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Uncertainty shocks in a model with mean-variance frontiers and endogenous technology choices☆

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ABSTRACT

This paper builds a model to show how increases in aggregate uncertainty – an uncertainty shock – can generate recessions. Uncertainty shocks in the model are able to both account for a significant portion of business cycle fluctuations observed in data and generate positive comovements between output, consumption, investment, and hours. The key assumption of the model is that firm managers endogenously choose what projects to undertake and that the menu of these projects lies on a positively sloped mean-variance frontier – high-return projects are also high-risk projects. In times of high aggregate uncertainty, managers choose to undertake low-risk projects, and thus low-return projects, which in turn leads to a recession. Moreover, the model also matches various stylized facts about time series and cross-sectional variations in TFP and suggests shortcomings in using TFP data to calculate exogenous TFP shocks.

1. Introduction

There is increasing evidence for the negative correlation between measures of economic activity and measures of uncertainty. For example, the correlation between the second moment of aggregate TFP, a measure of uncertainty, and real GDP is negative. This paper constructs a model where exogenous changes in the second moment of firm-level TFP – uncertainty shocks – endogenously generate business cycle fluctuations that account for some of these negative correlations.

In the model, risk-averse managers, in addition to making capital and labor hiring decisions, also decide on what projects to undertake. A manager's project choice determines the firm's stochastic TFP process. The critical assumption of this paper is that the menu of project choices, and thus TFP choices, available to the manager lie on a positively sloped mean-variance frontier. High-return projects are also high-risk projects. This generates a risk-return tradeoff for the manager. Whereas choosing a high-return project would, on average, generate more output, and thus profits, it does expose the manager to a higher amount of risk.

The presence of risk-return tradeoffs in the model cause exogenous changes in aggregate uncertainty - uncertainty shocks - to have important effects. Uncertainty shocks alter the riskiness of the project choices available to the manager causing them to reoptimize and adjust their production decisions. For example, as illustrated in Fig. 1, risk-averse managers in the model find that a sudden increase in aggregate uncertainty makes their current project choice too risky, and they thus reoptimize by choosing a low-risk project. The low-risk project is also a low-return/low-TFP project. Consequently, during times of high aggregate uncertainty firm-level production falls, which in turn causes aggregate production to fall. A recession

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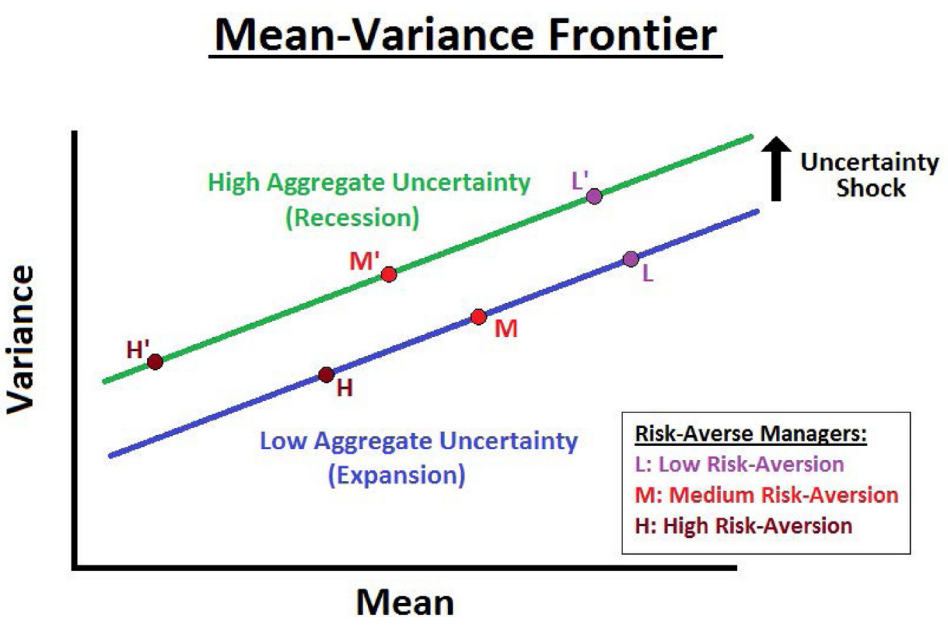

Fig. 1. The mean-variance frontier.

ensues. This mechanism not only qualitatively generates the observed negative correlation between the second moment of TFP and GDP, but is quantitatively also able to explain a significant portion of the variability observed in GDP data. Moreover, this mechanism also generates comovement between consumption and investment; a feature that eludes many real business cycle models driven by second moment shocks.

In addition to generating sizable business cycle fluctuations in real variables, the model in this paper also provides a rich set of results with regard to TFP. First, as described above an increase in aggregate uncertainty causes managers to endogenously choose low-return/low-TFP projects which in turn results in an endogenous drop in the mean level of aggregate TFP. This result replicates the observed negative correlation between the first and second moments of TFP in the data. Second, in the model, an assumption of heterogeneous risk preferences among the managers generates important heterogeneity in the amount of reoptimization each manager performs in response to changes in aggregate uncertainty. Specifically, as illustrated in Fig. 1, during times of high aggregate uncertainty, low risk-averse managers reoptimize their choices very little along the frontier (L to L'), and thus, the average return/TFP level at firms run by low risk-averse managers falls very little during these periods. On the other hand, high risk-averse managers reoptimize significantly in response to high aggregate uncertainty (H to H'), and thus, in high aggregate uncertainty periods the average return/TFP level at their firms falls by a significant amount. This heterogeneity in responses causes the cross-sectional variance of firm-level TFP levels – cross-sectional dispersion of TFP – to rise and cross-sectional skewness to fall during recessions; two observations that are also true in the data.

The results discussed above when taken together, point to a broader contribution of the model, in that not only does the model explain how uncertainty shocks can lead to economically significant fluctuations in real variables, such as output, consumption, labor hours, and investment, it also provides a structural framework to explain how the various moments of TFP may be related. In particular, the model shows how a shock to one moment of the aggregate TFP series can propagate through firm-level decisions causing changes to other moments of both the firm-specific and aggregate TFP series.[1]

Understanding how exogenous shocks affect the different moments of the TFP series is important, because if such shocks cause endogenous movements in TFP, then it becomes difficult to disentangle the magnitude of TFP movements in the data that are exogenous vs. endogenous. For example, as explained above, in the model an exogenous increase in aggregate uncertainty results in an endogenous drop in the first moment of the aggregate TFP process. This suggests that in the data part of the fluctuations in the level of TFP may be purely endogenous and not indicative of the presence of independent exogenous TFP shocks. In my baseline calibration, exogenous changes in uncertainty are able to endogenously explain roughly a quarter of the variability in the mean level of TFP in the data. Further, in the model the true magnitude of the exogenous increase in the second moment is endogenously dampened by managers choosing relatively lower risk projects. This dampening effect illustrates how the second moment of TFP in the data can be a systematically biased estimate of the true underlying exogenous uncertainty shock.

[1] This result is similar to Curdia and Reis (2010) who empirically make a more general case for correlated shocks. I add on to this case here by providing a model that explains how optimization by economic agents can lead to a subset of macroeconomic shocks being correlated.