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Dynamic optimality principles and sensitivity analysis in models of economic growth

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Abstract

A dynamic model of investment process for an innovator in a market environment is designed. The "light" dynamics of innovator is described by the system of exponential trajectories with quickly changeable growth parameters. The innovator operates in the inert market environment presented by "heavy" exponential trajectories. The model consists of three decision making levels for dynamical identification, optimization of the commercialization time and optimal control design. On the first level the innovator makes assessment for the market commercialization time using econometric characteristics of the current state of the market. On the second level the innovator optimizes its commercialization time basing on its own current technology stock and taking into account the forecast of the market commercialization time. On the third level the innovator solves an optimization problem for the innovation policy minimizing investment expenditures. Properties of sensitivity and robustness are investigated for the optimal profit result and innovation feedbacks.

Key words: dynamic optimality principles, maximin strategies, game equilibrium, sensitivity analysis

1 Introduction

In this paper we deal with a dynamic model of innovation for a technology innovator which operates in the competitive market environment. Three main

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interacting objectives of the innovator are in the focus. These three tasks can be formulated shortly as: (i) observation and assessment of the market potential innovation, (ii) selection of the possible innovation scenario and optimization of the commercialization time, (iii) optimal design for the investment level. The main feature of the model is in its dynamic setting: all three problems are considered as the time evolved processes. At each moment of time the innovator can make a decision on the new innovation scenario, optimal time of innovation and optimal investment level in the feedback interaction basing on information about the current econometric characteristics of its own technology stock, the market technology stock and the market technology rate. The problem is to find a policy strategy for assessing the potential market innovation, choosing a scenario, optimizing the commercialization time and the investment level.

In the problem of designing optimal investment level we use the basic constructions of the models of optimal growth and allocation of resources [1], [6]. The construction of the benefit and expenditure functionals is based on integral payoffs for the problem of the optimal control with discount coefficients [5], [11], and, in particular, on payoff patterns for the problem of allocation of drug control efforts [4]. We adapt the time-delay dynamics of the model of a firm's R&D investment [12] for description of the controlled investment process. In dynamic selection of scenarios and optimization of the commercialization time we develop the static model of optimal timing of innovations [2].

In our research we apply dynamic optimality principles [3], [9], [10] to all three levels of the model. We use also patterns of the differential games theory [7], [8], [9] for modeling the identification process of the market innovation trajectories which can be interpreted as dynamics of a "heavy" object with weak controllability. For composing dynamics of the market technology growth and the investment process of the innovator we adjust econometric measurement formulas for R&D activities with time lag in interaction between technology and economy [12].

The dynamic model involves two objects. The "light" dynamics of the active innovator is given by the system of exponential trajectories with quickly changeable growth parameters. In the identification part of the model we assume that the identified object - the market environment, has the "heavy" dynamics with weakly variable (controllable) parameters of exponential trajectories. This assumption gives the opportunity to describe the cluster of trajectories, to assess the attainability set of the market potential innovation, and to analyze sensitivity of the predicted commercialization times. Basing on the evaluated time of the market innovation the innovator can make decision on selection of the innovation scenario. There are two possible strategies. The first strategy is oriented on the local maximum of the profit function with the