International Review of Economics and Finance 51 (2017) 545–561

Contents lists available at ScienceDirect

International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref

International R&D funding and patent collateral in an R&D-based growth model

Wei-Chi Huang [a], Ching-Chong Lai [a,b,c,d], Ping-Ho Chen [b,*]

[a] Department of Economics, National Cheng Chi University, Taiwan
[b] Institute of Economics, Academia Sinica, Taiwan
[c] Institute of Economics, National Sun Yat-Sen University, Taiwan
[d] Department of Economics, Feng Chia University, Taiwan

ARTICLE INFO

JEL classification:
E44
O31
O40

Keywords:
International R&D funding
Patent collateral
R&D-based growth model
Optimal patent protection

ABSTRACT

This paper develops an R&D-based growth model featuring international R&D funding and patent collateral. Several main findings emerge from the analysis. First, with an inelastic labor supply, a rise in the fraction of patent collateral is beneficial to both innovations and economic growth. Second, when labor supply is inelastic, a rise in either the foreign interest rate or the fraction of borrowed R&D funding is harmful to innovations and economic growth. Third, our numerical results show that the above two findings are robust when labor is supplied elastically. Finally, our numerical results indicate that, regardless of whether labor supply is inelastic or elastic, the government can implement an optimal patent breadth policy to maximize the social welfare level. Our numerical results also point out that this optimal patent breadth will decrease in response to a reduction in the foreign interest rate, a rise in the fraction of the collateral, and a reduction in the fraction of borrowed R&D labor costs.

1. Introduction

In this paper, we develop an R&D-based growth model that features international R&D funding and patent collateral. We then use the model to examine how the international borrowing interest rate and the fraction of patent collateral will affect innovations and economic growth. In addition to providing a positive analysis of R&D investment and economic growth, this paper also presents a normative analysis regarding how the government will set its optimal patent protection from the viewpoint of welfare maximization.

This paper is motivated by the following three observations. Firstly, R&D entrepreneurs are subject to difficulties in obtaining finance. According to Zúñiga-Vicente, Alonso-Borrego, Forcadell, and Galán (2014), there are some reasons why R&D firms find it difficult to obtain sufficient funds from the banking system. The first reason is that R&D projects are subject to extreme uncertainty about their success. The second reason is that, to prevent bankers from revealing the information on R&D projects to industrial competitors, R&D firms are reluctant to disclose the details of their R&D projects in loan application documents. The third reason is that R&D projects are featured with the idea-based nature and the lack of tangible products. Due to the shortfall between R&D expenditure and funding in the form of loans from banks, R&D firms are forced to borrow from households and other non-bank funding sources to meet their R&D costs.

Secondly, the financing of business enterprise R&D from abroad is observed in OECD data. It is commonly believed that R&D funding

* Corresponding author. Institute of Economics, Academia Sinica, Nankang, Taipei 115, Taiwan.
E-mail address: 97258503@nccu.edu.tw (P.-H. Chen).

http://dx.doi.org/10.1016/j.iref.2017.07.009
Received 14 February 2017; Received in revised form 7 July 2017; Accepted 10 July 2017
Available online 20 July 2017

is critical for the growth effect of R&D investment. In their recent paper, using empirical data, Aghion, Farhi, and Kharroubi (2012) find that, by virtue of credit and liquidity constraints, R&D is more affected by a countercyclical monetary policy than by physical investment. To reflect this fact, Chu and Cozzi (2014) set up a Schumpeterian growth model that features a cash-in-advance (CIA) constraint on R&D investment. A notable specification of their model is that R&D entrepreneurs fully fund their investment from the home country. However, based on practical data, OECD (2011, p. 92) documents the following statement. "On average, R&D funding from abroad plays quite an important role in the funding of business R&D. In the EU, it represented around 10% of total business enterprise R&D in 2008. … For Austria, Ireland, the Slovak Republic and the United Kingdom, funds from abroad represented 20% or more of total business enterprise R&D."[1] As is obvious, the Chu and Cozzi (2014) specification ignores the fact that R&D companies obtain a considerable portion of their R&D funding from abroad.

Thirdly, the financing of business enterprise R&D is observed to be subject to patent collateral. It is quite possible that R&D firms will face financial frictions when they source R&D funding from the home country and/or abroad. A significant number of empirical studies, such as Brown, Martinsson, and Petersen (2012), Hochberg, Serrano, and Ziedonis (2014), and Mann (2016), point out that R&D patents often serve as collateral when entrepreneurs issue bonds to borrow funds for R&D. Among existing studies, Mann (2016) finds that in the U.S. during the period from 1990 to 2013 there has been an increasing tendency for patenting firms to pledge their patents as collateral. In 2013, about 40% of patenting firms posted their patents as collateral to obtain innovative financing. Based on these empirical findings, it is interesting to shed light on how patent collateral provides a vehicle to affect R&D investment and economic growth.

Up till now, to the best of our knowledge, no theoretical analysis has been devoted to dealing with international R&D funding and patent collateral in an R&D-based model.[2] To address the importance of these two R&D-related factors, this paper develops an R&D-based growth model that is able to reflect the realistic situation where R&D firms can obtain R&D funding from the international market and R&D patents can serve as collateral. With this framework, we are able to analyze how the international borrowing interest rate and the fraction of patent collateral will affect R&D investment, economic growth and social welfare.[3]

The normative analysis of this paper focuses on the factors determining optimal patent protection. In this regard, our study is most closely related to the literature on the optimal patent protection level. Within the literature, Iwaisako and Futagami (2003) and Futagami and Iwaisako (2007) show that stronger patent protection generates two conflicting effects on social welfare. On the one hand, it encourages R&D investment, and hence is beneficial to the growth rate and the social welfare level. On the other hand, a stronger patent protection tends to raise the markup price of intermediate goods. This tends to lower output production and the consumption of final goods, and hence is harmful to the social welfare level. Accordingly, the government will choose its optimal patent protection policy at the level where these two conflicting effects are balanced. Moreover, Chu and Furukawa (2011) find that under a centralized economy, the optimal patent protection level increases with the size of a quality improvement but decreases with the rate of time preference. In departing from these existing studies, this paper highlights how the optimal patent protection level interacts with international R&D funding and patent collateral.

The remainder of this paper is organized as follows. In Section 2, we construct an R&D-based growth model featuring international R&D funding and patent collateral. In Section 3, by focusing on the case where labor supply is perfectly inelastic, we discuss the growth effects of R&D-related shocks, and then analyze the optimal patent breadth policy and how it reacts to international R&D funding and patent collateral. Section 4 deals with whether our results in Section 3 are robust when labor supply is elastic. Finally, in Section 5, the main findings of the analysis are summarized.

2. The model

In this section we set up an R&D-based growth model that can be treated as an extension of the pioneering work by Romer (1990). In the Romer (1990) model, R&D investment leads to the creation of new varieties of intermediate goods. We extend the expanding-variety Romer (1990) model by bringing international R&D funding and patent collateral in R&D firms into the picture. In what follows, we will briefly describe the economy's structure.

2.1. Households

Consider an economy that is populated by a large number of identical and infinitely-lived households. Each household is endowed with one unit of time that is divided between labor L and leisure $H(=1-L)$. The lifetime utility of the representative household is given by:

$$\int_0^{\infty}\left[lnC_t+\Omega ln(1-L_t)\right]e^{-\rho t}dt;\quad \Omega>0,\rho>0, \tag{1a}$$

[1] See OECD (2011, p. 92) for the real values of R&D funds from abroad in OECD countries.

[2] In their open-economy R&D-growth models, Aghion, Howitt, and Mayer-Foulkes (2005) and Chu, Cozzi, Pan, and Zhang (2016) build up a distance-to-frontier R&D-based growth model, in which R&D entrepreneurs are subject to credit constraints rather than patent collateral constraints. However, these studies stress that a backward country's innovations will make its growth rate converge to the leading country's *exogenous* growth rate. This paper instead examines how international R&D funding and the international borrowing interest rate affect the *endogenous* growth rate. In addition, Amable, Chatelain, and Ralf (2010) set up an R&D-based growth model that features patents as collateral. However, their analysis does not involve international R&D funding.

[3] Turnovsky (1997) and Lai and Chin (2010) develop an open-economy endogenous model that features international funding and an imperfect world capital market. However, in their studies the economy's growth is driven by capital accumulation. Our analysis instead focuses on the relation between international funding and economic growth in an R&D-driven endogenous growth model.