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Research paper

Dynamics and welfare in recombinant growth models with intellectual property rights: A computational method[☆]

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ABSTRACT

We extend the continuous time Tsur and Zemel's (2007) endogenous recombinant growth model with both physical capital and knowledge accumulation to allow for a basic IPRs system driven by public intervention as in Marchese et al. (2018). We analyze the effect of different policy regimes on social welfare comparing the outcomes in a decentralized and centralized frameworks. This requires to carefully study the transition dynamics associated to different values of the policy parameter. To this aim, we present a computational approach, extending the method developed by Privileggi (2011, 2015), to provide a novel procedure capable of approximating the transition dynamic paths and performing Skiba-point analysis even in our complex framework. Our numerical analysis shows that stricter policy regimes generate higher welfare levels and that a strictly positive tax level may be needed to avoid stagnation.

1. Introduction

Knowledge is by far one of the most important determinants of long-run economic growth; thus, in the economics literature great emphasis is placed on assessing the impact of different types of policies on knowledge accumulation. In such a framework, the role played by intellectual property rights (IPRs) policy is still controversial since two opposite effects need to be balanced. On the one hand, a tighter IPRs policy allows stronger incentives for economic agents to engage in knowledge creation activities; on the other hand, the same policy increases the cost borne by the public domain to exploit the newly created knowledge in order to generate further innovation. The net impact of these two opposite effects determines whether tighter IPRs policy regimes might lead to higher or lower levels of social welfare, thus indicating whether they might be desirable for the society as a whole.

The main contributions of this paper are twofold: (i) we provide a non-trivial extension of Tsur and Zemel's [16] model based on physical capital and knowledge accumulation to introduce a basic IPRs system driven by public intervention in order to compare the decentralized and the centralized outcomes; (ii) and we present a numerical approach to compute

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social welfare in such a complex framework in order to analyze how it is affected by different policy regimes. In our setup, the government completely finances the production of knowledge by relying upon a tax-subsidy scheme, and once knowledge has been produced it is immediately released for free in the public domain, as in [5]. This allows us to analyze how different degrees of public intervention affect the overall macroeconomic outcome both in the short and in the long run, quantifying the associated welfare effects. In order to do so, our computational procedure yields the approximation of the complete transition path of our endogenous growth model with IPRs, where knowledge does not evolve only because of profit seeking behavior (as traditionally discussed in the growth literature [2,14]), but also because of externalities that characterize knowledge advances during the Weitzman's [18] combinatorial nature of knowledge accumulation. This description of the complexity underlying knowledge dynamics is consistent with some empirical evidence [1] and allows us to better understand the relationship between policy, growth and welfare in real world economies.

To evaluate the effect of policy on welfare, we perform a comparative dynamics exercise analyzing how different values of the policy instrument will be reflected in the evolution of consumption over time, and thus on the level of social welfare. A critical aspect of such an approach consists of computing the value of consumption along the whole transitional dynamic path. We need to distinguish between three different kind of trajectories: those occurring along a characteristic curve labeled as 'turnpike', those outside the turnpike but eventually converging to the turnpike, and those never converging to the turnpike but ending up in stagnation. Because such types of transitional dynamics are tough objects to deal with, we rely on a wide range of numerical techniques in order to quantitatively assess different consumption paths and the social welfare they generate. The method we adopt in this paper provides a non-trivial extension of previous works by Privileggi [10–12], who has developed a reliable approach to study the transitional dynamics in continuous time recombinant growth models á-la Tsur and Zemel [16]. Specifically, we first apply a suitable transformation to the ODE defining the optimal transition dynamics in order to study their associated "detrended" system; such a transformation is a first novel technical contribution of the paper and leads to a system of ODEs [system (29)] that can be treated numerically. Next, a numerical method based on [11] is applied to such system in order to approximate the optimal policy along the (transitory) turnpike, while techniques extending those discussed in [12] are employed to approximate the transition dynamics starting outside the turnpike and leading toward the turnpike, as well as those describing the path toward a steady state. A bisection algorithm (Algorithm 1), providing a key step in the construction of the whole time-path trajectories starting off the turnpike and leading toward sustained growth, constitutes the second major original technical contribution. The resulting approximated trajectories allow to perform welfare analysis and comparative dynamics. The numerical procedure we develop in this paper can be applied also in other frameworks in order to numerically identify the stable arm leading to the equilibrium sustaining persistent growth — versus all smooth trajectories leading to a stagnation trap — arising from a dynamic optimization bang-bang problem, in which the whole growth enhancing stable arm is composed by multiple but joined (continuous) trajectories.

The paper proceeds as follows. Section 2 introduces our extended recombinant growth model and discusses short and long-run equilibria and the eventual convergence towards an asymptotic balanced growth path equilibrium. Sections 3–5 are the core of this paper, where we present a computational approach to fully analyze all types of transition dynamics associated to different policy regimes. Specifically, in Section 3, after introducing a suitable detrendization of variables, we characterize and compute the optimal consumption path along the turnpike, while in Section 4 we focus on trajectories that start off (above) the turnpike. We develop an algorithm (based on a bisection routine) to identify the intersection point between paths starting above the turnpike and their continuation along the turnpike itself, together with the optimal policies along the early transition, so that we can build the whole optimal consumption paths as piecewise functions by joining the early trajectories with their continuation along the turnpike. In Section 5 a similar kind of analysis is performed for studying trajectories not converging to the turnpike but leading to stagnation. All these findings allow us to assess the impact of different policy regimes on welfare, thus understanding how economic policy should be used in order to promote improvements in social welfare. Section 6 presents a specific illustrative example to test the performances of our approach and shows that welfare increases with the policy parameter and that a strictly positive tax level may be required to avoid stagnation. Section 7, as usual, concludes and discusses directions of future research.

2. Model and asymptotic equilibria

The model we consider is a continuous time Ramsey [13]-type model of endogenous growth with optimal knowledge creation; the setup is similar to [16] with the exception that the IPR system and government intervention follows [5]. The social planner maximizes social welfare by choosing the level of consumption, $c(t)$, and government expenditure, $G(t)$, taking into account the dynamic evolution of capital and knowledge. Social welfare is defined as the infinite discounted (ρ is the pure rate of time preference) sum of instantaneous utilities; the instantaneous utility function takes the following iso-elastic form: $u(c) = \left(c^{1-\sigma} - 1\right)/(1-\sigma)$, where $\sigma \geq 1$ is the inverse of the intertemporal elasticity of substitution.[1] A unique final consumption good is competitively produced in the economy according to a Cobb-Douglas production technology combining physical capital, $k(t)$, and the stock of knowledge, $A(t)$: $y(t) = F[k(t), A(t)] = \theta k(t)^{\alpha} A(t)^{1-\alpha}$ where $0 < \alpha < 1$ is the capital share and $\theta > 0$ a scale parameter measuring the total factor productivity. Apart from this consumption good, in the economy also knowledge is competitively produced by R&D-firms which sell the newly created knowledge to the government, which

[1] For $\sigma = 1$ $u(c)$ boils down to logarithmic utility.