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Long-run productivity risk: A new hope for production-based asset pricing? [☆]

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ABSTRACT

The examination of the intertemporal distribution of US productivity risk suggests that the conditional mean of productivity growth is an important determinant of macro quantities and asset prices. After establishing this empirical link, I rationalize it in a production economy featuring long-run productivity risk, Epstein and Zin (1989) preferences, and investment frictions. Both convex capital adjustment costs and convex reallocation costs across consumption and investment produce an annual equity premium as sizeable as in the data.

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1. Introduction

Aggregate productivity is one of the most important indicators of both the macroeconomic and financial conditions of a country. Fama (1981, 1990), Cochrane (1996), and Balvers and Huang (2007), among others, have already documented the existence of a relevant link between the movement in asset prices and real economic activity at business cycle frequency. All of these studies, however, share one common feature: they do not distinguish the specific impacts that different sources of productivity uncertainty can have on stock prices. In particular, they do not disentangle the role of predictable fluctuations that are active at low frequency and that explain productivity growth rate swings over long horizons. In this paper, this type of fluctuation is referred to as long-run productivity risk.

This paper investigates the possibility that long-run productivity risk is the original source of both the long-run consumption and dividend risks studied by Bansal and Yaron (2004). The first step of my analysis documents the existence of a predictable component in US productivity growth that affects both aggregate stock market prices and major macroeconomic variables. The second step of this study consists in proposing a novel production-based dynamic stochastic general equilibrium (DSGE) model with long-run productivity shocks that produces improved asset price implications.

Working with aggregate productivity data, I show that the conditional mean of annual productivity growth is time-varying and extremely persistent. Most importantly, productivity news is tightly related to both stock market and interest rate fluctuations. These results are robust across different identification schemes and different productivity measures. In addition, the long-run component in productivity also has a strong economic significance: consumption, investment, and

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output all show a statistically significant positive exposure to the long-run productivity component. Together, short-run and long-run productivity shocks explain up to 70% of the volatility of the macroeconomic variables mentioned above.

After demonstrating an empirical link between productivity, asset prices, and macroeconomic variables, this study develops a production-based asset model with complete markets featuring long-run uncertainty about the productivity growth rate. The main goal of this second step is to explore in detail the theoretical implications of productivity growth predictability (long-run productivity risk) in the context of a model with endogenous investment and recursive utility. This theoretical approach bridges part of the gap between the current long-run risk literature and the macroeconomic literature by proposing a workhorse framework in which to study the co-movements of asset prices and quantities simultaneously over both the short and the long horizon.

The model is extremely parsimonious. Productivity growth is exogenous and affected by two different sources of uncertainty: a short-run shock that is *i.i.d.* (standard in the real business cycle [RBC] literature), and a long-run component that is responsible for small but persistent fluctuations in the drift of productivity. The representative consumer has [Epstein and Zin \(1989\)](#) and [Weil \(1989\)](#) preferences. These preferences disentangle the intertemporal elasticity of substitution (IES) from the relative risk aversion coefficient (RRA) and are sensitive to the intertemporal distribution of risk. Capital accumulation is subject to [Jermann \(1998\)](#) convex adjustment costs so that the supply curve of new capital is not perfectly flexible. As a result, the price of new capital is time-varying and increases when the economy seeks to increase aggregate investment, consistent with standard *q*-theory (see, among others, [Zhang, 2005](#); [Liu et al., 2009](#); [Li and Zhang, 2010](#)).

Under this setup, the model successfully reproduces key features of both asset prices and macroeconomic quantities such as consumption, investment, and output. This is significant because the reconciliation of asset market factors with aggregate quantities behavior has proved a challenge for modern DSGE models (see, among others, [Rouwenhorst, 1995](#); [Jermann, 1998](#); [Lettau and Uhlig, 2000](#); [Boldrin et al., 2001](#); [Cochrane, 2005](#)). In particular, the model presented here produces a sizable equity premium and a low average risk-free rate, with a moderate amount of RRA and an IES slightly larger than one. While in common production economies the premium is generated through an unrealistically high contemporaneous correlation between returns and consumption growth, in my model this correlation is very low, as in the data. Furthermore, the model delivers an implied risk-free rate as persistent as that observed in the data, while the excess returns are in contrast almost unpredictable, again consistent with the empirical evidence.

Although these results look very promising, it has to be acknowledged that the returns volatility puzzle remains partially unexplained in my framework. Embodied in the model is a relevant trade-off between the volatility of the quantities and that of asset returns. This trade-off is generated by the need for a real friction that allows for time variation in the marginal price of capital. The more severe the friction, the less volatile the quantities. On the other hand, the weaker the friction, the smoother the equity returns. In order to match the volatility of the quantities, the adjustment costs are calibrated to be very small. The introduction of the long-run component, however, yields non-negligible fluctuations in the stock price even with a very mild friction. The long-run shocks, in fact, are able to produce substantial shifts in the demand of new capital and generate relevant price movements even if the new capital supply curve is not very steep.

The performance of the model in regard to second moments improves substantially when we focus on contemporaneous correlations. The model is able to produce the right amount of co-movement not only between returns and real variables, but also across the macro variables. A well-known problem with standard RBC models is that they produce an almost perfect correlation between consumption and investment. In the data, however, the contemporaneous correlation between consumption and investment growth is about 45% at quarterly frequencies in the post-World War II period and about 39% at an annual frequency when pre-World War II data are included. Under the benchmark calibration, when the IES is sufficiently high the substitution effect dominates the income effect for the long run: good news for the expected productivity growth rate provides a strong incentive to reduce consumption and invest more. Meanwhile, good news for the short run implies an increase in both consumption and investment. The overall correlation between consumption and investment is positive but moderate, in line with the data.

To my knowledge, this paper is one of the first to study the interaction between predictability in productivity growth and recursive preferences. The results in this study show that the IES has an extremely important impact on the dynamics of both quantities and prices, mostly in response to long-run shocks. The RRA, in contrast, has only a marginal impact on quantities, as in [Tallarini \(2000\)](#).

The present study also proposes a novel analysis of the role of different frictions in capital accumulation. Specifically, I compare my benchmark specification with [Jermann's](#) adjustment costs to a specification in which there is no adjustment cost, and to one that adopts the time-friction of [Boldrin et al. \(2001\)](#) by assuming that both labor and investment decisions are determined before the realization of productivity shocks. This experiment is particularly interesting because it relates asset price implications to very different consumption smoothing possibilities.

Three relevant results emerge from this study. First, a real friction on investment is absolutely required in order to allow the [Bansal and Yaron \(2004\)](#) results to hold also in a production economy. Second, in an economy in which both labor and capital allocations across the consumption and the investment sectors must be decided one period in advance ([Boldrin et al., 2001](#)), the asset pricing results deteriorate substantially. This is because a one-period delay in the adjustment of investment plays no relevant role with respect to news about productivity gains or losses to be realized in the long-run. A comparison of impulse responses with respect to long-run news shows that the behavior of the model with the [Boldrin et al. \(2001\)](#) time-friction closely resembles that of the model without adjustment costs, and hence it fails to expose the equity market to long-run risk.

The third result consists in showing that the replacement of the [Boldrin et al. \(2001\)](#) time-friction with a convex reallocation cost produces positive asset pricing results, comparable to those obtained with capital adjustment costs. Specifically, when

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