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1. Theory.

- **Empirical question.**

How technological innovation has affected European and American economies differently in terms of Total Factor Productivity and labour from 1970 to 2000 ?

My objective is to explore the relations between production and research and development (R&D), patent, education and training.

- **Why is this question important to research ?**

Investment is the commitment of current ressources in the expectation of future returns. The distinctive feature of investment as a source of economic growth is that the returns can be internalized by the investor. The most straightforward application of this definition is to investments that create property rights, such as investment in tangible assets like innovations. However, we may broaden the meaning of capital formation to include investment in human capital through education and training. While these investments produce returns that can be transferred. The studies leave no doubt at all that investment matters for growth on a time scale of two or three decades. For the developped economies, the favorable effects of macroeconomic policy work mainly through investment. That is why from a political relevance, this question may incite some economical policies which encourage to R&D and training. From an economical point of view it may shed light on the « productivity paradox ».

- **What has been written on the question ?**

Denison[1] has analysed the slowdown in the U.S. economic growth since 1973, using an aggregate model of production. He has attributed the slowdown primarily to the decline in aggregate productivity growth. The results from Jorgenson[2] bear out this conclusion. The decline in the rate of aggregate productivity growth accounts for 80 percent of the decline in the rate of growth of output. In addition, the slowdown in productivity growth for the economy as a whole is fully explained by the decline in productivity growth at the sectorial level. These results show that an aggregate production function may be appropriate for study of long-term U.S. economic growth.

In the study of total productivity two distinct approaches have been employed. First, total productivity may be treated as an index number, the ratio of indexes of total output and total input. Since the rate of growth of output and input vary from period to period, the rate of growth of total factor productivity may vary. Second, total factor productivity may be treated as a function of a particular form (for example an exponential function of time). The parameters of such a function may be treated as unknown to be estimated from data on output and input. Where total factor productivity grows exponentially, the rate of growth remains constant.

In either approach changes in the index of total factor productivity may be interpreted as shifts in an aggregate production function or as *disembodied* technical change. This interpretation of an index of total factor productivity with a constant rate of growth was first proposed by Tinbergen[3]. The corresponding interpretation of total factor productivity with a rate of growth that varies was first given by Solow[4]. More recently, Helpman and Trajtenberg[5] have developed a schumpeterian model of growth with a disembodied technical change. This model is driven by succcessive improvements in « General Purpose Technologies » (GPTs such as steam engine, electricity, or microelectronics). Each new generation of GPTs prompts investments in complementary inputs and impacts the economy after enough such compatible inputs become available. The long-run dynamics take the form of recurrent cycles : during the first phase of the cycle output and productivity grow slowly or even decline, and it is only in the second phase that growth starts in earnest. In accordance with Schumpeter's line of thought, Aghion and Howitt[6] have placed technological innovations at the heart of economic change. Their analysis shows that innovations do not immediately lead to an increase of productivity and growth, but rather to cycles that are initiated by deep and prolonged slowdows and end with the economy's transition to higher steady state growth path.

Moreover, changes in the index of total factor productivity have been interpreted by Solow as technical change *embodied* in new capital goods[7]. In this analysis, Solow assumes that embodied technical change takes place at a constant exponential rate, but according to him it is clear that the rate of growth could be treated as varying from period to period. Solow assumes, implicitly, that investment goods are perfect substitutes in production. In reaction, Jorgenson[8] developed a model of embodied technical change free of these two restrictive assumptions. More recently, Solow[9] combined innovation and continuous improvement (e.g. learning-by-doing) in a model.

- **<u>What policy implications can we draw from this research ?</u>**

I have first studied the evolution of two complementary processes : innovation and learning. For innovation to be efficient, a learning process is required. But, over time learning tends to decrease as technology has been completely developed. As a consequence unless a new innovation occurs, productivity growth at a given rate cannot be sustainable. The arrival of new technology that raises long-run output can trigger a recession in the transitional period. Understanding economic change implies considerring two kinds of investment : tangible investments that trigger technological change and human capital investments that favour knowledge production and users' skills development. The studies leave no doubt at all that investment (physical and human) matters for growth on a time scale of two or three decades. For the developped economies, the favorable effects of macroeconomic policy work mainly through investment. Thus, the policy implications we may draw from this research is an encouragement to R&D and training. Furthermore, I would like to see if the complementarity between innovation process and learning process leads to a complementarity between these two policies which encourage to more R&D and more training.

2. Methodology.

- **<u>Research design : Multi-variate analysis.</u>**

I will concentrate on statistica analysis of many cases.

- <u>Dependent variables</u> are GDP and GDP per capita.

- Independent variables are capital expenditure, gross domestic investment, change in inventories, R&D expenditure, scientists and engineers in R&D, technicians in R&D, population aged 15-64 (working population), school enrollment, science and engineering students.

I have two objectives : First, see the correlation between dependant ant independant variables. That is why I will do a static regression on all the countries. Second, see the differences between USA and European countries. Thus, I will do a dynamic time-serie regression on USA and Europe.

- **Sample.**

- Countries : OECD countries or more precisely USA and European countries such as Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

- Time period : similar historical period from 1970 to 1997.

- **Data and data sources.**

- Data : GDP, GDP per capita, Capital expenditure, Gross domestic investment, Change in inventories, Research and development expenditure, Scientists and engineers in R&D, Technicians in R&D, Population aged 15-64, School enrollment, Science and engineering students.

- Data sources : The 2000 World Development Indicators CD-ROM from World Bank.

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