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R&D and aggregate fluctuations

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ABSTRACT

Empirical observations raise interesting questions regarding the sources of the excessive volatility in the R&D sector as well as the nature of the relation between the sector and aggregate fluctuations. Using US data for the period 1959–2007, we identify sectoral technology and capital investment-specific shocks by employing a Vector Autoregression. The identifying assumptions are motivated by a two-sector dynamic general equilibrium model. Controlling for real and nominal factors, we find that capital investment-specific shocks explain 70 percent of fluctuations of R&D investment, while R&D technology shocks explain 30 percent of the variation of aggregate output, net of R&D investment. Technology shocks jointly explain almost all the variation of output in the R&D sector and 78 percent of the variation of output in the rest of the economy. They also constitute the main factor of the procyclicality of R&D investment.

1. Introduction

The research and development (henceforth R&D) sector is considered one of the main driving forces of sustainable growth in the long run. However, investment in R&D as well as employment in the R&D sector exhibit substantial fluctuations relative to those of aggregate production and aggregate employment. Contrary to the Schumpeterian view, R&D appears to be procyclical in the data. These facts raise interesting questions regarding the sources of the excessive volatility, and the nature of the relation between the R&D sector and aggregate fluctuations. The purpose of this paper is to examine the impact of technology shocks on the R&D sector, as well as the contribution of the sector to annual fluctuations.

The previous literature has found that neutral technology shocks and shocks that improve the efficiency of newly produced capital are important sources of output fluctuations.[1] The identified technology shocks might be, to some extent, the result of R&D activities which were not modeled explicitly. It is also possible that some technology innovations emerging from R&D sectors are not well captured by the aggregate Solow residual and the real price of capital investment. This paper builds upon Fisher (2006), and introduces sectoral productivity and capital investment-specific shocks into a conventional

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[1] E.g. see Greenwood et al. (2000) and Fisher (2006).

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two-sector dynamic stochastic general equilibrium (DSGE) model with R&D, which motivates three long-run identifying restrictions.

The identifying assumption for investment-specific shocks is the same as the one utilized by Fisher (2006), where the real price of capital investment is affected only by investment-specific shocks in the long-run. Unlike Fisher's model, the two-sector model implies two sectoral technologies which affect sectoral labor productivities in the long-run. The output in the R&D sector is used as an input in the production of the non-R&D output, but the reverse is not true. Therefore, we argue that it is reasonable to assume that, in the long-run, the output of the R&D sector (thus labor productivity) is affected only by R&D technology shocks and capital investment-specific shocks. This long-run implication is used as an identifying restriction for R&D technology shocks. Then, technology shocks in the non-R&D sector are identified by imposing the restriction that in the long-run, labor productivity in the non-R&D sector is affected only by the three technology shocks. Following Fisher (2006), those restrictions are then imposed on a Vector Autoregression (VAR) to identify the shocks. The VAR is estimated using US macroeconomic time series along with data on R&D investment and GDP from the Bureau of Economic Analysis (BEA) and the National Science Foundation (NSF) satellite account for the period prior to 2008.

To quantify the impact of R&D on aggregate fluctuations, we first estimate a VAR using seven post-war annual time series. Similar to Fisher (2006), the shocks are identified by imposing long-run restrictions which are justified by the theoretical model. Data on R&D are only available at the annual frequency. Thus, we focus our analysis on those frequencies.[2] The plausibility of the empirical impulse responses is assessed by comparing them with the theoretical ones which are generated by the simple equilibrium model.

We find that capital investment-specific shocks play the largest role in driving the fluctuations of R&D investment while R&D productivity shocks affect considerably the fluctuations of output in the non-R&D sector. Our economic model demonstrates that factors that contribute to the stock of R&D are not limited to the resources listed under R&D expenditures in the official accounts. While there can be direct additions to the stock of R&D within the R&D sector (identified from data on R&D expenditures), there can also be costly transfers from the non-R&D sector contributing to the stock of R&D. We show that the price of a transfer is inversely related to positive R&D shocks. As a result, an innovation in the R&D sector may induce a transfer of resources from the non-R&D sector as an investment in the stock of R&D which, in turn, augments the production of the non-R&D output. Our calibration suggests that at the steady state such transfers are positive. Despite the fact that the size of the R&D sector is small, R&D specific shocks have a significant impact on aggregate fluctuations.

Our analysis designates that capital investment-specific shocks constitute the main source of fluctuations in R&D investment and improvements in productivity in the R&D sector induce a considerably positive impact on the output of the non-R&D sector. The variance decomposition implies that R&D productivity shocks explain 30 percent of the variation of output in the non-R&D sector. Non-R&D productivity shocks, on the other hand, play a smaller role in driving the fluctuations of output in the two sectors. We find that technology shocks jointly explain almost all the variability of output in the R&D. Among the three shocks, capital investment-specific shocks cause the biggest impact on hours for both sectors. Our results confirm Ouyang's (2011) findings, showing that technology shocks are important factors of the procyclicality of R&D since capital investment-specific and R&D productivity shocks, being the main sources of output volatility in the two sectors, induce output responses of the same sign.

In a separate exercise, we treat R&D solely as an expense according to the NIPA definitions and estimate a VAR which corresponds to a simplified one-sector version of our model. Doing so, we show that capital investment-specific shocks and neutral technology shocks generate similar results to previous studies. This exercise also signifies that if the R&D sector is excluded from the model and R&D is not treated as an investment, the effect of technology shocks on hours is overstated to some extent.

There are a few theoretical papers in the literature showing the role of R&D in driving aggregate fluctuations. Comin and Gertler (2006) stress the significance of R&D in generating medium-run fluctuations using an endogenous growth model. Butler and Pakko (1998) and Fátas (2000) demonstrate that R&D shocks improve the persistence of the dynamics of output and productivity.[3] Maliar and Maliar (2004) show that a DSGE model with R&D can account for the asymmetry in the shape of business cycles. However, R&D moves countercyclically in their model, which is at odds with observations in the data. Barlevy (2007) addresses this issue by arguing that R&D might be procyclical because of a dynamic externality inherent to R&D.

The empirical literature which relates R&D with fluctuations has been relatively more limited. Lach and Schankerman (1989) and Lach and Rob (1996) find that both R&D activities and capital investment are affected by a common shock which has very persistent effects. Geroski and Walters (1995) conclude that although aggregate demand affects innovation activity, it plays only a modest role as opposed to aggregate supply.

One issue in the literature is that there are no good measures of the contribution of R&D to technological improvements as they are reflected by the fluctuations of aggregate production. Patents might be an indicator of the inventive activity but they are not very explicit about the degree of the effect of R&D on macroeconomic fluctuations. Griliches (2000) argues that patent applications are usually taken early during research processes in expectation of long run gains. As a result, there is lag

[2] Comin and Gertler (2006) show that information extracted from annual data regarding medium-run fluctuations is virtually the same as that extracted from quarterly data.

[3] Among others, see Braun and Nakajima (2009) also demonstrate the significance of R&D in a DSGE model.