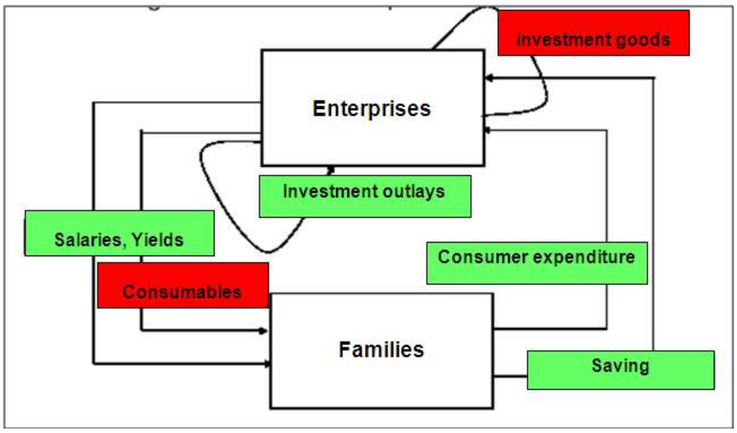


Diagram of product and income flows



H-D Model

Product/National Income Formula

Y(t) = C(t) + S(t) (1)
Y(t) = C(t) + I(t) (2)

Combining formula (1) and (2) we obtain

S(t) = I(t) (3)

i.e. savings = investments

LS2

H-D Model

Investments increase capital stock and replace the part consumed every year

K(t+1) = K(t) + I(t) – D(t), (4)

Where K(t + 1) is the capital stock of period t + 1, I(t) is the investment of period t, and D (t) is the part of capital consumed (amortized)

If we suppose that D(t) = δK(t), where d is a constant between zero and one, we obtain the capital accumulation equation

K(t+1) = (1- δ) K(t) + I(t) (5)

Diapositiva 7

LS2 Saving se riferito a una riduzione dei consumi;
SAVINGS invece se è proprio un risparmio del reddito
Laura Stara; 25/10/2017

We define s(t) as the average propensity to save, i.e. the quota of income which is saved.

s(t) = S(t)/Y(t) (6)

We assume that s(t) is constant over time, i.e. s(t) = s, where s is a constant between zero and one.

From (6) we get

S(t) =sY(t) (7)

Therefore we can rewrite the equilibrium state (3) in this way

sY(t) = I(t) (8)

We define ϕ(t) the capital-product ratio.

ϕ(t) = K(t)/Y(t) (9)

The value of ϕ(t) obviously depends on the type of production technology, indeed, it's the reverse of capital productivity.

We assume that ϕ(t) = ϕ, constant.

This equation (9) implies the following production function of Y(t):

Y(t) = K(t)/ ϕ (10)

….I.e.

$K(t) = \phi\, Y(t)$ (11)

Given the equation (11) it's also true that

$K(t+1) = \phi\, Y(t+1)$ (12)

Given the equations (5), (11) and (12) the capital accumulation equation (5)

$K(t+1) = (1-\delta)\, K(t) + I(t)$ implies

$\phi\, Y(t+1) = (1-\delta)\, \phi\, Y(t) + I(t)$ (13)

Replacing the equilibrium condition on the capital market, $S(t) = I(t)$, and given the aggregate saving equation (6) we obtain:

$\phi\, Y(t+1) = (1-\delta)\, \phi\, Y(t) + sY(t)$ (14)

This equation explains the evolution of the level of production, and therefore the level of income over time

Dividing for ϕ we obtain

$$Y(t+1) = (1-\delta)\,Y(t) + (s/\phi)\,Y(t) \qquad (15)$$

Now, we define g the growth rate of the economy, where

$$g = [Y(t+1) - Y(t)]/Y(t) \qquad = Y(t+1)/Y(t) - 1 \qquad (16)$$

According to the definition, the rate of economic growth in the H-D model is given by the following expression

$$g = s/\phi - \delta \qquad (17)$$

Summary

- The main indication of the HD model is that the long-term growth rate g depends on two fundamental variables:
  - the propensity to save s,
  - the capital productivity (measured by the product per unit of capital which, according to the equation (10), it's defined as $1/\phi$)
- The main interpretation of this result was that to emphasize the role of the savings that directly influence the process of capital accumulation.
- Centralized economies, such as India and, above all, the Soviet Union, followed these indications
- And also developed countries, to decide intervention policies for the development of lagging countries.

Some doubts

Can we really believe that s and ϕ are exogenous parameters?
What happens in the H-D model if we introduce technological progress?
And labour?

We have analyzed the national income (the total product) but we are concerned by the per capita income... we must first introduce demographic dynamics.

Demographic dynamics in the H-D model

We consider the equation that, in the H-D model, defines the evolution of national income :

$$Y(t+1) = (1-\delta)\,Y(t) + Y(t)\,s/\phi$$

We define N(t) the number of people at time t, and n the annual population growth rate, therefore

$$N(t+1) = N(t)(1+n) \qquad (18)$$

Dividing by N(t) both the aggregate income terms we obtain

$Y(t+1)/N(t) = (1-\delta)\ Y(t)/N(t) + Y(t)/N(t)\ [s/\phi]$ (19)

Defining $y(t) = Y(t)/N(t)$ the per capita income at time t, and considering that $N(t) = N(t+1)/(1+n)$ we can rewrite the (19) as:

$(1+n)\ y(t+1) = (1-\delta)\ y(t) + y(t)\ [s/\phi]$ (20)

We divide $(1+n)\ y(t+1) = (1-\delta)\ y(t) + y(t)\ [s/\phi]$ by y(t)

$(1+n)\ y(t+1)/y(t) = (1-\delta) + [s/\phi]$

Note that $y(t+1)/y(t) = 1+g^*$, where

$g^* = g(y) = [y(t+1)-y(t)]\ /y(t) = y(t+1)/y(t) - 1$,
I.e., the growth rate of per capita income

Hence

$(1+n)(1+g^*) = (1-\delta) + [s/\phi]$

Therefore:

$1 + n + ng^* + g^* = (1- \delta) + [s/\phi]$

Since ng * is very small (p.e. 0.02 * 0.01), we can neglect it, and we obtain:

$g^* = s/\phi - \delta - n$ (21)

As the population growth rate increases, the rate of growth per capita income decreases;
note that $g^* = g-n$

Conclusions

- The model is useful for very simplified economies, perhaps in the early stages of development: emphasis on primary accumulation.
- There is no labor as a production factor (its supply is perfectly elastic), the population eats and *apparently* doesn't produce
- The production function is very simplified (constant marginal and average returns)
- Technology and knowledge are lacking (it's hidden in productivity, but it's constant)
- The model is neutral: type if-then

Conclusions

- Another problem with the theoretical HD model is that depending on how the expectations are introduced in the model (important for investments) , the model has a single path of balance ... if you are not on the path you are in a state of imbalance: the model is too rigid: all parameters are given (exogenous)
- Certainly, the most important model parameter is the saving ratio. Can it be considered a parameter easily manipulated by the government? Usually, it depends. Certainly, in the past, this was the basis for defining the development policies in general

Endogenous saving ratio

- The saving ratio has, according to some academics, a U-reversed form with respect to per capita income.
- If we take this into account, the model becomes nonneutral and therefore able to say why some countries have systematic differences in their growth rates.
- To grow, rich countries need to transfer capital to fuel the poorer countries

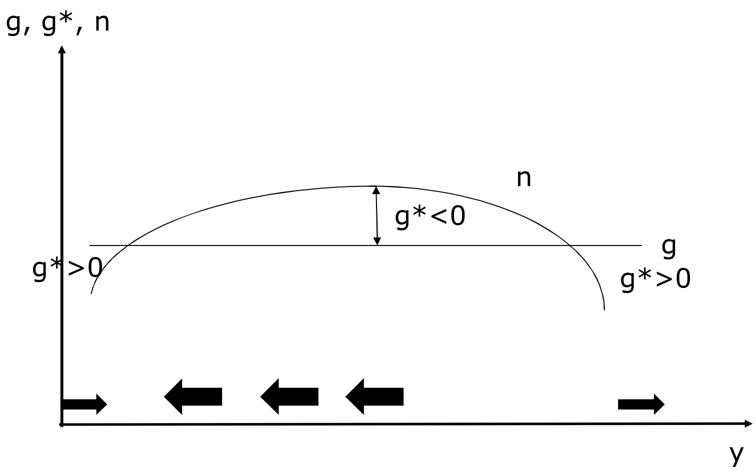
Growth of the endogenous population

Even n can be endogenous:

- n low for y low
- n grows as y grows ... constant birthrate along with decreasing mortality
- then also birthdate decreases with the increase of per capita income

Let us see how the model works on a chart (remember that g*=g-n)

Demographic transition model



Demographic transition model: outcomes

- The H-D model is no longer neutral
- Even a temporary intervention can lead the economy out of the trap (beyond y1). How?
- Investment support policies (g (t) goes up) or demographic policies (n (t) goes down).