Resource Flexibility and Capital Structure
Jiri Chod\textsuperscript{1} and Jianer Zhou\textsuperscript{2}

1 Introduction

Firms such as car manufacturers have been making great effort to become more agile in production of multiple models in the same facility to better respond to changing customer demand. The initiatives of flexibility are costly and typically involve millions of dollars. Firms can use both equity and debt financing to fund such investments, which raises the question of how capital structure of a firm affects its choice of flexibility.

The Modigliani-Miller Theorem states that in the absence of taxes, bankruptcy cost and other market imperfections, firm’s investment decisions are independent of its financing decisions. This implies that capital structure does not affect firm value. Jensen and Meckling (1976) challenged the notion by identifying the “asset substitution problem,” in which shareholders of a levered firm can extract value from debtholders by substituting low-risk assets with high-risk assets after debt is in place. Because of limited liability, shareholders seek more risk and deviate from value maximizing investment decisions.

In this paper, we consider a multi-product multi-resource levered newsvendor problem and show that financial leverage results in underinvestment in flexible resource and overinvestment in dedicated resources. We contribute to the existing literature by demonstrating the asset substitution problem in the context of choosing operational flexibility. Our theoretical results contribute to explaining empirical findings of MacKay (2003) that suggest a negative relation between financial leverage and production flexibility.

2 Model

Unlevered firm. We first consider an all-equity two-product firm which chooses capacity of three resources while facing uncertain demand for its two products. As in Van Mieghem (1998), two resources are product-dedicated whereas the third resource is product-flexible. In the first time epoch, demands for the two products are uncertain and the firm chooses the optimal mix of dedicated and flexible capacities. In the second time epoch, demand uncertainty is resolved and the firm produces to order using the available capacities. Because the firm does not rely on debt financing, it maximizes (expected) profit in each time epoch. Thus, the optimal capacity vector is such that the marginal cost of each type of capacity equals to the marginal revenue it is expected to generate.

Levered firm. We then consider the same scenario except that the firm’s own capital is limited. (This is the case when the shareholders are unable to raise more equity and/or unwilling to dilute their control of the firm by raising equity from outside investors.) Thus, to finance capacity investment the firm needs to issue debt. To avoid the trivial case, we assume that the firm’s own capital is sufficiently small so that the optimal capacity investment requires borrowing.

The first time epoch during which demand is uncertain, has now two stages. In the first stage, the firm issues the optimal amount of debt which we assume to be fairly priced. In the second stage, the firm allocates the available capital (equity + debt) among the three types of capacity. In the second time epoch, demand

\textsuperscript{1}Boston College, chodj@bc.edu
\textsuperscript{2}Boston College, zhoujd@bc.edu
uncertainty is resolved and the firm uses the available capacity to satisfy demand. Depending on the realized demand, one of the following two events occurs. (i) If the firm is able to repay the debt, the shareholder value equals the initial equity plus the operating profit minus the interest. (ii) If the firm is unable to repay its debt, it defaults and is taken over by the debtholders. The shareholder value is wiped out in this case. We assume that the firm always maximizes the (expected) shareholder value.

The first-order conditions characterizing the optimal capacity vector are such that the marginal cost of each type of capacity equals to its expected marginal benefit to the shareholders, which is zero when the firm defaults. In other words, when choosing the optimal capacity mix the firm ignores the magnitude of the loss in bankruptcy states because of the limited liability.

3 Analysis

We hereafter refer to the above model of an unlevered firm and to that of a levered firm as “first-best” and “base-case,” respectively. While in the first-best scenario the firm chooses capacity that maximizes firm value, in the base-case the firm chooses capacity to maximize shareholder value, which is unaffected by the magnitude of the loss in bankruptcy states because of the limited liability. (Although the magnitude of loss incurred in the bankruptcy states affects shareholder value by affecting the cost of capital, when the firm chooses capacity the debt structure has already been fixed.) Because the debtholders anticipate the firm’s risk-seeking capacity decision and price the debt accordingly, it is the shareholders who ultimately bear the entire agency cost by facing a higher cost of capital.

We consider two firms facing the same demand distribution: an all-equity firm (which chooses the first-best capacity vector) and a firm that needs to rely on debt financing (and thus chooses the base-case capacity vector). We show that, for the two firms to choose the same capacity vector, the levered firm must face lower relative cost of flexibility, defined as the ratio of the cost of flexible capacity and the cost of dedicated capacity. We also consider an all-equity firm and a firm that needs to rely on debt financing both of which face the same demand distribution and the same relative cost of flexibility. We show that if the two firms choose the same total capacity, the levered firm chooses more dedicated and less flexible capacity. Finally, we show that when total demand is fixed (while demand for each product is uncertain), a levered firm always chooses less flexible and more dedicated capacity relative to an all-equity firm.

All of these results suggest that financial leverage reduces flexibility. Once the debt is in place, a limited-liability levered firm has incentives to overinvest in more risky dedicated capacity and underinvest in risk-mitigating flexible capacity to extract value for the debtholders. In other words, financial leverage which induces risk-seeking and flexibility which mitigates risk are strategic substitutes in the sense that the larger its leverage, the less flexibility the firm prefers.

We illustrate this result in a numerical study assuming that demands follow a bivariate log-normal distribution. To focus on the case in which bankruptcy risk is relevant, we consider relatively small profit margins for both products, in which case the optimal capacity is below the demand mean. In this study, we examine the effects of financial leverage, demand variability and correlation and the relative cost of flexibility on the magnitude of the “asset substitution problem,” i.e., on the deviation of the base-case capacity mix from the first-best.

Increasing demand uncertainty has two effects on the optimal capacity mix. First, the firm substitutes the
dedicated capacity with the flexible capacity to hedge against the increasing demand risk. Second, the firm reduces total capacity investment in response to the increasing demand risk and cost of external financing. When demand risk is relatively small, the first effect dominates so that the dedicated capacity decreases while the flexible capacity increases in demand risk. When demand risk is relatively large, the second effect dominates so that both capacities decrease in demand risk. Furthermore, as demand uncertainty increases so does the bankruptcy risk, and the underinvestment in flexibility due to the agency conflict between the shareholders and debtholders becomes more significant.

As demand correlation increases and the potential benefit of risk pooling decreases, the firm substitutes the flexible capacity with dedicated capacities. The increasing bankruptcy risk further exacerbates the agency problem of underinvesting in flexibility. The effect of the relative cost of flexibility on the asset substitution is non-monotone. When flexibility is costless or prohibitively expensive, the firm invests in flexible or dedicated capacity only, respectively, in which case no asset substitution can take place and the levered firm chooses the first-best capacity investment. In other words, financial leverage affects the capacity investment only at intermediate levels of the cost of flexibility at which the firm chooses both types of capacity.

Finally, we measure the magnitude of the agency cost as the loss in shareholder value in the base-case relative to the first-best. Our numerical experiments show that this cost can amount up to about 15% of the first-best shareholder value as financial leverage becomes very large.

4 Conclusion

This paper studies a multi-product multi-resource firm that chooses the optimal capacity mix under demand uncertainty while relying on debt financing. We show both analytically and numerically that the firm’s capacity investment decision deviates from the first-best due to an agency conflict between the shareholders and the debtholders. Namely, we show that a levered firm underinvests in flexibility in order to take advantage of its limited liability, and as a result faces a higher cost of external financing. Our numerical analysis further indicates that the agency problem is more prominent when demand risk is high and/or when the hedging effect of operational flexibility is weak. Our theoretical findings are consistent with and help to explain the empirical evidence in the existing finance literature.

References


