Macro Spring 1 Essay 2

Using Economic Theory Discuss the Determinants of GDP per Capita in the Long-run, and the Growth Rate of GDP per Capita in the Long-run. Examine how These Two Phenomena Respond to a Permanent Decrease in the Growth Rate of the Population.

GDP per capita is a measure of total economic output for each person in an economy. Unlike the short run, the determinants of long run GDP per capita are less influenced by cyclical or temporary fluctuations within the economy, such as fluctuations in prices of changes in fiscal or monetary policy, instead, more structural indicators are needed to determine GDP per capita in the long run. In modern economic theory, there are three main contributing factors to long run GDP per capita growth.

Firstly, capital accumulation, defined as the total physical stock of capital, this is an aggregate of all the machinery, factories, office spaces, et cetera, within an economy. A higher level of capital stock is associated with long run GDP per capita growth as it increases the productivity of each worker, thus allowing an economy to expand its production possibility frontier, and causing greater long run GDP per capita. Secondly, size of labour force, defined as the total number of people willing and able to work within an economy (Blanchard, 2017), a greater labour force allows for more products to be made. However, it must be considered that the labour force itself is included within the per capita measurement of GDP, therefore, an expansion of the labour force that coincides with overall population growth may not necessarily result in an increase of GDP per capita if there is diminishing returns to scale. Due to the marginal output per worker being less than one, adding an additional worker would result in less additional output than the previous worker, thus resulting in a reduction in overall output per capita. Consequently, it may be better to use labour force participation, as an increase in the proportion of the population working increases output per worker. Thirdly, technological progress. Defined as the discovery of new and improved methods of producing goods, changes in technology lead to an increase in productivity of all factors of production including labour and capital (CFI, 2022). By increasing in the quality of capital, this allows for greater productivity by reducing the value of capital needed for each worker to produce the same amount as previously. Furthermore, technological progress allows for new products which are of greater value then before, hence producing these output increases overall GDP per capita in the long run.

In order to examine how these phenomena react to a permanent decrease in population growth we must establish a model to derive how these determinants react to each other. The Solow-Swan growth model is used to predict the impact of factor inputs on output (GDP) per capita. The model establishes a theoretical one-good economy and a production function with constant returns to scale, whilst also allowing capital and labour to be substituted for each other in the ratio of each others marginal product. Hence, Solow's production function is a many to one mapping of capital and labour to output:

$$Y = F(K, N)$$

Since there is constant returns to scale, any proportional change in both capital and labour would result in the same proportional change in output. For example, doubling of both capital and number of workers would result in a doubling of output. This can be described as,

$$xY = F(xK, xN)$$

To account for technological progress, the model appends a coefficient to the number of workers, A, which refers to the state of technology in the economy:

$$Y = F(K, AN)$$

The implication that follows is that for any doubling of the state of technology has explicitly the same impact of doubling the number of workers. In practice, this holds as innovation that doubles the marginal output per worker would result in half as many workers needed to make the same number of goods. AN henceforth will be referred to as effective workers, as it implies the amount of workers needed to produce the same output without current state of technology: 1 worker with technology that doubles their output is *effectively* the same as 2 workers without said technology.

Since it is established that there is constant returns to scale, we can set x from equation (2) equal the reciprocal of effective workers $\frac{1}{AN}$ thus creating out per effective capita production function:

$$\begin{aligned}\frac{Y}{AN} &= F\left(\frac{K}{AN}, \frac{AN}{AN}\right)\\ &= F\left(\frac{K}{AN}, 1\right)\\ &= f\left(\frac{K}{AN}\right)\end{aligned}$$

Here, the aggregate production function is essentially divided by the number of effective workers, AN itself becomes a constant since $\frac{AN}{AN}$ is 1, and thus not a determinant in the output per capita aggregate production function. For simplicity, this relationship can be expressed as function $f\left(\frac{K}{AN}\right)$. To establish an equi# Using Economic Theory Discuss the Determinants of GDP per Capita in the Long-run, and the Growth Rate of GDP per Capita in the Long-run. Examine how These Two Phenomena Respond to a Permanent Decrease in the Growth Rate of the Population.

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Allowing for technological progress, the number of effective workers increases over time. Consequently, to retain the existing ratio of capital to effective workers, $\frac{K}{AN}$, an increase in the capital stock K proportional to an increase in the number of effective workers AN is needed. Furthermore, the capital stock depreciates over time as the value of machinery decreases and repairs need to be made. Therefore, additional investment, on top of that needed to retain the capital to effective worker ratio, is needed to prevent the value of capital stock deteriorating over time due to depreciation. Also, the growth rate of workers impacts the ratio of capital to effective worker; if over a period of time the number of workers decrease, then less investment is required to retain the current ratio of capital to effective worker. Combining these determinants, the value of future capital stock K_{t+1} can be derived:

$$\frac{K_{t+1}}{AN} = (1 - \delta + g_N + g_A)\frac{K_t}{AN} + \frac{I_t}{AN}$$

To derive changes in capital stock over time, $K_{t+1} - K_t$, we can subtract K_t from both sides of the relation:

$$\frac{K_{t+1}}{AN} - \frac{K_t}{AN} = (g_N + g_A - \delta)\frac{K_t}{AN} + \frac{I_t}{AN}$$

To bridge the gap between changes in capital stock and output in the long run, the investment-savings relation can be used, whereby in an economy with no public sector, current investment I_t is equal to savings: the savings rate S multiplied by output Y.

$$I_t = sY_t$$

Inserting this into the capital stock relation,

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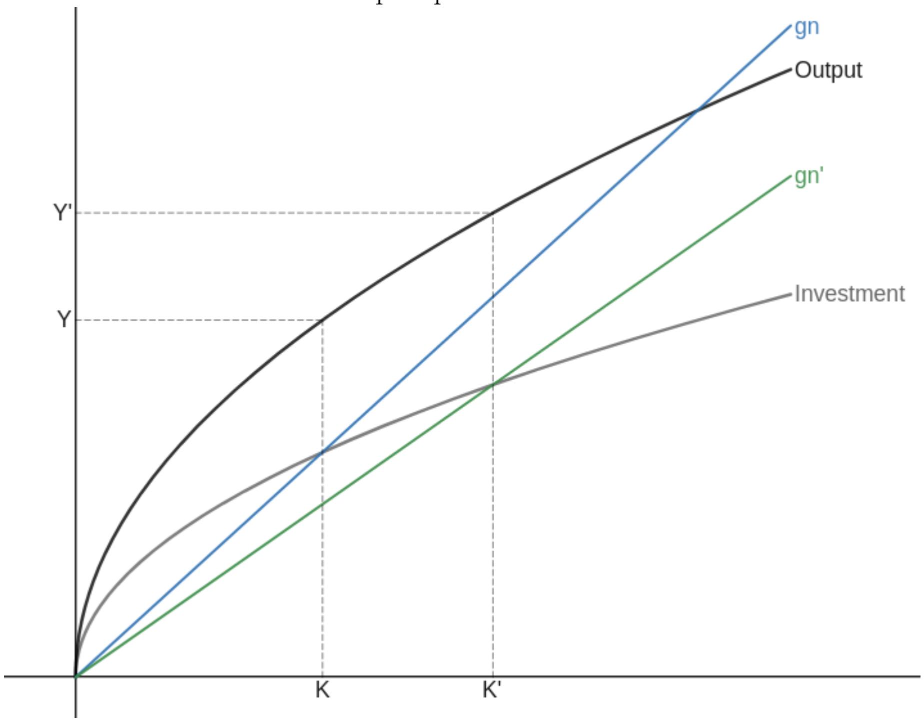
Or in terms of the per capita aggregate production function:

$$\frac{K_{t+1}}{AN} - \frac{K_t}{AN} = (g_N + g_A - \delta)\frac{K_t}{AN} + sf\left(\frac{K_t}{AN}\right)$$

In response to what would happen if there were a permanent decrease in the population growth rate, the coefficient g_N would decrease. Consequently, this has the effect of flattening the capital accumulation curve from $gn \rightarrow gn'$. As a result, the capital per effective worker increases from $K \rightarrow K'$ and the output per worker increases from $Y \rightarrow Y'$.



(Beight-Welland, 2023)

To conclude, we can see that a permanent decrease in population growth would result in a increase in output per effective worker, and thus overall GDP per capita. Furthermore, capital per worker increases since if capital is accumulated at the same rate after the permanent population decrease, more capital is available between fewer workers.

Bibliography

1. CFI. 2022, December 11, *Technological Progress - Definition, Phases, How To Measure.* Corporatefinanceinstitute. [online] Available at: https://corporatefinanceinstitute.com/resources/economics/technological-progress/ [Accessed 15 March. 2023].
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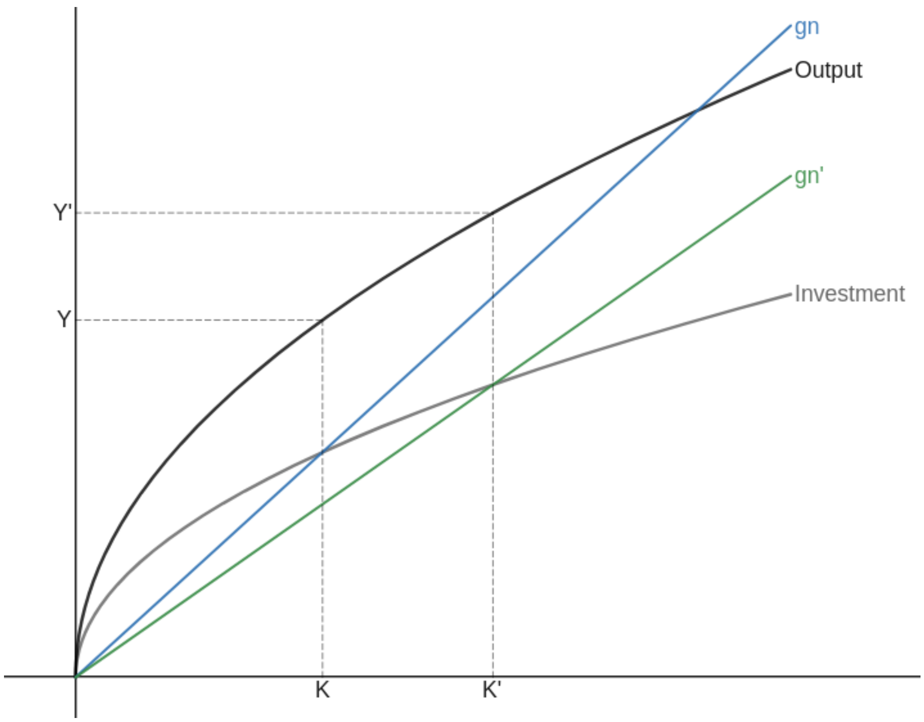

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