

**Macroeconomia 2 / Macroeconomics 2**

**Exercise book**

**Term 2**

**2020/2021**

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## 1. Growth rates and real convergence

**1.1 (Excel-based) Download the file “Aula Prática 1” from Aquila and perform the following exercises:**

1.1.1 Perform the necessary calculations and fill in the columns:

* + - 1. Population (1991-2017)
      2. GDP per capita (1960-1990)
      3. GDP growth rate
      4. Population growth rate
      5. GDP per capita growth rate

1.1.2 Compute the average annual growth rates (discrete and continuous) of GDP and GDP per capita for the following five periods: 1960-73; 1973-86; 1986-2000; 2000-2007; 2007-2017

1.1.3 Compare the annual average growth rates in these five periods and comment on the differences. What possible reasons do you see for this variation?

1.1.4. Plot the evolution over time of GDP per capita and of the GDP per capita growth rate in a graph and comment on the fluctuations of the data.

1.1.5 At the average annual growth rates for 1960-2017, how many years from 2017 will it take for GDP per capita to reach 25,000 Euros? What about if the growth rate is the same as the average for 2007-2017?

1.1.6 At the average annual growth rates for 1960-2017, how many years from 2017 will it take for GDP per capita to double? What about if the growth rate is the same as the average for 2007-2017?

**1.2 (Excel-based) Consider the following data and answer the questions:**

**Table 1. GDP (billion US$) for the World, Euro Area and eight countries (2010 constant prices)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1987** | **1997** | **2007** | **2017** |
| USA | 8 232 | 11 170 | 15 055 | 17 305 |
| Japan | 4 005 | 5 277 | 5 848 | 6 156 |
| Germany | 2 265 | 2 917 | 3 441 | 3 866 |
| Brazil | 1 193 | 1 466 | 1 957 | 2 279 |
| Russia | 1 458 | 859 | 1 504 | 1 680 |
| India | 381 | 669 | 1 333 | 2 631 |
| China | 689 | 1 776 | 4 597 | 10 161 |
| South Africa | 210 | 249 | 359 | 427 |
| Euro Area | 7 982 | 10 186 | 12 912 | 13 689 |
| **World** | **34 019** | **45 297** | **63 204** | **80 095** |

Source: World Bank national accounts data and OECD National Accounts data file (<https://data.worldbank.org/indicator/NY.GDP.MKTP.KD>)

1. Look at the data in table above, plot the data in a graph, and try to identify significant changes and trends (for example, change in the ranking of countries by GDP size, the pace of growth in the various economies, the share of world GDP of the top 4 economies in each year, periods of slower or faster growth, etc.).
2. Compute the average annual growth rate (discrete and continuous) for each country and for the Euro Area and the World, for the periods 1987-1997, 1997-2007, 2007-2017, as well as for the whole period, 1987-2017. Compare your results with your preliminary observations made in (a).
3. If each economy continues to grow at the annual average rates of the last 10 years (2007-2017), how long will it take for each of them to double in size?
4. Compare the growth performance of the Euro Area with that of the other economies/groups in Table 1 and comment.

**1.3 (Excel-based) Consider the following data and answer the questions:**

**Table 2. Population in eight countries and in the Euro Area and the World (in millions of people)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1987** | **1997** | **2007** | **2017** |
| USA | 242 | 273 | 301 | 326 |
| Japan | 123 | 126 | 128 | 127 |
| Germany | 78 | 82 | 82 | 83 |
| Brazil | 141 | 168 | 191 | 209 |
| Russia | 146 | 148 | 143 | 145 |
| India | 834 | 997 | 1 180 | 1 339 |
| China | 1 084 | 1 230 | 1 318 | 1 386 |
| South Africa | 35 | 44 | 50 | 57 |
| Euro Area | 308 | 319 | 333 | 341 |
| **World** | **5 020** | **5 879** | **6 683** | **7 530** |

Source: <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=BR-DE-JP-XC>

1. Plot the data in a graph and look for interesting trends
2. Compute the average annual growth rate (discrete and continuous) for each country/group and for the World, for the periods 1987-1997, 1997-2007, 2007-2017, as well as for the whole period, 1987-2017.
3. At the annual average rate of growth of the last 10 years (2007-2017) how long will it take for the population to double in each country and on the Euro Area and the World? Comment on your findings.

**1.4 (Excel-based) Consider the following table, which you have to fill with your calculations, and answer the questions:**

**Table 3. GDP per capita (in US$) for the World, Euro Area and for eight countries (2010 constant prices)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1987** | **1997** | **2007** | **2017** |
| USA |  |  |  |  |
| Japan |  |  |  |  |
| Germany |  |  |  |  |
| Brazil |  |  |  |  |
| Russia |  |  |  |  |
| India |  |  |  |  |
| China |  |  |  |  |
| South Africa |  |  |  |  |
| Euro Area |  |  |  |  |
| **World** |  |  |  |  |

1. Estimate GDP per capita using the data from tables 1 and 2, above.
2. Plot the data in a graph and look for interesting trends and events in the data.
3. Compute the average annual growth rate (discrete and continuous) for each country/group and for the World, for the periods 1987-1997, 1997-2007, 2007-2017, as well as for the whole period, 1987-2017.
4. In each period, which economies converged to the USA and which ones diverged?
5. At the average annual growth rates for 2007-2017, how many years from 2017 will it take for China and India’s GDP per capita to equal that of the USA in 2017?
6. At the average annual growth rates for 2007-2017, how many years from 2017 will it take for China and India’s GDP per capita to be the same as the USA’s?
7. Is the world GDP per capita converging towards the Euro Area’s? Explain and comment.

**1.5 Consider the information in the following table and answer the following questions:**

|  |  |  |
| --- | --- | --- |
|  | **GDP per capita (2010 prices), Euros** | |
|  | **2000** | **2018** |
| Portugal | 16 200 | 17 900 |
| Malta | 13 800 | 21 600 |
| European Union (28) | 22 900 | 28 200 |

1.5.1 Find the average annual growth rates of GDP per capita for Portugal, Malta and the EU-28 in the period 2000-2018.

1.5.2 If Portugal, Malta and the EU-28 keep growing in the future at the same average growth rates as in the period 2000-2018, calculate how many years it will take for Portugal and Malta to reach the average GDP per capita of the EU-28.

**1.6 Consider the information in the following table.**

|  |  |
| --- | --- |
|  | **GDP per capita (2019)** |
| Economy A | 8 500 € |
| Economy B | 12 520 € |

1.6.1 In order for there to have been real convergence between these two economies in the last twenty years, the GDP per capita of Economy A as a percentage of that of Economy B in 1999 should have been less than, equal to or greater than 68%? Justify your conclusion.

1.6.2 Suppose that Economy A has been growing at an average annual growth rate of 4.3% while Economy B has been growing at an average annual growth rate of 2.3%. If the two economies continue to grow at these respective rates, what will their approximate GDP per capita be in the year when Economy A finishes catching up with Economy B in terms of GDP per capita?

**1.7 Consider the following data and answer the questions.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **GDP per capita in US$** | | | | |
|  | **1987** | **1997** | **2007** | **2017** |
| **USA** | 34 017 | 40 916 | 50017 | 53 083 |
| **Russia** | 8 461 | 8 726 | 10 246 | 10 904 |
| **Brazil** | 9 986 | 5 804 | 10 517 | 11586 |
| **India** | 457 | 671 | 1 130 | 1 965 |
| **China** | 636 | 1 444 | 3 488 | 7 331 |

1.7.1 Compute the average annual growth rate (continuous) of GDP per capita for each country in the total period 1987-2017.

1.7.2 Which of these economies are diverging from the USA in terms of GDP per capita? Justify your answer.

1.7.3 Considering the GDPpc growth rates which you calculated for 1987-2017, in what year will China reach the level of GDPpc that the USA had in 2017?; ii) Do you find that projection, purely based on historical rates, to be realistic? Why or why not? (iii) Which factors could potentially delay or accelerate that catching up process?

## 2. Growth accounting

**2.1** Consider an economy whose production function is given by: Y = A.K0.7.L0.3. If, in 2020, this economy’s GDP (Y) grew by 1.2%, the physical capital stock (K) grew by 0.8% and the employed population (L) grew by 0.5%, calculate by how much Total Factor Productivity (A) grew in 2020.

**2.2** Consider an economy whose production function is as follows: Y = A.K0.6.(h.L)0.4 , and whose GDP in 2019 amounted to 50 Billion monetary units. Assuming that, in the period 2019-2039, the average annual growth rates of technical progress (A), the physical capital stock (K), the stock of human capital per worker (h) and the employed population (L) will respectively be 2%, 1.5%, 1% and 0.5%, calculate the level of GDP of this economy in 2039.

**2.3** Suppose that output, Y, in an economy is produced by combining physical capital, K, with skilled labour, h.L, according to a constant-returns *Cobb-Douglas* production function with disembodied technical progress:

Y(t) = A(t).K(t)0.4.[h(t).L(t)] 0.6

where K is the stock of physical capital, L is the labour force and h is the average level of human capital per worker. In the last 20 years the labour force grew at an annual rate of 0.6%, the average human capital pr worker grew at an annual rate of 1% and the stock of physical capital grew at an annual rate of 2.5%. Assume that the annual growth rate of GDP was 3% in the last 20 years. Calculate the average annual growth rate of the total factor productivity, TFP, in this period.

**2.4** Suppose an economy with a Cobb-Douglas aggregate production function with disembodied technical progress, with elasticities of output relative to physical capital equal to 0.3 and to the human capital (h.L) equal to 0.7. Calculate the average annual growth rate of the labour productivity, assuming that the total factor productivity (TFP) has grown at an annual average rate of 1%, the average number of hours of schooling and training of the labour force has grown at an annual average rate of 0.5% and the stock of physical capital per worker has grown at an annual average rate of 2%.

## 3. The Harrod-Domar model

**3.1** The government of country A decided, for the period 2016-2020, the goal of average annual growth rate of labour productivity as 2.5%. The Statistics Office forecast an average annual growth rate of the labour force of 1.5% for this period, and estimated, also for this period, a capital-output ratio equal to 3 and a depreciation rate of 4%.Assuming the hypotheses of the Harrod-Domar model, make use of it to say what should be, in such conditions, the savings rate of this economy. Make a comment on the hypotheses and on the results.

**3.2** Suppose an economy which functions in accordance with the hypotheses of the Harrod-Domar model and in which total income (Y) increased from 128 billion euros in 2000 to 180 billion euros in 2015. Over the same period, the savings rate was 20% and the depreciation rate was 4%.

a) Estimate the value of the capital stock in 2015.

b) If the capital-output ratio had been larger, with all else constant, would the economy have grown faster or slower? Explain why that is the case.

c) According to the logic of the Harrod-Domar model, what factors influence economic growth and what measures can governments take to promote it?

**3.3** With regard to an economy which behaves in accordance with the hypotheses of the Harrod-Domar model, the following information is known for the period 2013-2018:

* The value of the physical capital stock increased from 600 million monetary units to 730 million monetary units
* The savings rate, which remained constant throughout the period, was 32%
* The capital-output ratio, which also remained constant throughout the period, was equal to 4.

Based on the information provided, indicate:

3.3.1 the output of this economy in 2013 and in 2018;

3.3.2 the depreciation rate (assuming that this rate also remained constant throughout the period 2013-2018).

**3.4** Comment on the following statement and correct it if necessary: “Capital accumulation is the engine of economic growth in the Harrod-Domar model because in this model physical capital is characterised by increasing marginal productivity".

**3.5** Consider the following data for three economies which behave in accordance with the hypotheses of the Harrod-Domar model:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Investment rate | Depreciation rate | Physical capital productivity | Warranted growth rate |
| Economy A | 35% | 4% | 0.2 |  |
| Economy B | 28% |  | 0.25 | 2% |
| Economy C | 30% | 2.5% |  | 5% |

Fill in the blank cells in the table.

## 4. The Solow model

**4.1** Suppose an economy which functions in accordance with the hypotheses of the Solow model and is adequately described by the following Cobb-Douglas production function:

*Y* = 0,2.*K*α.*L*1−α

Further assume that the population is growing at an annual rate of 0.5%, the depreciation rate of physical capital is 4%, the investment rate is 25% and the partial elasticity of GDP with respect to physical capital is 0.6. For simplification, assume also that the total population, labour force and employed population are identical.

a) Formalize the model which represents the functioning of this economy and find the steady state level of physical capital per worker. Represent this graphically.

b) Find the steady state levels of GDP per worker, consumption per worker and investment per worker. Represent these values graphically.

c) With everything else constant, what will be the effect upon the steady state of an increase in the population growth rate to 1%? Represent this change graphically.

d) With everything else constant, what will be the effect upon the steady state of an increase in the investment rate to 30%? Represent this change graphically.

**4.2**. Consider an economy which functions in accordance with the Solow model and which is adequately described by the production function Y = 0,4.Kα.L1−α. Assume that the partial elasticity of GDP with respect to physical capital is 0.4, the population growth rate is 1% and capital depreciates at 5% per annum.

a) Find what the investment rate must be if the steady state level of physical capital per worker is *k\** = 2.5?

b) Once *k* is at *k\**  = 2.5, what is the growth rate of GDP?

**4.3** Suppose an economy which functions in accordance with the hypotheses of the Solow model, with the following Cobb-Douglas production function:

Y = 0,4.Kα.L1-α

We also know that the partial elasticity of GDP with respect to physical capital is 0.6, the depreciation rate is 4%, the population growth rate is 0.5% and the steady state level of physical capital per worker is 7.36 monetary units. For simplification, assume also that the total population, labour force and employed population are identical.

a) Find the steady state value of GDP assuming that the total population consists of 10 million people.

b) Find the level of the investment rate which is consistent with this steady state level of physical capital per worker.

c) Provide an economic explanation for the mechanism which leads the stock of physical capital per worker to return to its steady state level if at any time it increases above 7.36. What does this imply in relation to the ability of capital accumulation to bring about sustained productivity increases in the Solow model?

**4.4** Suppose an Economy A which functions in accordance with the hypotheses of the Solow model, with the following Cobb-Douglas production function:

Y = 0,3.K0,4.L0,6

The investment rate is 20%, the population growth rate is 1% and the depreciation rate is 4%. We also know the initial values of K and L, which are as follows: K0 = 11 million monetary units; and L0 = 10 million people.

a) What is the future trend of the capital-output ratio in this economy? And what is the future trend of labour productivity?

b) Assume that this economy takes 20 years to reach the steady state. Characterize this

equilibrium state in terms of the level and growth rates of the following variables: labour force,

stock of physical capital, GDP, investment.

c) Consider that this economy is in the steady state and the government of this country decides to create a special income tax, which consists of a tax of 5% on GDP. What are the consequences upon the level and growth rate of GDP per worker?

d) What are the effects, both in the short term and the long term, of a sudden increase in the labour force to 11 million people (for example due to the massive return of refugees in a given year)?

e) Now consider another Economy B which has a similar production function, but which differs from Economy A only in terms of the savings rate, which is equal to 5%. Calculate the income gap between both economies (ratio of GDP per worker of both economies). And what will the value of this gap be if the partial elasticity of GDP relative to physical capital is 0.5 (holding the savings rate of Economy B constant at 5%)?

**4.5** Consider an economy that behaves according to the Solow model and whichis adequately described by the following aggregate production function:

Y = 0,4.Kα.L1- α

We also know that the partial elasticity of GDP with respect to physical capital is equal to 0.4, the labour force growth rate is 2% per year and capital depreciates at an annual rate of 5%.

a) Compute the investment rate consistent with a steady state stock of capital per worker of k\* = 2.5.

b) If physical capital per worker is already equal to k\* = 2.5, what is the growth rate of GDP in this economy equal to?

c) Depict graphically the situation described in (a), above.

**4.6** Consider an economy described by the following Cobb-Douglas production function:



In which the only production factors are physical capital and the labour force. Suppose that the hypotheses of the Solow model apply, with an investment rate equal to 20%, an average annual growth rate of the labour force equal to 1% and physical capital depreciating at 4% per year. Furthermore, we know that the initial levels of the K and L variables are equal to: *K*0 = 11 monetary units and *L*0 = 10 million people.

a) Find whether the capital-output ratio has a tendency to increase or decrease in this economy. What about the average labour productivity?

b) Redo these calculations for an investment rate of 16% and a labour force growth rate of 1.2%

c) Compare the findings from (1) and (b) above, and interpret the differences from an economic perspective.

**4.7** Consider an economy which behaves in accordance with the hypotheses of the Solow model and about which it is known that the investment rate equals 25%, the depreciation rate equals 4% and the labour force is unchanging. The production function of this economy is as follows:

Yt = Kt0.4.Lt0.6

4.7.1 Find the steady state level of physical capital per worker of this economy. In addition, find the level of labour productivity which corresponds to that steady state.

4.7.1 Suppose that, starting from the steady state, the government of this country is considering two alternative immigration policies. The first one consists of the immigration of a number of migrants corresponding to 10% of the population in one go, albeit without any effect upon the population growth rate thereafter (which continues to be zero). The second one consists of the immigration every year of a number of migrants such that the population growth rate undergoes a permanent increase from 0% to 2%. Explain the consequences of these two alternatives in terms of the Solow model and depict the two situations in a graph.

**4.8** Consider an economy which behaves according to the Solow model and has the following aggregate production function:

Y = A.Kα.(h.L)(1-α)

The variables Y, K, h and L stand for the level of output, physical capital, human capital per worker and the labour force. The variable A, which represents the level of technology, is constant and equal to 1, while the elasticity of GDP with respect to physical capital is equal to 0.8.

Assuming that human capital per worker remains constant and equal to 1, that the depreciation rate is 3.5% per year, and that the labour force grows at 0.5% per year, compute the investment rate which is compatible with a steady state capital-output ratio equal to 4.

**4.9** Discuss the following questions: under what circumstances does the Solow model predict that two economies with different levels of GDP per capita will converge to the same long-run level of GDP per capita?

## 5. The Romer model

**5.1** Indicate which variables influence technical progress in the Romer model and explain what each of those variables consists of.

**5.2** Consideran economy which behaves according to the Romer model, in which λ=1, φ=0.5 and the labour force grows at a constant annual rate of 1.5%. Assuming that the economy is already in its balanced growth path, compute the growth rate of GDP per capita.

**5.3** Consideran economy which behaves according to the Romer model, in which, starting from an initial balanced growth path, there is a sudden one-off increase in the number of researchers due to a new policy to attract foreign researchers. Explain the short- and long-run impacts of that increase on the growth rate of GDP per capita and the mechanisms that account for those impacts.

**5.4** Consider an economy which behaves as per the Romer model and whose production function for new ideas (technical progress) is given by the following expression:

r(A) = θ . LAλ/A1-Φ

, in which the variables have their usual meaning.

Currently, the number of workers involved in R&D activities is growing at an annual rate of 4% and the stock of ideas is growing at an annual rate of 3.5%. It is further known that λ = 0.7 e Φ = 0.2.

Indicate whether or not this economy is currently on its balanced growth path. Justify your answer.

**5.5** Discuss the following statement, and if necessary correct it: "Unlike what is the case in the Solow model, in the Romer model faster population growth is associated with slower economic growth."

**5.6** Discuss the following statement, and if necessary correct it: “Unlike what is the case int he Solow model, in the Romer model technical progress is endogenous”.

**5.7** Consider the following equation from the Romer model, in which *A* stands for the stock of ideas and *LA* stands for the number of researchers.

dA/dt = θ . *LA*λ . AΦ

Interpret the economic meaning of λ > 1 and φ < 0.

**5.8** Consider an economy which behaves as per the Romer model, with regard to which it is known that the number of researchers is growing at an annual rate of 5% and the stock of ideas is growing at 3% per year. We also know that λ = 0.8 and φ = 0.2. Show that this economy is not on its balanced growth path.

**5.9** Consider the following information for the Portuguese economy in the 30-year period between 1982 and 2012:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **L** | **LA** | **A** | **Y** |
| **1982** | 4 307 | 8 553 | 1 084 | 82 151 |
| **2012** | 5 495 | 56 192 | 16 715 | 155 717 |

L = Labour force (thousands); LA = Number of researchers (FTE in R&D); A = Number of patents + Scientific publications; Y= GDP (millions of euros) at 2006 constant prices.

With a view to characterising the Portuguese economy in its balanced growth path:

a) Estimate the value of [λ/(1-φ)], assuming the average annual growth rates of researchers (LA) and of the stock of ideas (A) indicated in the table above.

b) Using the above estimate, the average annual growth rate of the active population (L) obtained from the data in the table, and assuming that there is no unemployment, calculate the average annual growth rate of the Portuguese economy which corresponds to the balanced growth path of this economy.

c) Calculate the average annual growth rate of the Portuguese economy in this 30-year period and compare it to the findings in (a) and (b) above. Comment on the differences.

**5.10** Consider an economy which behaves in accordance with the Romer model and in which λ=1, φ=0.5 and the population grows at a constant rate of 1.5% per year. Assuming that the economy is in its balanced growth path, calculate the growth rate of GDP *per capita* of this economy.

**5.11** Consider the following information: Eurostat expects the population of the European Union to keep growing until the year 2045, reaching a maximum of 529 million in that year and decreasing thereafter. In light of the Romer model, discuss what might the consequences of this expected trajectory be for the growth of GDP per capita in the European Union, and what factors might counteract that tendency.

## 6. Climate change and social discounting

**6.1.** Consider that the total global CO2 emissions in 2014 (E) amounted to 9.8 billion tonnes. Estimate the annual growth rate of the CO2 emissions per unit of GDP (E/Y) between that year and 2034 that is consistent with:

* total global CO2 emissions of 11 billion tonnes in 2034;
* annual growth of GDP per capita of 1.5% throughout the period; and
* 1% annual growth of the global population.

**6.2** Consider the hypotheses from 6.1 above but assume that it is not possible to reduce the CO2 emissions per unit of GDP. In that case, what is the maximum achievable annual growth rate of global GDP per capita in the period?

**6.3** Continue to consider the hypotheses from 6.1 above. Further assume that:

* the global economy functions in accordance with a Cobb-Douglas production function with constant returns to scale and partial elasticity of GDP with respect to physical capital of 0.8;
* in the period 2014-2034, disembodied technical progress will increase at 1.4% per annum, emissions per unit of GDP (E/Y) will decrease at 1.4% per annum, and human capital per capita (h) will increase at a rate of 1% per annum.

Compute the annual growth rate of the capital stock in the period 2014-2034 that is compatible with these data.

**6.4** (Excel-based) Open the Excel file available in Aquila for this class, and consider the following data:

* World GDPpc (2018), constant prices: 10857.9 US$
* Estimated future annual growth rate of World GDPpc, in the absence of impacts of climate change: 1.85% (assumed constant in the period 2018-2100)
* Table A: Estimated costs associated with climate change in terms of impact upon annual GDPpc growth rate, under the no mitigation (costs of climate change) and full mitigation (costs of full mitigation) scenarios:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **2018-2028** | **2028-2048** | **2048-2100** |
| **Cost of no mitigation:** | -0.6% | -2.0% | -3.5% |
| **Cost of full mitigation:** | -2.8% | -1.8% | -0.5% |

a) Compute the baseline World GDP per capita projections for the period 2018-2100 considering a constant 1.85% annual growth rate, disregarding (for now) the impacts of climate change.

b) Considering the expected impacts of climate change on the GDPpc growth rate represented in Table A, extrapolate the annual World GDP per capita figures for the period 2018-2100 under the No Mitigation and Full Mitigation scenarios. Represent the Baseline, No Mitigation and Full Mitigation scenarios in a graph. Under these assumptions, in what year does World GDPpc under the Full Mitigation scenario overtake the No Mitigation scenario?

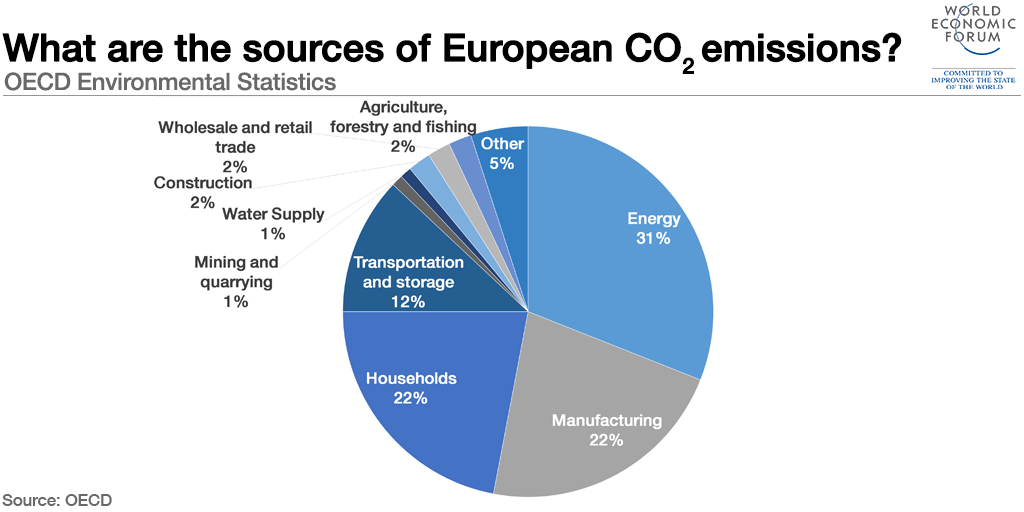
c) For both the No Mitigation and Full Mitigation scenarios, estimate the annual GDPpc loss relative to the Baseline scenario, over the period 2018-2100.

d) For both the No Mitigation and the Full Mitigation scenarios, calculate the Present Value of the total GDPpc loss relative to the Baseline scenario over the period 2018-2100 using a 2% discount rate. Which of the two scenarios involves a greater total loss in terms of Present Value?

e) Now do the same using a 6% discount rate. Which of the two scenarios involves a greater total loss in terms of Present Value using this new discount rate?

f) Contrast your findings in (d) and (e), above, and comment on what the implications of the use of different discount rates are for the economics of climate change.

**6.5** Consider the following graph, which indicates the main sources of CO2 emissions in Europe in 2019. Discuss which policy initiatives might have the greatest impact in terms of reducing CO2 emissions.



**6.6** Discuss the different impacts of a significant reduction in the consumption of fossil fuels, driven by a combination of technological innovation and a quantitative limit imposed on fossil fuel consumption per unit of GDP, for the following groups of countries:

* rich, advanced economies operating at the technology frontier
* economies that rely on exports of fossil fuels, face volatile prices and revenues and have limited technological capabilities
* poorer economies with no fossil fuel reserves, fossil fuel-dependent production processes and very limited scientific and technological capabilities?

Suggest possible public policies that could help to share the global costs and benefits of such a reduction in fossil fuel consumption more equitably.

**6.7** Explain why the choice of the appropriate social discount rate is such a central focus of debates in the economics of climate change.

## 7. Representing and measuring inequality. The Kalecki and Piketty models.

**7.1** Consider the following alternative distributions of the same total income:

|  |  |  |  |
| --- | --- | --- | --- |
| **Individuals** | **Distribution A** | **Distribution B** | **Distribution C** |
| 1 | 240 | 836 | 0 |
| 2 | 780 | 836 | 0 |
| 3 | 849 | 836 | 0 |
| 4 | 1007 | 836 | 0 |
| 5 | 1304 | 836 | 4180 |
| Total | 4180 | 4180 | 4180 |

**a)** Represent on the same graph the Lorenz curves that correspond to the three distributions.

**b)** Compute the Gini coefficient of Distribution A from its graphical representation. Without making any calculations, indicate the Gini coefficients of Distributions B and C.

**c)** Indicate the Lorenz dominance relationships between Distributions A, B and C and discuss them in light of the Gini coefficients computed in (b) above.

**7.2** Discuss the following statement, and correct it if necessary: “If economy A has a lower Gini coefficient than economy B, we may conclude that the Lorenz curve of economy A dominates the Lorenz curve of economy B”.

**7.3** Consider the following income distribution data for a sample of countries:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Gini Index | Lowest 10% | Lowest 20% | Second 20% | Third 20% | Fourth 20% | Highest 20% | Highest 10% |
| United Kingdom | 33.2 | 2.9 | 7.5 | 12.2 | 16.8 | 23.0 | 40.6 | 25.4 |
| United States | 41.5 | 1.7 | 5.0 | 10.2 | 15.3 | 22.6 | 46.9 | 30.6 |
| Mozambique | 54.0 | 1.6 | 4.2 | 7.6 | 11.2 | 17.4 | 59.5 | 45.5 |
| South Africa | 63.0 | 0.9 | 2.4 | 4.8 | 8.2 | 16.5 | 68.2 | 50.5 |
| Brazil | 53.7 | 1.0 | 3.2 | 7.3 | 12.0 | 19.2 | 58.3 | 42.4 |
| Germany | 31.7 | 3.1 | 7.8 | 12.9 | 17.0 | 22.6 | 39.7 | 24.8 |
| India | 35.7 | 3.5 | 8.1 | 11.7 | 15.2 | 20.5 | 44.4 | 30.1 |
| China | 38.6 | 2.6 | 6.4 | 10.6 | 15.3 | 22.3 | 45.4 | 29.4 |
| Finland | 27.1 | 3.9 | 9.4 | 14.0 | 17.5 | 22.4 | 36.7 | 22.4 |
| France | 32.7 | 3.1 | 7.9 | 12.8 | 16.7 | 21.7 | 40.9 | 26.6 |
| Norway | 27.5 | 3.5 | 9.0 | 14.1 | 17.7 | 22.7 | 36.5 | 22.3 |
| Portugal | 35.5 | 2.4 | 6.7 | 12.0 | 16.3 | 22.3 | 42.7 | 27.3 |
| Slovenia | 25.4 | 3.9 | 9.6 | 14.5 | 18.2 | 22.6 | 35.1 | 21.0 |
| Angola | 42.7 | 2.1 | 5.4 | 9.6 | 14.5 | 21.9 | 48.5 | 32.3 |

a) Rank these countries from more to less unequal based on their Gini index score.

b) Rank them from more to less unequal based on their S80/S20 index score.

c) Rank them from more to less unequal based on their S90/S10 index score.

d) Make a comment on the three rankings above: are there any differences? Which geographical patterns can you identify? Based on this data, do you consider Portugal to be more or less unequal than China?

e) Represent the Lorenz curves that correspond to the distribution of income of the most equal and the most unequal countries (based on the Gini index criterion).

**7.4** Discuss whether the existence of high levels of inequality in an economy can worsen the effect of a recession like the one we are currently experiencing.

**7.5** Consider an economy described by the Kalecki model as presented in the theoretical lectures, in which investment equals 3,000 monetary units (m.u.), the capitalists’ autonomous consumption equals 200 m.u. and the capitalists’ propensity to consume equals 0.6. Consider further that expenditures with production inputs other than wages amount to 4,000 m.u. and the entrepreneurs’ mark-up equals 60%.

a) Find the total level of profits (P), wages (W), income (Y) and the wage share (α) in this economy.

b) Assume that capitalists decide to increase investment by 25%. Compute the effect of this change on profits (P), wages (W), income (Y) and the wage share (α). Comment on your findings.

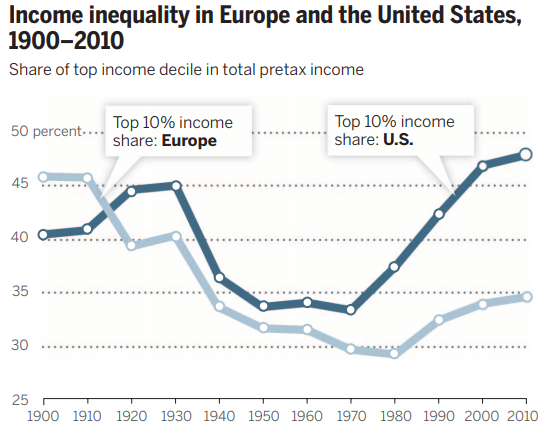
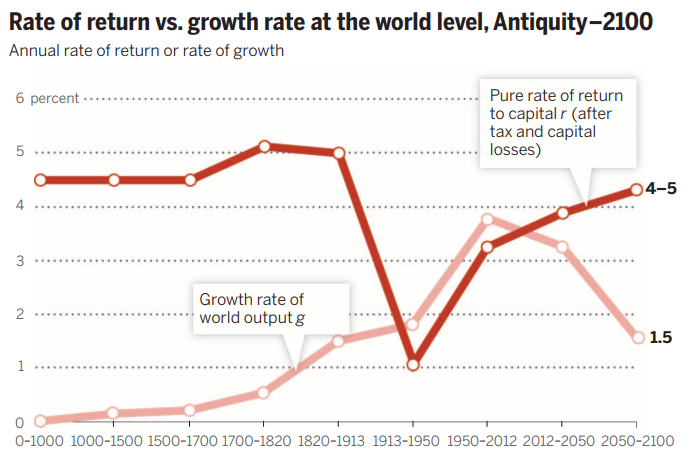
c) By how much did total income grow as a consequence of the increase in autonomous investment from (a) to (b)? Interpret these results from an economic perspective.

d) Assume that investment is back at its original level (I=3,000). Now consider that the mark-up rate, k, increases to 70%. Find the total level of profits (P), wages (W), income (Y) and the wage share (α). Compare these results with those in (a) and interpret them from an economic perspective.

e) Under the assumptions indicated in (d), assume once again an increase in investment by 25%. Find the total level of profits (P), wages (W), income (Y) and the wage share (α).

f) By how much did total income grow as a consequence of the increase in autonomous investment from (d) to (e)? Contrast that increase in income with that estimated in (c), and interpret the difference from an economic perspective.

**7.6** Consider the following two figures, taken from Piketty, T. and Saez, E. (2014), “Inequality in the long run”, *Science*, 6186, Vol. 344: 838-843.

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Discuss:

a) how the information in the two Figures may be related under Piketty’s model.

b) possible explanations for r having been temporarily lower than g in a large part of the 20th Century, as depicted in the top Figure.

c) possible explanations for the recent return to r>g, and possible consequences thereof.

## 8. Industrialisation and industrial policy

**8.1** Does industrialization matter? Why (and for what) or why not? More generally, does the structure and trajectory of economic growth matter? Why (and for what) or why not?

**8.2.** Discuss what patents are, what they are used for, and their beneficial or detrimental effect to the pursuit of industrial policies.

**8.3** Discuss how the various stages of maturity of different industries (infant industry, mature industry, declining industry) involve their own specific challenges for industrial policy. Try to structure your answer by filling in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Stages of the industry/product cycle | | |
| Infant industry | Mature industry | Declining industry |
| Characteristics of the stage |  |  |  |
| Goals of policy |  |  |  |
| Specific policies |  |  |  |

**8.4** Discuss whether and how technical progress, namely the creation of new industries, can give rise to macroeconomic fluctuations.

**8.5** Imagine an economy that is dependent upon exports of primary commodities and/or simple, light consumer goods and/or services like tourism, and upon imports of capital goods, or productive capacity (like, for example, machines, equipment) and of industrial raw materials and intermediate products, or capacity to utilise the productive capacity (like, for example, electricity, chemicals, metal alloys, spare parts). This economy wants to industrialize and, to do so, requires significant investment in productive capacity. Discuss the dilemmas, the industrial policy options, and the macroeconomic challenges that this economy will face.

## 9. Social Security

**9.1** For a given economy with a pay-as-you-go system, it is expected that labour will grow by 0.3% per year over the next 20 years and that, due to the aging of the population, the number of pensioners grow at an average annual rate of 1.6%. The government also wants the average pension to grow 2% a year.

a) What should the annual GDP growth rate be in order to maintain the balance of the social security system without increasing the rate of contributions to the system, assuming that the functional distribution of income does not change during this period?

b) Consider, now that while the functional income distribution remains unchanged, average labour productivity grows at 1% per annum and employment grows at 0.2% per annum. Show which policy measures can maintain the balance of the system, quantifying the magnitude that each should take if taken in isolation.

**9.2** Consider an economy whose social security system is based on a pay-as-you-go system. Its Office of Studies and Planning has the following projections for the next 20 years: the working/age population in 2019 (all employed) is estimated at 5 million people and is expected to grow to 5.526 million by 2039; the number of pensioners will grow at the annual average rate of 4% in the period; it is also predicted that GDP, at constant prices, will grow at the annual average rate of 4% and that there will be no change in the functional distribution of income. Based on these elements, the Government has set the objective of increasing the average retirement pension by 1% per annum, in real terms, without raising the rate of contributions but maintaining the balance of the system.

a) Check that the objective set by the Government to increase pensions, under the above economic projections, is attainable.

b) If it is not feasible, what change can be made to the contribution rate to help achieve this objective?

c) If 600,000 migrant workers enter the labour force, evenly distributed throughout the 20 years, and assuming that the rate of growth of labour productivity remains unchanged from (a), what should be the change in the rate of contribution to achieve the government's goal? Comment.

**9.3** Consider an economy whose Social Security is based on a pay-as-you-go system, where for the next twenty years (2019 to 2039) the following information is projected: GDP, at constant prices, will grow at the average annual rate of 2%; the labour force, at the end of the period, will be 20% higher than in 2019; the number of pensioners in proportion to the working population will also be 30% higher in 2039; the weight of wages in total income generated in the economy will remain constant over time; and real wages are expected to accompany the growth in average labour productivity. Suppose, furthermore, that the Government's objective is to increase the average retirement pension in real terms by 1% per annum without increasing the rate of social security contributions.

a) Demonstrate that this Government objective is not feasible.

b) Indicate and explain adequately an example of an additional measure that the Government could take to make possible the objective considered above.

c) If the Government chooses to stimulate the economy, what should GDP growth be to ensure the desired real growth of the average retirement pension?

**9.4** In economy X, GDP per capita (Y/N) grew by 3% per year between 2010 and 2018, while, due to demographic ageing, the share of the working-age population in the total population (P\*/N) decreased by 2% per year in the same period.

a) If average labour productivity (Y/L) grew by 2% per year in this period, compute by how much the employment rate (L/P\*) grew in this period.

b) Consider the data from (a) and assume further that the working-age population remained constant throughout the same period, that the average wage decreased by 5% per year, and that the both the rate of social security contribution and the contribution from the government budget to the social security remained unchanged. Under these assumptions, what was the annual rate of change in the average pension?

**9.5** Discuss the following statement: “Population ageing in advanced economies can only be adequately addressed through a combination of delaying the retirement age and reducing the average pension.”

**9.6** If, in country A, GDP per capita grew in 2018 by 3.4%, average labour productivity grew by 1.6% but the ratio of employed persons to old-age pensioners has remained constant, what conclusion can you reach regarding the share of old-age pensioners in this population? Explain your calculations.

**9.7** Consider a pay-as-you-go social security system which is currently balanced and which financed by the workers’ contributions, on the one hand, and transfers from the government budget, on the other hand.

9.7.1 In the period under analysis, assume that wages remain unchanged, the ratio of old-age pensioners to the total population grows by 1.5% and the employment rate in the total population (L/N) decreases by 1,9%. Under these circumstances, by how much should the payroll tax rate on wages (b) increase in order for the average pension (P) to increase by 0.8%?

9.7.2 Now assume that the average wage increases by 1.2% and the payroll tax rate remains unchanged, while demographic ageing causes the share of old-age pensioners in the total population to increase by 1.3% and the employment rate to decrease by 0,7%. What would be the required change in the average pension in order for the social security system to remain in balance?

**9.8** Discuss the main risks posed by a private fully-funded social security system as opposed to a publicly-funded pay-as-you-go system.

## 10. Financialisation and the global economy

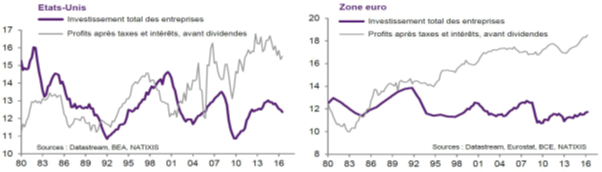
**10.1** Discuss the impact of financialisation on economic growth, taking into consideration the information displayed in the following graphs.

**Figure 1: Financial Sector Assets as a Percent of GDP, USA, 1950-2015**

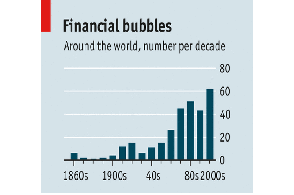


**Figure 2: Standard intermediation vs shadow intermediation, USA, 1945-2015**



**Figure 3: Total corporate investment (darker line) and profits after taxes and interest, as a share of GDP, USA (Left) and euro zone (right), 1980-2017** 

**Figure 4: Number of financial bubbles per decade, worldwide, 1860s-2000s**



**10.2** Consider the following features of the world economy in the last two decades:

- the share of financial activities in GDP, the expenditure of non-financial firms in negotiating financial assets as a share of their total expenditure, and the share of profits accruing to the financial sector have increased significantly

- financial concentration has increased and shadow financing has become a dominant part of the global financial system

- profits have increased significantly faster than productive investment, and the trajectories of profits and productive investment are delinked;

- average labour productivity has increased three times faster than average labour compensation, and their trajectories are delinked;

- private capital is expanding into education, health, social security provision and other areas traditionally not part of the market.

Discuss what specific problems may be posed for the formulation and success of productive growth strategies in this economy.