**Econ 102**
**Economic Growth**
*Solutions*

2.  Discuss how and why each of the following might affect US per capita GDP growth:

    a)  An increase of foreign direct investment into the US from Europe is caused by a decline in the value of the European currency, the euro.

*Foreign Direct Investment will increase the capital stock in the US, and the productivity of other factors of production, like labor. This will lead to increases in the US per capita GDP.*

    b)  Congress passes a law exempting capital gains from taxation.

*Lower taxes on capital gains provide a greater incentive for people to save and acquire financial assets whose prices will rise over time (capital gains). The increased saving will provide increased funding that firms can access to finance the purchase of investment goods, which means that the growth rate of the capital stock will eventually increase. As a result, the GDP per capita will also be likely to increase due to the increases in future capital and possible technology that result from a large influx of cash into the financial system.*

    c)  College tuition across the US increases by 2% per year in nominal terms, while inflation is steady at 2%.

*From these numbers, the cost of tuition is rising exactly as much as the rate of inflation, which means that the real cost of college is constant. Everything else being equal, there is no change in GDP per capita, because there will be no effects on any of the factors (capital, human capital, etc.).*

    d)  Fertility drugs increase the maximum childbearing age of US women.

*The increase in childbearing age of US women will make it possible for them to have more children. If they do, then this will increase the future population (and labor force) of the United States. By looking at our production function Y=AF(K,L,H,N) we see that output will rise with the rise in L, but with each additional unit of labor added, all else equal, we will see smaller changes in Y due to diminishing returns. Smaller increases of Y with a higher growth rate in population will lead to lower growth rates in GDP per capita.*

    e)  Lengthening the life of patents on new inventions.

*A patent is the exclusive right to profit from a new invention, and it is granted for a limited number of years. Extending the patent life means that inventors will continue to profit for a longer time, increasing the return on the inventions themselves. This should stimulate people to devote more of their time and resources to searching for new inventions, increasing the rate at which the country experiences technological*

*progress. Essentially this should have the effect of increasing the "A" parameter in the production function. The larger is "A", the higher is GDP per capita, and the faster "A" grows, the faster GDP per capita grows.*

   f)  Due to lower than expected tax revenues (due to tax cuts and the recession), the state of Michigan is forced to slash spending on higher education.

*This would lower the amount of money funneled into higher education, which may impact the amount of grants, loans, and projects funded by institutions of higher education, decreasing the growth in human capital.  Lower levels of human capital will lead to a lower GDP per capita.*

   g)  Congress increases the research and development tax credit, which reduces a firm's tax bill if it engages in research into developing new technologies.

*This too will tend to induce firms to engage in more R&D activity, which should increase the rate at which new technologies are developed and adopted. Like the extended patent length, this in turn will cause the level of productivity in the economy to grow more rapidly, and thus stimulate growth of GDP.*

*Be aware that all the above increases in GDP are subject to diminishing returns, so it is important to understand the difference between increasing GDP and increasing the GDP growth rate.  Both e and g present situations in which A (our technology variable) grows, which leads to higher growth rates, but the other answers just provide information about growth in the levels of GDP per capita.  Mankiw presents the difference as important long run-phenomena and provides an example of an increased saving rate, which increases <u>levels</u> of productivity and income, but <u>not</u> to higher long-run growth rates in these variables.  So, in the answers above, except for e and g, if there is an increase in a variable that will increase GDP, it is safe to say that the <u>long-run</u> growth rate will stay constant.  Mankiw also presents that the data reflect that most countries see higher growth rates initially, but the rates eventually return to normal, so we can also say that in the short run we have increases in growth rates.  See page 138 of Mankiw for a further exposition on this topic.*

   3.  A Bangladeshi worker who immigrates to America is likely to find that her average labor productivity is much higher in the U.S. than it was at home.  The worker is, of course, the same person she was when she lived in Bangladesh. How can the simple act of moving to the U.S. increase the worker's productivity? What does your answer say about the incentive to immigrate?

*Although the individual worker is the same person she was in Bangladesh, by coming to the U.S. she gains the benefit of factors that enhance average labor productivity in this country, relative to her homeland.  These include more and better capital to work with, more natural resources per person, more advanced technologies, sophisticated entrepreneurs and managers, and a political-legal environment that is conducive to high productivity.  It is not guaranteed that the value of the immigrant's human capital*

*will rise (it may not, for example, if she speaks no English and has no skills applicable to the U.S. economy), but normally it will.*

 *Since increased productivity leads to higher wages and living standards, on economic grounds the Bangladeshi worker has a strong incentive to immigrate to the U.S. if she is able to do so.*

4. Why small differences in growth rates matter

  In 1986 your aunt deposited $100 in a bank account at 4 percent interest to help out with your college tuition bill in 2006. Interest is compounded annually (so that interest paid at the end of each year receives interest itself in later years). The account was worth $100 in 1986; $100 \times 1.04 = $104 in 1987; $100 \times 1.04 \times 1.04 = $100 \times (1.04)^2 = $108.16$ in 1988; and so on. Since 20 years will have elapsed between 1986, the year the account was opened, and 2006, the year she withdraws the money, the value of the account in the year 2004 is $100 \times (1.04)^{20} = $219.11$.

  Economic growth rates are similar to compound interest rates. Real U.S. GDP per person was $3,412 in 1870 and $37,500 in 2003 (both in 2003 U.S. Dollars). Suppose that real GDP per capita in the U.S. had grown at 2.5 percent per year instead of the actual 1.82 percent per year, from 1870 to 2003. How much larger would real GDP have been in the U.S. in 2003?

*If the U.S. had grown at the 2.5 percent rate for the period 1870-2003, real GDP per person in 2003 would have been $3,412 \times (1.025)^{133} = $91,051$.  Actual GDP per person in the U.S. in 2003 was $37,500, so at the higher rate of growth output per person would have been $91,051/$37,500 = 2.43 times higher.*

5. The web reading by Paul M. Romer "It's all in Your Head," outlines what New Growth Theory is all about.  Use the reading to answer the following questions:

  a) Can policymakers alter the rate of technological change?  Why?
 *Yes.  If Romer is correct, then the right <u>incentives</u> can bring about innovation.  Think of the Manhattan Project, which found the technology that applied theory in a short period of time.*

  b) If there were no railroads in the early United States, what mechanisms would have fueled the growth of the economy?
*Canals, wagons, and roads.*

  c) What are the three features that make growth possible?
*Cooperation and trade makes it possible to share small bits of knowledge;*
*More unexplored possibilities than we can imagine;*
*Markets create incentives for people to exert effort and share information*

6.   (True/False/Uncertain--Explanation determines grade) Suppose Toyota builds four new automobile factories in the U.S. in 2007, and the combined value of the 4 new factories is 12 billion dollars. This investment increases the capital stock of the U.S., thereby increasing the productivity of U.S. workers.  In addition, this investment also increases the growth rates in productivity and the growth rates of income in the U.S. economy for 2007 and for subsequent years.

*<u>Uncertain</u>, depends on whether or not we are talking about the long or short run.. Growth rates are subject to diminishing returns, so you will see higher GDP, and productivity, but this investment will not increase the growth rates in productivity and income in the Long run.  But, if we are talking about the immediate effects and the following couple of years, then this can be a valid statement.  Mankiw states that this leads to "higher growth only for awhile." Defining "awhile" is difficult though, because international data support this time span as being several decades.*

7.   Thirteen Central, Eastern and Southern European countries applied to join the European Union (EU), and were kept waiting for about ten years, some even longer. In December 2002, the European Council met in Copenhagen    and decided to accept as members the following ten nations: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia, starting in May of 2004.  The Council also expects that it will accept Bulgaria and Romania into the European Union by 2007, and it has now opened accession negotiations with Turkey.  A major political concern is that all 13 countries are significantly poorer than the current members. Due to the internal transfer system of the EU, Eastern European membership will imply a heavy burden on the citizens of the incumbent EU countries. In this question, we are going to calculate how long it will take for the newly accepted countries to reach the living standards of the EU, if indeed they ever will. The following table gives the per capita real GDP of the 13 countries, and the EU average in 1999. It also gives their expected growth rates in 2000. Assume that countries will keep growing at the given rates until they reach the level of the EU average.  [PLEASE NOTE THAT SOME OF THE ACTUAL GROWTH RATES AND GDP PER CAPITA FIGURES HAVE BEEN CHANGED TO MAKE THE PROBLEM MORE INTERESTING]

| Country | Real GDP per capita | Growth rate of GDP per capita | Ratio of per capita GDP to EU average | Years to double this ratio |
|---|---|---|---|---|
| EU average | $25,660 | 2.7% | *1* | *-* |
| Hungary | $5,218 | 4.8% | *0.2034* | *33.3* |
| The Czech Rep. | $5,170 | 1.5% | *0.2015* | *-* |
| Poland | $4,257 | 5.7% | *0.1659* | *23.33* |
| Slovenia | $9,994 | 3.6% | *0.3895* | *77.8* |

| Estonia | $4,259 | 5.5% | *0.1660* | *25* |
|---|---|---|---|---|
| Cyprus | $13,389 | 2.3% | *0.5218* | *-* |
| Malta | $13,025 | 4.1% | *0.5076* | *50* |
| Romania | $2,323 | 7.3% | *0.0905* | *15.2* |
| Bulgaria | $1,691 | 4% | *0.0659* | *53.9* |
| Lithuania | $3,420 | 4.3% | *0.1333* | *43.75* |
| Latvia | $3,092 | 3.6% | *0.1205* | *77.8* |
| Slovakia | $3,818 | 5% | *0.1488* | *30.4* |
| Turkey | $6,230 | 2.9% | *0.2428* | *350* |

a) Without any calculations, are there any countries that will not be able to catch up to the level of per capita income in the EU?

*The growth rate in the Czech Rep and Cyprus are lower than the EU average. If both they and the EU keep growing at this rate for all time, they will never be able to reach the level of the EU. In fact, the income gap will widen.*

b) For Hungary, calculate the ratio of its real per capita GDP to that of the EU average. The growth rate of a fraction is approximately equal to the growth rate of the numerator minus the growth rate of the denominator. How rapidly, therefore, will this ratio of Hungary's GDP to EU GDP grow? Using the Rule of 70 from Mankiw (p. 184), how many years will it take for this ratio to double? Will Hungary, by then, have caught up to the EU in terms of real per capita GDP? If not, about how much longer do you think it will take?

*Hungary has an income of $5,218 and grows at a rate of 4.8% a year. The EU average income is $25,660, and it grows at a rate of 2.7%. The ratio of Hungary's real per capita GDP to the EU average is 0.2034. The difference in Hungary's and the EU's growth rates is 2.1%. Then, using the rule of 70, we know that it will take approximately 70/2.1=33.3 years for the real per capita GDP ratio to double. That is after 33.3 years, Hungary's real per capita GDP will be 0.2034×2=40.68% of the EU real per capita GDP. So, even after 33.3 years, Hungary will not have reached the EU's standards. After another 33.3 years, the ratio will be about 82% of the EU average.*

c) Repeat the same calculations for the other countries in the table to find their ratios of per capita GDP to the EU's, and the numbers of years it will take for these ratios to double. Will any of them catch up to the EU in this number of years?

*See the table above. Only Malta will be able to catch up to the EU by doubling the ratio. This will take 50 years. The reason is that the only two countries with GDP per capita of 50% of the EU or more are Malta and Cyprus, but Cyprus has a smaller growth rate than the EU average.*

d) What is wrong with the assumption of keeping the growth rate constant as countries are accumulating capital and growing? How will that affect your calculation in c?

*High growth rate due to high capital accumulation does not last long due to diminishing returns to capital. For poor countries, the returns to capital are high, which is why they tend to grow fast. But, as they accumulate capital, i.e. as they grow, productivity of capital will decrease. That is, output will keep increasing, but at a decreasing rate. This will most likely increase the number of years required to catch up to the income level in the EU.*

  e)   What other factors will affect the rate of growth for these applicant countries?
*The prospect of EU membership will increase the foreign investment in these countries. This will increase the capital stock in Eastern Europe and thus increase the productivity, and eventually their growth rates. In the path of towards membership, these countries will also adopt laws that will protect property rights. Security on this issue will increase rates of saving and capital accumulation, and thus the growth rates. Furthermore, EU member countries will integrate their economies to Western Europe, and start trading freely with the EU members.  Gains from trade will increase the wealth, and thus savings rate, and also through flow of technology due to liberalization, their productivity will increase as well. Through both of these channels, the growth rates in Eastern Europe will increase. Because of all these factors, eastern enlargement will increase Eastern European growth rates above what they were in the past, and they will be able to reach the EU standards sooner then what our calculations suggest.*

  8.  Hester's Hatchery raises fish.  At the end of the current season she has 1,000 fish in the hatchery.  She can harvest any number of fish that she wishes, selling them to restaurants for $5 apiece.  Because big fish make little fish, for every fish that she leaves in the hatchery this year she will have two fish at the end of next year. The price of fish is expected to remain at $5.  Hester relies entirely on income from current fish sales to support herself.

    a)  How many fish should Hester harvest if she wants to maximize the growth of her stock of fish from this season to the next season?
*She should leave all fish in the hatchery.*
    b)  Do you think maximizing the growth of her fish stock is an economically sound strategy for Hester?  Why or why not?
*Maximizing growth is not economically sound, because Hester would have no current income to support herself.  If she dies of hunger, what good does it do for her to have as many fish as possible the next year…*
    c)  How many fish should Hester harvest if she wants to maximize her current income?  Do you think this is a good strategy?
*She should harvest all fish if she wanted to maximize her current income .  This is also not a good strategy as she would have no source of income in later years.*
    d)  Explain what this example implies for the economy as a whole.
*A higher living standard tomorrow must be purchased at the cost of current sacrifices. Because achieving higher economic growth imposes real economic costs, such as*

*giving up current consumption to invest or working longer hours to produce more, higher growth should be pursued only if the benefits outweigh the costs.*