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The Role of Advertising and Imitation in the Evolution of Industry Profitability

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Abstract

We study how advertising and imitation at the firm level influence industry profitability in an evolutionary context. We show that advertising expenditure has a non-linear effect on industry?s profitability. When no firms enter or exit an industry, advertising when combined with imitation improves the mean of the industry?s profitability while reducing its variation. When firms enter and exit an industry, advertising with imitation first increases and then reduces both the mean and the variation of the industry?s profitability. Our analysis has implications to industrial economics based strategy analysis in the absence of strategic interactions.

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ABSTRACT

We study how advertising and imitation at the firm level influence industry profitability in an evolutionary context. We show that advertising expenditure has a non-linear effect on industry's profitability. When no firms enter or exit an industry, advertising when combined with imitation improves the mean of the industry's profitability while reducing its variation. When firms enter and exit an industry, advertising with imitation first increases and then reduces both the mean and the variation of the industry's profitability. Our analysis has implications to industrial economics based strategy analysis in the absence of strategic interactions.

INTRODUCTION

Recent work in strategy (Knudsen, Levinthal & Winter, 2013) has thrown new light on the linkage between fundamental firm-level processes and firm-level profitability. Specifically, the rate of adjustment of firm-level scale was shown to influence firm-level profitability in important ways. Following this line of inquiry, we wish to focus on another particular mechanism of linkage, namely the role of firm-level adaptive behavior in the evolution of industry profitability. Specifically, this linkage identifies the joint adjustment of advertising and imitation as critical determinants of industry structure and profitability.

There is a long line of work in the behavioral tradition and organizational economics that studies the linkage between adaptive behavior and industry level processes (Cyert & March, 1963; Tadelis, 2002; Williamson, 1975, 1991). Firms adapt their pricing strategies and transaction modes according to feedback received from the market. Another related tradition in organization science has studied how policies and capabilities may change through processes of intentional firm-level adaptation (Lenox, Rockart & Lewin, 2006, 2007; Levinthal, 1997; Rivkin, 2000, 2001). Typically, the analysis in this latter line of work is considerably simplified as the objective function of the firm only contains a single unambiguous argument: fitness, defined as a placeholder for firm-level performance. The firm is seen as manipulating a set of policies, one at a time, to achieve increases in fitness. In contrast, organizational economics typically considers trade-offs between conflicting policies, such as insurance and profitability. In this work, we wish to examine how potentially conflicting firm-level policies influence the basic adaptive process among firms and thereby the level of profitability achieved in an industry.

In the industrial organization (IO) based strategy literature, static scale economies were proposed as one source of entry barriers and an important structural determinant of monopoly rents and industry profitability. In addition to structural factors, governmental entry barriers, and more subtly, behavioral responses in oligopoly settings were identified as separate sources of monopoly rents. Our approach revisits this line of work, but takes a very different perspective.

In the present work, we consider how adaptive behavior at the firm-level influences the level of industry profitability even in the absence of strategic interactions studied in game theoretic approaches. We develop a model where a fixed number of firms have access to different production technologies and consequently differ in their production costs. To increase profits, these firms consider two policies: level of advertising and rate of incremental imitation. Higher advertising expenditure will increase market share while imitation of low cost firms decreases average cost. In a context where price is exogenously given, we show how, and why, firm-level adjustment of these two policies influences the level of industry profitability independent of entry and exit barriers. While imitation clearly has an overall positive effect on profitability, advertising expenditure will have a non-linear effect on the industry's net profit – it increase first and then decreases. Adding entry and exit to the model does not alter this finding. While advertising (and R&D) has been shown to produce an endogenous barrier to entry that preserves a minimum level of concentration and profitability (Sutton, 1991), our results point to a different effect. As firms use advertising campaigns to gain market share, and thereby increase profits, they perhaps unwittingly influence the overall industry profitability, possibly to their own disadvantage. This insight provides an important extension to resource and capabilities views of strategy (Barney, 1991; Dierickx & Cool, 1989; Lippman & Rumelt, 2003; Peteraf, 1993) and ultimately questions the now dominant approach of separating firm- and industry-level sources of profitability.

The paper is organized as follows. We first present the contextual description of an industry in which firms' have different production costs and undertake advertising and imitation. We then describe the features of a firm and the industry in which it operates mathematically. Later, we present and explain the simulation results of the model in the evolutionary context. Finally, we end with conclusions.

CONTEXT DESCRIPTION

Assume that an industry consists of a set of firms which produce non-differentiated products, i.e. products that are homogenous and substitutable. These firms have access to different production technologies (or factors of production), and as a result the firms differ in their production costs. Otherwise they are identical. Also assume that the market size or the number of customers the firms wish to serve is fixed. Though this is not a perfectly competitive scenario, the firms nevertheless compete against each other by undertaking two strategies to increase their profits: advertising and incremental imitation.

Firms undertake advertising and marketing campaigns to generate "social goodwill" for themselves, and also to acquire market share from other firms to increase their profits (Buzzell, Gale & Sultan, 1975; Martin, 1979; Montgomery & Wernerfelt, 1991; Prasad & Sethi, 2003; Prescott, Kohli & Venkatraman, 1986; Rumelt & Wensley, 1981; Salde, 1995). The sizes of the campaigns are determined by their respective profitability in the sense that high profitable firms spend more capital (or effort) on their advertising campaigns to gain more market share relative to their low profitable counterparts (Nerlov & Arrow, 1962; Schmalensee, 1986). Here, we focus is on the transfer of market shares or customers between the firms. The case where firms increase their market shares by introducing new customers to the market is not considered here.

In addition to market share acquisition, the firms also engage in improving their production technologies via incremental imitation to reduce their production costs (Mansfield, 1961; March, 1991). Assuming that the production costs of all the firms is common knowledge, the high cost (less efficient) firms try to imitate the production technology of the least cost (most efficient) firm in the industry. The amount of capital (or effort) firms invest in the imitation process depends on both their respective profitability and cost advantages (Aghion, Harris, Howitt & Vickers, 2001; Banbury & Mitchell, 1995; Grahovac & Miller, 2009; Lippman & Rumelt, 1982; Reed & Defillippi, 1990). The imitation process will improve the profitability of the firms and make them more efficient.

Here, the analysis is performed in the evolutionary context of the industry. The firms in the industry undertake advertising and imitation simultaneously in each period. The effect of these two processes is studied over multiple periods and the evolution of the industry’s profit after accounting for the advertising and imitation costs and other characteristics are analyzed (Hannan & Freeman, 1977; Nelson & Winter, 1982; Schaffer, 1989).

Two scenarios are considered: one in which there is no entry or exit of firms into or from the industry. Another in which one firm enters and all loss making firms exit the industry every period.

The demand function for the industry's homogenous product is specified in advance and is assumed common knowledge. Also at the beginning, the number of firms and the quantity produced by each firm is fixed, and it is assumed that all firms start with equal market shares. In the no-entry-no-exit scenario the product's market price remains constant across periods, while in the entry-and-exit scenario the price depends on the number of firms in the industry.

MODEL DESCRIPTION

There are N firms in the industry. Initially, the firms are assigned production costs and advertising goodwill. The i^{th} firm's production cost per unit of output c_{i0} is generated randomly from a uniform distribution U[.,.] with c_{ul} and c_{ll} as its upper and lower limits respectively, i.e.

$$c_{i0} \sim \mathrm{U}[c_{ul}, c_{ll}] \;\; \forall \;\; i \in \{1, \ldots, N\}. \tag{1}$$

The goodwill of all the firms is initialized to unity, i.e.

$$g_{i0} = 1 \;\; \forall \;\; i \in \{1, \ldots, N\}. \tag{2}$$

The quantity of output produced by any firm in the industry is assumed to be q_0.

In each period t, the market price p_t is computed assuming a linear market demand function as

$$p_t = mQ_t + k, \tag{3}$$

where Q_t is the market supply, and m and k are demand function's slope and intercept respectively. The quantity of output or market share of the i^{th} firm is proportional to its goodwill, and is computed as

$$q_{it} = \left(\frac{g_{it}}{\sum_{j=1}^{N} g_{jt}}\right) Q_t, \tag{4}$$

where g_{it} is its goodwill in period t. Thus a linear relation is assumed between a firm's goodwill level and its output quantity or sales. The firm's per period profit π_{it} is computed as

$$\pi_{it} = (p_t - c_{it}) q_{it}. \tag{5}$$

Advertising: The firms in the industry use advertising expenditure to create and improve their goodwill, and thereby their market shares (Dixit & Norman, 1978; Fershtman, Mahajan & Muller, 1990; Schmalensee, 1986). A firm's goodwill is assumed to follow the well-known Nerlov-Arrow goodwill accumulation equation (Buratto, Grosset & Viscolani, 2005; Nerlov & Arrow, 1962), which assumes that current and past advertising expenditures are investments that affect the future goodwill of a firm and the demand for its product(s). It also considers the fact that the past expenditure losses its effectiveness overtime which results in the depreciation of goodwill. The dynamics of the goodwill of the i^{th} firm in period t is given by

$$\frac{dg_{it}}{dt} = \beta \pi_{it} \mathbf{1}_{\{\pi_{it} > 0\}} - \delta g_{it}, \tag{6}$$

were β is the advertising parameter, which specifies the fraction of profits a firm spends on advertising, and δ is the depreciation parameter. The term $(\beta \pi_{it})$ signifies the advertising cost for the firm. Note that without loss of generality it is assumed here that a unit of profit is transformed into a unit of goodwill. The indication function $\mathbf{1}_{\{\pi_{it} > 0\}}$ captures the scenario where unprofitable firms cannot invest in advertising.

Imitation: The firms imitate the least cost (or the most efficient) firm of the entire industry via the modified Exponential Recency-Weighted Average (EWA) reinforcement learning rule (Sutton & Barto, 1998) in an incremental fashion (Camerer & Teck-Hua, 1999; Erev & Roth, 1998). Thus, the production cost c_{it} of firm i in period t is given by

$$c_{it} = c_{it} - \propto \mathbf{1}_{\{\pi_{it}>0\}}(c_{it} - c_{low}), \tag{7}$$

where $\propto$ is the imitation parameter, which signifies the rate of imitation, and c_{low} is the production cost of the most efficient firm in the industry. The amount spent on (or the cost of) imitation in each period depends on the profit a firm obtains as well as its cost advantage relative to the least cost firm. We also assume that the cost of imitation is proportional to the rate of imitation.

The profit left after spending on advertising and imitation, i.e. net profit, is given by

$$\Pi_{it} = \left[1 - \mathbf{1}_{\{\pi_{it}>0\}}\left(\beta - \frac{\propto(c_{it}-c_{low})}{\mathbf{max}_i(c_{it}-c_{low})}\right)\right]\pi_{it}. \tag{8}$$

In the entry-and-exit scenario, only one firm with initial output quantity of q_0 enters the industry per period. The firms entering the industry are assumed to posses the capability to cross the entry barrier, in that their production cost is chosen at random below the current market price. Also, firms with negative profits leave the industry (Levinthal, 1991; Nelson & Winter, 1982; Schaffer, 1989). The number of firms exiting the industry each period will depend on their imitation rate and on the number of firms entering the market.

RESULTS

We study the influence of the advertising and imitation policies and their interaction on the evolution of the profitability of the industry. The simulation is carried out with the following parameter values: N=90, number of periods T=100, m=-1/500, k=4, c_{ul}=2.0 and c_{ll}=1.0. The rate of advertising depreciation δ is set to 0.05 unless otherwise mentioned. The advertising and imitation parameters (β , $\propto$) are varied to study their effect. The outputs measured are the mean and standard deviation of the net profits of all the firms in the industry. First, we describe results for the individual effects of advertising and imitation for the no-entry-no-exit scenario, and later, describe results for their joint effects.

Proposition 1: *[No-entry-no-exit] In an industry with a homogenous product and heterogeneous costs, increasing advertising expenditure will have a non-linear effect on the industry's net profit, i.e. it increases first and then decreases.*

Since all the firms in the industry are assumed to have equal market shares in the first period, for a given market price heterogeneous costs will lead to heterogeneous profits. When firms invest in advertising, an amount equivalent to $(\beta\pi_{it})$, they not only try to preserve their market share, which otherwise would depreciate with a rate of δ, but also try to acquire more from others. With less advertising expenditure, as a percent of a firm's profit, the net gain, i.e. increase in profits due to increase in market shares less the cost involved, by high profit firms is more than that of their low profit counterparts. Hence, for lower δ, i.e. $\delta = 0.001, 0.005$ & 0.01, both the mean and variation of the net profit of the industry increases as depicted in figures 1 and 2.

As the advertising expenditure is increased further, i.e. for $\delta = 0.05, 0.1$ & 0.2, the increase in marginal profits due to increases in market shares will not keep up with the marginal cost involved. As a result, the marginal benefit of the advertising campaigns for the firms will start to decrease, which in turn will reduce the pace of acquisition of new market shares. This will lead to falling levels of the mean and variation of the net profit of the industry as shown in figures 1 and 2.

Since the total market supply does not change with time, the mean of the market shares of the firms in the industry remains constant. The market shares of individual firms, however, depend on their respective history of profits (Buzzell et al, 1975; Fershtman et al, 1990; Montgomery & Wernerfelt, 1991; Prescott et al, 1986; Rumelt & Wensley, 1981). The profit variation (standard deviation) between high and low cost firms increases monotonically with advertising costs, and so does the variation in their market shares as shown in figure 3.

Insert Figure 1 about here

Insert Figure 2 about here

Insert Figure 3 about here

Proposition 2: *[No-entry-no-exit] In an industry with a homogenous product and heterogeneous costs, the industry's net profit increases in advertising depreciation.*

According to equation (6), the goodwill generated by a firm increases with the advertising expenditure $(\beta\pi_{it})$ and decreases with the depreciation rate δ, both proportionately. Although firms start off with equal market shares and goodwill, soon they start to differ based on these characteristics and profitability because of heterogeneous costs. When the depreciation rate is increased, both low cost and high cost firms loose more goodwill per period, but because the low cost firms invest more in advertising (because of more profits) relative to high cost firms, the net effect of the increased depreciation is that the subsequent market shares of the low cost firms will increase more. This effect occurs recursively as the industry evolves overtime, and it improves the profits of the low cost firms considerably relative to the high cost firms, thereby increasing the mean of the industry's net profit, as depicted in figure 4. The effect of the increased depreciation rate can also be seen in the increased variation of the net profits and market shares of the firms in figures 5 & 6.

Insert Figure 4 about here

Insert Figure 5 about here

Insert Figure 6 about here

Proposition 3: *[No-entry-no-exit] In an industry with a homogenous product and heterogeneous costs, advertising when combined with imitation improves the mean of the industry's net profit, while reducing its variation.*

In the model, firms imitate the least cost firm in the industry, and it is assumed that the imitation cost is proportional to the rate of imitation $\propto$. When firms undertake advertising and imitation simultaneously, i.e. when they try to preserve and acquire more market share and reduce costs at the same time, the asymptotic level of the mean of the firms' profits raises above the asymptotic level of the case where firms do just advertising. The rate of profit increase in the initial periods depends on the rate of imitation. As firms spend more and more on advertising while imitating, the costs outweigh the benefits and the asymptotic profit level starts to fall, as shown in figure 7.

In general when firms in an industry undertake imitation, the cost variation between them decreases and eventually all firms will become similar. Overtime, the cost advantage diffuses and the industry becomes more and more competitive (Fershtman et al, 1990). So, when both advertising and imitation are carried out, the variation of the firms' profits will be lower than when firms do just advertising, as shown in figure 8. Moreover, the profits variation will reach asymptotic level when all the firms become similar in terms of cost, and the rate at which this happens depends on the rate of imitation.

Insert Figure 7 about here

Insert Figure 8 about here

Proposition 4: *[With entry-and-exit] In an industry with a homogenous product and heterogeneous costs, advertising with imitation increases and then reduces both the mean of the industry's net profit and its variation.*

In the entry and exit scenario, a new firm enters the industry every period and reduces the market price according to the demand function in equation (3). When firms undertake advertising and imitation simultaneously, the mean of the industry's net profit increases first, similar to the no-entry-no-exit scenario. However, when the market price falls to a certain level, the profits of individual firms start to decrease thereby decreasing the mean of the industry profit (Aghion et al, 2001; Martin, 1979), as depicted in figure 9.

The variation of the firms' profits is similar to the no-entry-no-exit scenario in the initial periods. As new firms enter, their unit production cost is less than the current market price. The new firms along with the imitation process of the firms already in the industry reduce the variation of the firms' profits in the later periods, as can be seen in figure 10.

Insert Figure 9 about here

Insert Figure 10 about here

CONCLUSIONS

It has been widely acknowledged that firm level adaptive processes influences industry level processes (Cyert & March, 1963; Tadelis, 2002; Williamson, 1975, 1991). We study how advertising and imitation policies at the firm level influence industry profitability in an evolutionary context. Our analysis suggests that advertising expenditure has a non-linear effect on industry's profitability. When no firms enter or exit an industry, advertising when combined with imitation improves the mean of the industry's profitability while reducing its variation. When firms enter and exit an industry, advertising with imitation first increases and then reduces both the mean and the variation of the industry's profitability.

Our study on advertising and imitation has obvious relevance to industrial economics and market structure, both in terms of explaining the determinants of rents (Weiss, 1968) as well as market shares (Buzzell et al, 1975; Dixit & Norman, 1978; Schmalensee, 1982). The study can also have policy implications in that it can suggest the amount of resources for advertising and imitation to maximize profitability taking into account the costs involved in the absence of strategic interactions in an industry.

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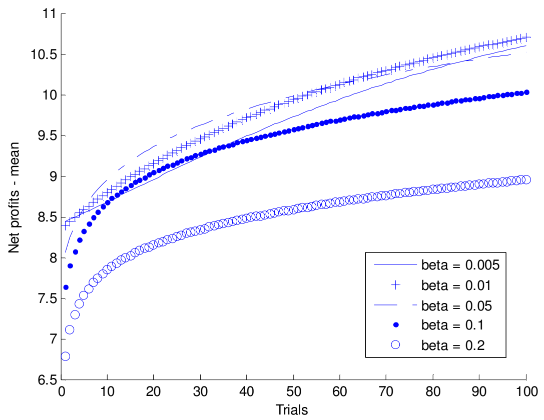


Figure 1: Net profit – mean

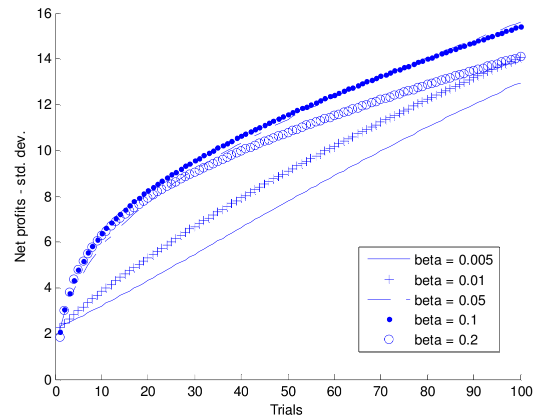


Figure 2: Net profit – std. dev.

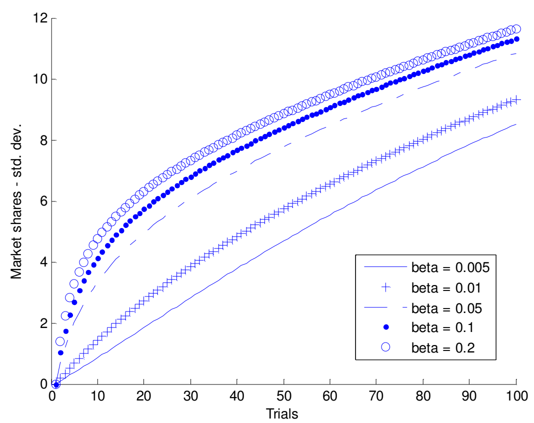


Figure 3: Market shares – std. dev.

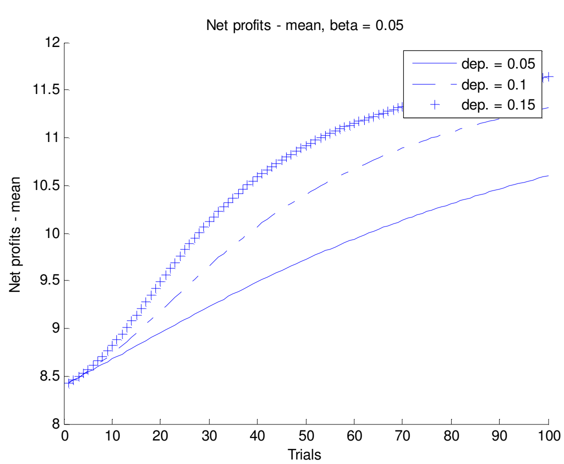
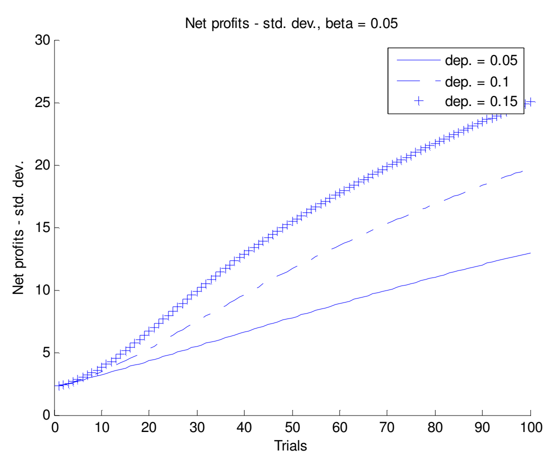


Figure 4: Net profit – mean



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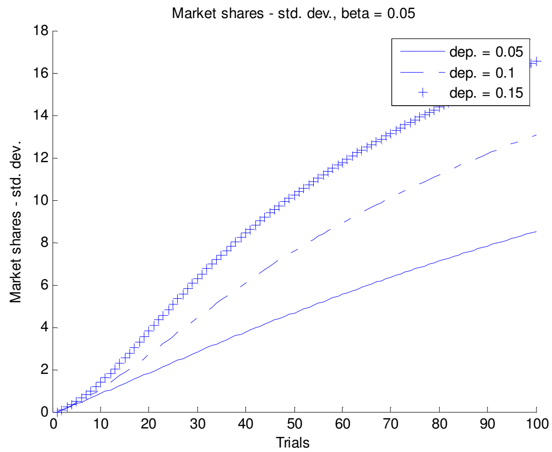

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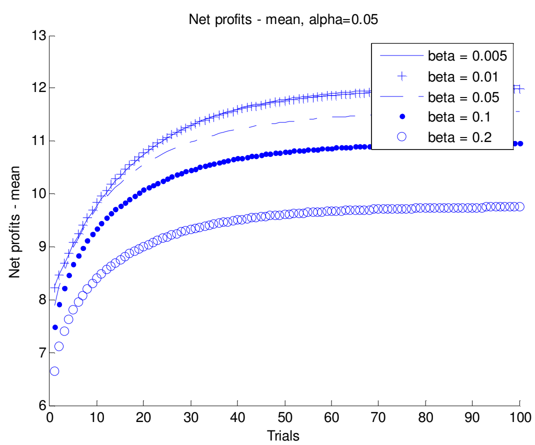

Figure 7: Net profits – mean

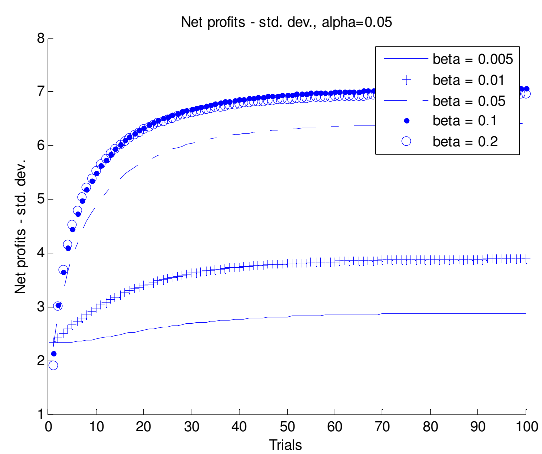

Figure 8: Net profits – std. dev.

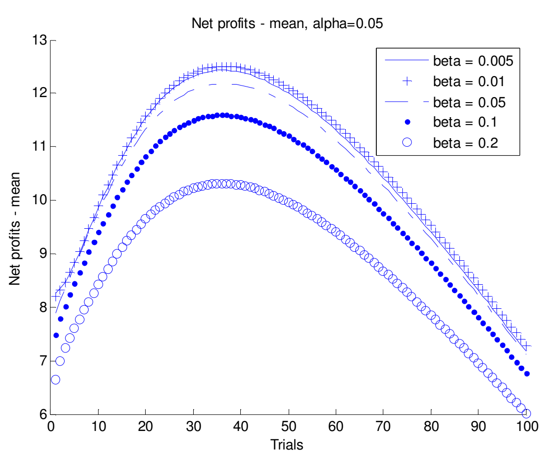

Figure 9: Net profits – mean

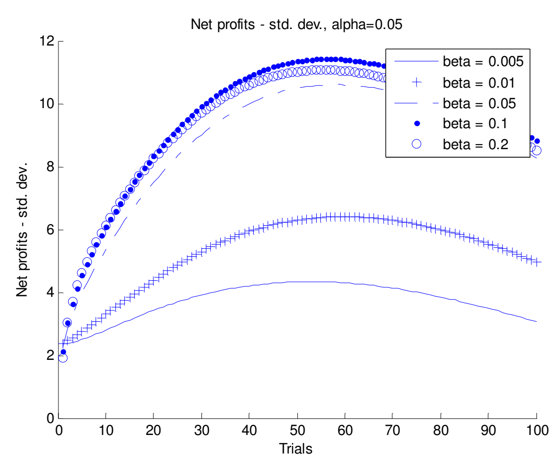

Figure 10: Net profits – std. dev.