Journal of Economic Dynamics & Control 57 (2015) 227–249

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Riskiness, endogenous productivity dispersion and business cycles

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ARTICLE INFO

Article history:
Received 17 December 2014
Received in revised form
20 April 2015
Accepted 21 May 2015
Available online 10 June 2015

JEL classification:
E32
L11
L25

Keywords:
Countercyclical productivity dispersion
Business cycles
Firm dynamics

ABSTRACT

In the data, cross-sectional productivity dispersion is countercyclical at both the plant level and the firm level, see e.g. Bloom (2009). I incorporate a firm's choice of risk level into a model of firm dynamics with real business cycle features to explain this empirical finding both qualitatively and quantitatively. In the model, in every period, each firm chooses the investment amount and the risk level associated with a production project every period. All projects available to each firm have the same expected flow return, determined by the aggregate and idiosyncratic shocks to the firm's productivity, and differ from one another only in their risk. The endogenous option of exiting the market and the limited funding for new investment jointly play an important role in motivating firms' risk-taking behavior. The model predicts that, in each period, relatively small firms are more likely to take risk and hence exhibit a higher exit rate, and that the cross-sectional productivity dispersion, measured as the standard deviation of the realized individual component of productivity, is larger in recessions.

1. Introduction

Cross-sectional productivity dispersion increases in bad times, as does volatility. This is the case for productivity at the plant, firm, and industry levels (Fig. 1). Recently, this phenomenon has attracted growing attention.[1] Macroeconomists are divided over the explanation for this pattern. The majority of the literature views an economic downturn as a result of an exogenous increase in uncertainty combined with various frictions. Meanwhile, other researchers advocate the hypothesis that increased dispersion and volatility is a consequence of recessions. The goal of this paper is to complement existing theories on what causes the negative correlation between business cycles and cross-sectional productivity dispersion.

This paper studies a mechanism through which limited liability and the option of exiting the market jointly induce more risk-taking behavior in recessions and increase the realized productivity dispersion as a result.[2] The main intuition behind the mechanism is that firms will take more risk when there is little to lose. Imagine a firm with limited capital. The firm can always exit and take with it the value from liquidating its capital. Or the firm may choose to continue its production. If the firm is on the edge of exiting, that is, the additional benefit from continuing is not very large, it may find some extra risk

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[1] Examples are Higson et al. (2002, 2004), Bloom (2009), Bloom et al. (2014), Bachmann and Bayer (2013), Arellano et al. (2010), Bachmann et al. (2013), Kehrig (2011), to name a few.

[2] In what follows, the difference between a firm and a plant is not distinguished. The optimal number of plants or establishments a firm should have, although an interesting and important consideration, is not the focus here.

http://dx.doi.org/10.1016/j.jedc.2015.05.015
0165-1889/

very appealing. With such risk, the worst case scenario (in which the project fails, yielding no payoff, and the firm may have to exit) occurs with positive probability. This does not seem too bad given that the firm has very little to lose to begin with. Or, also with positive probability, the project may succeed and result in exceptionally high output, which can significantly improve the firm's situation and pull it away from the edge of exiting. A bad shock pushes more firms to the edge and, as a result, they all choose to take more risk, which in turn leads to a more dispersed distribution of realized individual productivity.

The model employed is in line with the standard industry dynamics model with firm entry and exit built in the seminal work of Hopenhayn (1992), with aggregate technology shocks as the driving force of business cycles.[3] Specifically, the model features the following elements: Firms are heterogeneous in size and idiosyncratic shocks and can choose the level of risk to which their production is exposed. Firms cannot save or borrow, and therefore the investment cannot exceed the revenue at hand net of the operating costs. In each period, each firm has the option to exit the market and take the revenue from selling all of its capital. The choice of risk level is the major new twist to an otherwise standard model in order to capture the willingly chosen lack of diversification and additional exiting hazard, both of which can be size-dependent and can affect a firm's contemporaneous payoff.[4] For each firm, the productivity of a riskier project is a mean-preserving spread of the productivity of a less risky one. Although firms are risk-neutral and riskier projects do not give a higher expected flow payoff, there is a positive fraction of firms that strictly prefer to take on risky projects. This is because the option of exit provides a lower bound for a firm's continuation value as a function of working capital and creates a local convexity called the *risky region*. This convexity gives the firms an incentive to randomize over their future values by choosing riskier projects, and when the uncertain productivity is realized, dispersion arises. Due to the assumption that preowned capital has a discounted selling price, the risky region in the quantitative model also lies on the lower end of the capital axis. Therefore, cross-sectionally, smaller firms tend to take higher risk and exhibit higher volatility. In bad times, this risky region gets larger and the fraction of firms willing to take risks rises. In fact, if the productivity shock is bad enough, aggregate or idiosyncratic, even firms of the largest sizes will fall into the risky region and willingly take on extra risk. Consequently, the average riskiness in firms' production increases following a bad productivity shock, and so does the realized productivity dispersion.

The nature of the mechanism leads to its prediction on firm dynamics and the cyclicality of productivity dispersion by firm size groups, in addition to the model's direct implication on the cyclical feature of the whole economy. Note that the by-size predictions are twofold: (i) on the cross-sectional differences in firm dynamics and (ii) on the time-series differences in the correlation with cyclical indicators.

First, the model predicts that, on average, smaller firms bear higher risks than bigger ones and, in addition, smaller firms are more volatile over time. This claim is supported by the previous findings.[5] A well-known fact is that the survival rate increases in firm size while average growth rate decreases in size. If we look at the entry and exit behavior, Fig. 2 shows that, as plant size grows, not only do the entry and exit rates drop but their volatility decreases too. Combined with the pro- and countercyclicality in entry and exit rates, respectively, this suggests that smaller businesses contribute more to the entry and exit volatility by facing even higher risks in recessions. Fort et al. (2013), Haltiwanger et al. (2013), and Haltiwanger (2012) document the “up or out” dynamics of young businesses and the difference in cyclical sensitivity by size (young and small businesses are more vulnerable to business cycle shocks and their net growth rates fall more in contractions). In fact, Gertler and Gilchristm (1994), Davis and Haltiwanger (2001), Chari et al. (2013), and Fort et al. (2013) point out that small firms are more responsive to contractions, especially those associated with tighter credit markets. This also shows up in the cyclicality of stock returns; see, for example, Perez-Quiros and Timmermann (2000). Evidence also shows a lack of diversification in the higher risks faced by small businesses, according to findings in the entrepreneurship literature, suggesting an inverse relationship between the size of a business and its level of risk. Examples are Hamilton (2000), Moskowitz and Vissing-Jørgensen (2002), and Herranz et al. (2009).[6]

Meanwhile, the result of the quantitative exercise shows that the productivity dispersion within each size group exhibits similar degrees of countercyclicality, measured as the correlation between the standard deviation in the realized individual productivity and the aggregate cyclical indicators. This does not come as a surprise. The theoretical model predicts that smaller firms will consistently show larger productivity dispersion. However, it is the *changes* in the dispersion in response to aggregate productivity shocks that determine the cyclicality. Moreover, in the model, it is with positive probability that both the aggregate and idiosyncratic shocks can be so bad that even some of the largest firms will prefer riskier production projects. Similarly, the smaller ones sometimes choose not to take any risk. Hence, admittedly, the parameter values largely determine which size group has the larger degree of countercyclicality of productivity dispersion. As it turns out, the calibrated model predicts consistent countercyclicality across size groups with the correlation coefficients on similar scales.

[3] However, I do not consider the general equilibrium in this paper. Instead I focus on the aggregation of the firms' individual decisions.

[4] One can think of this as a change of sales strategy that has short-term impact on a firm's revenue, which is similar to the idea of pricing experiments studied by Bachmann and Moscarini (2012). However, the choice of risk level is not intended to capture the R&D expenditure, which is largely procyclical and may only pay off in the long run.

[5] Moscarini and Postel-Vinay (2012) document that large firms contribute disproportionately to the changes in the unemployment rate. However, unemployment rate and other cyclical indicators are not perfectly lined up, hence their paper does not contradict other findings.

[6] See Quadrini (2009) for a detailed review.