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HUMAN CAPITAL ACCUMULATION AND GROWTH IN AN ICT-BASED ECONOMY

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This paper develops a model of endogenous growth that can be used to explain some important features of an economy in which ICT (Information and Communication Technologies) play a central role. In particular, human capital accumulation is present in the economy, and this mechanism turns out to be the true engine of growth of the model.

Some essential aspects of an ICT economy are taken into account, in particular the embodied nature of technological progress (typically the innovations that are present in the ICT sector are embodied in the new capital goods), the central role of R&D (the amount of resources devoted to it is high, particularly in the USA), the link between innovation and market power (ICT markets are non-competitive) and the accumulation of human capital (education is important in acquiring the knowledge necessary to use the new technologies).

Following the contributions of Romer (1990), Rivera-Batiz and Romer (1991) and Lucas (1988) (for the modelisation of R&D activity and of human capital accumulation) and that of Boucekkine and de la Croix (2003) (for the the modelisation of an ICT-based economy) a multi-sectoral model is built. In particular, this model considers discrete time with infinite horizon, endogenous growth, horizontal differentiation and human capital accumulation. Furthermore, technological progress is mainly embodied (the idea is that new softwares need new hardware to be run) and the innovators have a market power represented by copyrights (the inventor of a new variety of software obtains these copyrights forever).

The economy considered consists of 4 sectors:

- **the final good sector**: it produces a composite good (used to consume or to invest in physical capital) using efficient capital (bought from the equipment sector) and human capital;

- **the equipment sector**: it produces efficient capital (sold to the final good sector) using physical capital (hardware) bought from the final good producers and immaterial capital (software) bought from the intermediate good producers;

- **the intermediate good sector**: it produces immaterial capital (software, sold to the equipment sector) using human capital;

- **the R&D sector**: it researches for new varieties of immaterial capital, in order to expand their range.

Furthermore, the economy is characterised by a representative household that consumes, saves for future consumption, supplies human capital for production activities and accumulates human capital by devoting a fraction of its time to non-productive activities (schooling).

The analysis of the optimality conditions that hold at the equilibrium, of the balanced growth path and of the steady state of the model allow to obtain explicitely the value of the growth rates of the different quantities. In particular, from this analysis it turns out that the growth rate of production in the economy depends only on technological and preference parameters, while it doesn't depend neither on the absolute dimension of the economy (i.e. its total human capital stock) nor on the population growth (that is equal to zero). As a consequence, an important property of the model is that it doesn't display any scale effect. In addition, the long-run growth rate of the economy doesn't depend on the productivity of the final good sector, of the equipment sector and of the intermediate good sector, while it is affected by the productivity of schooling. Hence, in this model the true engine of growth is represented by the accumulation of human capital.

Further properties can be illustrated through numerical simulations, that are performed considering a calibration of the model such that it is able to reproduce some of the empirical facts available. In particular, it can be shown that an increase in the competitivity reduces the growth rate of the economy, while an increase in the monopoly power increases growth, through a reallocation of human capital among the different sectors. This is an apparently counterintuitive result, since many papers conclude that product market competition is unambiguously good for growth. In reality, these works are based on the assumption that the engine of growth in the economy is the continuous improvement of the quality level of existing goods. The present paper shows that this is no longer true when we consider a horizontal differentiation model of endogenous growth where firms invent new varieties of intermediate goods but, at the same time, the true engine of growth is represented by human capital accumulation.

Finally, numerical simulations show that this model exhibits another important property, represented by the so-called "imbalance effect" between physical and human capital. Indeed, the growth rate of output depends on the ratio between these two capital stocks, in the sense that when the economy starts from a level of the physical capital/human capital ratio that is different from the steady-state value, the growth rate of production turns out to be higher.

In conclusion, the model proposed, that considers R&D activity with horizontal differentiation and human capital accumulation in order to reproduce some central aspects of an ICT-based economy, gives the following main results:

- the presence of scale effects is excluded;
- the productivity of schooling affects the long-run growth of the economy, while the productivities of the other sectors don't have this effect;
- a positive relationship between market power and growth can be found;
- imbalance effects may originate in the economy.

All these results are important and allow to shed more light on the properties of an economy in which the new technologies play a central role.

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