Stochastic Demand, Risk Aversion, and Heterogeneous Capital: A Simulation Model of the Firm

by

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Abstract

In recent years, several theorists have examined the effects of demand stochasticity and risk aversion on long-run plant capacity and short-run output. The standard result is that stochastic demand and risk aversion reduce firm capacity.

For this result to be nontrivial, entrepreneurs must be able to choose from alternative production technologies and cost structures – that is, heterogeneous capital must be available. This result raises interesting questions regarding the equilibrium potential of an industry composed of heterogeneous physical capital.

A simulation of four cost structures (differing in both minimum average total cost and flexibility) and two entrepreneurial types (differentiated by risk aversion) facing demand which is either stationary or stochastic is run. Heterogeneous capital is found to be a potential equilibrium result. Further, neither stochastic demand nor diverse entreprenuerial types are necessary for this result. The single most influential factor determining any particular mix of heterogeneous capital is initial entry.

Dedication

This work is dedicated to my wife, Valerie, and children, Laura, Ashley, and Jonathan – each of whom invested considerable opportunity costs in its completion.

Acknowledgments

Special thanks to Lawrence A. Boland for his knowledge, direction, and patience – all necessary conditions for the completion of this work. Also, thank-you to the other members of my committee, Irene Gordon and Zane Spindler, who made this effort much less difficult than it otherwise would have been.

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CHAPTER I

Introduction

In recent years, several theorists have examined the effects of stochastic demand and risk aversion on long-run plant capacity and short-run output. Beginning with Richard R. Nelson's (1961) examination of stochastic demand, theorists have examined such related issues as risk aversion and uncertain costs (Robert K. Jaediche and Alexander A. Robickek 1964), risk-aversion and stochastic demand (David P. Baron, 1970), and heterogeneous production processes in competitive industries (Steve A. Lippman, Kevin F. McCardle and Richard P. Rumelt, 1991).

The above theorists modelled stochastic-industry demand faced by either a risk-neutral entrepreneur[1] or a risk averse entrepreneur[2]. The standard result is that stochastic demand and risk aversion reduce firm capacity.

For this result to be nontrivial, entrepreneurs must be able to choose from alternative production technologies and cost structures — that is, heterogeneous capital must be available. This raises several interesting questions.[3] Among these are: (1) given stochastic demand, is heterogeneous capital an equilibrium outcome? or (2) even if

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1 See Nelson (1961) or Mills (1984).

2 For example, see Jaediche and Robickek (1964), Baron (1970), Paul Flacco (1983,86,90).

3 The questions that follow are restated later in the chapter as hypotheses.

heterogeneous capital is observed,[4] will the industry converge to a single production method — one with some optimal level of cost efficiencies and output flexibility?

Further, some of the above cited theorists[5] postulated industries consisting of only risk-neutral entrepreneurs; the others postulated only risk-averse entrepreneurs. Suppose both types initially coexisted. Given heterogeneous entrepreneurial types and heterogeneous capital, additional questions are: (3) given that risk-neutral entrepreneurs do not require a risk premium to compensate for utility loss from stochastic profits, will risk-neutral entrepreneurs dominate the market? (4) given that risk-averse entrepreneurs choose less risky capital structures, will risk-averse entrepreneurs be the beneficiaries of stochastic dominance by some particular cost structure and dominate the market? or, (5) does entrepreneurial market composition depend on some other factor such as the order of entry into the market?

The standard reduced-capacity results follow from strictly analytic methodology. Without a measure of either entrepreneurs' uncertainty or their utility functions, the theories are empirically untestable. One alternative to empirical market testing is to simulate a market of heterogeneous capital and heterogeneous entrepreneurs facing stochastic demand.

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4 Several theorists have stated casual observation suggests that heterogeneous capital does exist. For examples, see Walter Oi (1983) or Lippman et al. (1991). These are discussed in the next chapter.

5 Op Cit.

In the following chapters, the results of a simulation study are presented. The results are used to determine the generality of the previous findings and as a means of determining possible answers to the above questions.

HYPOTHESES

The tested hypotheses are as follows:

H1a: *Stochastic demand is a necessary condition for heterogeneous capital.* If heterogeneous capital and stationary demand can coexist, then H1a is false.

H1b: *Heterogeneous capital does not preclude industry equilibrium.* If the simulations do not converge to both heterogeneous capital and a stable industry structure, then H1b is false.

H2a: *Entrepreneurial heterogeneity is a necessary condition for heterogeneous capital.* If homogeneous entrepreneurs and heterogeneous capital can coexist, then H2a is false.

H2b: *Given heterogeneous capital, entrepreneurial heterogeneity does not preclude industry equilibrium.* If the simulations do not converge to both firm ownership by heterogeneous entrepreneurs and industry equilibrium, then H2b is false.

H3: *Differing order-of-entry conditions are sufficient to result in heterogeneous capital.* If the simulation results are independent of order-of-entry conditions, then H3 is false.

H4a: *Since risk-neutral entrepreneurs do not see risk as a cost, risk-neutral entrepreneurs will dominate ownership of any multi-entrepreneur type industry.*

H4b: *Since risk-averse entrepreneurs will choose low risk/return cost structures, risk-averse entrepreneurs will dominate a multi-entrepreneur type market.* If risk-neutral entrepreneurs' market share is significantly greater then risk-averse entrepreneurs' market share, then H4a is true and H4b is false. Similarly, if the risk-neutral entrepreneur's market share is significantly greater, then H4a is false and H4b is true. If neither entrepreneur dominates, then both H4a and H4b are false.

In the remainder of this introduction, an overview of the presentation and limitations of scope are presented.

OVERVIEW

In Chapter II, some of the recent literature on stochastic demand is reviewed. The review is limited to stochastic demand, predictability, risk aversion, and capital heterogeneity. This literature provides the basis for most of the assumptions used in the simulations.

In Chapter III, the simulation model is developed and presented. The simulation provides the empirical results, which are used to determine the potential validity of the hypotheses.

Chapter IV presents the results and analysis of the simulations.

Chapter V presents some generalizations arising from the results in chapter IV.

LIMITATIONS OF SCOPE

The theory of the firm is very broad encompassing all principles of economics and applying them to areas as diverse as single market actions of individuals (e.g., Adam Smith, 1776) to multi-party multiple transactions of organizational structures (e.g., Jean Tirole, 1988). Clearly, there is too much here to be treated in a single work. However, some individual topics within the theory require mention.

Theories of the entrepreneur describe the entrepreneur singularly as an innovator[6], or an arbitrator[7], or as having several functions.[8] For the purposes of the simulations, the entrepreneur is the Kaldorian (1934) entrepreneur. The entrepreneur is the firm's coordinator with the dual role of maximizing profits and minimizing the effects of uncertainty. For the purpose of the simulations, coordination is limited to choosing a particular cost structure.

To ensure that risk-aversion has economic effects, the entrepreneur is prevented from diversifying the firm's business risk. This is accomplished by limiting the model's entrepreneurs to those who own a substantial portion of the firm and for whom the purchase cost of the firm is a substantial portion of personal wealth.

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6 See J. Schumpeter 1921 and 1942 (1976, p.131-132).

7 See I. Kirzner (1973, p.85).

8 Eg., N. Kaldor (1934) ascribed the functions of uncertainty bearing, supervision, and coordination to the role of the entrepreneur.

The firm is a production function with its coordinating entrepreneur. Output is created on the basis of actual demand. Thus, there is no finished-goods inventory.[9]

The differences in cost structures are based on differences in plant and equipment. The differences could have been based on differences in financing methods[10], quality of labor, or monitoring or other agency costs. The purposes in using plant-and-equipment cost structures are: (1) to limit the discussion to tractable parameters; and, (2) to limit the discussion to what can be casually observed — physical differences in how things are done (i.e., heterogeneous capital).

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9 It may be helpful to think of these firms as construction-trade firms or 'make-to-order' suppliers. Alternatively, these firms could be thought of as supplying a very perishable (infinitely high-storage cost) product. All three are consistent with both the models cited from the literature and the simulation model.

10 For example, the equipment could be leased, rented, or financed by various proportions of equity and debt — long or short terms and various restrictions, obligations, and interest rates. In the stochastic-demand literature, these options are ignored and the simple Modigliani-Miller (1963) propositions applied. This thesis follows this convention.

Chapter II

Uncertainty, Risk Aversion, and Output

Since the late 1950's, a line of literature has attempted to incorporate some of Marshall's Representative Firm's 'real-world' features into the modern theory of the firm. Beginning with R. W. Clower's (1959) "Some Theory of an Ignorant Monopolist", economists and accountants have studied such issues as discovery of demand (Clower), stochastic demand, risk aversion, and conditions resulting in capital heterogeneity.

In this chapter, this literature is briefly reviewed. Since this literature is extensive, the review is limited to those papers which bear directly on the simulation model presented in Chapter III. The order of presentation is historical.

Common to this literature is the assumption of unpredictable price variations with predictable price-variation parameters. Except for Walter Oi (1983, 1987), the models follow the now standard Robinson/Chamberlain assumptions of homogeneity across firms and the conclusions are based on standard static-equilibrium methodology.[11]

Also, except for Oi, the models are developed within the production-function framework of the Equilibrium Firm.

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[11] Some authors make these assumptions explicit. For example, with respect to homogeneous prediction abilities, see Richard R. Nelson (1961, p.61 (fn.)); with respect to homogeneous utility functions, see David P. Baron (1970, pp.470-1).

DISCOVERY OF DEMAND

Clower (1959) observed that producers do not have direct access to consumers' demand curves — demand must be discovered. Using a model of a monopolist, Clower traced a series of possible iterative steps the monopolist might take in the discovery process.

Clower's model was an 'Introductory Principles' monopolist — no competitor's reaction, no taxes, no regulations, a stationary demand curve, and stationary marginal costs. But as Clower illustrated, the problem had no simple solution.

To determine the demand curve's position, Clower's monopolist iteratively produced and sold its output. After a series of iterations, the quantity clearing price and price clearing quantity were determined. However, even having resolved the market-clearing price and quantity, the monopolist may still be incorrect in its estimation of the elasticity of the demand curve.

Given Clower's results, most post-Clower authors in the area of 'demand discovery' used models of perfectly competitive firms.

STOCHASTIC DEMAND

The seminal article in a series of literature dealing with stochastic demand was written by Richard R. Nelson (1961). Nelson examined the short-run output decisions of a perfectly competitive firm producing a nonstorable product for a stochastic-demand market.

In Nelson's model, demand varies within a stable probability distribution. The parameters of the distribution are known to the firm. Information is assumed to result from the firm's predictive abilities. For example, perfect information results from perfect prediction. And, zero predictive ability means that the firm knows only the mean and the probability of any possible price, but does not know which price will occur in the next period.

Nelson concludes that the elasticity of the firm's short-run supply curve is positively related to the predictive ability of the firm. Nelson's argument is summarized as follows: If a perfectly competitive firm's predictive ability is perfect, it will produce at the level of output where marginal cost equals price. If the firm has no predictive ability, then the firm will maximize its profits by producing at that level of output where marginal cost equals the demand curve's mean. If demand varies unpredictably about a constant mean, then production will be constant.

Using a similar model, Walter Y. Oi (1961, 1963) discusses the importance of both prediction and matching of inputs to outputs. According to Oi, if a competitive firm can increase output when its demand is predicted to be high, and decrease output when demand is predicted to be low, then the firm can increase its profits.[12] Thus, as repeated by Oi (1963), given the ability to match inputs to outputs, prediction is profitable.

Nelson's and Oi's models simply maximized the mathematically expected profit of the firm. Authors following Nelson and Oi, extended

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12 Oi, as Nelson (1961), argues that high output and high price coincide, as do low output and low price, thus mean total revenues exceed the mean price times mean output.

the stochastic demand literature by including the effects of risk-aversion in their models.[13]

RISK-AVERSION

Robert J. Jaediche and Alexander Robickek (1964) introduced a risk-averse entrepreneur. Their entrepreneur faced normally distributed variations in both demand and variable costs. The entrepreneur's utility function was quadratic — positive with respect to wealth and negative with respect to risk. They assumed risk and profits to be positive functions of output.[14]

Jaediche and Robickek concluded that a firm with such an entrepreneur would produce less than the profit-maximizing output. Their reasoning can be summarized as follows: Given that the probability of selling an entire period's output is inversely related to the amount of output, a reduced output with a greater certainty of sales yields utility which is equal to or greater than that resulting from production equal to expected but uncertain sales.

By entering the concept of utility maximization into the objective function of the firm, Jaediche and Robickek treated profits as subjectively valued by the entrepreneur. Since profits were only one argument in the entrepreneur's utility function, profits' importance in

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13 Nelson explicitly excludes the effects of risk aversion. See Nelson (1961, p.62.).

14 Jaediche and Robickek used risk as a measure of the probability of an erroneous prediction resulting in losses. Thus, only erroneous predictions of high demand would lead to losses. Erroneous predictions of low demand would result in profits from the sale of the entire output.

determining output was limited by certainty and by the entrepreneur's risk-return preferences.

In modelling utility, Jaediche and Robickek used a quadratic utility function. Following theorists examined other utility functions with a view to determining the uniqueness or generality of Jaediche and Robickek's findings. In particular, they examined one measure of risk aversion — absolute risk aversion (hereafter, ARA).

David P. Baron (1970) and Agnar Sandmo (1971) concluded that decreasing ARA was necessary to conclude that output would be less than the mathematically-expected profit maximizing output. Baron (1971) and Hayne Leland (1972) reached the same conclusions after studying noncompetitive models of the firm.

The effects of decreasing ARA were extended by others. Raveendra N. Batra (1974) and Batra and Aman Ullah (1974) concluded that resource use, and thus output, would be a negative function of risk within an industry or an economy. Duncan M. Holthausen (1976) argued that the amount of physical capital stock would be a negative function of price variation. Zvi Adar, Amir Barnea, and Baruch Lev (1977) found that given a change in fixed costs (such as property taxes or other levy), the entrepreneur would decrease output by decreasing the firm's physical capital.

Paul R. Flacco's (1983) conclusions provide a summary of the theory. Assuming decreasing ARA, Flacco concludes that the elasticity of the firm's supply curve is a negative function of risk aversion. Additionally, Flacco concludes that the entry/exit price for firms is a positive function of risk aversion.

In their response to Laurence Booth (1990) and to Torstein Schmidt and John Tressler (1990), Flacco and Brent G. Kroetch qualified earlier findings as follows: For decreasing ARA and stochastic demand to result in decreased output, risk must be multiplicatively increasing with output — additive risk yields certainty results. Further, the extent to which output is affected by uncertainty and risk-aversion depends on the specific parameters of each.[15]

Following Flacco and Kroetch, the remaining general findings of the above cited theorists are as follows: (1) prediction is beneficial to the firm (Nelson and Oi); and, (2) risk aversion combined with multiplicatively increasing output risk decreases long-run firm capacity (Adar et al., Flacco and Kroetch).

Since long-run capacity changes are only one alternative to risk reduction, Rulon Pope and Randall A. Kramer (1979) argue that firms could use risk-reducing inputs. They offer agricultural use of pesticides as an example of such a risk-reducing input. They conclude that since risk is a cost, and if risk-reducing inputs exist, then the use of risk-reducing inputs will be positively related to risk aversion.[16]

David E. Mills (1984) concludes that a perfect competitor, facing uncertain demand, will exhibit flexibility in its technological and organizational structure. Flexibility permits the firm to match short-run

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15 Flacco and Kroetch state that the interaction of increased risk associated with increased output may "produce an ambiguous result in the general case" (p.636).

16 In effect, Pope and Kramer treat risk-reducing inputs as a type of insurance.

demand fluctuations with changes in output.[17] While costly, flexibility results in a cost curve particularly suited to the variation in demand faced by the firm.[18]

HETEROGENEITY

While Mills assumes the choice of intra-industry technology to be a common one, he notes that technologically heterogeneous competitive firms could be supported in an industry with stochastic demand, provided that an available discrete set of cost options exist.[19] Oi (1983) states that empirical observations did not support the assumption of homogeneous firms within industries.

Oi presents a list of "empirical regularities associated with firm size that have not been satisfactorily explained (p.148)". He presents a model of comparative advantage of monitoring and coordination which provides an explanation for these regularities. Oi's list was as follows:

> "Large firms are characterized by high capital/labor ratios, higher capital utilization rates, investments in new vs. used capital equipment, labor forces with more education, salaried, and full-

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[17] Necessarily, this implies that the firm has some short-run predictive ability.

[18] Mills notes that flexibility is not costless. A flexible technology or organizational structure will have a higher minimum average cost than an alternate, less flexible, structure.
Also, Mills obtains the output results noted earlier (ie., stochastic demand reduces capacity). However, he accomplishes these results without reference to risk aversion. His results follow directly from stochastic demand.

[19] Ibid, p.60 fn.#1.

> time employees, higher wage rates, more fringe benefits, volume production of standardized goods, more resources allocated to recruiting and training, and more vertical integration and industrial safety" (p.150).

Using the framework of the Contractual Firm, Oi explains the firm's choice of technology as a function of the relative monitoring and coordination abilities of the entrepreneur.

Oi argued that an entrepreneur, with a comparative advantage in coordination, will choose a technology which requires relatively less monitoring. Since such technology tends to be specialized, and less labour is required, the marginal product of labour will be higher and wages in this firm will also be higher. Further, since the entrepreneur will invest relatively more time coordinating, the firm will be relatively larger. The converse holds where the entrepreneur has a comparative advantage in monitoring.

Oi's use of comparative advantage in coordination provides an explanation for the observed higher wages paid by larger firms, the tendency for larger firms to produce output targeted at the general market rather than at specialized markets, the higher fixed-cost to variable-cost ratios observed in larger firms, and the observation that larger firms tend to purchase both new equipment and a newer technology (p.150).

Steven A. Lippman et. al.[20] (1991) examined the sufficient conditions for firm heterogeneity. Unlike the previously discussed models, Lippman's model requires only the installation of capacity but not production prior to the resolution of demand. Price is either high or low: at high prices all firms produce: at low prices only the more efficient producers produce. Thus, Lippman's model represents an industry's 'peak-load' capacity as an independent firm. In addition to being a price-taker, Lippman's 'peak-load-capacity firm' is a perfect competitor in the traditional sense of being able to costlessly enter or exit.

Since Lippman's 'peak-load-capacity firm' produces only at high prices, it is less flexible than the low-cost firms. This is at odds with Mills' view of flexibility (above). However, Mills' assumes that since all firms faced the same market conditions, all firms would adopt the same technology. In Lippman's (implicit) view, it is the industry that is flexible and it is the coexisting variety of technologies which provide the flexibility.

Further, Lippman's 'peak-load' firm exhibits another type of flexibility. The 'peak-load-capacity' firm enters and exits costlessly and is a relatively small firm. This results in a 'presence' flexibility. The firm enters when the market provides sufficient 'shoulder-room' for additional firms, and exits costlessly when market conditions deteriorate. As with Mills' production flexibility, Lippman's firm pays the price of higher operating costs for its 'presence' flexibility.

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20 Steven A. Lippman, Kevin F. McCardle, and Richard P. Rumelt, are hereinafter referred to as Lippman.

CHAPTER SUMMARY

The general results of the literature are as follows: (1) given multiplicative-output risk, both risk-aversion and stochastic demand result in decreased firm capacity; (2) given some short-run predictive abilities, firms may adopt flexible output capacity; and (3) both output flexibility and (Lippman's) presence flexibility result in higher minimum average total costs.

For these results to be nontrivial, entrepreneurs must be able to choose from alternative production technologies and cost structures — that is, heterogeneous capital must be available. As stated in the introductory chapter, the availability of heterogeneous capital raises interesting questions. These questions are addressed and the generality of the above results are examined with a simulated market described in the next chapter.

Chapter III
The Model

The results of the stochastic demand models suggest that deviations from mathematically-expected capacity may be explained by stochastic demand or risk aversion. While interesting, our inability to measure either entrepreneurs' uncertainty or entrepreneurs' utility functions, makes these results empirically untestable.

Further, even if perception or utility were measurable, the homogeneity assumption suggests that only one of the following can obtain: (1) alternatives to existing capital structure are not chosen and heterogeneous industry ownership does not exist; or (2) any alternatives to existing capital structure or any heterogeneous ownership does not survive and an industry converges to a single type of cost structure and ownership. Thus again, assuming homogeneity permits no testable results.

Since neither perception or utility is empirically testable (particularly under the homogeneity assumption), a simulation is devised to determine the generality of the above results.

Simulations and Proof:

The simulation results presented are not intended to pose as proofs of the hypotheses. Rather as intended with simulations in general, the results show what may happen within certain parameters.

To some extent, simulation results are functions of both the simulation design and the particular parameter values chosen. But, if the parameter values could exist outside the model, then the results could occur outside the model. In this sense, the simulations serve as tests of the existential statements in the hypothesis.

OVERVIEW OF THE MODEL

Two types of entrepreneurs are postulated — one type being risk averse, the other being risk neutral.

Following Lippman (1991), current period production is determined from a known demand curve, knowledge of both previous period's output of each firm, and current entries and exits. This method results in homogeneous perception of demand by all entrepreneurs.[21]

Entrepreneurs choose between four cost structures: (1) low cost, high flexibility; (2) high cost, high flexibility; (3) high cost, low flexibility; and, (4) low cost, low flexibility. Cost (low or high) is minimum average total cost; flexibility is output flexibility — the degree to which total costs rise with increases of output.

Costs and flexibility are based on the costs and capabilities of each firm's particular physical assets. In order to preserve degrees of freedom, the financing methods are assumed not to differ between entrepreneurs or firm types.[22]

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[21] This is not meant to deny the importance of differences in either perception or prediction abilities. Rather, it is a simple means of restricting outcomes to differences in utility.

[22] This is clearly an unrealistic assumption. Since debt requires fixed periodic payments, the risk averse can be expected to prefer equity to debt. However, following Modigliani and Miller (1963), the risk neutral would be indifferent between equity and debt. (Taxes are not considered in this simulation.)

A total of 66 simulations result from varying conditions including risk neutral or risk averse or both types of entrepreneurs, under either stationary or stochastic demand and under varying entry conditions. The model is described in greater detail in the remainder of this chapter.

THE MODEL

The model consists of:

A. *Two groups of entrepreneurs:*

E(1): $U = \partial W/W$; and,

E(2): $U = \ln(\partial W/W - \sigma^2(\partial W/W))$;

where: U is utility, $\partial W/W$ is ROR (rate of return on invested capital) from the current period and $\sigma^2(\partial W/W)$ is the variance of the last five years' ROR. E(1) is risk neutral while E(2) is risk averse with declining ARA.[23]

For the purposes of the simulation, entrepreneurs are not limited to one firm or to this particular industry. However, since uncertainty plays a central role in the model, it is necessary to specify that entrepreneurs are unable to entirely diversify a firm's business risk. Thus, while any entrepreneur's purchase of a firm would not deplete that entrepreneur's financial capital, the purchase represents a significant portion of capital.

The first condition requires the use of ROR rather than profits: the latter condition results in risk aversion having economic effects.

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[23] It should be noted that although we follow Sandmo, Leland, and Flacco in that our risk-averse entrepreneur exhibits declining absolute risk aversion, for the purpose of this model the specific forms of the utility functions are not relevant. It is only necessary that the utility functions differ in risk aversion.

B. *Four firms*[24]:

Table III.1 provides the major cost classifications for the four firms. These costs represent the physical-plant costs and do not include those additional marketing and other costs which may be incurred by the enterprise but are neither functions of the plants nor dictated by the type of physical capital employed by the plant.

The particular types of costs are generalizable to most enterprises. Fixed costs are those costs which must be incurred to permit the firm to exist. Periodic or 'switch-on' costs are those costs which must be incurred to operate an existing plant and variable per unit costs are variable operating costs.

All equipment is assumed to be purchased from a competitive industry and to be 'general use' equipment[25]. These assumptions permit both expansion and exit without changing the cost base. Further, the 'general-use equipment' assumption permits the ignoring of industry expansion/contraction effects on demand of this equipment — thus, obviating the need to adjust the beginning cost structures.

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24 The cost structures are based on a forecasting study done by the author for a vinyl-windows start-up manufacturer. For the purposes of the current study: (1) the figures are rounded; (2) interest rates are real rates; and, (3) the cubed labour term creates the short-run capacity constraints.

25 The major setup costs included: (1) the capitalized value of leased 'light-industrial' zoned mall space; (2) standard air compressors; (3) copper tubing; (4) computers and associated equipment; (5) delivery vehicle; and, (6) welding equipment. Of these six, only the welding equipment can be considered specialized equipment — and only to the extent that its' use is limited to welding vinyls.

Table III.1

Firm Types and Associated Costs

Firm Number:	#1	#2	#3	#4
Fixed Costs:				
Plant and Equipment:	100000	150000	0	25000
Inventory Float:	100000	100000	50000	50000
int(1):	0.05	0.05	0.05	0.05
int(2):	0.07	0.07	0.07	0.07
Capital Replacement:	7950	11926	0	1988
Periodic Costs:				
Rental:	0	0	3559	0
RM(constant):	100000	100000	50000	50000
Labour (Constant):	100000	100000	50000	50000
Variable Costs:				
Labour (per unit):	1	1	20	10
Rental (per unit):	0	0	1	0
Materials (per unit):	0.1	0.1	0.2	0.2
Labour (Q(x)):	0.04	0.039	0.17	0.168
Summary:				
Q(Min. ATC):	140	143	68	68
ATC (at Min.):	2356	2382	2382	2356
MC (at Min. ATC):	2356	2382	2382	2356
Output Flexibility:	High	High	Low	Low
Minimum ATC:	Low	High	High	Low

Fixed costs consist of the opportunity costs of invested funds (the interest rate x capital) plus capital replacement, which is taken as the principal portion of the amortized value of the initial cost over the life of the plant. Since capital replacement will occur each period[26], the first period's principle portions are used for each period. Int(1), the lower interest rate, is used to calculate these values.

The 'inventory float' figures represent inputs which are unlikely to vary in quality or composition during the life of the plant.[27] Since such inputs are changed during the production process and are subject to breakage and wastage (thus, they are more risky than fixed assets), lenders or investors require a higher interest rate. Int(2) is used to determine the periodic costs of 'inventory float'.

Periodic or 'switch-on' costs consist of equipment rental costs (for firm #3 only), modernizing raw material inventories, periodic fixed costs (eg., property taxes, utility hookups,...), and a base labour supply (eg., administration, marketing, shop-floor personnel, economists,...).

Variable costs include raw material inputs (eg., electricity, sales volume rental, inventory costs — both raw and finished goods) and labour. Labour (Q(x)) is given the cubed term to reflect rapidly diminishing marginal product of labour as applied to the fixed assets.

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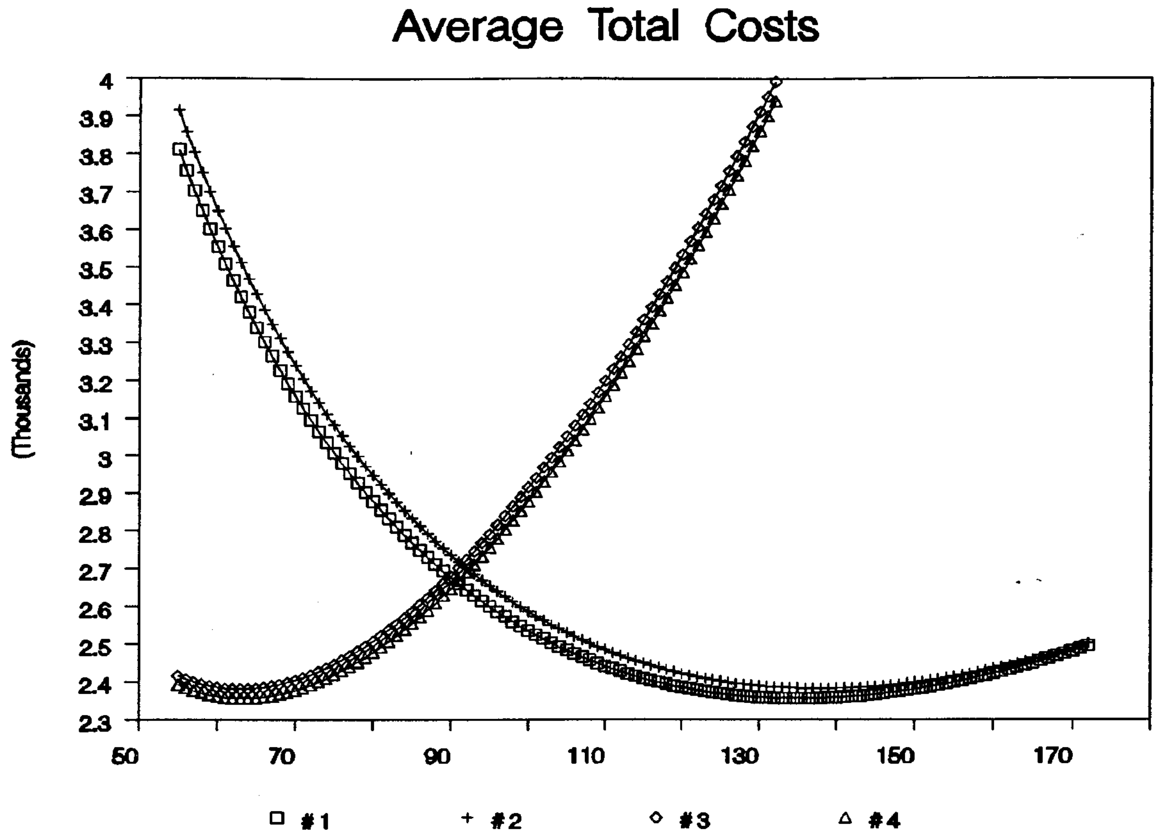
26 Continuous replacement of capital facilitates two of our previous assumptions: (1) costless exit — the equipment will be modernized each period and is thus salable at the original cost; and (2) periodic cost structure adjustment — since the equipment is modernized each period, there is no need for periodic cost-structure readjustments.

27 In the vinyl windows industry, these are the vinyl extrusions which are purchased in lengths varying from 3 to 5 meters (approximate) and are cut and welded into the frames and braces for windows.

Figure III.1



Using the categorizations in Table III.1, average total costs are (plant and equipment x int(1) + Inventory float x int(2) + Capital Replacement) + (Periodic Costs) + (linear per unit costs (Labour + Rentals + Materials) + non-linear per units costs (labour)) all divided by output. For firm #1 these are [(100000 x 0.05) + (100000 x 0.07) + 7950 + (0 + 100000 + 100000) + (1 + 0 + 0.1)xQ + $0.04Q^3$]/Q which reduces to $219950Q^{-1} + 1.1 + 0.04Q^2$. Marginal cost is then = $1.1 + 0.12Q^2$.

Figure III.1 illustrates the average total costs of the four firms. As illustrated, firms #1 and #2 are both larger and relatively more output-flexible. Firms #3 and #4 have approximately one-half the capacity of the larger firms.

Table III.2

	Flexibility	
Costs	High	Low
High	Firm #2	Firm #3
Low	Firm #1	Firm #4

Table III.2 illustrates the relative costs and flexibilities of the four firms. Firms #1 and #2 are the highly output-flexible firms[28]; firms #1 and #4 are the low cost firms[29]. Although not shown in the table, due to being the smaller firms, firms #3 and #4 exhibit 'presence flexibility'[30].

C. *Demand:*

Demand is market demand and is given as:

$$P = \alpha - \beta Q;$$

where: P is the market price;

: Q is market demand for the current period;

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28 As a measure of output flexibility, Mills (1984, p.68) uses the inverse of the second derivative of the cost function. For a quadratic cost function, this reduces to the inverse of the second derivative of the squared term. The cost structure in Table III.1 has no squared term. Rather, to better reflect the capacity constraints of the particular technology discussed, a cubed variable is used. Thus, the appropriate reduced measure of flexibility of the given cost structures is the inverse of the second derivative of the cubed term.

29 Their minimum average total cost (herafter, ATC) is less than the minimum ATC of the other two firms.

30 'Presence flexibility' was the term used to describe Lippman's 'peak-load-capacity' firm in the previous chapter.

: α is the vertical intercept; and,

: β is the slope of the curve.

Demand is either stationary or stochastic with a stationary mean. The intercept and slope are:

$$\alpha = \alpha + \gamma(R_1 - R_2);$$

$$\beta = \beta + \gamma(R_3 - R_4);$$

where: α is the mean intercept;

: β is the mean slope;

: R_i is an interval [0..1] random number generated by the program for each period with i = 1..4; and,

: γ is a coefficient chosen to set a reasonable limit to the variability of the demand curve.

The values chosen for the simulation are: $\alpha = 3500$; $\beta = 1$; $\gamma = 0.05$ for stochastic demand; and $\gamma = 0.00$ for stationary demand.

D. *Optimal firm output* is determined by:

$$MR = MC:$$

where: $MR = \alpha - \beta(Q^M + 2Q^f)$;

: Q^M = Previous period's market output – current exits + current entries – the firm's previous period's output, all of which are known to the firm;

: Q^f = the firm's current period's output;

: MC = the first derivative of total cost.

E. *Order of Entry:*

To enter the industry, an entrepreneur chooses a firm type which produced positive utility in the preceding period and produces positive utility in the current period (after entry).[31]

Similarly, exits required a preceding negative period and a current negative period.[32] In all simulations, only the firm with the most negative utility exits.[33]

The eleven entry methods used are as follows:

0: In each iteration and given existing firms, the firm producing the highest utility enters. In the first iteration, the firm producing the highest utility enters;

1..4: Firm #1..#4 enters in the first round; then the firm producing the highest utility, given existing firms, enters in subsequent iterations (as in condition 0:);

5: A maximum of one firm type enters in each iteration (ie., a maximum of four firms per iteration per entrepreneur type). If a

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[31] This required continued experimentation. A firm was entered: if the result was positive utility, then the firm remained; if the result was negative utility, then the entry was cancelled.

[32] If both the preceding and current periods were negative, the firm was withdrawn and the current period proceeded without the withdrawn firm. On occasion, this resulted in a profitable current period for all remaining firms.

[33] Entry/exit conditions are largely arbitrary. The reason for the single firm exit rule was that, in the business world, some 'would-be exitters' may delay exitting when they see a competitor exitting. In a noncompetitive market, an exit may signal a larger per-firm market for remaining firms; in a competitive market, an exitting firm may be an indication of many exits, thus signaling better future conditions for remaining firms.

firm type does not produce positive utility, then that firm type does not enter. For example, if firm-type #2 does not produce positive utility, then only one each of firm-types #1, #2, and #3 are eligible to enter. ;

6: Any number of firms of any type enter. The only limitation to entry is that the firm must produce positive utility.

1M...4M: A mature industry consisting only of firms type #1 to #4. Following the establishment of an industry of a particular firm type, entry of other firm types is permitted according to the rules in 0.

For 5: and 6:, upon seeing the entry intentions of other firms, a firm which previously declared entry may 'change its mind'. The order is: (1) exit (one only); (2) entry in the order of: (a) highest utility; (b) highest utility following entry of the first,...; and, (3) refusal to enter.[34]

Since cost structures (efficiency and flexibility) and risk aversion are the variables of interest, it was expected that the order of entry would be irrelevant. It was initially expected that the sole result from differing order-of-entry conditions would be an increase in degrees of freedom.[35]

As illustrated in Table III.3, a total of 66 simulations result from the demand types (stationary and stochastic), entrepreneur types (risk

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[34] This may be thought of as a business-license queue. The highest potential utility firms apply for (and receive) their licenses first. However, if the effects of subsequent entrants result in negative utility for previous applicants, then those previous applicants may decline to exercise their licenses.

[35] The eleven order-of-entry conditions resulted in 66 simulations. The particular order-of-entry conditions were chosen for simplicity.

neutral only, risk averse only, and both), and the eleven order-of-entry conditions.

Table III.3

Simulation Types

Entrepreneurial Type	Stationary Demand	Stochastic Demand
Risk-averse entrepreneur	11	11
Risk-neutral entrepreneur	11	11
Both entrepreneurs	11	11
Totals:	33	33

CHAPTER SUMMARY

The model consists of two entrepreneurs, one risk neutral and the other risk averse choosing between four firm types, each of which exhibit either high or low costs and either high or low flexibility, and facing either stationary or stochastic demand. The eleven order-of-entry conditions result in sixty-six simulations.

Chapter IV
Results

This chapter presents the results of the simulations. Some general comments are made; These are followed by the results in order of (1) convergence and (2) hypothesis.

General Comments

The simulations are iterative procedures. Iterations are terminated at the lesser of: (1) given existing firms, when entrepreneurs' utility is stationary at 5 decimal places; (2) when utility is cyclical at 5 decimal places; or, (2) 200 iterations. The limit of 200 iterations is chosen due to both computer RAM and processing time limitations.[36]

CONVERGENCE

Table IV.1 categorizes each of the 66 simulations by the number of iterations required to achieve convergence. Column 'Ent. Type' (entrepreneur type) indicates the entrepreneur type entered in each row's simulations: 0 is the risk-neutral entrepreneur, 1 is the risk-averse entrepreneur, and 2 is both. Column 'Demand Type' is 0 for stationary

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[36] Due to the author's comparative advantage in spread-sheets, the program was written in Lotus 1-2-3 2.1(c). Additionally, spreadsheet programs permit both the monitoring of each iteration and the direct access at any time at any cell in the program.
As measured by disk-space, summary worksheets ranged in size from 182K (risk-neutral entrepreneur/stationary demand) to 996K (both entrepreneurs/stochastic demand).

Table IV.1

Iterations Required for Convergence

		Iterations				
Ent. Type	Demand Type	>199	150-199	100-149	50-99	<50
0	0 1	0 4	0 2	0 5	2 0	9 0
1	0 1	0 3	0 3	0 3	5 2	6 0
2	0 1	0 11	0 0	0 0	1 0	10 0
Total		18	5	8	10	25

demand simulations and 1 for stochastic demand simulations. Eleven simulations are summarized in each row.[37]

Forty eight or 73% of the simulations converged. All 33 stationary demand simulations reached convergence in less than 100 iterations. However, only two stochastic demand simulations converged within that period, while 18 did not converge within 200 iterations. These 18 included all 11 of the simulations involving both entrepreneur types and stochastic demand.[38]

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37 The eleven simulations are the result of the eleven order-of-entry conditions.

38 As a test of the 200 iteration limit, a stochastic-demand heterogeneous-entrepreneur market was extended. The stationary utility criteria was reached at approximately 1200 iterations. However, by 1500 iterations the stationary utility criteria was breached and not regained. At 2000 iterations, this writer's marginal utility was less then the opportunity cost of continuing the simulation.

HYPOTHESES RESULTS

H1a: *Stochastic demand is a necessary condition for heterogeneous capital.*

H1b: *Heterogeneous capital does not preclude industry equilibrium.*

H2a: *Entrepreneurial heterogeneity is a necessary condition for heterogeneous capital.*

H2b: *Given heterogeneous capital, entrepreneurial heterogeneity does not preclude industry equilibrium.*

Results: Table IV.2 shows the frequency of presence of firm types at the final iteration. Except for the stochastic demand simulations, at termination[39] for each simulation type, all firm types were present at least once.[40] Thus, the particular parameters chosen for the simulations did not prevent any particular firm type from entering or remaining in the simulation.

Table IV.3 presents the firm-type combinations at termination. Firm #4 appeared most frequently — alone 37 times, and in combination with other firm types, 26 times, for a total of 63 times. Second in

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39 For the stationary demand simulations, the terminal iteration is shown. For stochastic demand simulations, since convergence occurred only 15 of 33 times (within 200 iterations) the firm is counted if it appeared during the last 5 iterations.

40 Each simulation type consisted of eleven orders-of-entry. Thus for simulation type 'Entrepreneur 0, Demand 0', Firm #1 was present at termination in three of the eleven simulations.

Table IV.2

Frequency of Firm Presence at Termination

Ent. Type	Demand Type	#1	#2	#3	#4	Freq. of Convergence
0	0	3	2	4	9	11/11
	1	2	0	4	11	7/11
1	0	2	2	1	11	11/11
	1	1	0	2	11	8/11
2	0	2	2	6	10	11/11
	1	1	0	5	11	0/11
Total	0	7	6	11	30	33/33
	1	4	0	11	33	15/33
	Total	12	6	22	63	48/66

Table IV.3

Frequency of Firm Combinations at Termination

Ent Type	Dem. Type	#1	#2	#4	#1,4	#2,4	#3,4	#1,3,4	All
0	0	1	1	5	0	0	2	1	1
0	1	0	0	6	1	0	3	1	0
1	0	0	0	8	1	1	0	0	1
1	1	0	0	8	1	0	2	0	0
2	0	0	0	5	0	0	3	1	1
2	1	0	0	5	1	0	5	0	0
All	0	1	1	18	1	1	5	2	3
All	1	0	0	19	3	0	10	1	0
All	All	1	1	37	4	1	15	3	3

Note: In addition to the tabled results, firm-types #2 and #3 combined once during a 'Ent. Type 2', Dem. Type 0' simulation. No other possible firm combinations occurred.

appearances was Firm #3 — 22 times, but only in combination with other firms. Firms #1 and #2 appeared 11 and 6 times respectively, with each appearing once alone.

From Table IV.3, thirteen of the 33 stationary-demand simulations terminated with capital heterogeneity. Further, only 14 of the 33 stochastic-demand simulations terminated with capital heterogeneity. Thus, stochastic demand is not a necessary condition for capital heterogeneity and H1a is false.

As shown in Table IV.2, all stationary-demand simulations converged. Thus, heterogeneous capital does not preclude industry equilibrium and H1b is true.

From Table IV.3, 15 of 44 homogeneous-entrepreneurial simulations terminated with heterogeneous capital. Thus, heterogeneous entrepreneurial heterogeneity is not necessary for capital heterogeneity[41] and H2a is false.

As shown in Table IV.2, for the heterogeneous-entrepreneurial simulations, all eleven stationary-demand simulations but none of the stochastic demand simulations converged. Thus, entrepreneurial heterogeneity does not preclude a stationary-demand industry equilibrium. However, entrepreneurial heterogeneity does preclude a stochastic-demand industry equilibrium. Therefore, subject to demand being stationary, H2b is not rejected.

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[41] The Chi Square statistic of 0.051 suggests independence between each of homogeneous and heterogeneous entrepreneurial types and homogeneous and heterogeneous capital.

Conclusion: Neither stochastic demand nor entrepreneurial heterogeneity are necessary conditions for capital heterogeneity. Thus, H1a and H2a are refuted. Similarly, neither capital heterogeneity nor entrepreneurial heterogeneity precludes industry equilibrium. Thus, H1b and H2b are true.

However, not all stochastic-demand simulations converged. Further, all combined stochastic-demand heterogeneous-entrepreneurial simulations failed to converge. Thus, since the heterogeneous-entrepreneurial simulations require stationary demand for convergence, H2b is conditionally true.

H3: *Differing order-of-entry conditions are sufficient to result in heterogeneous physical capital.*

Results: Table IV.4 presents both the numbers of simulations and corresponding chi-square statistics relating the initial presence of a firm type corresponding to the terminal presence of each of the four firm types. Both Firms #1 and #2's terminal presence are significantly associated to their own initial presence. Similarly, Firm #4's terminal presence is significantly associated to its initial presence and Firm #3's terminal presence is associated to Firm #1's initial presence.[42] A further test of all sixteen possible outcomes yields a chi-square statistic of 14.11 – significant at approximately 0.125.

[42] The level of significance is approximately 0.125.

Table IV.4

Terminal Presence vs. Initial Presence

Terminal Presence	Initial Presence Firm #1	Firm #2	Firm #3	Firm #4
Firm #1	11‡‡ (35.20)	4 (0.55)	4 (0.44)	4 (0)
Firm #2	3 (0.96)	7‡‡ (20.88)	3 (0.02)	3 (0.14)
Firm #3	13 (2.62)	12 (1.13)	18 (0.34)	12 (0.56)
Firm #4	17 (0.37)	15 (1.72)	28 (0.39)	24* (3.77)

Note #1: levels of significance are shown as: * for 0.1; † for 0.05; ‡ for 0.01; and, ‡‡ for 0.001.

Note #2: The 16 chi-square statistics represent sixteen 2 X 2 matrices. Row labels are Firm X terminally present, terminally not present; the column labels are Firm Y: initially present, initially not present.

Conclusion: Since for all firm-types', terminal presence is not independent of initial presence, the simulation results are not independent of order-of-entry conditions. Thus H3 is true.

H4a: *Since risk-neutral entrepreneurs do not see risk as a cost, risk-neutral entrepreneurs will dominate ownership of any multi-entrepreneur type industry.*

H4b: *Since risk-averse entrepreneurs will choose low risk/return cost structures, risk-averse entrepreneurs will dominate a stochastic-demand multi-entrepreneur type market.*

Results: Table IV.5 displays both the average terminal market shares and corresponding Z statistics for both stationary and stochastic market demand for the 22 dual entrepreneurial-types simulations.[43] For stationary demand, the risk-neutral (risk-averse) entrepreneurial type's market share is significantly above (below) 50%. While the risk-averse entrepreneurial type's market share is significantly greater than zero, the risk-neutral entrepreneurial type dominates the stationary-demand market.

For stochastic demand, the results are reversed. The risk-averse (risk-neutral) entrepreneurial type's market share is significantly above (below) 50%. While the risk-averse entrepreneurial type's market share is significantly greater than zero, the risk-neutral entrepreneurial type dominates the stochastic-demand market.

The result that entrepreneurial-type success depends on market conditions is counter-intuitive. A possible reason for the result lies in the firm type selected by differing entrepreneurial types. The risk-neutral entrepreneurs are indifferent to risk and will choose firms on the basis of expected returns. The risk-averse entrepreneurs choose firms on the basis of risk-adjusted returns. With stationary demand, risk is limited to early iterations where return variances result from the entry and exit of firms. As the market stabilizes, risk disappears. Being risk-indifferent, the risk-neutral entrepreneurs dominate the market.

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[43] The Z statistics are based on the binomial test of proportions of market share. The number of simulations (66) times the market share less 50% is divided by the square root of 66 (simulations) times 50% times (1-50%). The 50% is the market share which would result from a random, thus equal, sharing of the market.

Table IV.5

Market Share by Entrepreneurial Type

Entrepreneur	Demand Stationary	 Stochastic
Risk-Neutral	0.858‡‡ (5.825)	0.346‡ (-2.502)
Risk Averse	0.141‡‡ (-5.825)	0.653‡ (2.502)

Note: levels of significance are shown as: * for 0.1; † for 0.05; ‡ for 0.01; and, ‡‡ for 0.001.

However, under stochastic-demand conditions, recognizing risk as costly benefits the risk-averse. Having a lower minimum ATC than either Firms #2 or #3, Firm #4 is exposed to less risk in stochastic markets. Being smaller than Firm #1, Firm #4 is able to enter and remain in the market when Firm #1 can not.[44] Both types suffer losses from decreases in demand and have equal opportunities to exit. Since Firm #4 has more opportunities to enter and equal opportunities to exit, Firm #4 dominates the market.

Table IV.6 illustrates firm #4's market dominance.[45] While dominant for both stationary and stochastic demand simulations, firm #4's dominance is greater when facing stochastic demand.

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44 This is the Lippman 'presence flexibility'. In the simulated market, approximately 16 firm types #3 or #4 or eight firm types #1 or #2 could profitably produce. An increase in demand may be sufficient for a Firm #4 but not for a Firm #1.

45 Table IV.6 illustrates the industry structure for the 22 dual entrepreneurial-type simulations. The data are firm-type terminal-

Table IV.6

Market Share by Firm and Entrepreneurial Type
Frequency of Firm Presence at Termination

	Firm Types #1	#2	#3	#4
stationary	0.068 (0.124)	0.046 (0.112)	0.282 (0.262)	0.602* (0.351)
stochastic	0.043 (0.136)	0 (0)	0.023 (0.020)	0.933§ (0.138)

Note: significance of average values are: * for 0.2; † for 0.1; ‡ for 0.05; and, § for 0.01.

The risk-averse choose firm #4, the firm which dominates the market at termination. It is the risk averse entrepreneurs' preference for the eventually dominant firm which results in market dominance by the risk averse.[46] Also, to the extent that the risk-neutral entrepreneurs choose firm #4, the risk-neutral entrepreneurs are significantly present.

Conclusion: Without qualification, neither H4a nor H4b are true. However for stationary demand, risk-neutral entrepreneurs dominate the market. Thus for stationary demand, H4a is true.

Similarly, for stochastic demand, risk-averse entrepreneurs dominate the market. Thus for stochastic demand, H4b is true.

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average-market shares per demand type and corresponding standard deviations.

[46] Since firm type #4 is smaller than firm types #1 or #2, this result is consistent with Jaediche and Robickek (1964), Sandmo (1969), to Flacco (1986), all of whom predicted that risk aversion results in smaller firms.

CHAPTER SUMMARY

Neither stochastic demand nor entrepreneurial heterogeneity is a necessary condition for heterogeneous capital.[47] However, the presence of both stochastic demand and entrepreneurial heterogeneity prevent simulation convergence.

Differing order-of-entry conditions are sufficient to result in heterogeneous capital. For Firms #1, #2, and #4, initial firm-type presence is positively associated with own-type terminal presence. Further, an across firm-types test showed significant interdependence between initial and terminal presence.

The risk-averse entrepreneurial type dominates the stochastic demand simulations. This domination is significantly correlated with the stochasticly dominant firm — firm-type #4. Risk-neutral entrepreneurial types choose the riskier firm — firm-type #3. However in stochastic demand simulations, since convergence does not occur, these conclusions are not equilibrium outcomes.

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[47] The hypothesis results are summarized in Table IV.8.

Table IV.7

Hypothesis Results

Hypothesis	Result	Qualification
H1a	false	none
H1b	true	none
H2a	false	none
H2b	true	stationary demand
H3	true	none
H4a	true	stationary demand
H4b	true	stochastic demand

Chapter V
Generalizations

This chapter offers some additional observations and generalizations resulting from the simulations. These observations and generalizations are discussed in the following order: (1) leverage; (2) efficiency; (3) risk aversion; (4) demand; and, (5) additional considerations. Under additional considerations, prediction and other attributes of the firm are discussed.

The observations are those which, while not central to the simulation results, are necessary for completeness and, with the simulation results, provide the opportunity for generalization. In addition, some of the generalizations directly follow from the simulation results.

LEVERAGE

Simulations involving the entry of one firm per iteration[48] have early iterations similar to the early periods of a growth industry. For both the simulation and a growth industry, returns are high and any firm type can survive. In growth industries, since capacity growth is frequently greater than rates of return on existing capacity, many firms are highly leveraged.

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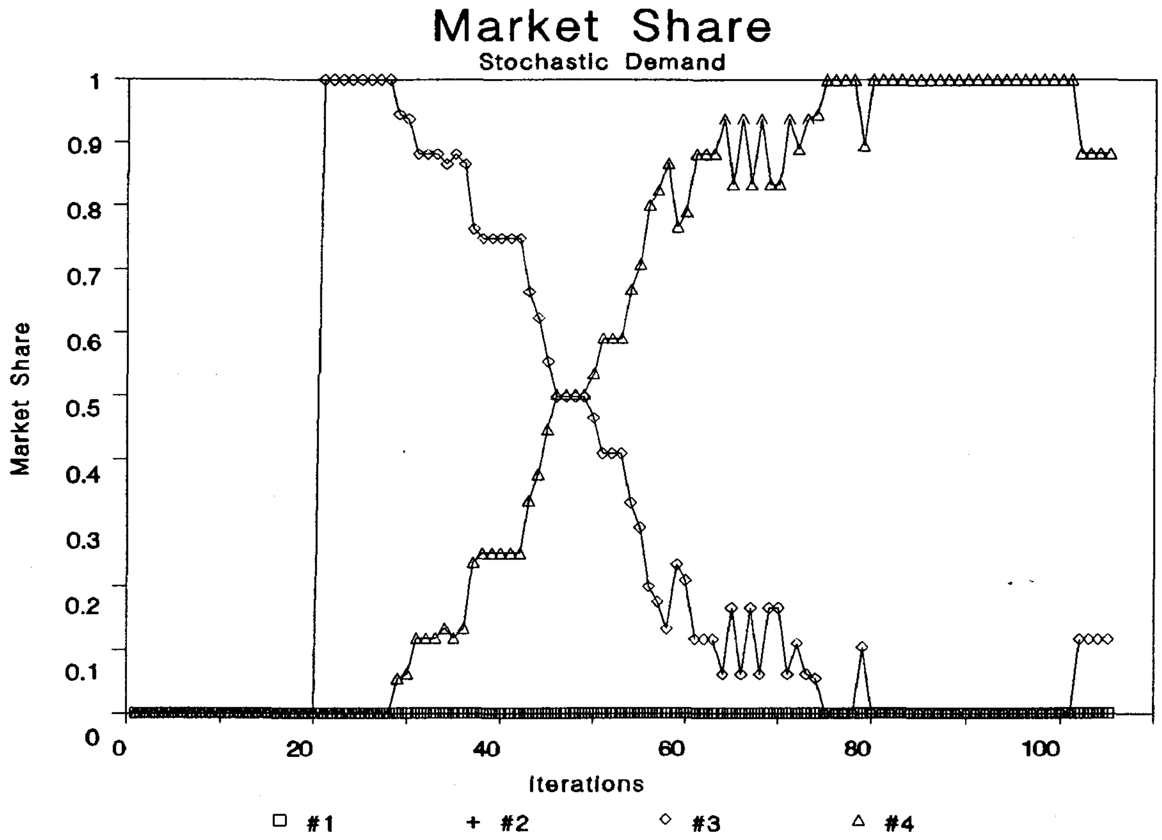
48 These simulations include all but the multiple entries permitted by order-of-entry conditions 5 and 6.

Figure V.1



With its low fixed costs but high periodic costs, firm-type #3 is similar to a highly leveraged firm. As illustrated in figure V.1, in the 'one-firm-per-iteration simulations' firm-type #3 enters early.[49,50]

However, leverage is costly. As illustrated in Figure V.1, once the simulation market fills, firm-type #3 is the first to exit.[51] Firm-type #3's

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49 Figure V.1 illustrates a stochastic-demand simulation of one entry per iteration with both entrepreneurs present.

50 For all figures, iteration 20 is the first active iteration. The first 20 iterations are used only for order-of-entry conditions 5 and 6 to 'preset' the simulations and permit the returns to stabilize.

51 In Figure V.1, at iteration #28 the market can not sustain additional firm-types #3. However, there is sufficient room for a firm-type #4 -- it

exit behaviour is similar to the exiting of highly leveraged firms in maturing industries.

Not present in the simulation but present in industry, is the ability of firms to change their firm type. In the simulation once the market fills, owners of firm-type #3 simply exit. While the simulation assumptions allow for an owner to exit one firm type and enter another, the ownership of particular firms is not identified.

Generalization: Where demand growth exceeds the ability of firms to expand, any firm type can enter and survive. Such an industry can be composed of a broad cross-section of both firm and entrepreneurial types. This is of particular advantage to undercapitalized entrepreneurs, who in mature markets would be unable to enter as entrepreneurs.[52]

In industry, the high returns generated from early entry into an expanding market may be sufficient to finance the conversion to other firm types. Owners of firm-type #3 may change the structure of their firms to either firm-type #1 or firm-type #4 — the low cost firms. While the extent to which this occurs is an empirical question, casual observation is consistent with a hypothesis that leverage is common and

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has a lower minimum ATC. Thus, a firm-type #4 enters and is profitable. However, this requires at least one firm-type #3 to leave. By iteration #76, all firm-types #3 have exited and have been replaced by firm-types #4. Since demand is stochastic, the market occasionally permits entry of an additional firm-type #3 (iteration #78 and #101), but such entry is not sustainable. Note that, in figure V.1, firm-types #1 and #2 never appear.

[52] They might enter, but returns on invested capital would accrue entirely to outside investors. This would leave the entrepreneur in a position of bearing the entire risk while working for a wage.

advantageous in growth industries and injurious to firms in maturing markets.

EFFICIENCY

Economic theory suggests that cost efficiency is a primary component of firm survivability.[53] As applied to heterogeneous capital, this argument suggests that the most efficient firm type is the sole survivor. The mechanism favouring the most efficient firm is the lure of potential profits awaiting the entrepreneur with a more efficient firm type.

Yet, the simulation results suggest otherwise. Several combinations of firm types with differing cost structures are potential equilibrium outcomes. Given these combinations, additional entry simply produces losses for all firms — including the latest entrant. For cost efficiency to guarantee success, some additional factor is required.

Three factors not present in the simulation are: (1) a single firm type with a significant cost advantage over other firm types; (2) a firm or group of firms, regardless of type, with financial capacity exceeding that of other firms; and, (3) the ability of entrepreneurs to change their firm types. The latter was discussed in the previous section.

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53 Cost efficiency was a major focus of the early 1930's debates of industry structure and supply. See Arthur C. Pigou (1928), Edward H. Chamberlain (1933), Joan Robinson (1933), Nicholas Kaldor (1934). In the literature cited in Chapter III, cost efficiency and flexibility are the major aspects of firm survival.

Significant Advantage:

In the simulations, cost structures are such that two firm types operate at each of the two minimum average cost levels. While firm-types #1 and #4 are the most cost efficient, firm-types #2 and #3 are present at the termination of 28 of the 66 simulations. The entry of a firm-type #1 or #4 would simply produce losses for all firms.

Generalization: For cost efficiency alone to determine the final composition of the simulated industry, the cost efficiency would need to be such that the most cost-efficient firm would produce profits while others produce losses.

With the presence of a firm with such cost efficiency, other firm types could simply not survive. However without such a firm type, cost structure alone is not sufficient to result in a predeterminable industry composition.

This is in accord with Lippman's model. Lippman's firms differ in cost and size. The larger, more cost-efficient firm operates in all demand conditions. However, when demand increases, the less cost-efficient firm enters.

Extending Lippman's model, if it is assumed that the increased demand is sufficient for a smaller but higher cost firm but insufficient for an additional larger but lower cost firm, then it is irrelevant that demand is temporarily high (as with Lippman's model). What is relevant is the relative cost differences between the firms and the market-demand elasticity — the supportable cost differences are inversely related to the elasticity of market demand.

For example, if market demand is highly inelastic, the market can support firms with large cost differences. With high market-demand elasticity, only small cost differences are supportable. For consistency with Lippman, the condition that the firms are small relative to the market (and therefore, the firm's average revenue equals marginal revenue) is sufficient to obtain Lippman's perfectly competitive industry.

If demand is stochastic, then two additional qualifications are required. Any observed increase in demand must be expected to last for a sufficient period of time to both create the firm and to recover all invested capital.[54]

For market demand with high stochastic frequency[55], entry will be limited to those firms which can be quickly created and for which exit is costless. Also, as with stationary demand (above), the choice of firm type will be that type which minimizes the likelihood of industry overcapacity and losses for the entrant. While not stated by Lippman but consistent with Lippman's model, this later condition favours smaller firms.

For market demand with low stochastic frequency, a greater number of firm types are available. In addition to those firm types which are viable under high-frequency stochastic demand, firm types requiring longer periods of time to create or to recover their invested capital

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54 In the simulated market, the assumption of full recovery of invested capital on exitting facilitated this expectation.

55 'Frequency' is here used as a measure of demand movement over time.

become viable. That is, as the stochastic frequency is lessened, the conditions of rapid creation and investment recovery disappear.

In the literature cited in Chapter II, stochastic frequency was not considered. Under the assumptions of homogeneous physical capital and homogeneous entrepreneurial types, frequency is simply not an issue. However, when heterogeneous physical capital is entered as a variable then, as discussed above, frequency matters.

While not simulated, stochastic frequency relative to both firm-creation time and investment-recovery time can be expected to affect the firm types entering the market. Subject to the elasticity of market demand, the cost advantage of a particular firm type is of less importance.

Financial Capacity:

In industry, the ability to enter and remain is a function of an entrepreneur's ability to coordinate assets including financial assets.[56] This ability results in a firm's financial capacity to meet financial requirements during periods of expansion or losses.

Generalization: Since there is no obvious correlation between abilities of coordinating physical assets and coordinating financial assets, there is no obvious winner in an industry where an additional entry causes losses for all. Given either stationary or stochastic demand, firm

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56 See Kaldor, 1934.

survival may simply depend on the entrepreneurs' financial asset co-ordination abilities relative to the extent of their respective losses.[57]

RISK AVERSION

Two aspects of risk aversion require comment. First is the effect of risk aversion on the timing of switching of firm types; second are the utility function parameters.

Firm-Type Switching:

Risk aversion has its greatest effect in the intermediate iterations. In early iterations for both stationary demand and stochastic demand, variance of returns is high. However the concurrent high returns, particularly of firm-type #3, attract entry by all entrepreneurial types. During the intermediate iterations (when the market fills), returns and return-variances decrease and firm-type switching occurs.

Firm-type switching occurs first with the risk averse entrepreneurial type. As previously shown in Table IV.6, the risk averse significantly prefer the stochastic dominant firm-type #4. The switching behaviour, from firm-type #3 to firm-type #4, occurs first with the risk averse. This early switching by the risk averse is most significant under the high-variance conditions of stochastic demand.

Generalization: To the extent that physical capital structure determines the returns and return variances of firms, observation of firm-type

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57 That is, the survivors will be those with the deepest pockets or the friendliest bankers.

switching by only some firms may be a means of estimating the composition of an industry by entrepreneurial type. However, any such estimates cannot be done to the exclusion of estimating prediction abilities[58] or changes in other abilities of entrepreneurs[59].

Utility Parameters:

To some extent, the particular simulation behaviour of the risk averse is an artifact of the particular utility-function parameters. Choosing different returns variance weightings would change the entry/exit behaviour of the risk averse. However, the particular parameters chosen are sufficient to result in differences in firm-type selection behaviour while not excluding any entrepreneurial type.

However, what is relevant to this discussion is that the availability of heterogeneous physical capital with its resulting differing return variances, permits entry of entrepreneurs who differ in risk aversion. Further, as shown in the previous chapter[60], the presence of heterogeneous entrepreneurial types increases the likelihood of heterogeneous physical capital.

Generalization: Where individuals differ in risk aversion, some individuals will be sufficiently risk averse to avoid certain risky endeavours. Modelling such individuals simply requires increasing the

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58 Discussed below under '**Prediction**'.

59 Discussed below under '**Additional Considerations — Other attributes of the firm**'.

60 See Table IV.3.

strength of the returns-variance term. Other individuals, both risk averse and risk neutral, may enter risky industries and their firms can survive.

The issue is one of degree of risk aversion. When this issue is combined with heterogeneous capital with differing returns and return variances, increased diversity of entrepreneurial types is likely. More risk-averse entrepreneurs choose a less risky capital structure while less risk averse choose higher-return/higher-risk capital structures.

DEMAND

The demand parameters were chosen for their simplicity and restrictive effects on the size of the simulations.[61] Two obvious questions are 'to what extent are the simulation results simply an artifact of the demand parameters?', and 'to what extent are the results the product of the value of the demand variation parameter, γ ?'. The first question is answered by examining possible extreme cases. The second question is answered by varying γ and observing the results.

Demand Parameters:

If demand is perfectly inelastic, then industry composition is strictly a result of order-of-entry. Once the market is filled, there is no room for additional firms. Subject to the existence of a firm with a clear cost

61 They were also extrapolated from the estimated demand for the vinyl-windows industry at the time of the initial forecasting study (discussed in footnote #25, Chapter IV).

advantage, any entry results in losses for all firms and ultimate survival depends on financial capacity (discussed above).

While industry demand cannot be entirely elastic, a large perfectly elastic range can be postulated. Any firm with costs below the associated elastic-range price is a potential survivor.

Since the market must eventually fill to some none-perfectly-elastic range, this case is analytically similar to the simulations and to the perfectly inelastic demand case. As with the foregoing, additional entry creates losses for all and eventual survival is a sole function of financial capacity.[62]

Finally, other demand parameters were used in some additional simulations. While with stochastic demand industry composition differs from the findings in Chapter IV, the hypotheses' conclusions are unchanged.[63]

Generalization: While demand parameters determine the total output of an industry and the total number of firms, demand parameters alone are unlikely to determine industry composition.

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62 See *'Efficiency'* (above, this chapter).

63 Since each iteration has a unique set of random numbers generated to create stochastic demand, some differences in industry composition are expected.

Demand Variation:

The model's value of γ is 0.05. To examine whether the degree of variation, (value of γ) is a major causative factor of the results, γ is varied.

The base value for γ is the percentage difference between the low and high ATC's of firm-types #1 and #3 — 0.005, approximately 0.1 of the difference used in Chapter IV. This difference is varied by multiples of 0 to 1 by increments of 0.1 and by multiples of 1 to 90 by increments of 1.[64] The order-of-entry condition is highest utility. For each multiple, the average and standard deviations of the terminal 20 iterations are computed.

Multiples of less than 0.5 yield no significant differences in market share by either firm type or entrepreneurial type from the stationary demand simulations. Similarly, multiples of 0.6 to 30 yield no significant differences from the stochastic demand simulations[65].

Multiples of greater than 30 yield significantly different results with respect to industry composition but not with respect to heterogeneous capital. Thus, the value of γ influences industry composition. As discussed later (this subsection), increasing demand variability decreases the importance of firms' non-random entry attributes, such as cost and flexibility, while increasing the importance of randomness.

The average terminal market shares, corresponding chi-square statistics (in brackets) and correlation coefficients between demand

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[64] The percentage difference in costs, 0.005, times a multiple of 10 = 0.05, the variation used in Chapter IV.

[65] These "no significant differences" include the failure to converge.

variability and the terminal averages of market shares are given in Table V.1 The figures shown are for multiples (column' Mult.') of 1 to 45, 46 to 90, and 1 to 90.[66]

Table V.1

Demand Variability and Market Share

Mult.	#1	#2	#3	#4	RN	RA
1..45	0 (0) 0	0 (0) 0	0.3127 (1.230) 0.905	0.6872 (4.945) -0.905	0.6934 (20.963) 0.816	0.3066 (13.355) -0.816
46..90	0.0024 (0.423) 0.348	0.00013 (.276) -0.058	0.8223 (0.349) 0.460	0.1752 (2.705) -0.471	0.9581 (0.436) 0.125	0.0419 (1.154) -0.125
1..90	0.0012 (0.590) 0.379	0.00006 (0.371) 0.071	0.5675 (1.582) 0.897	0.4312 (22.776) -0.899	0.8257 (3.201) 0.867	0.1742 (18.619) -0.867

Note: Numbers shown is the average of the average of the last 20 iterations for the simulation, chi-square statistics (in brackets), and the 'Mult. to market share correlations. None of the chi-square statistics are significant.

While none of the chi-square statistics are significant, for multiples up to 45 the correlation coefficients for firm-types #3 and #4 and for the entrepreneur types indicate a strong association between demand variability and their respective market shares.

66 Simulations with multiples greater than 90 occasionally converged with zero firms at termination. At a multiple of 100, only 5 of 10

For multiples 46 to 90, firm-type #1's correlation coefficient has increased while firm-types #3 and #4 and the entrepreneurs' correlation coefficients have decreased.

The correlation coefficients shown in row 'Mult. 1..45' are consistent with the simulation results in Chapter IV. As with Chapter IV's results of the order-of-entry criterion of highest utility and with one firm per iteration, for row 'Mult. 1..45', firm-types #1 and #2 fail to enter. Firm-types #3 and #4's market shares sum to one.

Consistent with Chapter IV's results, both firm-type #4's sign and the risk-averse entrepreneurial type's sign are negative and firm-type #3's and the risk-neutral entrepreneur's sign are positive. Chapter IV's results indicate a positive correlation between the risk-averse entrepreneurial type and firm-type #4. Thus, changing γ does not change previous conclusions regarding utility type and firm-types.

As the γ is increased, firm-type #1's market share increases while that of firm-type #4 decreases. This change suggests that the importance of firm characteristics may be a function of demand variability. That is, capital structures which are dominant at lower levels of risk may not be dominant at higher levels. Given Table V.1's results, firm-type #4 is such a firm type.

The signs of firm-type #1 correlation coefficient are as predicted by Mills. The output-flexible firm, firm-type #1, is positively correlated to the demand variability.

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simulations terminated with positive numbers of firms.

Table V.2

Standard Deviation of Price to Terminal Market Share

#1	#2	#3	#4	RN	RA
0.472	0.003	0.862	-0.864	0.847	-0.847

Note: Shown are the correlation coefficients between price standard deviations and market shares.

Table V.2 illustrates the correlation coefficients between output-price standard deviation and terminal firm-type market share. The correlations presented are those for multiples 1..90. Again, firm-type #1 is positively correlated to demand variability while firm-type #4's correlation coefficient is highly negative. Firm-type #2's correlation coefficient is near zero.

Firm-type #3 correlates positively with demand variability. While Table V.1 indicates that the firm-type #3's correlation decrease with variability, Figures V.2 to V.5 illustrate the opposite; firm-type #3 exhibits an increasing presence with increases in variability.[67]

Since firm-type #4's presence is decreasing, this increasing-with-demand-variability presence of firm-type #3 cannot be explained as the actions of a Lippman 'peak-load-firm'. However, leverage provides an explanation.

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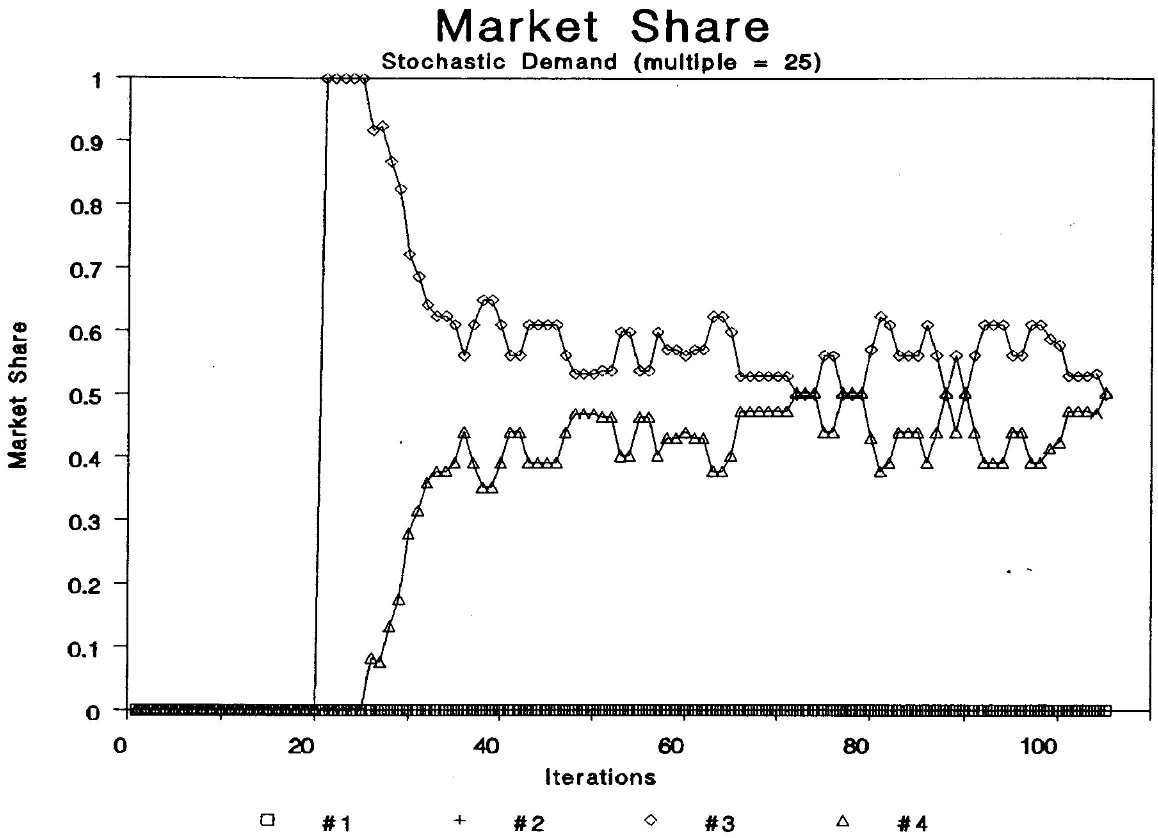
67 Demand variability increases with each figure, from a multiple of 25 in Figure V.2 to a multiple of 100 in Figure V.5.

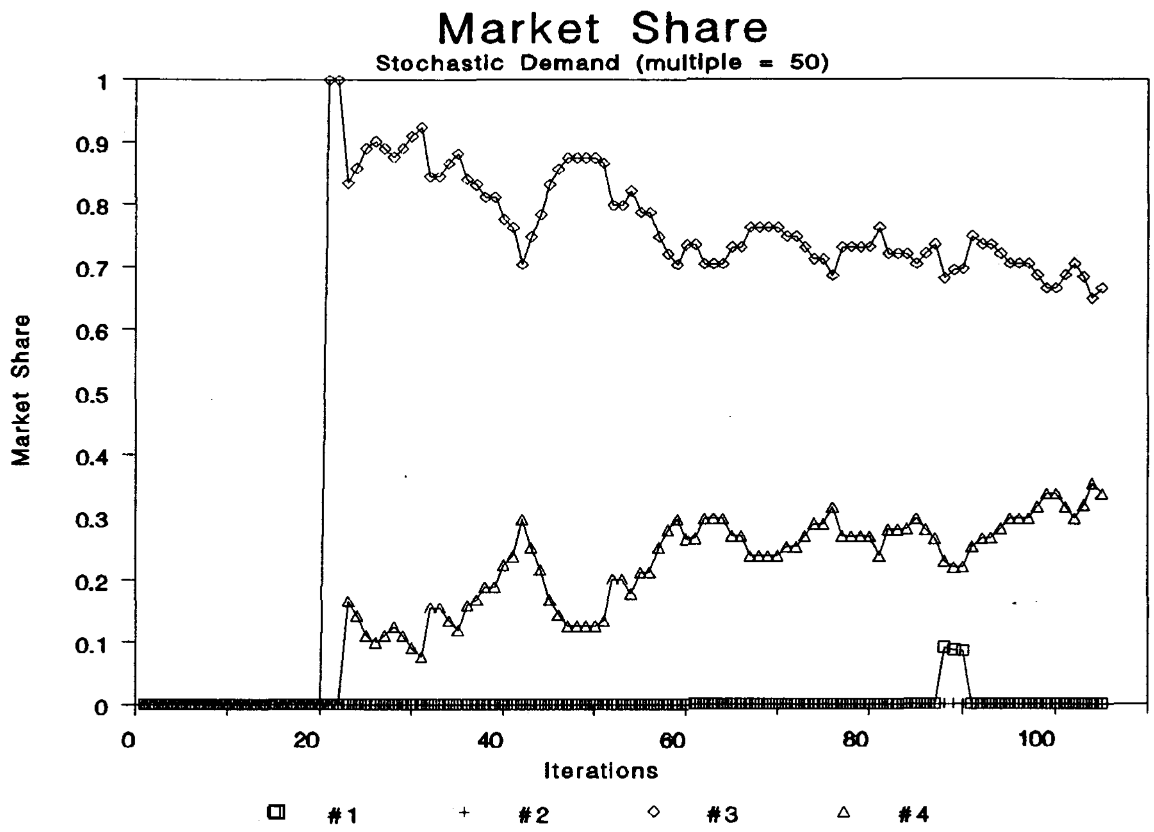
Figure V.2



The increasing demand phase of a highly-stochastic market differs from a high-growth market only in stochastic frequency. Subject to the constraints of firm creation time and given sufficient amplitude of demand variability, a small leveraged firm is able to enter the market. Thus, the simulation's small leveraged firm, firm-type #3 is able to enter a highly stochastic market.

The figures illustrate an additional point. As γ increases, firm-type #3's market share reduction slows. This is a direct result of increasing γ within the simulated market specifications. Decreases in price result in the normal exit behaviour. However, increasingly large increases in

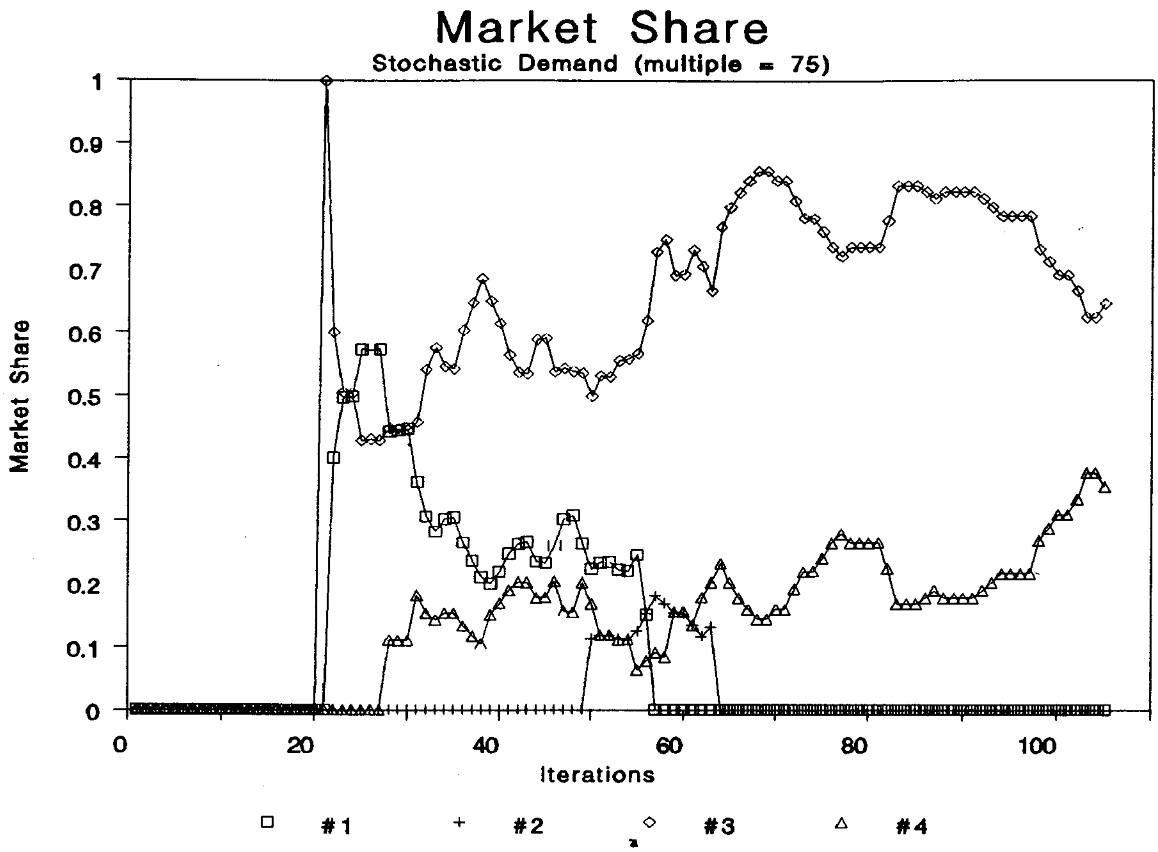
Figure V.3



demand, caused by the increases in stochastic amplitude, result in increased entry by firm-type #3. Thus, as with a growth market, the small-leveraged firm, firm-type #3, enters first.

Unlike a growth market, in a highly stochastic market other firms types are unable to achieve dominant market share. Each rise in demand results in entry initially by firm-types #3. The high frequency of demand variability reverses the demand-increase and causes losses — thus exits — for all firms. Thus, increases in demand variability reduces

Figure V.4



the importance of firm-types #1 and #4's cost efficiencies, thus reducing their ability to first enter and, consequentially, dominate the market.

Figure V.5 illustrates the four firm-types' market share at a stochastic-demand multiple of 100. At this multiple, all firm types enter at some time during the simulation.[68] Firm-type #3 is still dominant, but firm-type #4 is reduced in significance.

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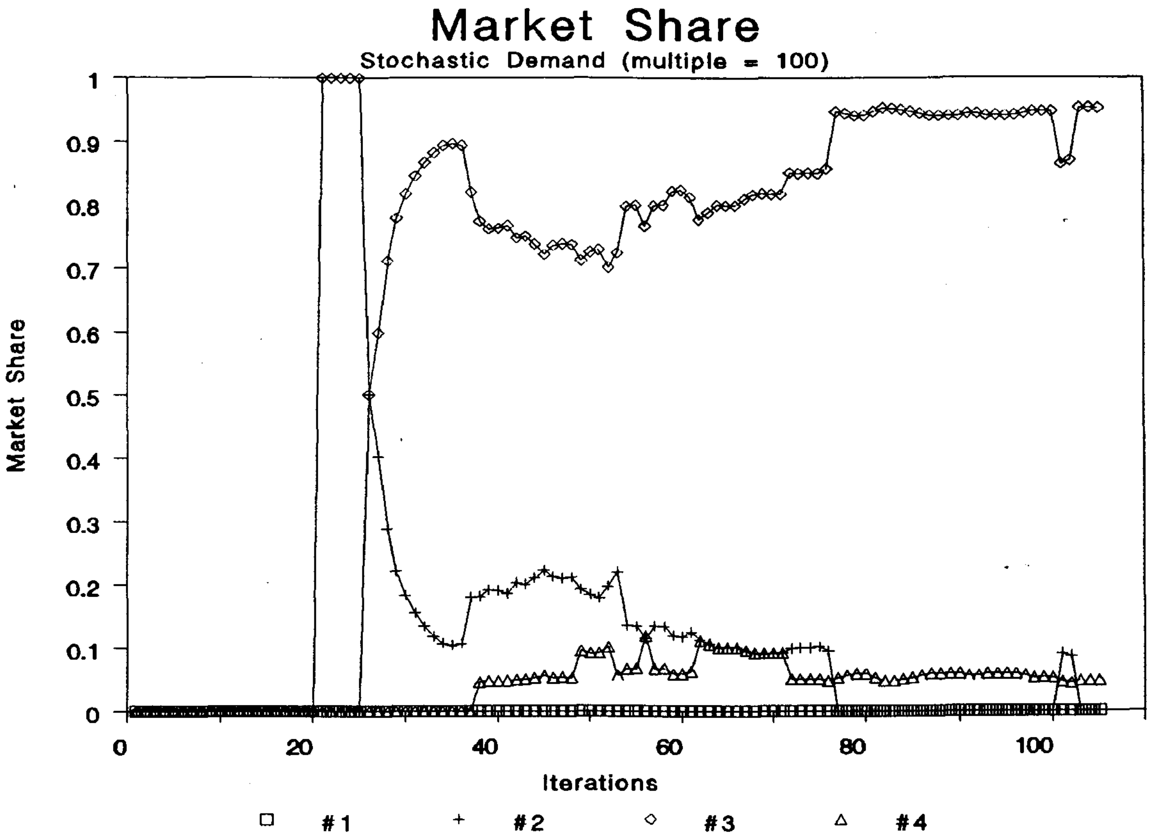
68 At a multiple of 100 approximately half of the simulations 'crash' — all firms exit and the program shows an 'ERR' message. Since all firms exiting is equivalent to the first iteration with no firms present, the 'ERR' message is a fault of the program. Figure V.5 illustrates one of the simulations which successfully completed 105 iterations.

Figure V.5



Higher levels of γ reduces the cost advantage of firm-type #4 over firm-types #2 and #3 and reduces the small-size advantage of firm-type #4 over firm-type #1. Thus, the increasingly random nature of the simulation at increased levels of γ increases the importance of probability and reduces the importance of other factors in determining entry.

At sufficiently high levels of γ, entry would be based purely on chance — even for firm-type #3. Thus, a highly stochastic market is a perverse form of growth market — any firm type can enter.[69]

The result of the hypothesis H1a is that while stochastic demand may increase the probability of capital heterogeneity, stochastic demand is not necessary for capital heterogeneity. Since the reported correlation coefficients cover only the terminal 20 iterations and as illustrated by figures V.1 to V.5, the correlation coefficients understate the capital heterogeneity present in the simulations.

Table V.3 exhibits the correlation coefficients between firm types and market share of the risk-neutral entrepreneurial type over changes in γ[70]. The positive correlation between firm-type #4 and the risk-averse entrepreneurial type are as predicted by Flacco.

According to Flacco, given stochastic demand risk-averse entrepreneurs will choose smaller capacity. As shown in Table V.3, this choice is reflected by the positive correlation between firm-type #4 and the risk-averse entrepreneurial type.

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69 Additional simulations where firm-type #3 was excluded (not shown) resulted in firm-type #4 being the prominent firm. As variability was increased, the results were as above — high levels of variability allowed all firm types to enter.

Also, various cost bases were examined — equal minimum ATC but differing flexibility and equal flexibility but differing ATC. As above, increases in variability decreased the importance of any cost or flexibility advantages.

70 The correlation coefficients for the risk-averse entrepreneurial type differ only in sign.

Table V.3

Firm Types: Entrepreneurial Types Correlation coefficients

#1	#2	#3	#4
0.2298	0.1045	0.8957	-0.8954

Note: Figures shown are the correlation coefficients between firm types and the risk-neutral entrepreneurial type. The risk-averse entrepreneurial type's correlation coefficients are reversed in sign.

Generalizations: Given stochastic demand, both Mills' conclusion that flexibility is beneficial and Flacco's conclusion that the risk averse choose a lower-output-capacity firm are supported by the simulations. However, the degree of demand variability matters.

At lower levels of variability, output flexibility may be inferior to the 'presence' flexibility of a low-investment low-capacity 'Lippman type' firm. At intermediate levels of variability, the additional investment required for a larger-capacity output-flexible firm may be profitable. At yet higher levels of variability, cost and flexibility become irrelevant. The random nature of high levels of variability allows any firm type to enter.

While the order-of-entry condition for this subsection's results is limited to a single firm with the highest utility in that iteration, other conditions were simulated. For multiples up to 45, as with the results presented, other order-of-entry conditions results differed insignificantly from Chapter IV's results.[71]

At multiples of 46 to 90, the other order-of-entry results approach those of the 'highest utility only' entry condition — the results previously

71 For example, given low variability (multiples up to 45), initial presence of firm-type #2 results in terminal presence of firm-type #2.

presented in this subsection.[72] Thus in this simulation, order-of-entry conditions become less significant with increases in demand variability. A possible reason is as follows: Since stochastic demand favours flexible firms, increased variability limits the market to fewer firm types. With its higher ATC, firm-type #2 is unable to survive a highly stochastic market.

ADDITIONAL CONSIDERATIONS

Several factors bearing on physical capital structure were not simulated. Among these are the effects of prediction and other attributes of the firm.

Prediction:

Not present in the simulations are heterogeneous prediction abilities across entrepreneurs. As with Lippman (1991), the firms are given the current period demand parameters.[73] Unlike Lippman, the simulated firms are not aware of current period output of other firms. Therefore, for both stochastic-demand simulations and early iterations of stationary-demand simulations, prediction ability is less than 100%. However, it is equal for all firms.

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72 For example, given high variability (multiples of 46 to 90), initial presence of firm-type #2 is not sufficient to result in its terminal presence.

73 Lippman provides the current period price. Under stationary demand at market maturity, Lippman and the simulations are identical.

Prediction could be modelled as an adjustment to the entrepreneur's utility function. An entrepreneur with high levels of predictive abilities could enter an industry otherwise thought to be excessively risky. Thus, a highly risk-averse entreprepreneur with high levels of predictive abilities would act as a risk-neutral entrepreneur with lower levels of predictive abilities.

If an entrepreneur is risk averse only with respect to potential losses, then, with perfect predictive ability, a risk-averse entrepreneur would behave in a fashion similar to that of a risk-neutral entrepreneur. If risk aversion includes variance of all returns, including positive returns, then predictive ability is positively correlated with Oi's (1961, 1963) and Mills' (1984) flexible-physical-capital structure.[74]

Generalization: One area of potential future research is examining the extent to which capital structure is correlated with predictive ability. However, since capital structure is also a function of risk aversion and order-of-entry, an empirical industry study would not be a trivial matter. A simulative approach may provide a best first approximation.[75]

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[74] In the simulations, the flexible firms are types #1 and #2; the less flexible firms are types #3 and #4.

[75] In the reported simulations, the use of a weighted average of past returns for any firm type or any entrepreneurial type as an entry criterion (eg., a positive five period weighted average required for entry; negative average for exit), results in that firm type or entrepreneurial type dominating the market. Since simulated demand is a stationary distribution, a weighted average of past demand is an unbiased predictor of future demand. This is just a special case of adaptive and rational expectations being identical and is unlikely to hold in the business world where demand distributions may not be stationary.

Other attributes of the firm:

Physical-capital structure is only one attribute of the firm. Firms not only produce output, they also determine their markets, administer their production processes, market their goods, finance both production and marketing processes, and in all of the foregoing, attempt to position themselves for future markets. All these attributes generate returns and return variances.

Although beyond the scope of this study, individually, each of these attributes could be regarded as a unique firm-type. Combined, these attributes could generate a plethora of firm types — each with a unique return and return variance. Given such combinations, physical capital structure alone may not be the single major consideration in determining either firm efficiency or firm survival.

Generalization: Given that physical capital structure is only one attribute of a firm, physical capital heterogeneity may well be expected. Disadvantages of a particular physical firm type may be offset by increased efficiencies in other aspects of the firm. Further, as discussed by Oi (1983), certain physical-capital structures may be essential for increased efficiencies elsewhere in the firm.

Chapter VI
Conclusions

This chapter first presents the summary and then the conclusions.

SUMMARY

The general consequence of the existence of stochastic-demand and risk-averse models is the reduction of firm capacity. For this to be nontrivial, alternative capital structures must be available.

Availability of alternative capital structures raises several questions. As stated in the introductory chapter, these questions are: (1) is heterogeneous capital an equilibrium outcome of these alternatives? (2) even if heterogeneous capital is observed, will the industry converge to a single production method? (3) given heterogeneous capital, do risk-neutral entrepreneurs dominate any equilibrium? (4) given that heterogeneity of capital may produce firms of differing returns and return variances, will risk-averse entrepreneurs dominate the market due to their choice of stochasticly dominant capital structure? and (5) does entrepreneurial market composition depend on some other factor such as order-of-entry into the market? In Chapter I, these questions are restated as hypotheses.

Since market testing of both entrepreneurial utility and entrepreneurial uncertainty is not possible, a simulated market was presented. The simulations consisted of two entrepreneurial types and four cost structures.

A total of 66 simulations were run. Half of these involved stationary demand, the others stochastic demand. One third involved only risk-neutral entrepreneurs, one-third involved only risk-averse entrepreneurs, and the remaining third involved both types of entrepreneurs. A total of eleven orders-of-entry were used to increase degrees of freedom.

The simulation results agree with the published results that both stochastic demand and risk aversion reduce firm capacity.

Hypotheses results are as follows:

(1) Neither stochastic demand nor entrepreneurial heterogeneity are necessary conditions for capital heterogeneity to exist. While entrepreneurial heterogeneity increases the likelihood of capital heterogeneity, entrepreneurial heterogeneity is not a necessary condition. However, stochastic demand combined with heterogeneous entrepreneurial types does not yield convergence thus denying the possibility of any conclusions regarding the equilibrium potential of these combinations.

These results do not support Mills (1984), who limited the capital-heterogeneity industry-equilibirum result to stochastic demand conditions. The simulation results suggest that stochastic demand is not necessary for heterogeneous capital and, further, that stochastic demand may not permit an industrial equilibrium to exist.

(2) Order-of-entry is sufficient to result in physical capital heterogeneity. This result holds for both stationary demand and low levels of demand variability and for both risk-neutral and risk-averse entrepreneurs.

(3) Given heterogeneous physical capital where each capital type is associated with a unique risk/return ratio, heterogeneous-entrepreneurial-industry ownership can exist.
If heterogeneous capital is available, then some capital structures may be stochasticly dominant. Risk-averse entrepreneurs enter the industry with the less-risky stochasticly-dominant capital structures. Risk-neutral entrepreneurs enter the industry with the highest-returns capital structures.[76]

Additional generalizations are as follows:
(4) For expanding markets, while all firm types can survive, leverage is beneficial. While the simulations were not deliberately designed to test leverage, the simulation results suggest that a levered firm is best positioned to exploit an expanding market. Conversely, leverage is not beneficial in mature markets and, in the simulations, prove harmful to the levered firm-type.

This is consistent with casual observations of market activity. Rapidly expanding industries frequently require more financial capital than is provided by earnings — this capital can only be provided through

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[76] This result is qualified by noting that equilibrium cannot be concluded from the combined stochastic-demand heterogeneous-entrepreneurial-types simulations.

external sources. Conversely, mature firms in mature industries who rely on increases in external financial capital to maintain operations are, by definition, unprofitable.

(5) Given heterogeneous capital, industry entrepreneurial composition may be heterogeneous. However, heterogeneity of entrepreneurial types decreases with increases in demand variability. Increases in variability increase the level of risk. As this risk increases, initially the highly risk-averse refuse to enter (or, if present, exit), then the less risk-averse refuse to enter. At sufficiently high levels of risk, only risk-lovers would enter.

This result is qualified by the following: a highly risk-averse entrepreneur with high predictive abilities may enter an industry seen by others as highly risky. Conversely, an entrepreneur with no predictive abilities may avoid an industry seen by others as having little risk. Consistent with Nelson (1961) and Oi (1963), predictive ability acts as a means of risk reduction.

(6) At low levels of demand variability, initial presence is highly correlated to terminal presence of firms. However, at higher levels of demand variability, this correlation weakens and eventually disappears. Increases in variability limits the number of firm types capable of survival.

(7) At low levels of demand variability, firm size is inversly correlated to terminal presence. Given some variability, smaller firms have an

advantage. Their smaller size allows them to enter while larger firms are unable to enter. However, at higher levels of variability, output-flexibility increases in importance. The larger capacity output-flexible firms enter in highly stochastic markets. While the smaller firms remain present, their size is not sufficiently advantageous to maintain dominance of the market. At yet higher levels of variability, none of size, costs, or output-flexibility influence outcomes. Entry becomes solely probablistic.

CONCLUSIONS AND IMPLICATIONS

The significant conclusions are: (1) heterogeneous entrepreneurial industry ownership and industry equilibrium can co-exist; (2) heterogeneous capital and industry equilibrium can co-exist; and, (3) given either stationary demand or low levels of stochastic demand and available physical capital structures, order-of-entry conditions are sufficient to result in heterogeneous industrial composition of either entrepreneurial types or physical capital.

The first conclusion suggests that simple return and variance measurements are insufficient measures of potential utility for firm owners. Particularly in small industries, across industry comparisons of returns and variances may mistate subjective returns.

The second conclusion suggests that in choosing physical capital, cost efficiency is only one firm attribute to be considered. As discussed in Chapter V (additional considerations), a particular firm structure may be necessary to achieve advantages from other potential attributes of the firm.

The third conclusion suggests that observed rates of return and cost advantages may not be prima-facia evidence of uncompetitive behaviour. If order-of-entry is sufficient to result in heterogeneous physical capital, then either economic profit or some form of X-inefficient behaviour is to be expected. Thus, order-of-entry conditions suggest that an industry's structure is as much determined by its history as by its current technology and current actions.

APPENDIX A

PROGRAM DOCUMENTATION

The following program documentation supplements Chapter III, The Model.

The program was written in Lotus 1-2-3 ®. Lotus prints the file as one line per cell address.[77] The format below is by row.[78] To facilitate reading the documentation, post-program comments are added. Program code is preceded by boxed comments and followed by bracketed italicized comments.

Section A:

This section provides the simulation type. The 'A' column provides the topic. (For example, 'A2: Utility' is the entrepreneur type — differentiated by utility.). The C column provides the differentia for each topic (eg., C2 is the risk-neutral entrepreneur). The G column provides the simulation label. The H column is the program switches: 0 for off; 1 for on. The I column indicates whether the switches are active or for display only. Rows 2 to 4 display the entrepreneur type. In this example, H4: is equal to 1; therefore, both entrepreneurs are entered into the simulation.

A2: [W6] 'Utility: C2: 'Risk Neutral Only: G2: 0 H2: 0 I2: 'DISPLAY

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[77] The cell addresses are followed by colons.

[78] That is, each paragraph represents one row.

C3: 'Declining ARA Only: G3: 1 H3: 0 I3: 'DISPLAY

C4: 'Both Risk Neutral and Declining ARA: G4: 2 H4: 1 I4: 'DISPLAY

Rows 5 and 6 are the demand curve parameters. Demand curve #1 (row 5) was the demand curve used in the simulations.[79] It was initially thought that several curves would be required. However, preliminary runs indicated that only the total number of firms changed. The general composition of the industry, whether firms or entrepreneur types, was not significantly altered for any demand curve which allowed all firm types to enter.

A5: [W6] 'Demand Curve: C5: 3500 {*intercept*}

D5: -1 {*slope*} E5: 0.05 {*gamma*} G5: 0
H5: 1 I5: 'ACTIVE

C6: 2400 D6: -0.001 E6: 0.001 G6: 1 H6: @IF(H5=1,0,1) I6: 'ACTIVE

Rows 7 and 8 indicate whether demand is stationary or stochastic.

A7: [W6] 'Demand: C7: 'Stationary: G7: 0 H7: 0 I7: 'ACTIVE

C8: 'Stationary Distribution: G8: 1 H8: 1 I8: 'ACTIVE

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[79] Note that H5: =1.

Rows 10 to 16 indicate the order-of-entry conditions. H11 is set to 1M, indicating that the simulation involves a mature industry of firm type #1.

A10: [W6] 'Order of Entry/Exit: C10: 'Highest/Lowest ROR only: G10: 0 H10: 0 I10: 'DISPLAY

C11: 'First = Firm #1: G11: 1 H11: 1M I11: 'DISPLAY

C12: 'First = Firm #2: G12: 2 H12: 0 I12: 'DISPLAY

C13: 'First = Firm #3: G13: 3 H13: 0 I13: 'DISPLAY

C14: 'First = Firm #4: G14: 4 H14: 0 I14: 'DISPLAY

C15: 'Pos/Neg. ROR: Max 1 per type: G15: 5 H15: 0 I15: 'DISPLAY

C16: 'Positive/Negative ROR (all/que): G16: 6 H16: 0 I16: 'DISPLAY

Section B:

This section provides the cost structures of the four firm types. Column D is firm type #1; E is #2; F is #3; and G is #4. Row 18 indicates the flexibility/cost structure of the firm. (For example, D18: H/L is High flexibility and Low cost.)

A18: [W6] 'STD(P)= D18: H/L E18: H/H F18: L/H G18: L/L

Row 19 numbers the firms.

A19: [W6] 'Firms (Cost Structure): D19: 1 E19: 2 F19: 3 G19: 4

Row 20 provides the expected useable life of the fixed assets. These figures are used to determine the annual replacement costs.

A20: [W6] 'Remaining Life (at Purchase): D20: 10 E20: 10 F20: 10 G20: 10

Rows 21 and 22 provide the investment requirements for each firm type. Rows 23 and 24 are the corresponding interest rates.

A21: [W6] 'Plant and Equipment: D21: 100000 E21: 150000 F21: 0 G21: 25000 {*Fixed assets*}

A22: [W6] 'Inventory Float: D22: 100000 E22: 100000 F22: 50000 G22: 50000 {*Raw materials inventory.*}

A23: [W6] 'int(1): D23: 0.05 E23: 0.05 F23: 0.05 G23: 0.05 {*The interest rate for long-lived assets.*}

A24: [W6] 'int(2): D24: 0.07 E24: 0.07 F24: 0.07 G24: 0.07 {*Interest rate for short-lived assets.*}

Row 25 provides the Principle portion of the first year's amortized value of the fixed assets.

A25: [W6] 'Capital Replacement:

D25: (D21)/((1-(1+D23)^-D20)/D23)-(D21*D23)

E25: (E21)/((1-(1+E23)^-E20)/E23)-(E21*E23)

F25: (F21)/((1-(1+F23)^-F20)/F23)-(F21*F23)

G25: (G21)/((1-(1+G23)^-G20)/G23)-(G21*G23)

Row 26 is the fixed rental cost of fixed assets. Row 27 is the per unit rental cost. These costs apply only to Firm #3.

A26: [W6] 'Rental(1): D26: 0 E26: 0 F26: (+G21/((1-(1+F24)^(-10))/F24)) G26: 0

A27: [W6] ' (per unit): D27: 0 E27: 0 F27: 1 G27: 0

Rows 28 and 29 are the raw materials costs: 28: annual costs and 29: per unit costs.

A28: [W6] 'RM(constant): D28: 100000 E28: 100000 F28: 50000 G28: 50000

A29: [W6] ' (per unit): D29: 1 E29: 1 F29: 20 G29: 10

Rows 30 and 31 are the per-iteration (period) and per-unit labour costs respectively.

A30: [W6] 'Labour(CNST): D30: 100000 E30: 100000 F30: 50000 G30: 50000

A31: [W6] ' (per unit): D31: 0.1 E31: 0.1 F31: 0.2 G31: 0.2

Row 32 is the capacity constraint.

A32: [W6] ' (Q(x)^3): D32: 0.04 E32: 0.039 F32: 0.17 G32: 0.1679

Row 33 provides the outputs corresponding to each firm's minimum ATC.

A33: [W6] 'Q(Min ATC):

D33: ((D21*D23+D22*D24+D25+D26+D28+D30)/(2*D32))^(1/3)

E33: ((E21*E23+E22*E24+E25+E26+E28+E30)/(2*E32))^(1/3)

F33: ((F21*F23+F22*F24+F25+F26+F28+F30)/(2*F32))^(1/3)

G33: ((G21*G23+G22*G24+G25+G26+G28+G30)/(2*G32))^(1/3)

Row 34 provides the minimum ATC for each firm.

A34: [W6] 'ATC:

D34:(D$21*D$23+D$22*D$24+D$25+D$26+D$27*D33+D$28+D$29*D33+D$30+D$31*D33+D$32*(D33^3))/D33

E34:(E$21*E$23+E$22*E$24+E$25+E$26+E$27*E33+E$28+E$29*E33+E$30+E$31*E33+E$32*(E33^3))/E33

F34:(F$21*F$23+F$22*F$24+F$25+F$26+F$27*F33+F$28+F$29*F33+F$30+F$31*F33+F$32*(F33^3))/F33

G34:(G$21*G$23+G$22*G$24+G$25+G$26+G$27*G33+G$28+G$29*G3 3+G$30+G$31*G33+G$32*(G33^3))/G33

Row 35 provides the marginal costs corresponding to the firms' minimum ATC. It was used as a means of assuring the accuracy of the minimum ATC figures.

A35: [W6] 'MC:

D35: +D27+D29+D31+3*D32*D33^2

E35: +E27+E29+E31+3*E32*E33^2

F35:+F27+F29+F31+3*F32*F33^2

G35: +G27+G29+G31+3*G32*G33^2

Section C:

This section is the simulation proper. Each row is one iteration. Since all iterations are identical, only one iteration is shown.

B40: +AM40+AP40*C40 {*Price, where: AM40 is the intercept; AP40 is the slope; and, C40 is industry output.*}

C40:(AV40+AZ39+BH40+BL39)*D40+(AW40+BA39+BI40+BM39)*E40+(AX40+BB39+BJ40+BN39)*F40+(AY40++BC39+BK40+BO39)*G40 {*Industry output, where: AV40 is new entrants/exits of firm type #1 for the risk-averse entrepreneur; AZ39 is previous period numbers of firm type #1 for the risk-neutral entrepreneur; BH39 is new entrants/exits for* *the risk-neutral entrepreneur; F40 is per firm output for firm type #1. Similarly, the remaining terms are for firm types #2, #3, and #4 and entrepreneurs risk-averse and risk neutral.}*

D40, E40, F40, and G40 are the per firm outputs for firm types #1, #2, #3, and #4 respectively. The individual variables for firm type #1 are explained.

D40: (-2*$AQ40-((2*$AQ40)^2-(4*-3*D$32*($AN40+$AQ40*($C39-@IF(AZ39#OR#BL39>0,D39,0)+($D39*($AV40+$BH40)+$E39*($AW40+$BI40)+$F39*($AX40+$BJ40)+$G39*($AY40+$BK40)))-D$27-D$29-D$31)))^(1/2))/(2*-3*D$32)

{Output for firm type #1 where: $AQ40 is the demand curve's slope;[80] *D$32 is the cubed capacity constraint; AN40 is the demand curve's intercept; $C39 is previous period's industry output; AZ39 is previous period's number of firm type #1's for the risk-averse entrepreneur; BL39 is previous period's number of firm type #1's for the risk-neutral entrepreneur; D39 is previous period output for firm type #1; AV40, BH40 are current period's entries/exits of firm type #1's for the risk-averse/risk-neutral entrepreneurs respectively; E39 is previous period output for firm type #1; AW40, BI40 are current entries/exits of firm type #2 for risk averse/risk-neutral entreprenuers respectively; $F39 is previous period output for firm type #3; $AX40, $BJ40 are entries/exits*

80 The demand curve parameters for the market and for the firms were set at different addresses. This was to allow for later testing of prediction effects. For the simulations in this thesis, prediction of the parameters was set to 1.

of firm type #3 for risk averse/risk-neutral entreprenuers respectively; $G39 is previous period output for firm type #4; $AY40, $BK40 are entries/exits of firm type #3 for risk averse/risk-neutral entreprenuers respectively; D$27, D$29, and D$31 are the variable costs.}

E40: (-2*$AQ40-((2*$AQ40)^2-(4*-3*E$32*($AN40+$AQ40*($C39-@IF(BA39#OR#BM39>0,E39,0)+($D39*($AV40+$BH40)+$E39*($AW40+$BI40)+$F39*($AX40+$BJ40)+$G39*($AY40+$BK40)))-E$27-E$29-E$31)))^(1/2))/(2*-3*E$32) *{Per firm output for firm type #2}*

F40: (-2*$AQ40-((2*$AQ40)^2-(4*-3*F$32*($AN40+$AQ40*($C39-@IF(BB39#OR#BN39>0,F39,0)+($D39*($AV40+$BH40)+$E39*($AW40+$BI40)+$F39*($AX40+$BJ40)+$G39*($AY40+$BK40)))-F$27-F$29-F$31)))^(1/2))/(2*-3*F$32) *{Per firm output for firm type #3.}*

G40: (-2*$AQ40-((2*$AQ40)^2-(4*-3*G$32*($AN40+$AQ40*($C39-@IF(BC39#OR#BO39>0,G39,0)+($D39*($AV40+$BH40)+$E39*($AW40+$BI40)+$F39*($AX40+$BJ40)+$G39*($AY40+$BK40)))-G$27-G$29-G$31)))^(1/2))/(2*-3*G$32) *{Per firm output for firm type #4.}*

H40 to K40 are the per firm total profits by firm type.

H40: +U40-Z40

I40: +V40-AA40

J40: +W40-AB40

K40: +X40-AC40

L40 to O40 are the per firm rates of return on invested capital calculated as profits/(invested capital).

L40: +H40/(D$21+D$22)

M40: +I40/(E$21+E$22)

N40: +J40/(F$21+F$22)

O40: +K40/(G$21+G$22)

P40 to S40 are the total number of firms by firm type summed across entrepreneur types.

P40: [W3] +AZ40+BL40

Q40: [W3] +BA40+BM40

R40: [W3] +BB40+BN40

S40: [W3] +BC40+BO40

T40: {*Not utilized.*}

U40 to X40 are the per firm revenues by firm types.

U40: +D40*$B40

V40: +E40*$B40

W40: +F40*$B40

X40: +G40*$B40

Y40: {*Not utilized.*}

Z40 to AC40 are the per firm total costs by firm type.

Z40:(D$21*D$23+D$22*D$24+D$25+D$26+D$27*D40+D$28+D$29*D40+ D$30+D$31*D40+D$32*(D40^3))

AA40:(E$21*E$23+E$22*E$24+E$25+E$26+E$27*E40+E$28+E$29*E40+E$30+E$31*E40+E$32*(E40^3))

AB40:(F$21*F$23+F$22*F$24+F$25+F$26+F$27*F40+F$28+F$29*F40+F$30+F$31*F40+F$32*(F40^3))

AC40:(G$21*G$23+G$22*G$24+G$25+G$26+G$27*G40+G$28+G$29*G40+G$30+G$31*G40+G$32*(G40^3))

AD40 to AG40 are per firm ATC by firm type.

AD40: +Z40/D40

AE40: +AA40/E40

AF40: +AB40/F40

AG40: +AC40/G40

AH40 to AK40 are the per firm AVC by firm type.

AH40: (D$26+D$27*D40+D$29*D40+D$31*D40+D$32*(D40^3))/D40

AI40: (E$26+E$27*E40+E$29*E40+E$31*E40+E$32*(E40^3))/E40

AJ40: (F$26+F$27*F40+F$29*F40+F$31*F40+F$32*(F40^3))/F40

AK40: (G$26+G$27*G40+G$29*G40+G$31*G40+G$32*(G40^3))/G40

AL40 to AQ40 are the demand curve parameters. The H$'s are the switches discussed in Section A, above.

AL40: @IF(H$5=1,C$5,C$6) {*The stationary intercept*}

AM40: @IF(H$8=1,AL40+@IF(H$5=1,E$5,E$6)*($BR40*AL40-$BS40*AL40),AL40) {*The intercept of the stochastic demand curve where: AL40 is the stationary intercept; E$5, E$6 are fractions of less than one (0.05 in the thesis simulations); and, $BR40, $BS40 are random numbers.*}

AN40: @IF(H$8=1,AM40,AL40) {*The simulation's demand intercept: AM40 for stochastic demand and AL40 for stationary demand.*}

AO40: @IF(H$5=1,D$5,D$6) {*The stationary slope.*}

AP40: @IF(H$8=1,AO40+@IF(H$5=1,E$5,E$6)*($BP40*AO40-$BQ40*AO40),AO40) {*The slope of the stochastic demand curve where: AO40 is the stationary slope; E$5, E46 are fractions of less than one (0.05 in the thesis simulations); and $BP40 and $BQ40 are random numbers.*}

AQ40: @IF(H$8=1,AP40,AO40) {*The simulation's demand slope: AP40 for stochastic demand and AO40 for stationary demand.*}

AR40 to AU40 are the risk-averse entrepreneur type's utility by firm types. Since the utility is ln based, an @if statement is used to provide '0' in place of negative values.

AR40: [W5] @IF((($AM40+$AP40*$C40)*D40-Z40)/(D$21+D$22)-@VAR(L36..L40)<=0,0,@EXP(@LN((($AM40+$AP40*$C40)*D40-

Z40)/(D$21+D$22)-@VAR(L36..L40)))) {*where: $AM40 is the demand intercept; $AP40 is the demand slope; $C40 is market output; D40 is current period per firm type #1 output; Z40 is current period per firm type #1 costs; D$21, D$22 are invested capital; and @VAR(L36..L40) is the variance of past five periods' returns.*}

AS40: [W5] @IF((($AM40+$AP40*$C40)*E40-AA40)/(E$21+E$22)-@VAR(M36..M40)<=0,0,@EXP(@LN((($AM40+$AP40*$C40)*E40-AA40)/(E$21+E$22)-@VAR(M36..M40))))

AT40: [W6] @IF((($AM40+$AP40*$C40)*F40-AB40)/(F$21+F$22)-@VAR(N36..N40)<=0,0,@EXP(@LN((($AM40+$AP40*$C40)*F40-AB40)/(F$21+F$22)-@VAR(N36..N40))))

AU40: [W6] @IF((($AM40+$AP40*$C40)*G40-AC40)/(G$21+G$22)-@VAR(O36..O40)<=0,0,@EXP(@LN((($AM40+$AP40*$C40)*G40-AC40)/(G$21+G$22)-@VAR(O36..O40))))

AV40 to AZ40 are the entry/exit values for each of the firm types for the risk-averse entrepreneur. These values are entered manually in each iteration.

AV40: [W2] 0

AW40: [W2] 0

AX40: [W2] 0

AY40: [W2] 0

AZ40 to BC40 sum the previous number of firms and the new entries/exits for each firm type.

AZ40: [W2] +AZ39+AV40

BA40: [W2] +BA39+AW40

BB40: [W2] +BB39+AX40

BC40: [W2] +BC39+AY40

BD40 to BG40 are the utility generated for each firm type for the risk-neutral entrepreneur type.

BD40: [W6] (($AM40+$AP40*$C40)*D40-Z40)/(D$21+D$22)

BE40: [W6] (($AM40+$AP40*$C40)*E40-AA40)/(E$21+E$22)

BF40: [W6] (($AM40+$AP40*$C40)*F40-AB40)/(F$21+F$22)

BG40: [W6] (($AM40+$AP40*$C40)*G40-AC40)/(G$21+G$22)

BH40 to BK40 are the entry/exit values for each of the firm types for the risk-averse entrepreneur. These values are entered manually in each iteration.

BH40: [W2] 0

BI40: [W2] 0

BJ40: [W3] 0

BK40: [W2] 0

AZ40 to BC40 sum the previous number of firms and the new entries/exits for each firm type.

BL40: [W2] +BL39+BH40

BM40: [W2] +BM39+BI40

BN40: [W2] +BN39+BJ40

BO40: [W2] +BO39+BK40

BP40 to BS40 are random numbers generated by Lotus 1-2-3. The numbers are interval based where the interval is zero to one. The @RAND function generates a new number each iteration including all previous iterations. Therefore, prior to each simulation, the random numbers are changed to constants with the /RV command.

BP40: 0.0400773354

BQ40: 0.2881440232

BR40: 0.7329259317

BS40: 0.1861808286

APPENDIX B

PROGRAM OUTPUT

The following is an example of the line output generated by the program. The simulation is dual-entrepreneur, stationary-demand, with each entrepreneurial type starting the simulation with two of each firm type.

While this simulation does not appear in the body of the text, it is instructive in that it contains many of the features of the dual-entrepreneur, stationary-demand simulations. As with all the stationary-demand simulations, the simulation quickly converges.

Since the convergence occurs rapidly, there is little opportunity for changes in market share and both entrepreneur-types maintain their original shares. Also typically, by the time the simulation converges, Firm #3 has exitted.

The results from the initial 35 iterations are shown. By iteration 35, the criteria of cyclical utility at five decimal places occurred.[81] The firm types are written as #1, #2, #3, and #4.

[81] Only the risk-neutral entrepreneurial-type's utility is shown. It is equivalent to rate of return.

Iteration	Price	Market Output	Rate of Return #1	#2	#3	#4
1	2523	977	0.092	0.060	0.114	0.099
2	1977	1523	-0.255	-0.221	-0.526	-0.331
3	2009	1491	-0.236	-0.206	-0.486	-0.304
4	1998	1502	-0.242	-0.211	-0.499	-0.313
5	2002	1498	-0.240	-0.209	-0.495	-0.310
6	2001	1499	-0.241	-0.210	-0.496	-0.311
7	2001	1499	-0.240	-0.209	-0.496	-0.311
8	2001	1499	-0.240	-0.210	-0.496	-0.311
9	2001	1499	-0.240	-0.210	-0.496	-0.311
10	2001	1499	-0.240	-0.210	-0.496	-0.311
11	2001	1499	-0.240	-0.210	-0.496	-0.311
12	2001	1499	-0.240	-0.210	-0.496	-0.311
13	2001	1499	-0.240	-0.210	-0.496	-0.311
14	2001	1499	-0.240	-0.210	-0.496	-0.311
15	2001	1499	-0.240	-0.210	-0.496	-0.311
16	2001	1499	-0.240	-0.210	-0.496	-0.311
17	2001	1499	-0.240	-0.210	-0.496	-0.311
18	2001	1499	-0.240	-0.210	-0.496	-0.311
19	2001	1499	-0.240	-0.210	-0.496	-0.311
20	2001	1499	-0.240	-0.210	-0.496	-0.311
21	2093	1407	-0.181	-0.161	-0.380	-0.233
22	2188	1312	-0.117	-0.109	-0.259	-0.151
23	2290	1210	-0.048	-0.053	-0.125	-0.061
24	2396	1104	0.027	0.007	0.019	0.035
25	2288	1212	-0.048	-0.054	-0.127	-0.062
26	2396	1104	0.027	0.007	0.019	0.035
27	2288	1212	-0.048	-0.054	-0.127	-0.062
28	2396	1104	0.027	0.007	0.019	0.035
29	2288	1212	-0.048	-0.054	-0.127	-0.062
30	2396	1104	0.027	0.007	0.019	0.035
31	2288	1212	-0.048	-0.054	-0.127	-0.062
32	2396	1104	0.027	0.007	0.019	0.035
33	2288	1212	-0.048	-0.054	-0.127	-0.062
34	2396	1104	0.027	0.007	0.019	0.035
35	2288	1212	-0.048	-0.054	-0.127	-0.062

Iteration	Firms owned by: Risk Neutral #1	#2	#3	#4	Risk Averse #1	#2	#3	#4
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2
7	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2
14	2	2	2	2	2	2	2	2
15	2	2	2	2	2	2	2	2
16	2	2	2	2	2	2	2	2
17	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2
19	2	2	2	2	0	0	0	0
20	2	2	2	2	2	2	2	2
21	2	2	1	2	2	2	1	2
22	2	2	0	2	2	2	0	2
23	2	2	0	1	2	2	0	1
24	2	2	0	0	2	2	0	0
25	2	2	0	1	2	2	0	1
26	2	2	0	0	2	2	0	0
27	2	2	0	1	2	2	0	1
28	2	2	0	0	2	2	0	0
29	2	2	0	1	2	2	0	1
30	2	2	0	0	2	2	0	0
31	2	2	0	1	2	2	0	1
32	2	2	0	0	2	2	0	0
33	2	2	0	1	2	2	0	1
34	2	2	0	0	2	2	0	0
35	2	2	0	1	2	2	0	1

Iteration	Per Firm Output #1	#2	#3	#4
1	162.4	164.3	80.5	81.2
2	127.2	128.8	62.2	62.7
3	124.3	125.8	61.0	61.5
4	125.2	126.8	61.5	62.0
5	124.9	126.4	61.3	61.8
6	125.0	126.6	61.4	61.9
7	125.0	126.5	61.3	61.9
8	125.0	126.5	61.3	61.9
9	125.0	126.5	61.3	61.9
10	125.0	126.5	61.3	61.9
11	125.0	126.5	61.3	61.9
12	125.0	126.5	61.3	61.9
13	125.0	126.5	61.3	61.9
14	125.0	126.5	61.3	61.9
15	125.0	126.5	61.3	61.9
16	125.0	126.5	61.3	61.9
17	125.0	126.5	61.3	61.9
18	125.0	126.5	61.3	61.9
19	125.0	126.5	61.3	61.9
20	125.0	126.5	61.3	61.9
21	127.8	129.4	62.7	63.3
22	130.8	132.4	63.2	64.7
23	133.9	135.6	64.7	66.2
24	137.1	138.8	66.3	66.8
25	134.0	135.7	64.8	66.3
26	137.1	138.8	66.3	66.8
27	134.0	135.7	64.8	66.3
28	137.1	138.8	66.3	66.8
29	134.0	135.7	64.8	66.3
30	137.1	138.8	66.3	66.8
31	134.0	135.7	64.8	66.3
32	137.1	138.8	66.3	66.8
33	134.0	135.7	64.8	66.3
34	137.1	138.8	66.3	66.8
35	134.0	135.7	64.8	66.3

Iteration	Per Firm Profits #1	#2	#3	#4
1	18316	14942	5708	7457
2	-50987	-55311	-26279	-24829
3	-47131	-51412	-24303	-22837
4	-48437	-52733	-24970	-23510
5	-47975	-52266	-24734	-23271
6	-48136	-52429	-24816	-23354
7	-48079	-52372	-24788	-23325
8	-48099	-52392	-24798	-23336
9	-48092	-52385	-24794	-23332
10	-48095	-52387	-24795	-23333
11	-48094	-52386	-24795	-23333
12	-48094	-52387	-24795	-23333
13	-48094	-52386	-24795	-23333
14	-48094	-52386	-24795	-23333
15	-48094	-52386	-24795	-23333
16	-48094	-52386	-24795	-23333
17	-48094	-52386	-24795	-23333
18	-48094	-52386	-24795	-23333
19	-48094	-52386	-24795	-23333
20	-48094	-52386	-24795	-23333
21	-36117	-40257	-19006	-17494
22	-23380	-27358	-12949	-11289
23	-9546	-13347	-6267	-4548
24	5357	1745	933	2613
25	-9692	-13496	-6337	-4625
26	5357	1745	932	2613
27	-9692	-13496	-6337	-4625
28	5357	1745	932	2613
29	-9692	-13496	-6337	-4625
30	5357	1745	932	2613
31	-9692	-13496	-6337	-4625
32	5357	1745	932	2613
33	-9692	-13496	-6337	-4625
34	5357	1745	932	2613
35	-9692	-13496	-6337	-4625

Iteration	Total Firms by Type: #1	#2	#3	#4
1	2	2	2	2
2	4	4	4	4
3	4	4	4	4
4	4	4	4	4
5	4	4	4	4
6	4	4	4	4
7	4	4	4	4
8	4	4	4	4
9	4	4	4	4
10	4	4	4	4
11	4	4	4	4
12	4	4	4	4
13	4	4	4	4
14	4	4	4	4
15	4	4	4	4
16	4	4	4	4
17	4	4	4	4
18	4	4	4	4
19	4	4	4	4
20	4	4	4	4
21	4	4	2	4
22	4	4	0	4
23	4	4	0	2
24	4	4	0	0
25	4	4	0	2
26	4	4	0	0
27	4	4	0	2
28	4	4	0	0
29	4	4	0	2
30	4	4	0	0
31	4	4	0	2
32	4	4	0	0
33	4	4	0	2
34	4	4	0	0
35	4	4	0	2

Iteration	Market Share					
	Firm Type				Entrepreneur	
	#1	#2	#3	#4	Risk Neutral	Risk Averse
1	0.332	0.336	0.165	0.166	0.500	0.500
2	0.334	0.338	0.163	0.165	0.500	0.500
3	0.334	0.338	0.164	0.165	0.500	0.500
4	0.334	0.338	0.164	0.165	0.500	0.500
5	0.334	0.338	0.164	0.165	0.500	0.500
6	0.334	0.338	0.164	0.165	0.500	0.500
7	0.334	0.338	0.164	0.165	0.500	0.500
8	0.334	0.338	0.164	0.165	0.500	0.500
9	0.334	0.338	0.164	0.165	0.500	0.500
10	0.334	0.338	0.164	0.165	0.500	0.500
11	0.334	0.338	0.164	0.165	0.500	0.500
12	0.334	0.338	0.164	0.165	0.500	0.500
13	0.334	0.338	0.164	0.165	0.500	0.500
14	0.334	0.338	0.164	0.165	0.500	0.500
15	0.334	0.338	0.164	0.165	0.500	0.500
16	0.334	0.338	0.164	0.165	0.500	0.500
17	0.334	0.338	0.164	0.165	0.500	0.500
18	0.334	0.338	0.164	0.165	0.500	0.500
19	0.334	0.338	0.164	0.165	0.500	0.000
20	0.334	0.338	0.164	0.165	0.500	0.500
21	0.363	0.368	0.089	0.180	0.500	0.500
22	0.399	0.404	0.000	0.197	0.500	0.500
23	0.443	0.448	0.000	0.109	0.500	0.500
24	0.497	0.503	0.000	0.000	0.500	0.500
25	0.443	0.448	0.000	0.109	0.500	0.500
26	0.497	0.503	0.000	0.000	0.500	0.500
27	0.443	0.448	0.000	0.109	0.500	0.500
28	0.497	0.503	0.000	0.000	0.500	0.500
29	0.443	0.448	0.000	0.109	0.500	0.500
30	0.497	0.503	0.000	0.000	0.500	0.500
31	0.443	0.448	0.000	0.109	0.500	0.500
32	0.497	0.503	0.000	0.000	0.500	0.500
33	0.443	0.448	0.000	0.109	0.500	0.500
34	0.497	0.503	0.000	0.000	0.500	0.500
35	0.443	0.448	0.000	0.109	0.500	0.500

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