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Technology shocks, capital utilization and sticky prices

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ABSTRACT

We quantitatively evaluate a business-cycle environment featuring endogenous capital utilization and nominal price rigidity that illustrates a negative relationship between labor hours and technology (TFP) shocks and a positive relationship between hours and investment (MEI) shocks. Sticky prices induce firms to suppress changes in output due to TFP shocks through changes in the utilization rate of the existing capital stock and labor demand. MEI shocks have an indirect impact on output via their link with capital utilization, and are shown to be the dominant driver of post-1979 US business cycles.

1. Introduction

What are the sources of observed fluctuations in macroeconomic aggregates? Following Kydland and Prescott (1982) and Long and Plosser (1983), business-cycle fluctuations are initiated by shocks to total factor productivity (TFP) which proportionately influence the efficiency of productive inputs. While these shocks can be interpreted broadly, they stand in contrast to Keynes' view that shocks to the marginal efficiency of investment (MEI) are a primary source of business cycles. Greenwood et al. (1988) analyze MEI shocks and match observed fluctuations in output almost as well as Prescott (1986) who only considers shocks to TFP.[1]

Since Gali (1999), a vast literature using extensions of the canonical RBC environment have raised doubts that TFP shocks are the main source of business-cycle fluctuations. While shocks to both TFP and MEI remain in these environments (e.g. Smets and Wouters, 2003; Ireland, 2003), they also commonly include competing shocks, real and nominal rigidities, and various mechanisms which have theoretical and empirical support for their inclusion.[2] While the increased complexity of these environments captures features of the data and addresses important macroeconomic questions, an in depth study of TFP and MEI shocks and their relationship with these various extensions has yet to be documented.

We study the role of such technology shocks in explaining macroeconomic fluctuations in an extension of Ireland (2003). To capture the full interaction of neutral TFP and MEI shocks, we extend the environment by adding endogenous capital utilization following Greenwood et al. (2000).[3] Combining endogenous capital utilization along with commonly

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[1] Greenwood et al. (2000) have further shown that MEI shocks explain about 30 percent of output fluctuations in a flexible-price environment.
[2] Several other key examples are Christiano et al. (2005) and Francis and Ramey (2005).
[3] The capital utilization mechanism explored by Greenwood et al. (2000) is a decentralized version of the mechanism explored by Greenwood et al. (1988).

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assumed capital adjustment costs allow us to analyze both an intensive and extensive margin of productive capital. We follow Ireland and include three additional shocks common to the literature (i.e. preferences, money demand, and money supply), as well as estimate key parameters of the model via maximum likelihood. However, our inclusion of endogenous capital utilization forces us to employ a different criterion when determining which parameters are to be estimated or calibrated prior to estimation. This difference allows us to better interpret the model and compare the results across data subsets and sticky versus flexible-price assumptions.

Our main contribution is to show that endogenous capital utilization, nominal rigidity, and active monetary policy are necessary ingredients to reproduce key empirical observations on the US economy's response to neutral TFP and MEI shocks recently made by Basu et al. (2006), Fisher (2006), and Canova et al. (2008). Fisher (2006) and Canova et al. (2008) find that labor hours fall in response to positive neutral TFP shocks and rise in response to positive MEI shocks. The decline in hours due to an increase in TFP is a robust feature of our sticky-price model due to the firm's desire to suppress the exogenous increase in output by decreasing the utilization rate of the existing capital stock. In the pre-1979 version of the model, a relatively high degree of nominal rigidity and a large interest rate response by the monetary authority to changes in real output induce firms to contract output in response to positive TFP innovations as reported by Basu et al. (2006). In contrast, positive MEI shocks have an indirect impact on output by inducing an increase in the utilization rate of the existing capital stock in order to finance a larger future capital stock. Using additional output to finance investment does not have the same impact on goods prices as an increase in consumption, so firms do not work against MEI shocks as they do against TFP shocks. Since these results hinge on the rigidity of nominal prices, we show that flexible-price versions of our economy display none of these observations.

Another result of the analysis is that MEI shocks dominate TFP shocks as the most important source of business cycles in the post-1979 data. This result coincides with the empirical results of Fisher (2006) and others that TFP shocks account for a small fraction of business cycle fluctuations. However, we show that this result is prevalent in versions of our model with and without the assumption of sticky prices. This suggests that features other than nominal rigidities are driving this result.

Our results suggest that several widely accepted features of a macroeconomic environment are important ingredients in accounting for key US business cycle observations. The environment need not resort to various (and potentially controversial) real frictions such as habit persistence (e.g. Francis and Ramey, 2005) or more sophisticated mechanisms for capital utilization (e.g. Christiano et al., 2005 or Schmitt-Grohé and Uribe, 2007).[4] This is not to say that models with these features are unable to generate the results presented here. For example, Justiniano et al. (2010) estimate an extension of Smets and Wouters (2003) using Bayesian techniques and show a dominance of MEI shocks over the business cycle, a positive response of labor hours to a positive MEI shock, as well as a negative response of labor hours to a positive (albeit, labor-augmenting) TFP shock.[5] Their model is a medium-scale DSGE framework featuring many of the frictions and mechanisms discussed above, and estimated using the entire post-war US data. Our framework is relatively more parsimonious and therefore able to focus upon technology shocks and their relationship with endogenous capital utilization and nominal rigidities. Furthermore, the fact that our flexible-price environment also suggests that MEI shocks are the dominant source of post-1979 business cycles leaves open the debate pertaining to the importance of the features in their environment delivering this result.[6]

The remainder of the paper is as follows. Section 2 presents the model. Section 3 presents the quantitative analysis. Section 4 concludes.

2. The model

2.1. Environment

The economy consists of a large number of identical households, a large number of identical final goods-producing firms, a continuum of intermediate good-producing firms indexed by $i \in [0,1]$, and a monetary authority. Intermediate firm i produces a distinct, perishable good i, which it sells in a monopolistically competitive market to final goods-producing firms to be used as an input in production.

Households have preferences over consumption (c_t), real money balances (M_t/P_t), and hours worked (h_t)

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, \frac{M_t}{P_t}, h_t, a_t, e_t\right), \tag{1}$$

where E_0 is the expectations operator conditional on information available at time 0 and $\beta \in (0,1)$ is the discount factor. The last two arguments in (1) are exogenous shocks to preferences which influence the relative weights of each input to

[4] Otrok et al. (2002) provide evidence against the assumption of habit-forming agents, while Groth and Khan (2007) show weak independent estimates of investment adjustment costs.

[5] While Justiniano et al. (2010) do not emphasize the impulse responses of labor-augmenting TFP in their paper, they refer the reader to a previous version.

[6] For example, Ireland and Schuh (2008) estimate a two sector, real business cycle model without money to illustrate that large innovations to investment and investment-specific technological progress have occurred since the productivity slowdown of the 1970s.