ONLINE APPENDIX FOR HOW CHAPTER 11 CHANGES THE GAME: INVESTMENT AND BANKRUPTCY IN THE U.S. AIRLINE INDUSTRY

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APPENDIX A: ILLUSTRATIVE MODEL

In this section I analyze a dynamic, continuous-time duopoly model of investment and reorganization to show how equilibrium investment behavior changes with Chapter 11 reorganization costs. This simple model, adapted from Acemoglu and Akcigit (2012) and Aghion et al. (2001), reveals two key insights. First, an exogenous change that makes Chapter 11 reorganization more costly will limit capital expansion when demand is high. Second, the same exogenous change will quicken capital retraction when demand is low. In other words, as Chapter 11 reorganization becomes more costly, firms will be less willing to invest when demand is good and more willing to get rid of capacity when demand is bad.

A.1. *Investment and Disinvestment*

Suppose two firms compete in continuous time, and their instantaneous profits are functions only of their size relative to one another. Under normal industry conditions, which we will label as high demand, larger relative size results in higher profit, creating an incentive to accumulate capital. To examine the role of bankruptcy, let us also consider what happens when industry demand falls precipitously. Suppose that the industry's demand state can be either high or low, and it evolves randomly according to two Poisson arrival processes. When demand is high, nature arrives at rate ψ to reverse the demand state. When demand is low, nature arrives at rate ψ' to reverse the demand state. An important feature of the low demand state is that profit is strictly decreasing in relative size, creating an incentive to disinvest capital. Thus, firm i's profit, conditional upon demand, can be given in reduced form by a function of i's capital level relative to its competitor. Finally, suppose this rela-

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tive level, n_i, takes on one of 5 values, such that $n_i \in N \equiv \{-2, -1, 0, 1, 2\}$. Flow profit is given by

$$\Pi(n_i) \in \{\pi_{-2}, \pi_{-1}, \pi_0, \pi_1, \pi_2\}\ ,\ \pi_{n+1} > \pi_n \text{ when demand is high, and}$$
$$\Pi'(n_i) \in \{\pi'_{-2}, \pi'_{-1}, \pi'_0, \pi'_1, \pi'_2\}\ ,\ \pi'_n > \pi'_{n+1} \text{ when demand is low.}$$

In summary, having more capital relative to your opponent is profitable in high-demand states, but costly in low-demand states.[1] Given this ordering, firms will want to increase their capital stock under normal industry conditions, and decrease it in times of distress, all else equal.

Firms act to change their capital levels via investment during high-demand states and disinvestment during low-demand states. When demand is high, each firm can increase its capital level by a Poisson investment process, which yields a unit increase to the capital stock at rate $x_i \geq 0$ and costs λx_i. In the same way, when demand is low, each firm can decrease its capital level at rate $y_i \geq 0$ at a cost of θy_i. The cost of disinvestment, θ, can be viewed as a measure of the irreversibility of investment, in that higher values of θ imply greater barriers to downsizing.

A.2. *Reorganization*

For a given firm at a given instant, the payoff relevant states are the demand state and the firm's relative capital level. To allow for the prospect of Chapter 11 reorganization, suppose that bankruptcy events arrive according to a state-dependent Poisson process. When Chapter 11 occurs, the affected firm experiences a single increment decrease in capital. Let D_{N_I}

[1]The fact that profit is increasing in size can be justified if size is related to quality, as in many network industries. In the airline industry, for instance, large fleet size may mean more flights per day at more convenient times for travelers, more destinations served per airport, more convenient connections, more opportunities for the redemption of flight miles, bigger and better planes, or even less crowded planes. Yet large size could be costly in downturns if, for example, fixed costs are linear in capacity, while variable profits are concave. If the demand state shifts variable profit only, then fixed costs may very well dominate when demand is low. Taking the airline industry as the example once more, if contractual commitments keep airlines flying planes even when weak demand would otherwise cause them to reduce capacity, then large fleet size can and does represent a major liability in such states of the world.

and B_{N_I} be the set of bankruptcy arrival rates when demand is high and low, respectively, and note that $d_{-2} = b_{-2} = 0$, such that bankruptcy is not possible when $N_I = -2$.

Upon bankruptcy, firms engaging in Chapter 11 reorganization pay a lump-sum, capital-dependent fee reflecting the total cost of reorganization, which encompasses legal and transactional fees, administrative costs, payouts to various stakeholders, and any other economic costs to the firm, such as reputational damage. These reorganization costs, $R(n_i) \in \{R_{-1}, R_0, R_1, R_2\}$, are independent of the demand state, and they are not paid when firms transition to lower states of their own accord (i.e. via costly disinvestment).

A.3. *Value Functions and Equilibrium*

Given the above setup, firms maximize the present value of future profits according to a common rate of time preference $r > 0$. Let V represent value functions in high demand states and W represent value functions in low demand states. We can then define firm values recursively as follows:

$$rV_2 = \pi_2 + x_{-2}\left[V_1 - V_2\right] + d_2\left[V_1 - V_2 - R_2\right] + \psi\left[W_2 - V_2\right] \tag{1}$$

$$rV_1 = \max_{x_1 \geq 0} \begin{cases} \pi_1 - \lambda x_1 + \left[x_1 + d_{-1}\right]\left[V_2 - V_1\right] + x_{-1}\left[V_0 - V_1\right] + ... \\ +d_1\left[V_0 - V_1 - R_1\right] + \psi\left[W_1 - V_1\right] \end{cases} \tag{2}$$

$$rV_0 = \max_{x_0 \geq 0} \begin{cases} \pi_0 - \lambda x_0 + \left[x_0 + d_0\right]\left[V_1 - V_0\right] + x_0'\left[V_{-1} - V_0\right] + ... \\ +d_0\left[V_{-1} - V_0 - R_0\right] + \psi\left[W_0 - V_0\right] \end{cases} \tag{3}$$

$$rV_{-1} = \max_{x_{-1} \geq 0} \begin{cases} \pi_{-1} - \lambda x_{-1} + \left[x_{-1} + d_1\right]\left[V_0 - V_{-1}\right] + x_1\left[V_{-2} - V_{-1}\right] + ... \\ +d_{-1}\left[V_{-2} - V_{-1} - R_{-1}\right] + \psi\left[W_{-1} - V_{-1}\right] \end{cases} \tag{4}$$

$$rV_{-2} = \max_{x_{-2} \geq 0} \left\{\pi_{-2} - \lambda x_{-2} + \left[x_{-2} + d_2\right]\left[V_{-1} - V_{-2}\right] + \psi\left[W_{-2} - V_{-2}\right]\right\} \tag{5}$$

$$rW_2 = \max_{y_2 \geq 0} \begin{cases} \pi_2' - \theta y_2 + y_2\left[W_1 - W_2\right] + b_2\left[W_1 - W_2 - R_2\right] + ... \\ +\psi'\left[V_2 - W_2\right] \end{cases} \tag{6}$$

$$rW_1 = \max_{y_1 \geq 0} \begin{cases} \pi_1' - \theta y_1 + y_1\left[W_0 - W_1\right] + b_1\left[W_0 - W_1 - R_1\right] + ... \\ +\left[y_{-1} + b_{-1}\right]\left[W_2 - W_1\right] + \psi'\left[V_1 - W_1\right] \end{cases} \tag{7}$$

$$rW_0 = \max_{y_0 \geq 0} \begin{cases} \pi_0' - \theta y_0 + y_0\left[W_{-1} - W_0\right] + b_0\left[W_{-1} - W_0 - R_0\right] + ... \\ +\left[y_0' + b_0\right]\left[W_1 - W_0\right] + \psi'\left[V_0 - W_0\right] \end{cases} \tag{8}$$

$$rW_{-1} = \max_{y_{-1}\geq 0} \begin{cases} \pi'_{-1} - \theta y_{-1} + y_{-1}\left[W_{-2} - W_{-1}\right] + b_{-1}\left[W_{-2} - W_{-1} - R_{-1}\right] + ... \\ + \left[y_1 + b_1\right]\left[W_0 - W_{-1}\right] + \psi'\left[V_{-1} - W_{-1}\right] \end{cases} \quad (9)$$

$$rW_{-2} = \pi'_{-2} + \left[y_2 + b_2\right]\left[W_{-1} - W_{-2}\right] + \psi'\left[V_{-2} - W_{-2}\right] \quad (10)$$

where x'_0 and y'_0 represent an opponent's strategies for a firm in state 0. The first term on the right-hand side of each equation is flow profit. For equations with maximization, the second term is the cost of investment or disinvestment. Note that firms cannot invest in state 2 or disinvest in state -2. The remaining terms give the intensities of each possible state change multiplied by their associated changes in continuation value. Note that, because reorganization costs are one-time values, they appear only when state changes occur due to reorganization. I assume that the overall rates of bankruptcy are not so large as to make investment or disinvestment unappealing in equilibrium.

A symmetric Markov Perfect Equilibrium will comprise a set of investment and disinvestment strategies which maximize each player's value in each payoff-relevant state conditional upon the same set of strategies being employed by the other player. Solving for equilibrium investment and disinvestment intensities yields the following:

$$x^*_{-2} = \max\left\{0,\ \frac{\pi_2 - \pi_{-2} - R_2 d_2 - 4\theta\psi}{\lambda} - (4(r+\psi) + 2(1+\gamma_2)d_2)\right\}$$

$$x^*_{-1} = \max\left\{0,\ \frac{\pi_1 - \pi_{-2} - R_1 d_1 - 3\theta\psi}{\lambda} - (3(r+\psi) + (1+\gamma_2)d_2 + (1+\gamma_1)d_1 - d_{-1})\right\}$$

$$x^*_0 = \max\left\{0,\ \frac{\pi_0 - \pi_{-2} - R_0 d_0 - 2\theta\psi}{\lambda} - (2(r+\psi) + (1+\gamma_2)d_2)\right\}$$

$$x^*_1 = \max\left\{0,\ \frac{\pi_{-1} - \pi_{-2} - R_{-1} d_{-1} - \theta\psi}{\lambda} - ((r+\psi) + (1+\gamma_2)d_2 - (1+\gamma_1)d_1 + d_{-1})\right\}$$

$$x^*_2 = 0$$

$$y^*_{-2} = 0$$

$$y^*_{-1} = \max\left\{0,\ \frac{\pi'_1 - \pi'_2 + R_2 b_2 - R_1 b_1 - \lambda\psi'}{\theta} - \big((r+\psi') + b_2 - b_1 + b_{-1}\big)\right\}$$

$$y^*_0 = \max\left\{0,\ \frac{\pi'_0 - \pi'_2 + R_2 b_2 - R_0 b_0 - 2\lambda\psi'}{\theta} - \big(2(r+\psi') + b_2\big)\right\}$$

$$y_1^* = \max\left\{0,\ \frac{\pi'_{-1} - \pi'_2 + R_2 b_2 - R_{-1} b_{-1} - 3\lambda\psi'}{\theta} - \big(3(r+\psi') + b_2 + b_1 - b_{-1}\big)\right\}$$

$$y_2^* = \max\left\{0,\ \frac{\pi'_{-2} - \pi'_2 + R_2 b_2 - 4\lambda\psi'}{\theta} - \big(4(r+\psi') + 2b_2\big)\right\}$$

A.4. *Comparative Statics*

Solving for equilibrium investment and disinvestment strategies reveals the two key features of capacity discipline at work: Higher reorganization costs slow investment in high-demand states and speed disinvestment in low-demand states. Intuitively, higher reorganization costs make disinvestment more expensive overall, increasing the risk of being large in a down market, thereby reducing the incentive to invest. At the same time, disinvestment outside of bankruptcy court protection becomes less expensive relative to filing Chapter 11, leading to quicker retraction outside of reorganization. The magnitude of each effect depends on the nature of competition between the duopolists.[2]

The unnumbered equations in the previous section give explicit expressions for optimal investment/disinvestment. As we would expect, firms want to grow when demand is expected to be good, and they want to shrink when demand is expected to be bad. Investment decreases in the arrival rate of the low demand state, while disinvestment falls with the arrival rate of the high demand state. Similarly intuitive is the result that investment declines with the price of investment, and disinvestment falls with the cost of disinvestment. Finally, disinvestment and reorganization are seen as imperfect substitutes. Disinvestment falls with the arrival rate of default for the largest firm.

We can analyze optimal investment/disinvestment rates to determine the impact of a change in bankruptcy policy. For example, an increase in the cost of reorganization is best proxied by an increase in the one-time reorganization costs $\{R_n\}$. The first and most intuitive effect of such a change is to reduce investment intensity during high-demand periods, as seen by $\frac{\partial x_n^*}{\partial R_{-n}} < 0,\ \forall n < 2$. This effect is stronger when investment costs (λ) are smaller and when the arrival rate of default for my rival (d_{-n}) is higher. If we further suppose that

[2] In particular, the disinvestment effect is stronger for more dominant firms, while the investment effect is stronger for weaker firms. While these effects do not directly describe how steady-state equilibrium industry structure changes with reorganization costs, Section A.6 shows that the qualitative implications of this section continue to hold when we weight intensities by long-run probabilities.

a legal reform has a larger impact on larger firms, such that $\Delta R_n > \Delta R_{n-1}$, we should expect the investment effect to be strongest for small firms and weakest for large firms because it is my rival's reorganization costs that impact my equilibrium investment rate.

The other component of capacity discipline is greater eagerness to disinvest during downturns, which we find in $\frac{\partial y_n^*}{\partial R_2} > 0$. Increasing the cost of reorganization for only the largest organizations (i.e. $n = 2$) increases disinvestment rates at all relevant levels. However, if we assume an across-the-board increase in reorganzation costs, this effect will be tempered by my rival's expected cost of default. If we again assume that $\Delta R_n > \Delta R_{n-1}$, then the overall effect of a legal reform that increases the cost of reorganization, especially for the largest of firms, will indeed be faster disinvestment. Moreover, the effect will be stronger the larger is the firm. Thus, on the whole, larger firms will have a stronger desire to get smaller, but a weaker desire to get larger.

A.5. *Duopoly Solution*

Following Acemoglu and Akcigit (2012), solving for the value functions is straightforward. Since costs are linear, any non-zero investment level must satisfy

$$V_{n+1} - V_n = \lambda \text{ for } n \in \{-2, -1, 0, 1\} \tag{11}$$

and any non-zero disinvestment level must satisfy

$$W_n - W_{n+1} = \theta \text{ for } n \in \{-1, 0, 1, 2\} \tag{12}$$

per the first-order conditions for each optimization problem. Combining 11 and 5 gives

$$V_{-2} = \frac{\pi_{-2} + \lambda d_2 + \psi W_{-2}}{r + \psi}$$

In similar fashion, combining 12 and 6 yields

$$W_2 = \frac{\pi_2' + \theta b_2 + \psi' V_2 - R_2 b_2}{r + \psi'}$$

According to 11 and 12, we know that $V_2 = V_{-2} + 4\lambda$ and $W_{-2} = W_2 + 4\theta$. These conditions give us a solvable system of two equations:

$$V_2 = \frac{\pi_{-2} + \lambda d_2}{r + \psi} + 4\lambda + \frac{\psi W_{-2}}{r + \psi} \tag{13}$$

$$W_{-2} = \frac{\pi'_2 + \theta b_2 - R_2 b_2}{r + \psi'} + 4\theta + \frac{\psi' V_2}{r + \psi'} \tag{14}$$

Using the solution to this system, we could solve for the remaining value functions, and then for optimal investment and disinvestment rates. An easier approach, described in Acemoglu and Akcigit (2012), is to use everything we have so far to find expressions for optimal policies in each state without explicitly solving for the value functions. This approach can be applied to find optimal investment rates without any additional assumptions on the bankruptcy arrival processes. First, combine 11 with 1-4 and 12 with 7-10 to get expressions for optimal investment and disinvestment in terms of value functions, assuming investment and disinvestment are always positive.

$$x^*_{-2} = \frac{\pi_2 - R_2 d_2 - \lambda d_2 + \psi W_2 - (r + \psi) V_2}{\lambda} \tag{15}$$

$$x^*_{-1} = \frac{\pi_1 - R_1 d_1 + \lambda d_{-1} - \lambda d_1 + \psi W_1 - (r + \psi) V_1}{\lambda} \tag{16}$$

$$x^*_0 = \frac{\pi_0 - R_0 d_0 + \psi W_0 - (r + \psi) V_0}{\lambda} \tag{17}$$

$$x^*_1 = \frac{\pi_{-1} - R_{-1} d_{-1} + \lambda d_1 - \lambda d_{-1} + \psi W_{-1} - (r + \psi) V_{-1}}{\lambda} \tag{18}$$

$$x^*_2 = 0 \tag{19}$$

$$y^*_{-2} = 0 \tag{20}$$

$$y^*_{-1} = \frac{\pi'_1 - R_1 b_1 + \theta b_1 - \theta b_{-1} + \psi' V_1 - (r + \psi') W_1}{\theta} \tag{21}$$

$$y^*_0 = \frac{\pi'_0 - R_0 b_0 + \psi' V_0 - (r + \psi') W_0}{\theta} \tag{22}$$

$$y^*_1 = \frac{\pi'_{-1} - R_{-1} b_{-1} + \theta b_{-1} - \theta b_1 + \psi' V_{-1} - (r + \psi') W_{-1}}{\theta} \tag{23}$$

$$y^*_2 = \frac{\pi'_{-2} - \theta b_2 + \psi' V_{-2} - (r + \psi') W_{-2}}{\theta} \tag{24}$$

Next, rewrite 13 and 14 as follows

$$\psi W_{-2} - (r + \psi) V_2 = -(\pi_{-2} + \lambda d_2 + (r + \psi) 4\lambda)$$

$$\psi' V_2 - (r+\psi')W_{-2} = -\left(\pi_2' + \theta b_2 - R_2 b_2 + (r+\psi')4\theta\right)$$

and recall that

$$W_{-2} = W_{-1} + \theta = W_0 + 2\theta = W_1 + 3\theta = W_2 + 4\theta$$
$$V_2 = V_1 + \lambda = V_0 + 2\lambda = V_{-1} + 3\lambda = V_{-2} + 4\lambda$$

Now we can simply substitute the expressions above into 15-24 to arrive at optimal investment and disinvestment rates without explicitly solving for any of the value functions. Starting from the top, let's sub in for investment intensities:

$$\begin{aligned}
x_{-2}^* &= \frac{\pi_2 - R_2 d_2 - \lambda d_2 + \psi W_2 - (r+\psi)V_2}{\lambda} \\
&= \frac{\pi_2 - R_2 d_2 - \lambda d_2 + \psi(W_{-2} - 4\theta) - (r+\psi)V_2}{\lambda} \\
&= \frac{\pi_2 - R_2 d_2 - \lambda d_2 - (\pi_{-2} + \lambda d_2 + (r+\psi)4\lambda) - \psi 4\theta}{\lambda} \\
&= \frac{\pi_2 - \pi_{-2} - R_2 d_2 - 4\theta\psi}{\lambda} - (4(r+\psi) + 2d_2)
\end{aligned}$$

$$\begin{aligned}
x_{-1}^* &= \frac{\pi_1 - R_1 d_1 + \lambda d_{-1} - \lambda d_1 + \psi W_1 - (r+\psi)V_1}{\lambda} \\
&= \frac{\pi_1 - R_1 d_1 + \lambda d_{-1} - \lambda d_1 + \psi(W_{-2} - 3\theta) - (r+\psi)(V_2 - \lambda)}{\lambda} \\
&= \frac{\pi_1 - R_1 d_1 + \lambda d_{-1} - \lambda d_1 - (\pi_{-2} + \lambda d_2 + (r+\psi)4\lambda) - \psi 3\theta + \lambda(r+\psi)}{\lambda} \\
&= \frac{\pi_1 - \pi_{-2} - R_1 d_1 - 3\theta\psi}{\lambda} - (3(r+\psi) + d_2 + d_1 - d_{-1})
\end{aligned}$$

$$\begin{aligned}
x_0^* &= \frac{\pi_0 - R_0 d_0 + \psi W_0 - (r+\psi)V_0}{\lambda} \\
&= \frac{\pi_0 - R_0 d_0 + \psi(W_{-2} - 2\theta) - (r+\psi)(V_2 - 2\lambda)}{\lambda} \\
&= \frac{\pi_0 - R_0 d_0 - (\pi_{-2} + \lambda d_2 + (r+\psi)4\lambda) - \psi 2\theta + 2\lambda(r+\psi)}{\lambda} \\
&= \frac{\pi_0 - \pi_{-2} - R_0 d_0 - 2\theta\psi}{\lambda} - (2(r+\psi) + d_2)
\end{aligned}$$

$$\begin{aligned}
x_1^* &= \frac{\pi_{-1} - R_{-1} d_{-1} + \lambda d_1 - \lambda d_{-1} + \psi W_{-1} - (r+\psi)V_{-1}}{\lambda} \\
&= \frac{\pi_{-1} - R_{-1} d_{-1} + \lambda d_1 - \lambda d_{-1} + \psi(W_{-2} - \theta) - (r+\psi)(V_2 - 3\lambda)}{\lambda}
\end{aligned}$$

$$= \frac{\pi_{-1} - R_{-1}d_{-1} + \lambda d_1 - \lambda d_{-1} - (\pi_{-2} + \lambda d_2 + (r+\psi)4\lambda) - \psi\theta + 3\lambda(r+\psi)}{\lambda}$$

$$= \frac{\pi_{-1} - \pi_{-2} - R_{-1}d_{-1} - \theta\psi}{\lambda} - ((r+\psi) + d_2 - d_1 + d_{-1})$$

$$x_2^* = 0$$

Next, solve for optimal disinvestment intensities.

$$y_{-2}^* = 0$$

$$y_{-1}^* = \frac{\pi_1' - R_1 b_1 + \theta b_1 - \theta b_{-1} + \psi' V_1 - (r+\psi')W_1}{\theta}$$

$$= \frac{\pi_1' - R_1 b_1 + \theta b_1 - \theta b_{-1} + \psi'(V_2 - \lambda) - (r+\psi')(W_{-2} - 3\theta)}{\theta}$$

$$= \frac{\pi_1' - R_1 b_1 + \theta b_1 - \theta b_{-1} - \big(\pi_2' + \theta b_2 - R_2 b_2 + (r+\psi')4\theta\big) - \lambda\psi' + (r+\psi')3\theta}{\theta}$$

$$\frac{\pi_1' - \pi_2' + R_2 b_2 - R_1 b_1 - \lambda\psi'}{\theta} - \big((r+\psi') + b_2 - b_1 + b_{-1}\big)$$

$$y_0^* = \frac{\pi_0' - R_0 b_0 + \psi' V_0 - (r+\psi')W_0}{\theta}$$

$$= \frac{\pi_0' - R_0 b_0 + \psi'(V_2 - 2\lambda) - (r+\psi')(W_{-2} - 2\theta)}{\theta}$$

$$= \frac{\pi_0' - R_0 b_0 - \big(\pi_2' + \theta b_2 - R_2 b_2 + (r+\psi')4\theta\big) - 2\lambda\psi' + (r+\psi')2\theta}{\theta}$$

$$= \frac{\pi_0' - \pi_2' + R_2 b_2 - R_0 b_0 - 2\lambda\psi'}{\theta} - \big(2(r+\psi') + b_2\big)$$

$$y_1^* = \frac{\pi_{-1}' - R_{-1} b_{-1} + \theta b_{-1} - \theta b_1 + \psi' V_{-1} - (r+\psi')W_{-1}}{\theta}$$

$$= \frac{\pi_{-1}' - R_{-1} b_{-1} + \theta b_{-1} - \theta b_1 + \psi'(V_2 - 3\lambda) - (r+\psi')(W_{-2} - \theta)}{\theta}$$

$$= \frac{\pi_{-1}' - R_{-1} b_{-1} + \theta b_{-1} - \theta b_1 - \big(\pi_2' + \theta b_2 - R_2 b_2 + (r+\psi')4\theta\big) - 3\lambda\psi' + (r+\psi')\theta}{\theta}$$

$$= \frac{\pi_{-1}' - \pi_2' + R_2 b_2 - R_{-1} b_{-1} - 3\lambda\psi'}{\theta} - \big(3(r+\psi') + b_2 + b_1 - b_{-1}\big)$$

$$y_2^* = \frac{\pi_{-2}' - \theta b_2 + \psi' V_{-2} - (r+\psi')W_{-2}}{\theta}$$

$$= \frac{\pi_{-2}' - \theta b_2 + \psi'(V_2 - 4\lambda) - (r+\psi')W_{-2}}{\theta}$$

$$= \frac{\pi'_{-2} - \theta b_2 - \left(\pi'_2 + \theta b_2 - R_2 b_2 + (r+\psi')4\theta\right) - 4\lambda\psi'}{\theta}$$

$$= \frac{\pi'_{-2} - \pi'_2 + R_2 b_2 - 4\lambda\psi'}{\theta} - \left(4(r+\psi') + 2b_2\right)$$

Summarizing, the set of investment and disinvestment intensities is as follows[3]

$$x^*_{-2} = \max\left\{0,\ \frac{\pi_2 - \pi_{-2} - R_2 d_2 - 4\theta\psi}{\lambda} - (4(r+\psi) + 2d_2)\right\}$$

$$x^*_{-1} = \max\left\{0,\ \frac{\pi_1 - \pi_{-2} - R_1 d_1 - 3\theta\psi}{\lambda} - (3(r+\psi) + d_2 + d_1 - d_{-1})\right\}$$

$$x^*_0 = \max\left\{0,\ \frac{\pi_0 - \pi_{-2} - R_0 d_0 - 2\theta\psi}{\lambda} - (2(r+\psi) + d_2)\right\}$$

$$x^*_1 = \max\left\{0,\ \frac{\pi_{-1} - \pi_{-2} - R_{-1} d_{-1} - \theta\psi}{\lambda} - ((r+\psi) + d_2 - d_1 + d_{-1})\right\}$$

$$x^*_2 = 0$$

$$y^*_{-2} = 0$$

$$y^*_{-1} = \max\left\{0,\ \frac{\pi'_1 - \pi'_2 + R_2 b_2 - R_1 b_1 - \lambda\psi'}{\theta} - \left((r+\psi') + b_2 - b_1 + b_{-1}\right)\right\}$$

$$y^*_0 = \max\left\{0,\ \frac{\pi'_0 - \pi'_2 + R_2 b_2 - R_0 b_0 - 2\lambda\psi'}{\theta} - \left(2(r+\psi') + b_2\right)\right\}$$

$$y^*_1 = \max\left\{0,\ \frac{\pi'_{-1} - \pi'_2 + R_2 b_2 - R_{-1} b_{-1} - 3\lambda\psi'}{\theta} - \left(3(r+\psi') + b_2 + b_1 - b_{-1}\right)\right\}$$

$$y^*_2 = \max\left\{0,\ \frac{\pi'_{-2} - \pi'_2 + R_2 b_2 - 4\lambda\psi'}{\theta} - \left(4(r+\psi') + 2b_2\right)\right\}$$

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[3] One drawback of the model is that equilibrium investment intensities will not depend on features of the bankruptcy regime unless bankruptcies occur in all states of the world. That is, if bankruptcy could only happen in low-demand states, then the model's simple setup would necessitate firm behavior to adjust such that the cost of disinvestment were equal to the difference in value functions in the relevant low-demand states. As a result, the effects of reorganization policy upon disinvestment would be severed from any potential effects upon investment.

A.6. *Duopoly Implications: Steady-State*

While investment rates are informative, they do not tell the whole story. The distribution of industry structures in equilibrium may change when R_n changes. Therefore, we compute the steady-state distribution, μ, a vector of long-run probabilities. The long-run rate at which the process leaves state i must equal the sum of the long-run rates at which the process enters state i. The steady-state vector μ is a solution to

$$\mu' Q = 0$$
$$\sum_i \mu_i = 1$$

where Q is the infinitesimal generator, or the intensity matrix, of the continuous-time Markov process and has elements q_{ij}.[4] The row sums in Q are zero, such that

$$q_{ii} \equiv \sum_{j=1, j\neq i}^{N} -q_{ij}$$

Given our equilibrium (dis)investment intensities, we can construct Q as follows:

$$Q = \begin{matrix} q_{11} & d_2 + x_{-2} & 0 & \psi & 0 & 0 \\ x_1 + d_{-1} & q_{22} & x_{-1} + d_1 & 0 & \psi & 0 \\ 0 & 2(x_0 + d_0) & q_{33} & 0 & 0 & \psi \\ \psi' & 0 & 0 & q_{44} & b_2 + y_2 & 0 \\ 0 & \psi' & 0 & y_{-1} + b_{-1} & q_{55} & y_1 + b_1 \\ 0 & 0 & \psi' & 0 & 2(y_0 + b_0) & q_{66} \end{matrix}$$

The condition $\mu' Q = 0$ yields the balance equations

$$\mu_i q_i = \sum_{j=1, j\neq i}^{N} \mu_j q_{ji}$$

which we express in long form as

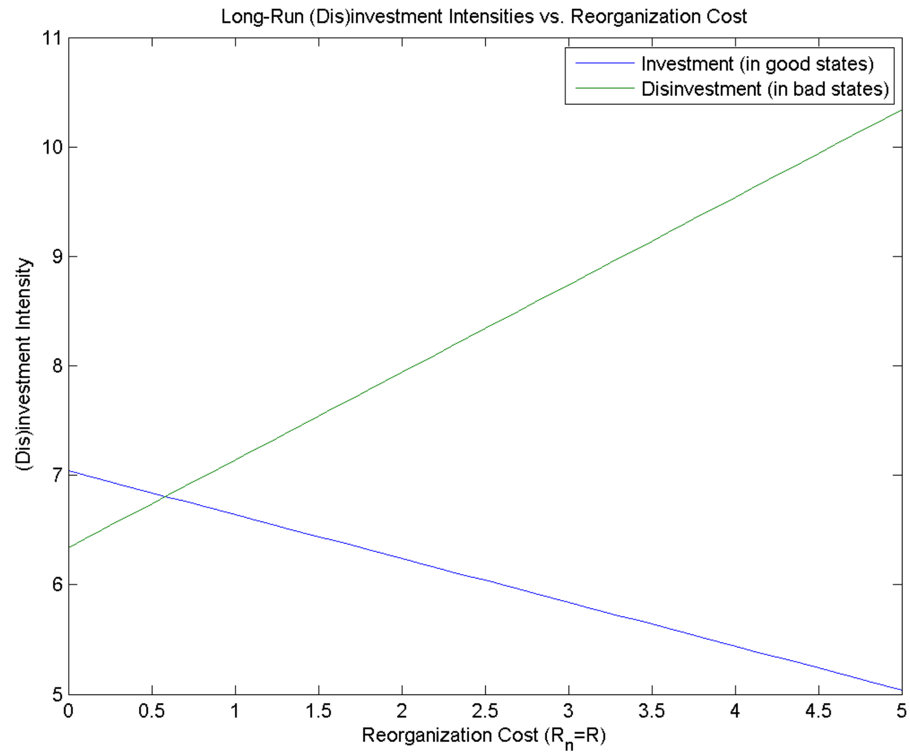
$$u_2 (x_1 + d_{-1}) + u_4 \psi' = u_1 (d_2 + x_{-2} + \psi) \tag{25}$$

$$u_1 (d_2 + x_{-2}) + u_3 2 (x_0 + d_0) + u_5 \psi' = u_2 (x_1 + d_{-1} + x_{-1} + d_1 + \psi) \tag{26}$$

$$u_2 (x_{-1} + d_1) + u_6 \psi' = u_3 (2x_0 + 2d_0 + \psi) \tag{27}$$

[4] The matrix Q corresponds to the matrix $P - I$ in discrete-time Markov processes.

FIGURE A.1.—Equilibrium Intensities



$$u_1\psi + u_5\left(y_{-1} + b_{-1}\right) = u_4\left(\psi' + b_2 + y_2\right) \tag{28}$$

$$u_2\psi + u_4\left(b_2 + y_2\right) + u_6 2\left(y_0 + b_0\right) = u_5\left(\psi' + y_{-1} + b_{-1} + y_1 + b_1\right) \tag{29}$$

$$u_3\psi + u_5\left(y_1 + b_1\right) = u_6\left(\psi' + 2y_0 + 2b_0\right) \tag{30}$$

$$u_1 + u_2 + u_3 + u_4 + u_5 + u_6 = 1 \tag{31}$$

When constraint 31 is substituted in, the system can be solved for μ. The expression, which is many pages long, is available upon request. Absent a simplified expression, we can parameterize the model and see whether changes in R_n have the same effect in steady-state as they do on the intensities for a given level. To illustrate, Figure A.1 presents the steady-state distribution of investment and disinvestment intensities as functions of reorganization cost for a parameterization of the theoretical model. For this particular parameterization, steady-state investment in upturns falls with R, while steady-state disinvestment in downturns rises with R.

APPENDIX B: BANKRUPTCY PROVISIONS, REFORMS, AND TRENDS OF INTEREST TO AIRLINES

B.1. *Provisions of Interest*

Section 1110 affords special provisions to holders of leases and secured financings of aircraft and aircraft equipment. This section gives bankrupt airlines the right to make any outstanding payments within 60 days in order to keep the aircraft. If the airline fails to make those payments or renegotiate lease terms, the lessor has the exclusive right to repossess the aircraft, similar to a secured creditor's position outside of bankruptcy. At first glance, this rule appears to favor the lessor. However, lease agreements are often far above market value for aircraft, and if a lessor repossesses the aircraft, it must then find another lessee in what is likely to be a down market. Repossession is therefore not a very attractive option for lessors. Moreover, should the lessor refuse the right to repossess the aircraft, the lease agreement is rescinded and becomes an unsecured claim on the airline, which takes a much lower priority for payment under bankruptcy protection. The lessor is therefore far less likely to be paid. Given the lessor's grim options in the case of default, renegotiation of lease terms becomes very attractive. Renegotiating leases and secured financings of aircraft is a major source of cost-cutting by airlines in bankruptcy. Benmelech and Bergman (2008) show that renegotiation of aircraft leases is common practice for airlines in financial distress. Moreover, when redeployability of aircraft is low, as in an overall market downturn, lessors are able to negotiate for even greater concessions.

Section 1113 of the Bankruptcy Code relates to collective bargaining agreements (CBAs). This section of the Code was enacted in 1984, although bargaining power would have been similar before this time, given the contractual treatment of CBAs. Section 1113 stipulates that a company can unilaterally revise terms of a CBA if attempts to renegotiate with unions have failed. This rule gives airlines significant bargaining power in negotiating more favorable terms with unions, which typically represent half of an airline's workforce.

Section 1114 of the Bankruptcy Code deals with retiree benefits. Under bankruptcy protection, a carrier can renegotiate or cancel defined benefit pension obligations, thereby requiring the Federal Pension Benefit Guarantee Corporation (PBGC) to foot the bill. Such a decision must first be approved by the court, which requires 1) that the company first negotiate with representatives of the retirees, and 2) that the decision is necessary for the firm's survival. Since defined benefit pension programs typically represent a huge burden on financially distressed carriers, renegotiating or cancelling them in Chapter 11 can yield enormous cost savings.

B.2. *Reforms of Interest*

Limits on the exclusivity period, coupled with changes to dismissal and conversion, are given as the first and foremost category of change relevant to this study, but other important changes support the conclusion that BAPCPA raised the perceived cost of Chapter 11, especially for large firms.

The second key reform area is employee wages and benefits. One of the more prominent features of the Act was its limitation of key employee retention plans (KERP). This measure was enacted to curb the abuse of such plans as a means of paying out insiders of the company before its coffers were empty. While it likely accomplishes that goal, the limitation is applied broadly to insider payments, which may have made it more difficult for large corporations to retain key employees. Related to the limitation on insider payments is an increase in the required payments to rank-and-file employees. Among other changes, BAPCPA doubled the maximum amount of priority wage and benefit claims per worker and the time-frame for recovery, from about $5,000 to $10,000 and from 90 days to 180 days, respectively. Given that labor costs represent about 1/3 of most airlines' operating expenses, this change likely moved a large sum of money higher on the priority claims list. Another change to the handling of benefits was the Act's grant of permission to unwind any modification made to retiree benefits in the 180 days prior to filing for Chapter 11, provided that the company was insolvent when the modification was made. This change essentially allows the court to reverse any reduction in benefits made before the company filed for bankruptcy. Important to note is that section 1114 permits unilateral modification (including wholesale cancellation) of retiree benefits if negotiations fall through and the court finds the modification to be necessary for the firm's survival. BAPCPA essentially grants employees greater bargaining power in the context of section 1114. An important change outside of BAPCPA in this regard is the Pension Protection Act of 2006 (PPA). While I do not cover it in any detail in this paper, PPA essentially increased the cost to the firm of both carrying and terminating underfunded pensions. The reform may very well have compounded the effects of BAPCPA.

The third major reform category is nonresidential property leases. In particular, the Act limits the time-frame for the assumption or rejection of such leases. Similar to its change in the exclusivity period, BAPCPA overrides the status quo of unlimited extensions by setting a 120-day limit with at most one 90-day extension. Any leases not assumed by the end of this period are deemed rejected. For airlines, this provision applies directly to airport gates or terminals, forcing airlines to decide much sooner whether to remain at certain airports. It should be noted, however, that the Act simultaneously eliminated certain provisions pertaining to airport gate leases in the same section. For instance, the reform deleted the requirement to take all or none of the leased gates at an airport. It is unclear how important these deletions are relative to the overall change in the timeline for accepting leases.

Finally, BAPCPA raised priority for recovery of recently delivered goods, utility costs, and taxes. Both the amount and timeliness of these payments were substantially increased, placing a greater cash burden on companies during the bankruptcy process. Given the prevalence of fuel costs and taxes in the airline industry, it is possible that these changes reduced the likelihood of successfully exiting Chapter 11.

B.3. *Trends in Bankruptcy*

Other, non-legislative changes are also worth noting. Bharath et al. (2010) identify an overall decline in absolute priority rule (APR) deviations from 10% of firm value to about 2% of firm value. A concomitant rise in the use of debtor-in-possession (DIP) financing and key employee retention plans (KERP) is observed and found to be related to the decline in APR deviations. DIP financing, which came to prominence in the 1990s, tends to impose rigid restrictions on firm operations, thereby limiting the power of management, while KERPs often align management incentives with creditors. If BAPCPA did indeed enhance the bargaining position of creditors, then DIP financing terms are likely to be even more favorable to creditors. To the extent that KERPs serve as an alternative means of paying out management in reorganization, these two trends could very well have left management's incentive to reorganize unchanged. Bharath et al. (2010) consider both innovations to have led to more creditor-friendly reorganizations. These authors also note that management turnover in bankruptcy has become more common, especially among managers with significant equity stakes. Yet another trend in Chapter 11 cases has been the increase in Section 363 sales, in which the entire company is sold to an outside party. If we view managers as the ones making investment decisions, this trend coincides with the effects of BAPCPA. A shift of bargaining power toward creditors and an increased likelihood of acquisition under Chapter 11 will both increase a manager's perceived cost of filing for bankruptcy.

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