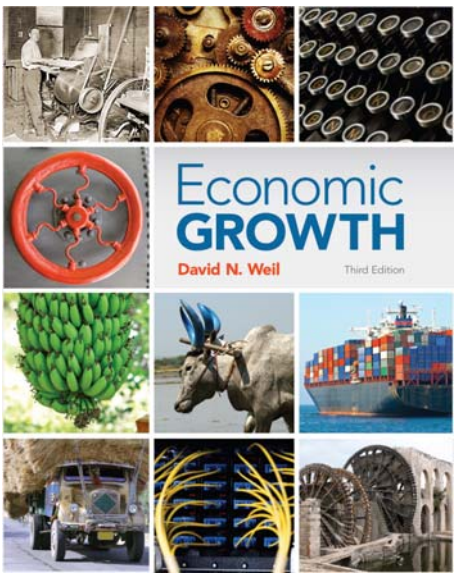
Chapter 3

PHYSICAL CAPITAL



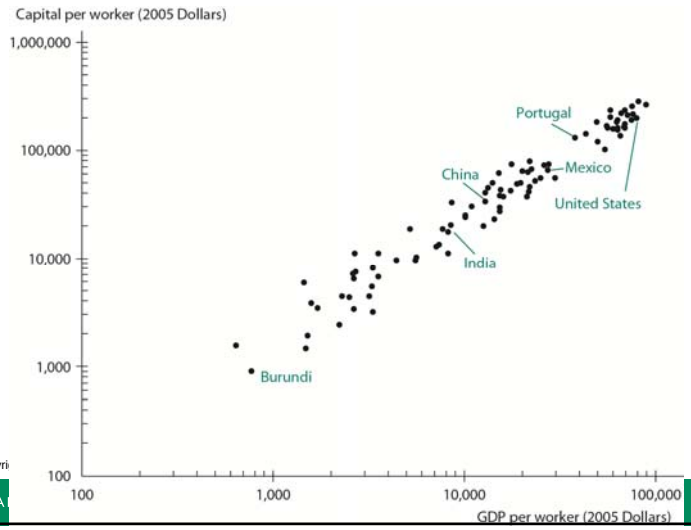
Presentations

- Groups, 3/4 people
- Mixed group
  - 5 groups of 4 students + 1 group of 5 students
- Theme: European issue/policy (your/our choice)
- 45/60 minutes
- Group and Individual assessment
- December/January?

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).

Early and current models of economic growth

Harrod-Domar model

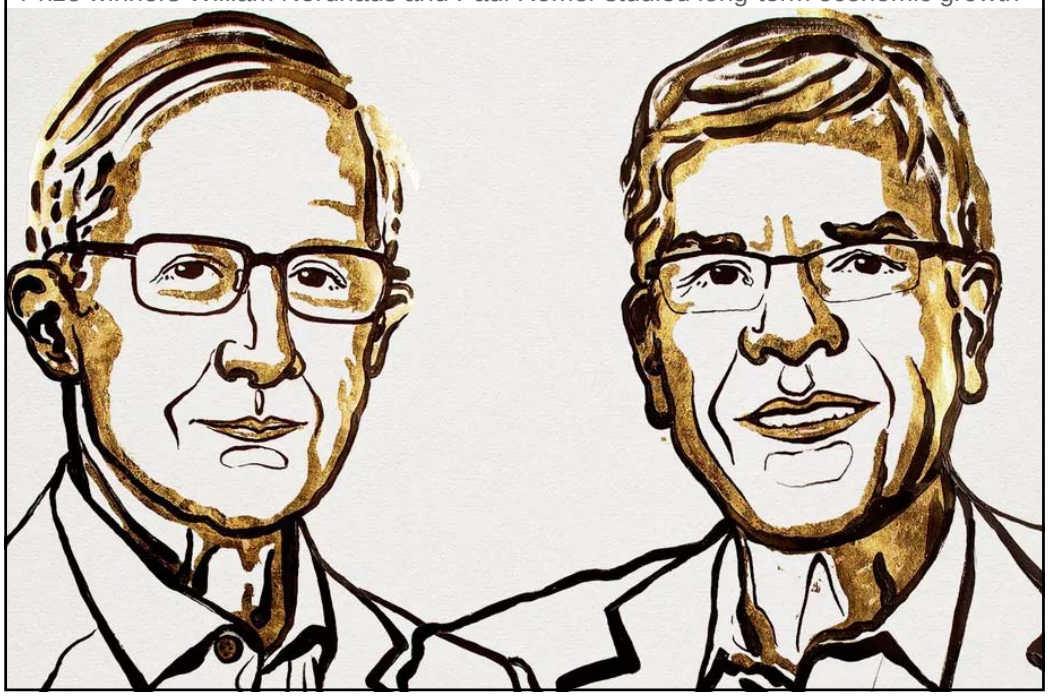
Solow model

} Exogenous growth theory

...

....Romer models.... Endogenous growth theory

Prize winners William Nordhaus and Paul Romer studied long-term economic growth



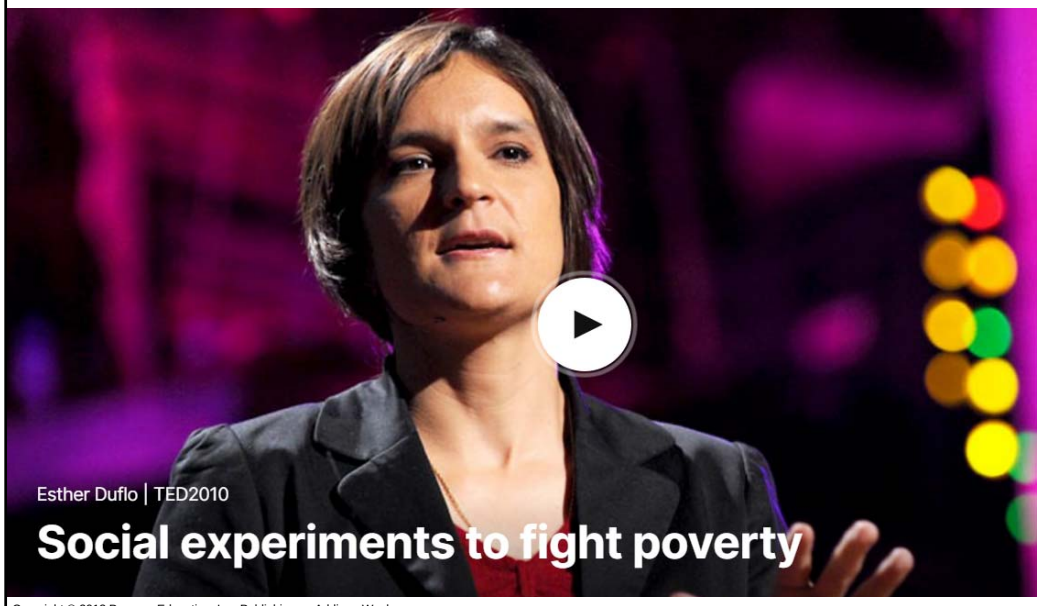
Nobel prize in Economics 2018

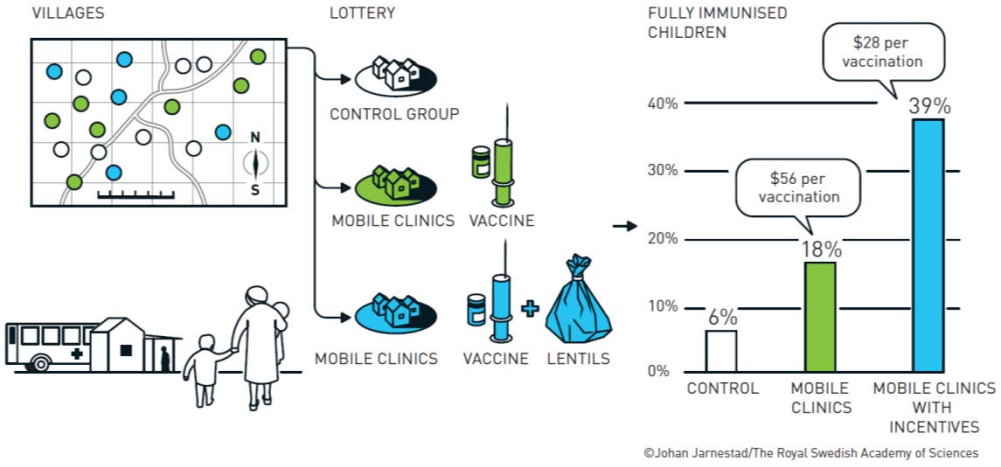
William Nordhaus and Paul Romer won the Nobel Prize in Economics for their work suggesting robust, long-term economic growth can go hand in hand with a healthier, happier planet — if the rules of business and government are set up the right way.

Endogenous growth theory

- Romer is one of the pioneers of the "endogenous growth theory," or the idea that economic growth is best driven by some of the most organic forces in a market: its people.
- "At the most basic level, an economy grows... whenever people take resources and rearrange them in a way that makes them more valuable,"
- It's a wrinkle of the productivity equation that many economists in the past (and even some present-day scholars) neglect to take into consideration, perhaps because it's much easier to count up things like physical capital and labor than the invaluable contributions of human minds to global progress.

- Despite recent dramatic improvements, one of humanity's most urgent issues is the reduction of global poverty, in all its forms. More than 700 million people still subsist on extremely low incomes. Every year, around five million children under the age of five still die of diseases that could often have been prevented or cured with inexpensive treatments.
- This year's Laureates have introduced a new approach to obtaining reliable answers about the best ways to fight global poverty.
- In brief, it involves dividing this issue into smaller, more manageable, questions – for example, the most effective interventions for improving educational outcomes or child health.
- They have shown that these smaller, more precise, questions are often best answered via carefully designed experiments among the people who are most affected.





Harrod-Domar Model

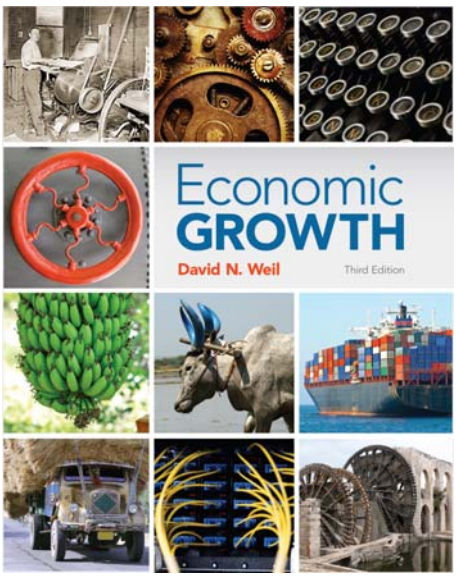
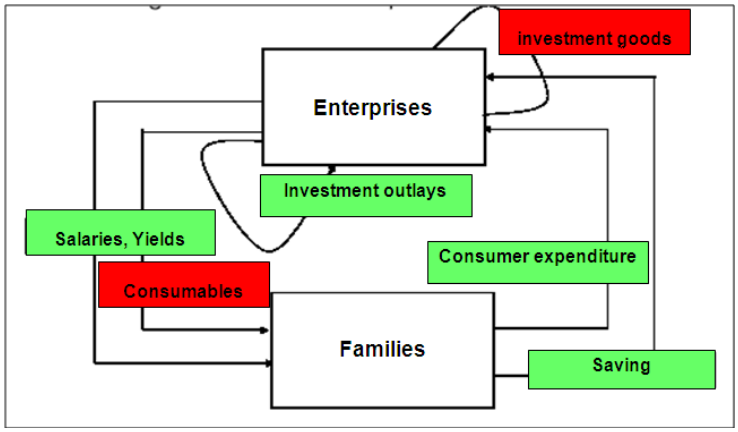


Diagram of product and income flows



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, worn out every year/period

$K(t+1) = K(t) + I(t) – D(t),$ (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 $D(t) = \delta K(t)$, where δ is a constant between zero and one, we obtain the capital accumulation equation

$K(t+1) = (1- \delta) K(t) + I(t)$ (5)

Diapositiva 15

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 parameter 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 $\phi(t)$ the capital-product ratio.

$\phi(t) = K(t)/Y(t)$ (9)

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

We assume that $\phi(t) = \phi$, constant.

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

$Y(t) = K(t)/\phi = 1/\phi * K(t)$ (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/ ϕ)
- The main interpretation of this result was 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) equation 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 "just eats" and *apparently* doesn't produce
- The production function is very simplified (constant marginal and average returns to capital)
- 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 balance path ... 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 non neutral and therefore able to say why some countries have systematic differences in their growth rates.

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- To grow, rich countries need to transfer capital to fuel the poorer countries

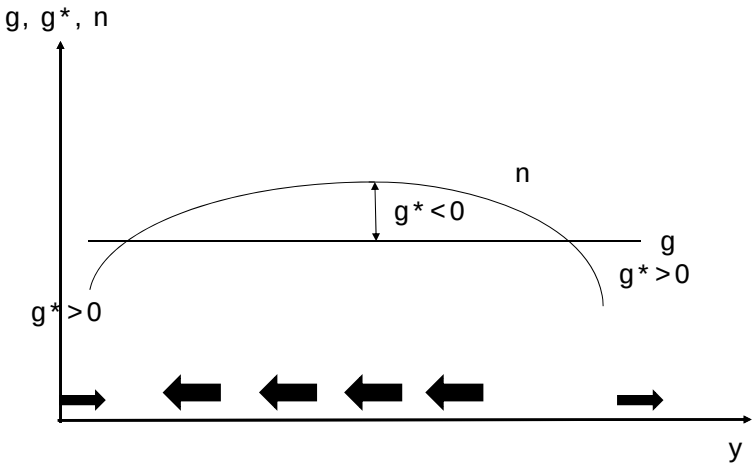
Growth of the endogenous population

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?
- Thanks to investment support policies (g goes up)
- or demographic policies (n goes down).