

Anastassios Gentzoglanis  
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Ciencia Ergo Sum, vol. 7, núm. 3, noviembre, 2000  
Universidad Autónoma del Estado de México  
México

Disponible en: <http://www.redalyc.org/articulo.oa?id=10401902>



*Ciencia Ergo Sum*,  
ISSN (Versión impresa): 1405-0269  
[ciencia.ergosum@yahoo.com.mx](mailto:ciencia.ergosum@yahoo.com.mx)  
Universidad Autónoma del Estado de México  
México

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# Innovation and Growth in the Knowledge-based Economy

ANASTASSIOS GENTZOGLANIS\*

Recepción: 18 de octubre de 1999

Aceptación: 14 de enero del 2000

**Abstract.** *If capital stock is considered in a broad sense, to include both physical and intellectual capital, the law of diminishing returns may not apply and the higher the investments in intangible assets the higher a country's growth rate. The so-called AK growth models by taking into account both tangible and intangible capital do succeed to establish a positive relationship between growth rate and the capital stock. The empirical studies confirm this relationship but they fail to make an explicit account of the contribution of intangible capital to growth. This stems from the fact that lots of investments in intellectual capital and other intangible assets are not counted as such in national income and product accounts. The development of the AK models help to identify the neglected elements of growth and show the importance of taking them explicitly into account in order to better explain the current growth rates of the new economy.*

**Key words:** *capital, stock, AK models, new economy, knowledge.*

## Introduction

It is well documented that a country's growth and development depend on its ability to create wealth over time. A country's endowment in natural resources was considered to provide a competitive advantage over countries with less of such resources. It was rapidly recognised though that a nation's ability to use efficiently its scarce resources was even more important than its abundance in resources. Countries such as Japan and Germany managed to enjoy high growth rates even though they were not rich in resources. Their capacity to shift resources from low-added-value goods and services to high-added-value activities allowed them to enjoy double-digit growth rates during the post war period. Lately, however, their economic wealth is wrapped up in the so-called "fourth-wave" know-how, that is in electrical machinery, motor cars

and metal-bashing industries. Presently, these countries face lots of difficulties in shifting investments from old, relatively low-added-value hardware strengths to new, high-added-value software opportunities and reap the benefits arising from investments in converging industries such as computing, telecommunications and content industries.

Countries with a strong service sector and long tradition in microchip design, in R&D infrastructure, in abundance of venture capital, entrepreneurial reward and marketing services are better placed to get advantage of this "new wave of innovation" already underway in the U.S. and some other industrialised countries. Apparently, developing countries are facing enormous difficulties in leapfrogging into this new wave of innovations, knowledge creation and sustained growth rates. Are we really at the late stage of the current innovation wave? Do latecomers have any chances in matching the performance of most developed countries, especially the U.S.? Can local and national governments launch catch-up programmes in innovation and knowledge creation to imitate the U.S. performance? Do these programmes really work? Do investments in the "new economy" and programmes which promote the knowledge-based sectors really contribute to the development of a new infrastructure that will enable the economies to realise high growth rates and economic prosperity?

Section I describes briefly the new economy, its knowledge-based industries and their contribution to employment, productivity gains and economic growth. It highlights the

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I would like to thank professors Pierre Doray, CIRST (University of Quebec in Montreal) and Eduardo Loria editor of *Ciencia ergo sum*, for their helpful comments and suggestions.

TABLE 1

## R&amp;D AND INVESTMENT IN TANGIBLE ASSETS OF NON FINANCIAL U.S. CORPORATIONS (1953-97)

| PERIOD  | R&D (%) | FIXED TANGIBLE INVESTMENT (%) | R&D AND TANGIBLE INVESTMENT | ADVERTISING EXPENDITURES (%) |
|---------|---------|-------------------------------|-----------------------------|------------------------------|
|         | (1)     | (2)                           | (3)                         | (%)                          |
| 1953-59 | 1.3     | 12.6                          | 13.9                        | 4.2                          |
| 1960-69 | 1.7     | 12.7                          | 14.4                        | 3.9                          |
| 1970-79 | 1.8     | 13.9                          | 15.7                        | 3.4                          |
| 1980-89 | 2.3     | 14.1                          | 16.4                        | 3.9                          |
| 1990-97 | 2.9     | 12.6                          | 15.5                        | 4.1                          |

SOURCE: NAKAMARA, L. (1999)

importance of these industries in manufacturing and the service sectors in the economy and traces some trends. Section II summarises recent advances in growth theory linking the stock of capital defined in broad sense (human and physical capital) to economic growth. The latter is endogenously determined according to the so-called AK growth models. These models are based on the assumption that returns to capital do not diminish as the capital stock increases. Although investment in physical capital is still important to explain growth, we argue that investments in human capital and other intangible assets that create knowledge and intellectual capital are even more important in the current globalised context of the new economy. Section III draws some conclusions and offers policy recommendations.

### I. The New Economy and the Knowledge-based Sector

Many countries, especially the industrialised ones are increasingly becoming knowledge-based through research and development and systematic pursue of innovative activities in industries such as biotechnology, information, telecommunications and computers. The creation of *intellectual capital* is increasingly deemed as the most valuable asset of a firm, the one that creates wealth by increasing productivity gains and by bringing more changes in product and production techniques as well as in the organisation of the work within

1. Not all expenses in intangibles are counted as investments in either the U.S. companies' financial accounts or the U.S. national income and product accounts. As more and more firms invest their cash flow in intangible assets this practice leads to an underestimation of corporate profits and renders the explanation of the economic and financial performance of the U.S. economy less comprehensive.

the production unit. The creation of intellectual capital gives rise to an increase in the *intangible assets* of the organisation that implements such changes and with it more value to its stakeholders.

One way to measure the importance of intellectual capital is thus to consider the value of intangible assets incorporated into a firm's value. A firm's market value is getting increasingly higher as its base in intangible assets increases. Firms with higher valuable intangible assets will have higher market to book values. The ratio of the market value of the firm to the replacement cost of capital, called *Tobin Q ratio*, is a good measure of the importance intangible capital occupies within an organisation. The higher the ratio the higher the importance of intangible assets and therefore the higher the value of the intellectual capital. High tech firms and firms in other knowledge-based industries should have high Tobin Q ratios. An economy dominated by knowledge-based industries should have a global Tobin Q ratio higher than the one of less knowledge-based dominated countries. Further still, investment in intangible assets increases the prospects for profits and the latter increase the market value of the firm (and the country). The higher the value the bigger the incentive for firms to invest more in intangibles and other R&D activities.

This is precisely what is currently going on in the U.S. and other industrialised countries. In the U.S., R&D expenditures have been rising rapidly in the past decade or so. Data show that R&D expenditures as a percentage of non financial corporate gross domestic product (GDP) have more than doubled since 1953.<sup>1</sup> By contrast, investments in tangible assets (plant and equipment) was more or less stable during the same period (1953-1997). Table 1 illustrates the point.

The ever increasing proportion of investments in intangibles as a proportion of GDP explains the high price/earnings ratios of many firms in the knowledge-based sectors of the economy. Normally, and over longer periods of time profits have tended to grow at the same rate as the economy as a whole. Lately, profits are growing at a higher rate than the economy because investments in intangibles and other R&D activities reduce measured current profits and raise expected future profits. Future profits are expected to grow because investment in intangibles create the belief that more products will be discovered and these will create more opportunities for market niches development and the realisation of further profits. Investments in intangibles and innovations arising out of them create positive anticipations on future profitability. Economies with a strong hold on the knowledge-based industries enjoy higher returns and increasing wealth.

Productivity gains are important and they are considered to be the cause of rising wealth. Productivity has been

growing in the past few years and it is higher in the knowledge-based industries compared to the traditional ones, although important spill over effects may explain the production gains in the economy as a whole. The same is true for employment growth and value-added per capital stock and per employed worker. Table 3 shows the growing importance of the knowledge-based industries in Canada in terms of employment, total factor productivity and value-added per capital for the years 1984-97.

For the Canadian economy a major part of employment growth has been attributed to trade, especially after the 1980s. Trade was also identified as the catalyst of structural change in employment performance during the same period (Gera and Massé, 1996). In their study, Gera and Massé (1996), found that Canada's transition to the knowledge-based economy has been slow compared to other OECD countries. This so-called *innovation gap* is a cause of concern for Canada given the importance of these industries in wealth creation. The elaboration of policies in promoting the innovative capacity of a country has been advocated by many as an efficient means in joining the club of technologically advanced countries.

The innovation gap is quite serious despite the fact that corporate R&D spending as a percentage of sales has been quite high for Canada. In a recent Survey of world's top 300<sup>2</sup> international companies carried out by the Department of Trade and Industry in Britain (1998), Canada is well above average (10.8% compared to the average of 4.6%) and it is classified among the top three spenders after Denmark (16.3%) and ahead of Finland (10.4%). The U.S. on the other hand is faring relatively well just a bit above average (4.9%).

Although these figures show that international competition in innovation is getting more intense, it is surprising to find out that the U.S. companies - the top performers in high-tech innovation - are spending just around the international average, and countries such as Canada, Finland and Denmark - not widely associated with top innovations - to fair quite well on these grounds. This leads us to think that either the U.S. firms spend more on intangibles which are not included in R&D expenses or that the majority of innovations do not necessarily arise from large companies but small start-ups.

Indeed, in a country where venture capital is widespread available (the average investment made by venture capital firms in the U.S. has doubled from \$3.5 million in 1992 to more than \$7 million today) and the risks are well rewarded no wonder to find more start-ups than in other countries, especially in telecommunications, computers, semiconductors, medical equipment and pharmaceuticals. Further still, innovation in the U.S. is spearheaded by the existence of a huge pool of diverse professional skills (chip designers, patent lawyers,

| PROFITS AND STOCK MARKET VALUE OF NON FINANCIAL U.S. CORPORATIONS (1953-97) |                                |                            |                              |
|---|--------------------------------|----------------------------|------------------------------|
| PERIOD  | AFTER-TAX BOOK PROFITS (%) (1) | STOCK MARKET VALUE (%) (2) | PRICE-EARNINGS RATIO (2)/(1) |
| 1953-59   | 8.8                            | 110                        | 12.56                        |
| 1960-69   | 8.3                            | 145                        | 17.48                        |
| 1970-79   | 7.7                            | 92                         | 11.90                        |
| 1980-89   | 5.2                            | 75                         | 14.55                        |
| 1990-97   | 6.3                            | 127                        | 20.21                        |

SOURCE: NAKAMARA, L. (1999)

| AVERAGE ANNUAL EMPLOYMENT, TOTAL FACTOR PRODUCTIVITY, AND VALUE-ADDED GROWTH RATES IN CANADIAN MANUFACTURING INDUSTRIES BY LEVEL OF KNOWLEDGE INTENSITY |                                     |                                    |  |
|---|-------------------------------------|------------------------------------|--|
| INDUSTRIES BY KNOWLEDGE   | EMPLOYMENT GROWTH RATE, 1971-91 (%) | TOTAL FACTOR PRODUCTIVITY, 1976-98 | VALUE-ADDED PER CAPITAL STOCK, 1984-97 |
| HIGH  | 1.16                                | 3.73                               | 1.93                                   |
| MEDIUM  | 0.21                                | 1.10                               | -0.71                                  |
| LOW   | -0.25                               | -0.04                              | -2.14                                  |
| ALL   | 0.30                                | 1.55                               | -0.27                                  |

SOURCE: GERA AND MASSÉ, (1996), CSLS, (1999) AS REFERRED TO <http://www.usherb.ca/ceref> AND COMPILATIONS BY THE AUTHOR.

| CORPORATE R&D SPENDING AS A % OF SALES, 1997 |            |             |     |
|--|------------|-------------|-----|
| DENMARK                                      | 16.3       | JAPAN       | 4.8 |
| CANADA                                       | 10.8       | GERMANY     | 4.3 |
| FINLAND                                      | 10.4       | FRANCE      | 4.1 |
| SWEDEN                                       | 8.0        | BELGIUM     | 3.8 |
| SWITZERLAND                                  | 6.3        | SOUTH KOREA | 3.0 |
| NETHERLANDS                                  | 5          | BRITAIN     | 2.5 |
| U.S.   | 4.9        | ITALY       | 2.0 |
| <b>AVERAGE</b>                               | <b>4.6</b> |             |     |

SOURCE: U.K. DEPARTMENT OF TRADE AND INDUSTRY, 1997.

software writers, high-tech marketeers, public relations experts, etc.), all the necessary and valuable expertise to bring the innovation to the market place.

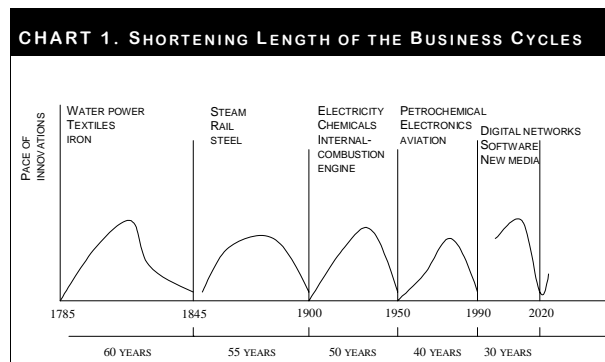
The five clusters of industries considered to be part of the new economy such as telecommunications, semiconductors, computers, medical equipment and pharmaceuticals

2. The results may differ from the recent ones reported by StatCan and OECD.

are all present in the U.S. These industries are currently the ones driving the present business cycle. Furthermore, global competition and shrinking product life-cycles are forcing companies themselves to take a short term view of their research and development. This in turn shrinks the business cycle. Indeed, business cycles are getting shorter and shorter and this brings about the importance of firms and countries to jump on the bandwagon as early as possible. The chart below shows the shrinking life of the business cycles, the first one lasted for 60 years and the fifth one (the current one) is expected to last 20 to 30 years only.

Although we are yet not quite sure where we are on the current business cycle, it becomes important, nevertheless, to realise that an early ride of the trend is in the interest of every country, especially the developing ones.

Research and development and other innovation activities and investments in tangible and intangible assets are essential to growth and development. To be sure entrepreneurial acti-



vity alone is not enough without management capacities and the availability of venture capital and markets that reward risk. Many start-ups fail because their owners are unable to make the transition from entrepreneurs to managers. Basic research, although does not generate necessarily scientific discoveries, it is nevertheless important because it provides innovators with techniques for solving industrial problems. Basic research is also important because it helps to train people to think scientifically and create expertise in the use of investigative tools.

A minimum of innovation is thus essential for a firm or a country should the latter be able to imitate and follow-up the scientific breakthroughs. Success in the market comes not only from just being an innovator but from being able to bring about improvements and establish a continuity or a trajectory of small technological adjustments and develop characteristics to be demanded by customers. The new growth models although in the right direction still lack flexibility and fail to take formally into account all these factors essential

for growth. The next section elaborates the new growth theory in more detail. It tries to identify and take into account the elements that may better explain the recent growth wave, especially the role of investments in intangible assets and other sorts of intellectual capital.

## II. Growth Theory and the AK Models

The theory generally accepted in explaining economic growth stems from Solow's (1956) seminal work on the production function. According to this theory the output of an economy depends on the use of its inputs which are normally grouped into two major categories, labour and capital. Normally an increase in inputs leads to an increase in output. Due to the law of diminishing returns, the successive increases in output become less and less important as more labour is added to a given quantity of capital or more capital is added to a given quantity of labour. The markets (capital, labour and product markets) are assumed to be perfectly competitive.

If this model were right it should have been observed a lower return on investment in industrialised countries for the second half of the 20<sup>th</sup> century compared to the first half. Moreover, the gap between rich and poor countries should have been narrowed. The stock of capital has been increasing over time in the most developed countries since the second world war. Instead of observing a fall in the returns on capital, we observed an increase of them. The change in technology accounts for the growth rates that cannot be explained by increases in capital and labour. Technological change was considered to be an exogenous factor capable of explaining the discrepancies between the actual (observed) growth rates and the rates predicted by the theory.

In recent years economists have tried to endogenize the process of technological change. Various models have been constructed and technological change has been the result of a complex way of interaction of factors related, first, to the industry structure (first generation models), and later, to the size of the firm. Other factors such as a firm's interactions with customers, its suppliers and its extra- and intra- mural efforts were deemed important in seizing opportunities arising from the discovery of new product and production techniques. Innovations and the knowledge incorporated into them explain better why the returns on capital do not decline as more capital is added to the economy. The latter suffices to explain why poorer countries have not caught-up yet the growth rates of rich countries despite the ever increasing accumulation of capital in these countries.

Innovation contributes to economic growth much more than the factors of production (capital and labour) can

account for. Apparently, innovation accounts for more than half of all economic growth. Given the sheer size of this factor in accounting for growth, countries and firms tend to develop strategies and laws that allow the innovative firms to reap the benefits of their innovations through patents, intellectual-property rights and trade secrets. Apparently, the more a firm invests in research and development (R&D) the higher its innovative index. Knowledge accumulated through this process is considered to be the most important result of innovation. Knowledge accumulation and innovation process are better explained though through the creation of networks, the establishment of inter-relationships and feedback procedures with the firm's clients, suppliers, competitors, government and Universities and research institutes. The old model which views innovation and knowledge creation as a pipeline is not adequate any more. This is especially true in the present context of rapid advances of sciences and technology whose impact is to render the economies more knowledge-based and globalised. The diffusion of new ideas and technologies give rise to new forms of competition and cooperation and provide better and faster ways to increase a country's growth rate. These developments in the comprehension of the process of innovation gave rise to a new generation of growth models, called AK models,<sup>3</sup> which provide a better explanation to the observed growth rates of many industrialised and developing countries.

According to AK models growth is endogenously generated and returns to capital do not diminish as capital stock increases. Without diminishing returns, a country can enjoy high growth rates even if it has a high capital stock. Thus, continued investments are consistent with continued growth. One important implication of AK models is that permanent changes in a country's policies lead to permanent changes in its GDP growth, when capital is viewed broadly to include intangible capital and human capital. One way to test this theory is to examine investment as a share of GDP and compare it to the growth rates of GDP for various countries over time. But before we do so it is important to present formally the AK models and their implications.

### 1. The Simple AK Models

The link between investment rates and growth rates is established by specifying the following utility function for a representative household which maximises its utility by choosing the optimal per capita consumption  $c$  and per capita investment in physical capital  $x_{kt}$  and human capital  $x_{ht}$  in each period:

$$\max [c_t, x_t]_{t=0} \sum \beta^t U(c_t) \tag{1}$$

for  $0 < \beta < 1$  and  $t$  is an index for time. This optimisation problem is subject to a resource constraint, a capital accumulation constraint and inequality constraints (Jones y Manuelli, 1990; Barro and Sala-i-Martin, 1988; Jones and Manuelli 1997; McGrattan and Schmitz, 1988):

$$c_t + x_{kt} + x_{ht} = A k_t^\alpha h_t^{1-\alpha} \tag{2}$$

$$k_{t+1} = (1 - \delta) k_t + x_{kt} \tag{3}$$

$$h_{t+1} = (1 - \delta) h_t + x_{ht} \tag{4}$$

$$c_t \geq 0, x_{kt} \geq 0 \quad \text{and} \quad x_{ht} \geq 0 \tag{5}$$

given  $k_0$ , where  $\alpha$  is the share of physical capital in production,  $k_t$  and  $h_t$  is the stock of physical capital and of human capital at time  $t$ ,  $A$  is the level of technology, and  $\delta$  is the rate of depreciation for both capital stocks. The per capita output can be expressed as:

$$y = A k^\alpha h^{1-\alpha} \tag{6}$$

where the exponents on the two accumulable factors sum to one (1), exhibiting thereby constant returns to scale (doubling the capital stock doubles the output).

The production technology of equation (2) exhibits constant returns to scale, thus by doubling the inputs we get twice as much output. A country with a high capital stock is still able to continue to grow as long as it continues to invest in capital (both human (intangible) and physical). Households choose investments so that a constant ratio of human capital to physical capital is achieved, that is  $(1 - \alpha)/\alpha$ . The total output can thus be written as a linear function of  $k$ , i.e.;

$$A k^\alpha h^{1-\alpha} = A[(1-\alpha)/\alpha]^{1-\alpha} k \tag{7}$$

and the output's growth rate is equal to the growth rate of physical capital.

If the level of technology does not change over time, this simple model clearly shows that the growth rate of output is a linear function of the growth rate of physical capital stock. Investments in capital (investment to GDP) lead to sustained output growth rates. The link is thus clear between the investment rate and GDP growth rate. The

3. Their name comes from the use of the simplest form of the production function, namely  $Y = AK$ , where  $A$  is a positive constant representing the economy's level of technology and  $K$  is the economy's stock of capital.





Such an affirmation is also valid for the most recent data on the world economy. More recent data show that growth rates have been quite impressive in the past decade or so (1990 to 1997). Almost 15% of the countries for which data have been compiled have registered growth rates exceeding 6%, while half of the countries covered grew at rates of over 3%. The most modest growth rates were registered by the high-income countries ranging in the average of 2.2% for the period. Although this performance is impressive indeed, it is much lower than the one registered by the low and middle-income countries. This finding seems to confirm the traditional growth models according to which countries with low stocks of capital are those with the higher potential for investment returns (diminishing returns to scale). The increase in capital mobility through the restructuring of financial systems and world wide deregulation has increased capital mobility and with it have grown the possibilities of growth and economic development. The table below summarises the GDP growth trend in the 1980s and 1990s around the world.

Intellectual capital and its importance in creating intangible but highly valuable assets such as *knowledge* is the basis of the so-called “*new economy*”. Knowledge is the key factor in explaining the current innovation spree and stellar performance of most industrialised economies in terms of long-term growth and job creation. The structural changes that we are currently undergoing towards more technology- and skill- intensive, knowledge-based economy, lead to better and more productive jobs with important implications for long term growth and prosperity.

More knowledge (better ideas) and skills as well as more physical capital (technology) provide the basis for better innovations and business ventures yielding thereby higher returns and creating more wealth. Apparently, the overall rate of return for some 17 successful innovations realised in the 1970s in the U.S. averaged 56% (this is compared favourably to the 16% of average return on investment for all American business over the past 30 years). It is not surprising to find out that more than half of the current U.S. economic growth is realised by industries that barely existed a decade ago. This shift towards knowledge-based industries and the increasing emphasis on investments generating such a knowledge create substantial spillover benefits to other sectors of the economy, provide further incentives to business firms to invest in skills-creation and high-wage jobs and generate higher returns to capital and labour not available to other sectors of the economy. Innovation and knowledge creation thus play an ever increasing role in economic growth.

FIGURE 1. THE CROSS-COUNTRY RELATIONSHIP BETWEEN INVESTMENT AND GROWTH

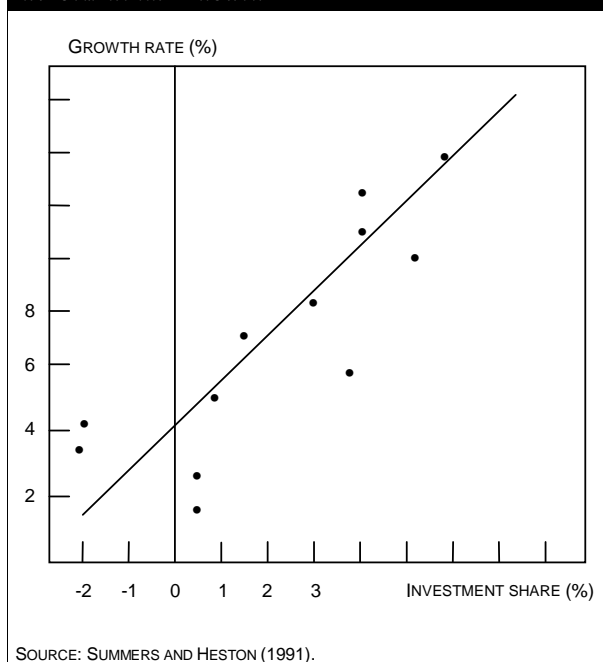


TABLE 5

|                         | AVERAGE ANNUAL GDP GROWTH |         |
|-------------------------|---------------------------|---------|
|                         | 1980-90                   | 1990-97 |
| <b>WORLD</b>            | 3.2                       | 2.4     |
| LOW INCOME              | 4.4                       | 3.9     |
| MIDDLE INCOME           | 2.9                       | 2.8     |
| LOWER MIDDLE            | 4.9                       | 2.3     |
| UPPER MIDDLE            | 1.8                       | 3.4     |
| HIGH INCOME             | 3.2                       | 2.2     |
| LOW & MIDDLE INCOME     | 3.1                       | 3.0     |
| EAST ASIA AND PACIFIC   | 7.5                       | 9.4     |
| EUROPE & CENTRAL ASIA   | N.A                       | -4.3    |
| LATIN AMERICA & CARIB.  | 1.6                       | 3.8     |
| MIDDLE EAST & N. AFRICA | 2.1                       | 2.9     |
| SOUTH ASIA              | 5.6                       | 5.6     |
| SUB-SAHARAN AFRICA      | 1.8                       | 2.0     |

SOURCE: WORLD BANK, 1999.

**Conclusions and Policy Recommendations**

The 1990s have been a period of rapid economic expansion for much of the world despite the fall of world economic growth from 3.2% in the 1980s to 2.4% in the 1990s. Countries in the low-to-middle income range have shown



the most rapid growth rates despite the turmoil of financial markets and setbacks from economic disruptions. High-income countries on the other hand have had an average growth rate of only 2.2% for the same period. Traditional economic theory predicts that countries with low capital stocks are the ones with high potential for investment returns. This is mainly true because of the assumption made of diminishing returns on capital.

If capital stock is considered in a broad sense to include both physical and intellectual capital the law of diminishing returns may not apply and this basic hypothesis can be removed from the models. Indeed, the AK growth models do take into account both tangible and intangible capital and dismiss the assumption of diminishing returns. They succeed in that way to establish a positive relationship between growth rate and capital stock in broad sense. The higher the capital stock the higher the growth rate. Recent empirical studies confirm this relationship but they fail to make an explicit account of the contribution of intangible capital to growth. We argue that in the new, knowledge-based economy growth depends on the capacity of a firm

and a country to convert rapidly the knowledge into valuable new products with a high value-added content especially in the five key industrial sectors of computers, telecommunications and information, semiconductors, pharmaceuticals and biotechnology and medical equipment. Conditions such as the existence of efficient capital markets, venture capital for start-ups, and high rewards for risk undertaking and the existence of a pool of professional skills locally are all essential in converting ideas to commercially viable products.

Developing countries lack a number of those essential elements and with them the capacity to realise high growth rates. Although catch-up programmes in innovation may have not worked in the past, policies aiming at developing the appropriate conditions and the supporting infrastructure to emulate the more advanced countries are worth pursuing. Success, however, depends on a multitude of factors which are absent from most developing countries. Laggards may find it impossible to leapfrog into the new wave of innovations, especially the countries that are far away from the current economic framework that made its proof. 🇺🇸



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