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Inflation, R&D and growth in an open economy ☆

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ABSTRACT

This study explores the long-run effects of inflation in a two-country Schumpeterian growth model with cash-in-advance constraints on consumption and R&D investment. We find that increasing domestic inflation reduces domestic R&D investment and the growth rate of domestic technology. Given that economic growth in a country depends on both domestic and foreign technologies, increasing foreign inflation also affects the domestic economy. When each government conducts its monetary policy unilaterally to maximize the welfare of domestic households, the Nash-equilibrium inflation rates are generally higher than the optimal inflation rates chosen by cooperative governments who maximize the welfare of both domestic and foreign households. Under the CIA constraint on R&D (consumption), a larger market power of firms amplifies (mitigates) this inflationary bias. We use cross-country panel data to estimate the effects of inflation on R&D and also calibrate the two-country model to data in the Euro Area and the US to quantify the welfare effects of decreasing the inflation rates from the Nash equilibrium to the optimal level.

1. Introduction

This study explores the long-run effects of inflation on economic growth and social welfare in an open economy. We develop a two-country version of the Schumpeterian growth model and introduce money demand into the model via a cash-in-advance (CIA) constraint on R&D investment in each country. Empirical evidence supports the view that R&D investment is severely affected by cash requirements.[1] We capture these cash requirements on R&D using a CIA constraint. Given this CIA constraint on R&D, inflation that determines the opportunity cost of cash holdings affects R&D investment, economic growth and social welfare.[2] In an open economy, inflation by affecting innovation and technologies also has spillover effects across countries through international trade.[3] Our model captures these spillover effects in the form of international technology spillovers and international business stealing, which are novel channels through which cross-border monetary spillovers shape the outcome of monetary policy competition across countries.

The results from our growth-theoretic analysis can be summarized as follows. An increase in domestic inflation decreases domestic R&D investment and the growth rate of domestic technology. Given that economic growth in a country depends on both domestic and foreign technologies, an increase in foreign inflation also affects the domestic economy. When each government conducts its monetary policy unilaterally to maximize the welfare of only domestic households, the Nash-equilibrium inflation rates are generally different from the optimal inflation rates chosen by cooperative governments who maximize the aggregate welfare of domestic and foreign households. We find that

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[1] We discuss these empirical studies in the literature review.

[2] See Chu and Cozzi (2014) for an analysis of the effects of inflation in a closed-economy Schumpeterian growth model with a CIA constraint on R&D investment.

[3] See Coe and Helpman (1995), Bayoumi et al. (1999) and Coe et al. (2009) for empirical evidence on technology spillovers across countries.

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under the special case of inelastic labor supply, the Nash-equilibrium inflation rates coincide with the optimal inflation rates. However, under the more general case of elastic labor supply, the Nash-equilibrium inflation rates become higher than the optimal inflation rates due to a cross-country spillover effect of monetary policy. The intuition can be explained as follows. When the government in a country reduces its inflation, the welfare gain from increased R&D is shared by the other country through technology spillovers, whereas the welfare cost of increasing labor supply falls entirely on domestic households. As a result, the governments do not reduce inflation sufficiently in the Nash equilibrium.

The wedge between the Nash-equilibrium and optimal inflation rates depends on the market power of firms. Under the CIA constraint on consumption, a larger markup reduces this wedge. This finding is consistent with the interesting insight of Arseneau (2007), who shows that the market power of firms has a dampening effect on the inflationary bias from monetary policy competition analyzed in an influential study by Cooley and Quadrini (2003). However, under the CIA constraint on R&D investment, we have the opposite result that a larger markup amplifies the inflationary bias from monetary policy competition. These different implications highlight the importance of the differences between the two CIA constraints. The main difference between the CIA constraint on consumption and the CIA constraint on R&D is that under the latter, an increase in the inflation rate leads to a reallocation of labor from R&D to production. As a result, higher inflation rates would be chosen by governments in the Nash equilibrium to depress R&D when the negative R&D externality in the form of a business-stealing effect determined by the markup becomes stronger. In contrast, under the CIA constraint on consumption, this reallocation effect is absent because an increase in the inflation rate reduces both R&D and production by decreasing labor supply. Given that increasing the markup worsens a monopolistic distortionary effect on the production of goods, governments would reduce inflation in the Nash equilibrium to stimulate production when this monopolistic distortion measured by the markup becomes stronger.

We use cross-country panel data to estimate the effects of inflation on R&D and find that there is a statistically significant negative relationship between the inflation rate and the R&D share of GDP. Our preferred regression estimate shows that the semi-elasticity of R&D with respect to inflation is −0.374 (i.e., a 1 percentage point increase in the inflation rate is associated with a decrease in the R&D share of GDP by 0.374%). We also calibrate the two-country model to aggregate data in the Euro Area and the US to simulate the quantitative effects of inflation on R&D. We find that the simulated semi-elasticities of R&D with respect to inflation are −0.448 in the Euro Area and −0.266 in the US. These values are in line with the regression estimate.

In the numerical analysis of the Nash equilibrium, we consider the case in which final goods are produced by a CES aggregate of domestic and foreign intermediate goods, which introduces an *international* business-stealing effect across countries. In other words, when a country decreases its inflation to improve domestic technology, domestic firms are able to capture a larger share of the global market due to the substitutability of domestic and foreign intermediate goods. This effect represents a negative externality of monetary policy. Together with the positive externality from technology spillovers, we find that the Nash equilibrium continues to feature an inflationary bias. Therefore, we proceed to quantify the welfare effects of decreasing the inflation rates from the Nash equilibrium to the optimal level. We find that the Friedman rule is optimal (i.e., a zero nominal interest rate maximizes welfare). In this case, decreasing the inflation rates from the Nash equilibrium to achieve a zero nominal interest rate in both economies would lead to nonnegligible welfare gains that are equivalent to a permanent increase in consumption of 1.038% in the US and 0.249% in the Euro Area. However, a unilateral deviation to decrease the inflation rate from the Nash equilibrium would hurt the domestic economy and only benefit the foreign economy. For example, we find that a unilateral decrease in the inflation rate in the Euro Area would reduce its welfare by 0.213% but increase welfare in the US by 1.079%.

1.1. Literature review

Given that one of the key assumptions of our model is the presence of a CIA constraint on R&D, here we first review the evidence in favor of this assumption. Hall (1992), Himmelberg and Petersen (1994), Opler et al. (1999) and Brown and Petersen (2009) find a positive and significant relationship between R&D and cash flows in US firms. According to Bates et al. (2009), the average cash-to-assets ratio in US firms increased substantially from 1980 to 2006, and this change is partly due to their increased R&D expenditures. Brown et al. (2009) provide empirical evidence that the increase in corporate cash flow in the 1990's drives the increase in R&D in that period. Recent studies by Brown and Petersen (2011) and Brown et al. (2012) explain this phenomenon by providing evidence that firms smooth R&D expenditures by maintaining a buffer stock of liquidity in the form of cash reserves. Furthermore, Brown and Petersen (forthcoming) show that firms use cash reserves to finance R&D but not capital investment. Berentsen et al. (2012) argue that information frictions and limited collateral value of intangible R&D capital prevent firms from financing R&D investment through debt or equity forcing them to fund R&D projects with cash reserves. A recent study by Falato and Sim (2014) provides causal evidence that R&D is a first-order determinant of firms' cash holdings. They use firm-level data in the US to show that firms' cash holdings increase (decrease) significantly in response to a rise (cut) in R&D tax credits,[4] which vary across states and time. Furthermore, these effects are stronger for firms that have less access to debt/equity financing. These results suggest that due to the presence of financing frictions, firms hold cash to finance their R&D investment. As for the effect of inflation on firms' cash holdings, Pinkowitz et al. (2003) and Ramirez and Tadesse (2009) provide empirical evidence to show that inflation has a negative effect on cash holdings because firms "prefer to lower their holdings of cash in anticipation of it losing value during inflation." Finally, Evers et al. (2009) use firm-level panel data to show that high inflation depresses firms' R&D investment by decreasing their liquidity holdings.

This study also relates to the growth-theoretic literature of inflation and economic growth, which explores the long-run effects of inflation on capital investment. Stockman (1981) and Abel (1985) provide the seminal studies of the CIA constraint on capital investment in the Neoclassical growth model. Subsequent studies, such as Stadler (1990), Gomme (1993), Dotsey and Ireland (1996), Wu and Zhang (1998) and Ho et al. (2007), explore the effects of monetary policy in endogenous growth models. Instead of analyzing monetary policy in capital-based growth models, we consider an R&D-based growth model in which economic growth is driven by R&D investment. The seminal study in this literature of inflation and *innovation-driven* growth is Marquis and Reffett (1994), who explore the effects of a CIA constraint on consumption in a Romer variety-expanding model.[5] In contrast, we consider a Schumpeterian quality-ladder model and analyze the effects of inflation via a CIA constraint on R&D investment as in Chu and Cozzi (2014).[6] Chu and Ji (forthcoming) and Huang et al. (2013) also analyze monetary policy via CIA constraints but in a Schumpeterian model with endogenous market structure. The present study differs from the closed-economy analyses in Chu and Cozzi (2014), Chu and Ji (forthcoming) and Huang et al. (2013) by

[4] Interestingly, firms' cash holdings have the opposite reaction to changes in investment tax credits.

[5] Chu et al. (2012) provide an analysis of the CIA constraint on consumption in a hybrid growth model in which economic growth in the long run is driven by both variety expansion and capital accumulation.

[6] See Chu and Lai (2013) for an analysis of the money-in-utility approach to model money demand in the quality-ladder growth model.