Economics of Growth and Innovation

ASSIGNMENT

Based upon the following readings:

Romer, P. (1986), "Increasing Returns and Long-Run Growth", Journal of Political Economy, 94, 1002-37. (Sections I-III)

Romer, P. (1990), "Endogenous Technological Change", Journal of Political Economy, 98, 71-102. (Sections I-II)

1. Introduction: Theories of Economic Growth

For centuries, economists have tried to explain economic growth and what it depends upon. Earlier models, provided by Adam Smith and Robert Solow, emphasized the role of capital accumulation. For instance, in Solow's model (exogenous), growth depends upon increasing the stock of capital goods to expand productive capacity. Thus, the combination of capital deepening[1] and technological improvement by nations explains the important tendencies in economic growth. However, his view is based on the fact that adding more capital goods to a fixed amount of labour will diminish the returns to capital. Also, increased accumulation of capital will force downwards the rate of return and eventually, the returns will be so low that no more accumulation of capital takes place. That leaves the technological progress, which is entirely exogenous to the model. So in reality, economic growth is left unexplained!

One can say that, in the long-run, Solow's model is stable, because it assumes a tendency towards equilibrium, a balanced economy, since the growth rate of all the variables is constant. So, according to this model, all the world's economies would converge to a certain level, which in reality doesn't happen.

Further work developed by Mankiw (1992) found that the Solow model performs well in explaining cross-country differences in income levels, especially when human capital is treated with the same importance as physical capital. However, a flaw remains, for it assumes that the level of productivity and rate of technological progress are the same across nations, which are not verifiable assumptions.

Hence, the uprising of the **new economic growth theories**, which are associated with names like **Paul Romer** whose work is briefly discussed in this assignment, seeks to make the "technological progress" variable endogenous. Basically, Romer "completes and enhances" Solow's work, by suggesting that the raw materials used in capital production don't change, but the further accomplishes in material combination, provided by technical progress, do change (companies response to market demands/incentives). So, technological progress is outcomes of the decisions undertake by companies, and, as such, technical progress must be an endogenous variable, and the driving force behind economic growth.

2. Diminishing vs. Increasing Returns of the production function

Solow's model for the long-run economic growth is based on diminishing returns of the production function. Therefore, *output* is produced using the *factors of production* - physical capital, raw labour, technology and natural resources – and assumes that there isn't international trade (homogenous good), technology growth is exogenous and individuals save a fraction of their income.

Given the production function (which follows a Cobb-Douglas production function), we can verify that if the capital stock is constant and the labour force increases, output rises but at a decreasing rate. The same thing happens if we level the labour force and increase the capital stock. This implies that the marginal product of capital is higher in capital poor economies. Hence, given the other factors and a fixed level of technology, there are decreasing returns. This means that, theoretically, in the absence of technological change, the economies should converge to a certain level, with no economic growth associated.

On the other hand, in Romer's approach to the long-run growth, increases in the capital stock or the labour force can lead to output rises at an increasing rate, and it can even increase at a monotonic rate over time. The difference is that technological change is viewed endogenously, and in the long-run it is driven by the accumulation/stock of knowledge.

The **production of new knowledge** itself presents **decreasing returns to scale** – given a certain point in time, doubling the inputs into research will not double the amount of new knowledge produced. Also, once it is produced, knowledge represents a positive externality, since other companies can benefit from it, thus generating associated scale economies.

However, the **production of goods as a function of the stock of knowledge and other inputs presents increasing returns**, and it can even present **increasing marginal product, because knowledge isn't bound**. And since there are diminishing returns to the production of new knowledge, this means that there is a maximum rate of growth for knowledge – then, the output may grow monotonically, but it can't surpass this upper bound.

3. Nonrival intangible capital goods and increasing returns

Modern economies and firms invest an increasing amount on resources in research and development (R&D). These two activities are of different nature, but both contribute to technical progress. The first results of these activities are a set of **intangible goods**, basically **knowledge, expertise and new designs for goods and equipment**. These intangible goods usually materialize into new and improved products and superior process technology.

According to Romer [2], a **nonrival good** implies that its use by one firm doesn't affect its use by another different firm. That's what happens with **intangible goods**. As mentioned previously, one of the arguments used by Romer to explain the endogenous economic growth model is that once the cost of creating new knowledge (it can be design, ideas or blueprints, etc) has been incurred, this knowledge can be used further times, without additional costs, and developing new knowledge, a new "set of instructions", is equivalent into incurring a fixed cost.

In addition, nonrival goods can be accumulated indefinitely, and treating knowledge as a nonrival good makes it possible for a *spillover*. These *spillovers* of new knowledge and technology are assumed to be freely available (scientific discoveries, and information in general are nonrival goods; many peoples and/or firms can use them at the same time). Contribution of these *spillovers* explains why in the model the total output of the economy grows faster than would indicate the use of inputs.

This assumptions clearly contrast with Solow's model, in which knowledge is treated exogenously to the model, implicating that it is nonrival and non excludable, and as a consequence there isn't any incentive into producing new knowledge by companies.

[1] Capital deepening: capital stock grows at a faster rate than the labour force

In conclusion, intangible assets are different from the other assets used by firms really because they are nonrival goods that have a high degree of excludability. While rival goods can only be used by one firm or person at any one time, nonrival goods can be used by different people, in different locations, at the same time. Economically, this implies that, because they are nonrival, they can be reproduced at lower costs than the ones required initially, when the assets were created. **This characteristic means the firm possessing intangible assets enjoys increasing returns to scale in production, since output can be increased without increasing all inputs.**

4. Increasing returns and competitive price-taking behaviour

What defines price-taking behaviour is when each firm that composes the industry is so small that it can sell their entire product at market price. In other words, no single buyer, or seller, can affect the price of the product.

When we look at Romer's endogenous model, and as we already mentioned, he gives emphasis to the fact that technological change derives from intentional individual actions in response to market signals. In that sense, there is a natural tendency to withdraw of *price taking* behaviour by firms, and an acceptation of a *price making* behaviour.

One explanation is related to the fact that technological change and knowledge are nonrival assets. In fact, firms that possess increasing returns to scale cannot function as price takers in their industry, unless the nonrival assets that give rise to the returns to scale can be obtained free of charge (if the intangible assets are not excludable). With increasing returns to scale, if obtaining nonrival assets involves a cost, firms with these assets will lose money if they act as price-takers. Consequently, firms with nonrival assets must price above marginal cost if they are to remain successful, or guarantee some exclusivity to that asset, for example through patents.

5. Excludability and endogenous technological change

According to Romer [2], e**xcludability** is a property that permits the effective exploitation of increasing returns to scale, caused by non-rivalry. As a function of both the technology and the legal system, it introduces a constraint in the market (in a form of a patent or a legal regulation) that prevents the immediate diffusion of that knowledge/technology to other companies. Without excludability, there would be no need to go through a transaction to acquire the idea: it would be freely available to everybody. Hence, it ensures marketable value and monopoly rents for ideas.

As implied by Romer's endogenous growth model, knowledge is the base for technological progress. In turn, this progress can be given by the amount of R&D investment by companies, and also by the government. Companies invest in R&D and product development in order to secure competitive advantages over their rivals. But once they are established, they can be diffused to other companies: this is based on the "nonrival" characteristic previously mentioned, but also on the fact that **technology is partially or temporarily excludable**, and so the owners have limited power to exclude others from using it. The original "owner" can keep control of the technology only for a certain amount of time, until a knowledge "spillover" takes place, justifying companies and government support for R&D in that area, reinforcing the stock of knowledge, giving lower prices for consumers , new knowledge for competitors and a higher economic welfare.

In addition, we must point out that these intangible assets can not be completely excludable, because excludability is a mechanism that fights the natural non exclusive nature of knowledge, and it can pose problems regarding social costs. For example, a long run patent, or excessive regulation can delay public benefits of some new technology (this happens frequently in the pharmaceutical industry), or even delay innovations of great importance that would have been possible, once the patent had a shorter life span. So, firms should be aware that the increasing returns can only be sustained with the next innovation.

The fact that partial excludability gives the owner of the proprietary knowledge and technology competitive advantage, can be turned into monopolistic profits. This is motivation enough for ongoing investments in R&D (intentional actions of firms/individuals), making knowledge and technological progress endogenous to the production function, resulting in a flow of innovation leading to improvements in quality. In the end, the pace of the economy growth is determined by the rate of investment in R&D.

6. End Remarks

Present work regarding economic growth models, suggests an evolutionary approach to growth [4], in which growth should be based in a more holistic approach of the firm, enhancing all the firms strategic capabilities rather than focusing only in R&D and human capital. Also, the policy and institutional framework must be taken into account since it provides the most to explaining the differences in economic growth from one country to another.

In the light of Romer's endogenous model, we can say that the modelling of human capital, technology, market incentives and knowledge spillovers allowed economists to assess the implications of policy interventions. One can say that policies should privilege acess to economies based in technological breakthroughs, which in turn provides access to further knowledge, at lower costs, and at a global level.

However, the models don't provide direct policy answers. No matter how mathematically correct a model is, economic growth still remains, in large parts, unexplained.

7. Bibliography

[1] **Romer, P. (1986), "Increasing Returns and Long-Run Growth",** *Journal of Political Economy*, **94, 1002-37. (Sections I-III);**

[2] **Romer, P. (1990), "Endogenous Technological Change",** *Journal of Political Economy*, **98, 71-102. (Sections I-II);**

[3] Rogers, M. (2002), "A Survey of Economic Growth", paper for the *Economic Record*;

[4] European Commission (2001), "Theories of Economic Growth", *European Competitiveness Report 2001*, 29-32, (Annex II.1).