Thesis

# Essays on Endogenous Growth and Innovation

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## Abstract

Improving the long-run economic growth rate is critical to human society. In fact, high growth rate can mitigate various issues in economic activities such as inequality. To achieve long-run high growth rate, it is necessary to increase the long-run growth factors like human capital, technology, and population. From Uzawa (1965) to Manuelli and Seshadri (2014) many seminal works examine the relationship between human capital accumulation and long-run economic growth. Concerning endogenous technology change, R&D-based growth models play an important role. The first generation R&D-based growth models consider that population size can indirectly promote R&D and long-run economic growth (scale effect). In addition to this, the second and third generation R&D-based growth models consider population growth as a source of R&D, even though they are non-scale effect models. Moreover, there exist endogenous fertility models that endogenize population growth. On the other hand, not many studies in endogenous growth examine the relationship between more than two of the growth factors, which independently achieve long-run economic growth.

In this thesis, as a point of departure of the analysis in the interaction between growth factors, we examine the effects of exogenous population growth on R&D, focusing on the cyclicality in R&D activity. Since Hanushek (1992) pointed out that there exists a trade-off between human capital accumulation and population growth, focusing on the link between exogenous population growth and R&D is central to analyzing the interaction. In fact, many previous studies endogenize the reproduction in second generation R&D-based growth models and examine three growth factors simultaneously. We focus on the cyclical behavior in R&D because R&D activities are closely related to cyclical behavior as observed in a classical business cycle, Schumpeter's creative destruction, product life cycle hypothesis, and medium-term business cycle. Introducing this cyclicality into an endogenous fertility model or a quantity--quality tradeoff model enables us to analyze the interaction between R&D and reproduction.

The rest of all of the thesis is organized as follows. In Section 2, briefly summarize the literature on population and cyclicality on economic growth. In Chapter 2 we propose a new method to examine both endogenous R&D, which is not only a source of technical progress but also causes cyclical behavior, and exogenous population growth simultaneously. Our method assumes the existence of an aggregate intermediate input, and that the final good is produced from labor and the aggregate intermediate input through a linear homogeneous production function. The aggregation

process of intermediate goods is assumed to be of decreasing returns to scale. Therefore, the final good production function becomes less than homogeneous of degree one between each intermediate goods and labor. Using this method, we can derive the dynamical system in which we can define both steady equilibrium and cyclical equilibrium paths. Based on this dynamical system, we characterize the balanced growth path as the unique steady equilibrium and the period 2 cycle driven by innovation, in which the average growth rate coincides with that of the balanced growth path.

In Chapter 3, based on the results in Chapter 2, we construct a semi-endogenous growth cycle model in which the population size has positive externality to the production of the intermediates. The long-run per-capita growth rate in the period 2 cycle is determined by population growth. Moreover, we discuss how cyclical behavior in a semi-endogenous growth model can explain seemingly inconsistent empirical studies on the scale effect.

In Chapter 4, we characterize R&D cycle in a fully-endogenous growth model. Assuming two types of R&D: horizontal R&D (uses capital) and vertical R&D (uses labor), there is a period 2 cycle in which the economy faces with relatively high R&D expenditures and with relatively low R&D expenditures reciprocally. The source of this cyclical behavior is the market structures in intermediates sector. The long-run average per-capita growth rate in the cycle is not determined by the labor growth rate, but by vertical R&D intensity measured by the ratio of engineers over labor. In the period 2 cycle, the economy also faces with stable average growth rate beyond ages and stationary upward trend in R&D expenditures. In addition to the above characteristics, there exists an R&D promotion policy which can increase both long-run and short-run growth rate.

Finally in Chapter 5, we conclude this thesis and offer a new direction for future research on the interaction between growth factors.