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Long run productivity risk and aggregate investment

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ABSTRACT

Long-run productivity risk – shocks to the growth rate of productivity – offers an alternative to microfrictions explanations of aggregate investment non-linearities, in particular the heteroscedasticity of investment rate. Additionally, consistent with the data, these shocks imply that investment rate is history dependent (rising through expansions), its growth is positively autocorrelated, and it is positively correlated with output growth at various leads and lags. A standard model with shocks to the level of productivity either predicts opposite investment behavior or fails to quantitatively capture these features in the data.

1. Introduction

U.S. nonresidential private fixed investment displays nonlinearities and the causes of these non-linearities have been a source of debate for macroeconomists. This is because the behavior of aggregate investment can shed light on the importance of adjustment costs to firms, on the nature of the shocks affecting the economy, and on household preferences. In particular, Caballero et al. (1995), Caballero and Engel (1999), Cooper et al. (1999) show that in partial equilibrium non-convex adjustment costs can lead to investment nonlinearities (i.e. non-linear responses of investment to shocks, such as heteroscedasticity). Thomas (2002) and Khan and Thomas (2008) (henceforth KT) argue that general equilibrium effects on prices undo much of this while Bachmann et al. (2011) (henceforth BCE) show that non-convex frictions can give rise to conditional heteroscedasticity in a DSGE model providing a counterexample to KT.[1]

While non-convex costs may be important, we offer an alternative explanation for the behavior of aggregate investment. The key finding is that shocks to the growth rate, as opposed to the level, of total factor productivity (TFP) naturally imply that the aggregate investment rate is heteroscedastic if households have preference for smoothing consumption over time.[2] Moreover, beyond explaining the conditional heteroscedasticity in the aggregate investment rate, the model generates other interesting dynamics in aggregate investment that are difficult to explain by standard models. In particular, as in the data, the model implies that the investment rate is history dependent in that longer expansions are associated with larger

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[1] The heart of the debate lies in whether general equilibrium forces can cancel out aggregate investment demand implied by micro lumpy investment. Consider firms that face a non-convex (i.e. fixed) cost to invest; such firms will have a cut off rule in deciding whether to invest a large amount or none at all. Suppose many firms are just below the cutoff and not investing, then a small positive aggregate shock can drive a large number of firms over the hump, resulting in large swings of investment as everyone suddenly invests (extensive margin). Without fixed costs firms will only adjust the quantity of investment (intensive margin) and such large swings in response to small shocks would not occur. According to the intuition in KT, general equilibrium forces prevent a large number of firms from concentrating just below the cutoff. This is because investment is valuable and some firms would invest earlier in expectation of higher returns. However, BCE show that both adjustment costs and general equilibrium forces play a relevant role. In particular, when extensive margin is calibrated to have a more important role in shaping aggregate investment than general equilibrium constraints, non-convex frictions can have a consequential effect on aggregate quantities.

[2] The growth rate shocks are exactly the types of shocks necessary to produce high Sharpe Ratios in a Long Run Risk model such as Bansal and Yaron (2004).

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increases in investment, that investment rate growth is positively autocorrelated, and that investment rate growth is positively correlated with output growth at various leads and lags. A standard model with shocks to the level of TFP cannot produce these features of aggregate investment. Finally, it is shown that if growth rate shocks are the drivers of business cycles, then matching the joint behavior of consumption, investment, and hours implies that the intertemporal elasticity of substitution (IES) should not be too low.

The importance of modeling growth rate (permanent) shocks and the interaction of such shocks with the IES has been a hotly discussed topic in finance (i.e. Bansal and Yaron, 2004; Alvarez and Jermann, 2005). Beyond providing a potential explanation of aggregate investment behavior, the findings offer additional confirmation for the importance of such shocks and for the likely range of the IES, even independently of asset pricing considerations.

The conditional heteroscedasticity in the aggregate investment rate refers to the conditional volatility of the investment rate being high in times of high past investment (see Fig. 1). As mentioned above, BCE show that this can be explained by non-convex adjustment costs. The model with growth rate shocks naturally implies that the investment rate is heteroscedastic, even without adjustment costs, as long as households prefer to smooth consumption over time. When there is no preference for smoothing consumption over time (this corresponds to an infinite intertemporal elasticity of substitution), capital adjusts to its optimal target capital (which is implied by the level of productivity and does not depend on past capital) immediately; therefore the investment rate is perfectly correlated with the realized growth rate of technology. If there is no heteroscedasticity in this growth rate, there will not be heteroscedasticity in the investment rate. When households have a preference for smoothing consumption, the realized investment rate will be positively related to both the realized growth rate of technology, and to the past investment rate; this is because in the past households were smoothing consumption and did not fully adjust capital to the long term trend. As a result, the high past investment rate amplifies shocks to the growth rate of technology, making the conditional volatility of investment rate higher when past investment rate is higher. The relationship between the investment rate, the growth rate of technology, and the past investment rate is true for both permanent (growth) shocks and transitory (level) shocks. However, because for level shocks the growth rate of technology and investment rate are negatively correlated, the amplification mechanism resulting in heteroscedasticity fails unless the transitory shocks are extremely persistent. Note that the growth rate of an AR(1) process is negatively related to its level (this weakens with high persistence). Because the past investment rate is high when the level of transitory productivity is high, which in turn is associated with a lower growth rate of future productivity, this works to dampen the mechanism resulting in near zero heteroscedasticity in a model with only transitory shocks.

History dependence is another important feature of aggregate investment. It refers to the investment rate rising through expansions, and falling through recessions (see Fig. 2). This feature of investment naturally arises in a model with growth rate shocks but *not* a model with level shocks. The intuition is as follows. When, as in standard models, shocks are to the level of productivity, firms have an optimal level of capital associated with each productivity level. When the productivity level increases due to a positive shock, so does optimal capital and firms choose the investment rate based on the distance to the optimum. Subsequent positive shocks are counterbalanced by mean reversion, resulting in little change to the currently optimal capital levels. The result is an initial jump in the aggregate investment rate, followed by a slow decline towards the long-run average, even as more positive shocks arrive. This is because firms are closer and closer to their optimal target capital. On the other hand, when the growth of productivity is persistent, a shock to productivity implies a permanent change in the level of productivity. Subsequent positive shocks are again counterbalanced by mean reversion, but this time it is the growth rate, rather than level of productivity that stays high. This results in further increases to productivity and to the optimal target capital, requiring even more investment. Thus the investment rate is history dependent, growing (falling) as the expansion (recession) gets longer.

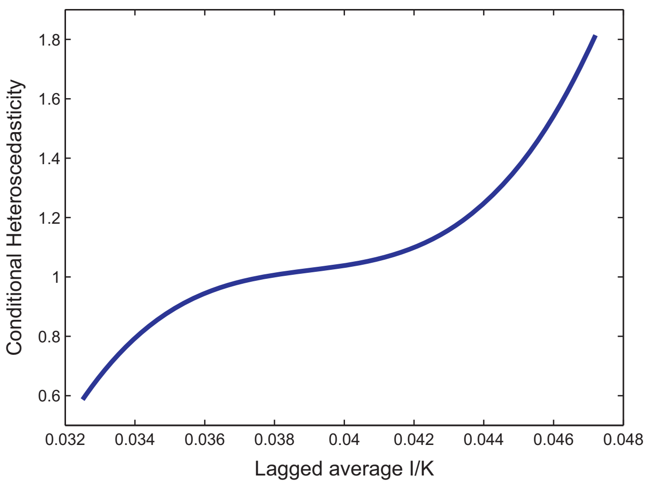

Fig. 1. Heteroscedasticity. This figure plots the heteroscedasticity range following the analysis in Bachmann et al. (2011). First I/K is regressed on its own lag, then residuals from this regression are squared. The mean of square residuals for each level of I/K lagged is plotted against I/K lagged.