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Innovation and imitation in a product-cycle model with FDI and cash-in-advance constraints

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ABSTRACT

This paper analyzes the long-run effects of monetary policy on innovation and imitation in a North–South product-cycle model with foreign direct investment (FDI) and separate cash-in-advance (CIA) constraints on innovative R&D, adaptive R&D, and imitative R&D. We find that if the CIA constraint is applied to innovative R&D, then a decrease in the Northern nominal interest rate will reduce the rate of Northern innovation and the extent of FDI while raising the rate of Southern imitation and the North–South wage gap. Regarding the effects of the Southern monetary policy, the object that is liquidity-constrained plays a significant role. If adaptive (imitative) R&D is subject to the CIA constraint, then a decrease in the Southern nominal interest rate will reduce (raise) the rate of Northern innovation and the extent of FDI while raising (reducing) the rate of Southern imitation. The stability of the long-run equilibrium is examined. We also analyze the responses of social welfare for Northern and Southern consumers to monetary policy.

1. Introduction

Technological progress resulting from research and development (R&D) has allowed consumers to enjoy goods with better quality. Advances in technology also cause improvements in transportation, making international production through foreign direct investment (FDI) quite common nowadays. When considering the location of production, firms can choose to produce goods domestically or abroad as a means of saving costs. The availability of FDI allows monetary policy in one country to have cross-country influences due to the adjustment of the production pattern for firms in response to these policy changes. In this paper we investigate the long-run macroeconomic effects of monetary policy in a two-country model with FDI and quality improvements of goods.

The macroeconomic effects of monetary policy have long been an important issue in macroeconomics. Based on a descriptive aggregate model, the pioneering paper of Tobin (1965) demonstrates that a higher money growth rate can positively affect the accumulation of physical capital due to the reduction in the real interest rate. Stockman (1981) and Abel (1985) develop a cash-in-advance (CIA) economy where consumption/investment is subject to the CIA constraint to analyze the impact of monetary policy.

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The CIA model subsequently undergoes various modifications in several studies that examine the effects of monetary policy on economic growth.[1] These studies focus on the effects of monetary policy on economic growth that depends on the accumulation of physical and human capital and ignore the impact on innovation resulting from R&D. However, the empirical evidence suggests that there is a significant relationship between R&D expenditures and cash flows (Hall, 1992; Opler et al., 1999 and Himmelberg and Petersen, 1994). Recently, several studies introduce the CIA-constrained property into an R&D model to examine the effects of monetary policy. However, most studies in this field tend to restrict their analysis to a closed economy and very few studies examine the cross-country effects of monetary policy. Based on a closed-economy product-cycle model, Chu and Cozzi (2012) and Huang et al. (2014) look at how monetary policy affects the market structure and employment. A model with Northern and Southern countries is developed by Chu et al. (2013) to analyze how monetary policy affects R&D and technology transfer via FDI.

This paper introduces the CIA constraint into a North–South product-cycle model with technology transfer via FDI to examine the effects of monetary policy on innovation, imitation, and production pattern.[2] Our product-cycle model presents innovative R&D in the North (a developed country), with adaptive R&D through FDI and imitative R&D in the South (a developing country). Innovation improves the quality of goods and Northern workers can work either in the R&D sector or in the production sector. Northern production firms choose either to carry out the entire production of the goods in the North or allow the goods to be produced through FDI in the South. Multinational firms produce products in the South through the use of state-of-the-art technologies (adaptive R&D) in order to take advantage of the lower Southern wage rate, but they face the risk of imitation by Southern firms. Southern firms can raise their rate of imitation (imitative R&D) by investing in imitation. Once Southern firms succeed at imitation, they are then able to use the state-of-the-art technologies to produce the highest quality products.

There are two features of this paper. First, imitation is costly and the rate of imitation is endogenized. Previous theoretical studies related to R&D and imitation tend to assume that imitation is costless and the rate of imitation is exogenous. Although assuming that imitation is costless can simplify the analysis a lot, empirical studies find that imitation is in fact a costly process. By asking firms to estimate typical costs required to duplicate several categories of innovations if a competitor has developed them, Levin et al. (1987) show that imitation is not free. Their survey data indicate that for a major unpatented new product, the cost of duplication is between fifty-one to seventy-five percent of the innovator's R&D cost for more than half of firms.[3] Using data from firms in the chemical, drug, electronics, and machinery industries, Mansfield et al. (1981) report that for 30 out of 48 products, the innovation cost exceeds \$1 million, while for 12 products, it exceeds \$5 million. They also note that on average the ratio of the imitation cost to the innovation cost is about 0.65. Since the cost of imitation is significant, the assumption of costless imitation may be convenient for analysis, but it considerably departs from reality. Besides failing to reflect reality, the lack of an appropriate consideration of the nature of imitation may not provide a complete picture for policy implications.[4]

Second, R&D activities are subject to CIA constraints. Brown and Petersen (2009, 2011) argue that since R&D has high adjustment costs, it is very expensive for firms to adjust the flow of R&D in response to transitory finance shocks. They provide direct evidence that U.S. firms relied heavily on cash reserves to smooth R&D expenditure during the 1998–2002 boom and bust in stock market returns.[5] Brown et al. (2009) estimate a dynamic R&D model for high-tech firms and find that cash holdings have a significant impact on R&D in young firms. Hall and Lerner (2010) show that in practice fifty percent or more of R&D spending goes to the wages and salaries of highly educated technology scientists and engineers. Because projects often take a long time between conception and commercialization and the departure of these highly educated workers will reduce a firm's profits, firms tend to hold cash in order to smooth their R&D spending over time, in order to avoid having to lay off these workers. These findings suggest that innovative-firms are subject to cash constraints. Furthermore, Mansfield et al. (1981) point out that innovators usually have a technological edge over their rivals in the relevant field. Often this edge is due to superior “know-how” - that is, better and more extensive technical information based on highly specialized experience with the development and production of related products. Thus, an imitator has to go through many of the same steps as an innovator. Their results suggest that an imitation-incentive firm, like an innovation-incentive firm, also relies on cash reserves to smooth its imitation spending due to high adjustment costs of imitation or the requirement for hiring highly educated workers.

In order to capture the cash requirements faced by innovative-incentive and imitative-incentive firms, we consider three scenarios based on the setting of CIA constraints: a CIA constraint on innovative R&D in the North, a CIA constraint on adaptive R&D in the South, and a CIA constraint on imitative R&D in the South.[6] While we examine the impact of the Northern monetary policy (a

[2] For example, Suen and Yip (2005) show that indeterminacy may occur in a one-sector CIA model with an *AK* production function. A two-sector model with human capital accumulation and a CIA constraint is found in Marquis and Reffett (1991) and Mino (1997). Wang and Yip (1992) examine the impact of monetary policy under various monetary models.

[3] The North–South product-cycle model is originally introduced by Vernon (1966) and subsequently developed by Segerstrom et al. (1990) and Grossman and Helpman (1991a, 1991b).

[4] Patents tend to raise imitation costs. For a major patented new product, the cost of duplication is between seventy-six to one hundred percent of the innovator's R&D cost for more than half of firms.

[5] For studies considering costly imitation, see Gallini (1992) and Chen (2018). Gallini (1992) develops a closed-economy model with costly imitation and finds that a rival's decision to imitate depends on the length of patent protection awarded to the patentee. Chen (2018) examines the effects of the strengthening of intellectual property rights in developing countries in a North–South model with costly imitation.

[6] Brown et al. (2012) argue that information friction and the lack of collateral value make R&D more sensitive to financing frictions; thus, R&D-incentive firms tend to hold cash to prevent themselves from financing R&D investment through debt or equity. Using a large sample of European firms, they find strong evidence that the availability of finance matters for R&D once they control for a firm's efforts to smooth R&D with cash reserves and a firm's use of external equity finance.