Investment, Strategy and Risk: Evidence from Hurdle Rates*

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Abstract

This paper uses direct evidence from reported hurdle rates and discount rates to assess theories of corporate investment appraisal. We find first that hurdle rates are frequently below discount rates, suggesting strategic or managerial behaviour. To test this we use probit analysis to discriminate between this group and an alternative group, where hurdle rates are higher than discount rates. We find that variables representing the opportunity for managerial or strategic investment (e.g. free cash flow) or the motivation (e.g. low growth) increase the probability of firms having hurdle rates below discount rates.

In a second stage of the analysis we analyse the *relationship* between hurdle rates and discount rates for both sets of firms separately. For example, we find that for the strategist firms, product R&D tends to be associated with a lower hurdle rate relative to the discount rate, while for the profit maximising group of firms, the opposite is the case. For the second sample, we also find that risk variables raise the hurdle and that there is some evidence for an irreversibility effect. Responses of the hurdle rate to entry also differ between the two groups.

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1. Introduction

Two diverse literatures suggest that capital investment may not fully be captured by the standard story of equilibration between marginal return and user cost. One, older, literature has emphasised a role for managerial discretion in investment appraisal (Marris 1964; Jensen 1986, 1993; see Kathuria and Mueller et al 1995 for some empirical evidence). A more recent literature has focussed on the effect on investment of irreversibility and uncertainty (Dixit and Pindyck 1994; Abel and Eberly 1994; Chirinko and Schaller 2002) It has not generally been recognised that these literatures share a common element in that both concern the role of real options in investment appraisal. This is of course clear in the case of the irreversibility literature where the option to wait or defer expenditure – sometimes known as growth options – is explicit. In the case of the earlier literature on managerial discretion the role of options is less obvious. Strategic moves, not justified by standard discounting rules, constitute options of a kind in that they purchase flexibility to commit (and abandon) at a later stage. In the terminology of real options these are known as *compound options* (Copeland et al 2000). While the link between the strategic literature and real options has not often been made, this link was central to the critique that standard DCF analysis was endangering the future of companies by excessive caution and short-term non-strategic thinking (Hayes and Garvin 1982, Kaplin 1986). It would, however, be misleading to portray the managerial/strategic literature simply as a sub-set of real option theory; it also has a thematic concern with motivational or behavioural issues, focused in particular on the objective of the firm or its managers. Whereas the growth options approach tends to assume profit maximising behaviour, much of the managerial literature does not take that as given.

In this paper we use evidence on the hurdle rates used by a large sample of firms to answer key questions posed in both the managerial/strategic and the irreversibility premium theories. First. we ask whether there is evidence in the sample for the existence of managerial discretion or strategic behavour when it comes to investment. We find that there is considerable evidence supporting the existence of a sub-set of firms who may be "over-investing" in terms of traditional investment appraisal techniques. One interpretation is that they are acting strategically, though it is often hard to distinguish this from managerial "empire building". In any event, this initial result establishes sufficient heterogeneity in the population to consider separately the determinants of hurdle rates for the managerial/strategist firms and for profit maximising firms. We find

substantial differences between the two samples on a number of dimensions, not least in the impact of product R&D, which tends to be associated with a lower hurdle for the strategist firms but a higher one for the profit maximising firms.

There have been surprisingly few direct studies of hurdle rates in capital investment appraisal. This is despite the wealth of theorising about such rates - as exemplified by the large literature on managerial "over-investment" and the more recent literature on the irreversibility premium (Dixit and Pindyck 1994, Chirinko and Schaller 2001).

In this study we report an analysis of the PIMS dataset of large industrial firms, mostly US based, for the period up to 1992. This period encompasses the 1970s decade of high and volatile inflation and the "deal decade" of the 1980s when companies reined in their capital expenditure and bought back their own stock under pressure from aggressive shareholders given new legal powers of disciplining corporate management (Blair 1995).

A major problem for the empirical study of hurdle rates is that they are generally unrecorded and have to be found by surveys of company managers, so that consistent observation over time is difficult. One such survey (of the Fortune 1000 companies) used a set of reported hurdle rates in manufacturing industry for a particular year and attempted to explain the considerable variation across the sample (Poterba and Summers 1995). Most companies in the sample appeared to use a real hurdle rate much higher than the real cost of equity. The modal difference was 3 percentage points but it was both much higher for some companies and it was negative for a substantial proportion – about a quarter of the total. However, despite entering a large range of financial and structural variables the authors failed to obtain any results to explain the diversity in hurdle rates which accorded with prior theory. The one partial exception was that the current ratio (a possible proxy for free cash flow) was found in a bivariate regression to be correlated with *higher* hurdle rates.[1] The authors report the "striking conclusion…that none of the traditional financial variables that might proxy for risk, like the firm's stock market Beta, correlates with hurdle rates" (p.47).

In this paper we use a range of (mainly non-financial) variables to discriminate between the cases where the wedge between the hurdle rate and the discount rate is positive or negative.

[1] A further bi-variate regression suggested that managers with financial backgrounds may be more inclined towards higher hurdle rates though the direction of causation here is somewhat unclear

We also aim to explain variation in the hurdle within the sub-samples defined as having a negative or a positive wedge. In what follows we first outline in Section 2 the theory underpinning negative or positive wedges. Section 3 describes the nature of the dataset we are using. We then set up a number of hypotheses in Section 4 and describe the testing framework in section 5. Results are presented in Section 6 with further discussion in Section 7. Section 8 concludes.

2. Why do hurdle rates differ from discount rates?

In the sample of firms considered in this paper, we found that substantial numbers of firms reported hurdle rates that were either above or below the discount rate. Accordingly we begin with relevant sketches of how the existing literature explains the existence of a negative or positive wedge between the hurdle and the discount rates.

The Case of a Negative Wedge

Industrial Organisation literature provides a number of possible explanations for hurdle rates lying *below* the discount rate; namely that a) firms may be able to pursue goals other than that of profit maximisation or b) firms may be acting strategically

Perhaps the earliest formal theories that allowed for hurdle rates of firms to differ systematically from discount rates are to be found in the managerial literature of the 1960s. This emphasised the significance of both discretionary behaviour by management (in situations of rather weak corporate governance and product market discipline) and of firm specific assets. For example, both Marris (1964), and Galbraith (1964) took seriously the issue of what motivates managers, reaching the conclusion that both pecuniary and non-pecuniary factors favoured growth as opposed to profit maximisation. Such behaviour results in “excess investment” with the marginal product of capital below the discount rate.

Corporate governance issues - conflicts between shareholders and managers - arise in the well-known Marris model of the firm in the choice between profit rates and growth rates in steady state conditions. This conflict is based upon a “Penrose” effect (Penrose 1959), according to which, at least beyond a certain point, there are costs attached, not to an increased *scale* of

operations, but to their *growth*, arising from limitations of managerial capacity[2]. Formally, any choice over the growth of the assets of the firm is subject to a trade-off between growth rates and profitability which is defined by the relation between the growth rates of assets (g) and the associated investment costs (I). We can therefore write:

$g = g(I)$

where $\partial g/\partial I > 0$ and $\partial^2 g/\partial I^2 < 0$

In addition to utility derived from the growth of the firm (associated with status and power as well as the fact that salaries tend to be higher in larger enterprises), managers are also assumed to value security in their own livelihoods. Where shareholdings are dispersed (as in many of the large firms in the US) and imperfect competition ensures that the product market does not enforce profit maximisation, security is threatened by hostile takeover where a raider sees the potential for a gain. As shown in a recent formulation of the managerial model by Kathuria and Mueller (1995) this possibility lies in the discrepancy between the actual and profit maximising value of the firm. Call this discrepancy v. In steady state conditions in which stockholders expect the level of dividends to continue in perpetuity, the value of the firm is simply the level of dividends divided by the discount rate r. Moreover, if v* is the value of the firm under profit maximisation (where the marginal product of capital is equal to the discount rate), v can be written as a function of the level of investment and of the underlying profits or cash flow (F) available to the firm.:

$v = v^* - (F-I)/r$

The probability of a take-over can now be written as p(v) with $dp/dv>0$[3]. Now if security depends upon the probability of such a take-over we can represent managerial motivation by a utility function with growth and the probability of take-over as arguments:

[2] The Penrose effect stresses the importance of firm specific investments in human capital, which mean that new managers are not immediately as productive as existing managers. In general, if we suppose that a manager's productivity is related to length of time with the firm, then higher rates of growth are associated with management teams of lower average experience, and lower productivity

[3] In the literature, immediate take-over when profits are not maximised is dependent upon the considerable fixed costs associated with takeover activity (see for example Odagiri 1981)

$U = U[g(I), p(v)]$

Maximising the level of U with respect to I yields the first order condition that the marginal utility from growth caused by an increase in investment should equal the decline in utility that increased investment has on the probability of a take-over[4]. Following the discussion in Kathuria and Mueller (1995) it is not unreasonable to suppose that p(0) = 0 so that the probability of take over is non-existent when profits are being maximised. This ensures that the marginal product of capital for the firm will lie *below* the discount rate. [5].

Managerial empire building at the expense of profitability is not, however, the only explanation for hurdle rates being below the cost of capital. The literature on real options and in particular, compound options, shows how hurdle rates lower than the discount rate can be justified in a number of cases. Specifically, where information is revealed only by investing in a first stage, where abandonment is possible, and where there are delivery lags it may be sensible for the firm to initiate projects with negative expected return (Dixit and Pindyck 1994, Bar-Ilen and Strange 1996).

In such cases, investment will typically create new opportunities for further investment because of intertemporal spillovers and options (Hayes and Garvin 1982, Kaplin 1986 ,Morris 1998, Schwartz and Trigeorgis 2001). These provide scope for further profit opportunities due to improvements in the firm's *strategic* position; this may mean access to new technologies,

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[4] $dU/dI = (\partial U/\partial g)\,(dg/dI) + (\partial U/\partial p)(dp/dI) = 0$
where $dp/dI = (dp/dv)\,(dv/dI) = (dp/dv)/i$
This gives $(\partial U/\partial g)\,dg/dI = -(\partial U/\partial p)dp/dv\,/i$ so that the marginal utility from investment that creates extra growth just equals the marginal disutility created by investment's effect on the probability of a take-over.

[5] Empirical evidence regarding the relevance of managerial preference for growth has been somewhat inconclusive (for a survey, see Short (1994)). Empirical testing has mainly been based on *a priori* identification of managerial firms based on ownership patterns, and this has proved difficult in practice. However the model has been used quite convincingly to explain the higher growth rates and lower profit rates consistently reported for Japanese firms (which face a much lower probability of takeover) as against US or UK firms (e.g. Odagiri 1981, 1992, Peck and Temple 1999). Moreover the empirical analysis of Kathuria and Mueller (op cit) – based on an analysis of 387 listed US firms between 1972 and 1990 - suggests that investment is better explained by discretionary behaviour rather than neo-classical behaviour under financial constraints. On their estimates of rates of return for these firms, roughly 75% had rates of return below their cost of capital. These firms were larger and growing less fast than those for which they found the converse.

markets, skills which can accrue directly because of the initial investment, but would have be unattainable if it had not been made. As the information content increases these strategic opportunities become harder to evaluate by external capital markets (Morris 1998). If *conventional* techniques of investment appraisal are only applied to *conventionally* measured cash flows there will be a tendency to reject sound investments. In effect the appraisal will have failed to take account of compound or expansion real options. Given asymmetric information between investors and firm management, it is likely that strategic investments can only be pursued where there is considerable autonomy for managers.

The Case of a Positive Wedge

There is also a sizeable literature on the alternative case of a positive wedge where the hurdle rate contains a premium over the discount rate. Recently a class of models has been proposed which focuses on potential discontinuities in the adjustment process (Abel and Eberly 1994; Dixit and Pindyck 1994; Abel *et al,* 1996; Chirinko and Schaller, 2002). The theory suggests that under a variety of circumstances the firm will be faced with a "zone of inaction" in respect of the marginal value of capital, q, where it is optimal to keep the capital stock constant even if it differs from its frictionless optimal value[6]. These circumstances include either fixed costs of adjustment or the existence of sunk (irreversible) capital costs under uncertainty . It is intuitively obvious that fixed costs of adjustment will cause firms to concentrate investment in bursts. Uncertainty combined with irreversible assets creates a "value to waiting" if the underlying stochastic variable has some persistence and if investment affects the future return on capital.[7] This is the case of the real option to defer: here the threshold marginal q depends on the level of uncertainty and there is an irreversibility premium over the normal cost of capital (Dixit and Pindyck 1994). Using what they regard as typical parameters representing volatility, Dixit and Pindyck show that the present value of a fully irreversible project would have to be twice the investment cost before investment would be justified. [8] Put differently, there is an irreversibility premium which should be added to the usual cost of capital in appraising investment projects.

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[6] A number of empirical studies have also confirmed this prediction of discontinuous adjustment at least for large projects (Caballero et al 1995; Nilsen and Sciantarelli 1996)

[7] The exceptional case where the return of capital is invariant to the capital stock is where there are constant returns to scale and perfect competition. . Where firms have monopoly power or where there are decreasing returns to scale the profit function of the firm is concave in the capital stock. For a review of the issues here see Caballero (1991) and Pindyck (1993)

[8] Dixit and Pindyck illustrate this by specifying a standard Brownian motion process for the value of the firm (V) as $dV= \alpha Vdt+\sigma Vdz$. Denoting the option value as F(V), the basic Bellman equation is :

The potential for an irreversibility premium has also been explored with partial irreversibility and fixed costs in a somewhat different framework (Abel and Eberly 1994, Abel *et al* 1996, Chirinko and Schaller 2002). Here the irreversibility premium arises from the modification to the equilibrium condition for capital adjustment with marginal cost of adjustment C_I, which includes the purchase and installation price, as well as true adjustment costs. A perturbation argument ensures that the firm is indifferent between an increase in capital in by one unit in period t and a decrease in period t+1 with subsequent periods unaffected. Of course present adjustment costs have to reflect interest and depreciation, but that is balanced by the marginal return on capital (π_K). We thus obtain (Romer 2000; Chirinko and Schaller 2001)

$$(1 + r + \delta)C_{I,t} = \pi_{K,t} + E[C_{I,t+1}]$$

The expectation of C_I for the next period however must take account of the irreversibility of investment. This is because firms cannot adjust smoothly in the presence either of fixed costs or uncertainty when investment assets are at least partially irreversible. Thus firms may be stuck in a position where their investment is not optimal - in the sense that without threshold effects it would be changed - but which in the presence of threshold effects it is not optimal to change. The anticipation of this non-optimality is one element of the irreversibility premium. The other element occurs if the firm anticipates disinvestment at the distress price p^-. [9] The effect of this modification to standard theory is to allow the hurdle rate to lie above the usual cost of capital rate. [10]

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rFdt=E(dF), where F=maxE[(V-I)exp(-rt)]. To expand dF requires the use of Ito's lemma. The Bellman equation thus becomes: $rFdt=\alpha VF'(V)dt+1/2\sigma^2V^2F''(V)dt$. Imposing the usual boundary conditions (See Dixit and Pindyck 1994, Chapter 5) gives a general solution of the form:$F(V)=AV^{\exists.}$ The root β is the solution of the non-linear equation:
$1/2\sigma^2\beta(\beta-1)+\alpha\beta-r=0$. This can be substituted into the boundary conditions, giving the critical value for $V=V^*=\beta/(\beta-1)$. If we follow the parameterisation in Dixit and Pindyck (1994) viz:$r=0.04$; $\sigma^2=0.04$; $\lambda_1=0.1$, we get a value of 2 for β .

[9] If the demand shift between t and t+1 is sufficiently adverse so as to move firms outside the zone of inaction, they will optimally sell capital at the distress price (p^-).

[10] Note that if there can be a price premium for installing extra capacity ex-post, the irreversibility premium may again turn negative due to the presence of an expansion option (Abel et al 1996). In their empirical work Chirinko and Schaller obtain a positive irreversibility premium for a limited sample of industries only. They argue that a

3. The PIMS DATASET

The main data source used in this paper is the PIMS database of large firms. PIMS (Profit Impact on Marketing Strategy) was established in 1972 at Harvard University and achieved a reporting base of over 3000 business units representing 450 companies. The PIMS programme is described in Buzzell and Gale (1987). The data are prepared by managers of each business unit under detailed guidance from PIMS consultants. Firms subscribe to PIMS as a way of benchmarking performance in different businesses; a digest of the results in ratio form is returned to firms to allow them to compare indicators such as R&D intensity, capacity utilisation, or profitability. The business units correspond to narrow market segments at least as fine as four-digit SIC. The full database contains about 500 variables and is collected in five-year blocks. Our sample period covers 1972 to 1984 during which period the vast majority of the firms were based in the USA. Data that are not in ratio form are disguised by being scaled using a constant term specific to each business unit. These data have of course all the virtues and shortcomings of any survey-based sample; they are direct and consistent in that all variables are collected from the same source. On the other hand, they are only as reliable as the reporting managers choose to be.

Most of the variables used in the following analysis are self-explanatory but we give here the exact definition of our terms “hurdle rate” and “discount rate”. The other variables are listed in Section 4 and annotated where necessary. PIMS tells its respondents that “the discount rate indicates the degree to which current income or cash flow is more valuable than future income or cash flow. Similarly, the capital charge rate “indicates the degree to which your business should be encouraged to seek (or be penalised for seeking) additional investment funds” (Core data form 3). Specific further instructions in respect of reporting each of these variables are:

Discount rate: “The discount rate is used in computing the present value of a stream of future income or cash flow. You can think of it also as your opportunity cost of capital (i.e. your company’s cost of debt and equity)”

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negatively signed premium may indicate the presence of firms who are adopting a managerial perspective e.g. resources firms.

Capital Charge Rate: "In calculating discounted net income what capital-charge rate should be applied to any additional investment that would be required to pursue the various strategy alternatives available to your business. The capital charge rate can be used to simulate financing costs for new investment" It is clear therefore that the capital charge rate is indeed a "hurdle rate" .[11]

Key descriptive statistics of the dataset are reported in the Data Appendix . It may be noted that out of a total of 2382 business units:
505 business units have a negative wedge with Hurdle< Discount
452 business units have a positive wedge with Hurdle>Discount

4. Hypotheses

We now move to a statement of three hypotheses to be tested by the data which arise from the discussion in Section 2.

First, consider the sample of firms with a negative wedge where hurdle rates are *below* the discount rate (we call this the BELOW sample)

***H1**: The existence of a hurdle rate below the discount rates is indicative of a management with some discretionary power;*

However, it is important to note that the existence of discretionary power need not imply "over-investment". Indeed, we need to test:

***H2**: The existence of a hurdle rate below the discount rate suggests the existence of strategic opportunities*

If H1 is true but not H2, then this indicates Jensen type "over-investment". If both are true, the low hurdle rate may be explained by managers acting to take advantage of strategic opportunities. It is then particularly important to see if firms without discretion are also able to act strategically.

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[11] This was confirmed by PIMS in private correspondence.

Turning now to the sample of firms with a positive wedge where hurdle rates are *above* the discount rate (the ABOVE sample), potential reasons for this have been given earlier. In particular, we have discussed the role of uncertainty and irreversibility in generating an irreversibility premium. Our third hypothesis H3 is, therefore, that;

H3*: the existence of a hurdle rate higher than the discount rate suggests a profit-maximising sample subject to an irreversibility constraint.*

5. Empirical Testing

Under H1 and H2, the occurrence of a negative wedge where the hurdle rate is lower then the discount rate (BELOW) is predicted by the *opportunity* and the *motivation* to act strategically. On the other hand under H3, the occurrence of a positive wedge (ABOVE sample), is predicted by a combination of risk and irreversibility under profit maximising behaviour and real options. For emphasis we set this out below:

SAMPLE OBSERVED	CODE	IMPLIES	HYPOTHESIS
HURDLE<DISCOUNT	BELOW	MANAGERIAL/ STRAGEGIC BEHAVIOUR	H1/H2
HURDLE>DISCOUNT	ABOVE	PROFIT MAXISIMISING WITH REAL OPTIONS	H3

Clearly we could encounter hybrid cases but as long as this is borne in mind, the dichotomy remains useful as a discriminator between different types of firm. In this first stage of analysis we accordingly use probit analysis to differentiate the observations in the ABOVE sample, by conditioning on the opportunity, and on the motivation, to act strategically, as well as on a variety of measures of risk.

<u>The opportunity</u>

Not all firms are in a position to maintain (long-run) investments at hurdle rates lower than the discount rate. The corporate governance literature suggests such opportunity is determined by the existence of free cash flow, combined with a lack of product market discipline from end-users

and competitors. Proxies available to us from the PIMS dataset and employed in this study were as follows:

- Liquidity [cash flow-to-sales ratio] - v503.
- Lack of market discipline [% channelled to distribution facility - v35]
- Lack of market discipline [% channelled to retailer - v37]
- Lack of market discipline 2 [wage cost per employee] v487
- Existence of barrier to entry 1[capacity quantum][12] v454
- Existence of barrier to entry 2 [ratio of fixed capital to sales] v201
- Existence of barriers to mobility [extent of market leader dominance] v336

The motivation

Managers may be motivated either by a concern for their immediate careers or by a desire to exploit strategic opportunities. The former motivation is represented by a set of variables which measure the lack of growth prospects in the industry concerned. Managers faced with low growth prospects will have most to gain from diversifying investments or expansion that is not justified by profitability. The second motivation derives from the potential strategic value of investments. We use here the extent of product and process R&D; these provide conditions under which inter-temporal spillovers are likely to be strongest. We include here major entry which may, depending on the nature of the strategic game, encourage firms to accommodate or to respond aggressively and increase capacity. The specific variables included are :

For growth prospects:

- lifecycle stage v4[13]
- capacity utilisation v236
- % sales from new products v302
- real market growth v366

For the strategic value of investments:

- major exit v71

[12] Specifically, the capacity quantum is the "minimum economically efficient amount" by which the standard capacity of the business could be increased, expressed as a percentage of the previous years capacity.
[13] Dummy (1-4) variable with 4 = mature

- major entry v70[14]
- Product R&D to sales ratio v132
- Process R&D to sales ratio v137

Risk factors

What constrains hurdle rates from being pushed lower than discount rates? We measure these constraints by a set of instability indices for both the industry and the end-users

- Industry instability v80[15]
- Immediate customer *stability* v24[16]

Additional controls

We used a number of additional controls, the most important of which is the discount rate; this acts as an indicator of the nominal inflation rate. Because most observations were taken from an era when inflation was significant and variable we also include a measure of the firm's own price - *Selling Price Inflation*. Further, it was sometimes difficult to assign a variable to one or other of the three sets above. For example, the existence *of Proprietary Processes* indicates the potential for technological led growth but also indicates the presence of barriers to entry. *Recent Technological Change* may indicate a risky environment but also opportunities for strategic pre-emption. We use these controls as set out below, with the relevant allegiance to our three different sets of variables shown in parentheses where appropriate. Finally we also made some allowance for further sources of heterogeneity across firms by considering the potential for differences between industries. The 4-digit US SIC code was not available for a significant proportion of our sample, but a large fraction are identified as being in manufacturing. We therefore add a manufacturing dummy in our basic specification. As an additional sensitivity check we also consider the results for the manufacturing sample alone.

- Discount rate v451
- Selling Price Inflation v340
- Proprietary processes v8 (Opportunity and Motivation)
- Recent technological change v11 (Motivation and Risk)

[14] Entry and exit are major if they account for 5% of sales and have taken place within 3 years
[15] RMSE index of industry sales instability over five years
[16] Index (1-3) of immediate customer stability

- Manufacturing Dummy ; *mandum*

Statistical summaries of these variables are reported in the Data Appendix.

6. Results: Discrimination between Firms

What kinds of characteristics help us to identify which firms employ hurdle rates in investment appraisal which lie below discount rates (BELOW sample)? To answer this, probit analysis was employed to discriminate between the BELOW sample and the alternative ABOVE sample of firms that have hurdle rates above the discount rate. Results are reported in Table 1. In this table (as well as Tables 1-3) four results are reported. First, for the full sample and for the complete range of variables discussed above; the second for a restricted range of variables which proved robust to standard testing down procedures. One advantage of this procedure is that it reduces the observations that have to be excluded because of missing variable values, allowing the sample size to increase. The third and fourth set of results repeats this procedure for the business units identified in our data as belonging to manufacturing.

It is evident from the diagnostics that a fairly high degree of discrimination is achieved between the BELOW and ABOVE samples. This is partly due to the importance of the discount rate as a control. However, the results also clearly indicate that both the opportunity and the motivation variable sets help in differentiating the two samples of firms, with the opportunity set dominating. Most importantly, the proxy for free cash flow is correctly signed and significant at all conventional significance levels in all four experiments. Other opportunity set variables, representing barriers to entry, such as the degree of capital intensity and lumpiness also appear to have some predictive power.

On the motivation side, high capacity utilisation and high real market growth, both of which should discourage strategic behaviour, contribute to an explanation of the distinction between the ABOVE sample and the BELOW sample. Membership of ABOVE is (weakly) predicted against by new entry, which may suggest non-accommodation to new entry, though this is not supported when the sample is restricted to manufacturing business units.[17] Product R&D, which

[17] Geroski (1995) cites evidence that new entry stimulates incumbents to introduce new products and processes which they had been holding back (p.1431)

could motivate strategic behaviour (and membership of the BELOW sample) is correctly signed but not significant as a discriminator.

The risk factors also play a role in explaining the dichotomy. Instability discriminates in favour of ABOVE sample firms especially when only the manufacturing sample is considered (regressions 1.3 and 1.4). This may constitute evidence for an irreversibility premium.

For the controls, the most significant variable (indeed of all the variables) is the discount rate. This will inevitably strongly correlate with the national inflation rate at any time, which may explain why the own selling price is insignificant as a control. At high inflation rates the motive to use a lower discount rate at the margin is strong for firms who are not tax-exhausted because of the beneficial effect of high inflation on the value of depreciation allowances. Thus this variable should more properly to be regarded as a control rather than differentiating between strategic and profit maximising behaviour. Given the variance in inflation rates both between countries and over time, the usefulness of the discount rate as a predictor should not be surprising.

The significance of the manufacturing dummy suggests that it is important to consider the probit estimates within manufacturing (regressions 1.3 and 1.4). Overall, the pattern is very similar across the four sets of results. One of our indicators of motivation – capacity utilisation does however appear to be less important when only the manufacturing sub-set is considered.

To conclude this discussion, our results suggest that indicators of managerial discretion and corporate governance can discriminate between firms using hurdle rates above and below the discount rate.

Table 1 **Dependent variable = 1 when firm is in ABOVE sample ; Robust Probit Estimates; sample= ABOVE + BELOW**

	(1.1)			(1.2)			(1.3) Manufacturing only			(1.4) Manufacturing only		
	Coefficient	t-ratio	Sig	Coefficient	t-ratio	Sig	Coefficient	t-ratio	Sig	Coefficient	t-ratio	Sig
Managerial Opportunity												
O1 Cash-flow sales (503)	-0.0004	-4.42	***	-0.0003	-4.11	***	-0.0004	-3.55	***	-0.0003	-2.94	***
O2 % channelled to distribution facility (35)	-0.0107	-2.51	**	-0.0108	-2.58	**	-0.0211	-4.38	***	-0.0200	-4.23	***
O3 % channelled to retailer (37)	0.0059	2.32	**	0.0063	2.57	**	0.0015	0.49				
O4 high wage cost per employee (487)	-0.0050	-1.08					-0.0029	-0.53				
O5 capacity quantum (454)	-0.0048	-1.54		-0.0044	-1.41		-0.0062	-1.45		-0.0061	-1.55	
O6 ratio of fixed capital to sales (201)	-0.0047	-1.98	**	-0.0044	-2.00	**	-0.0028	-0.90				
O7 market leader dominance (336)	0.0001	2.29	**	0.0001	2.28	**	0.0001	0.66				
O8 Market share rank (72)	-0.0455	-1.52		-0.0453	-1.53		-0.0568	-1.53		-0.0599	-1.79	*
Managerial Motivation												
M1 lifecycle stage (4)	0.1606	0.98					0.3302	1.58		0.2673	1.32	
M2 capacity utilisation (236)	0.0121	2.96	***	0.0130	3.24	***	0.0110	2.20	**	0.0081	1.54	
M3 % sales from new products (302)	-0.0023	-0.60					-0.0066	-1.64		-0.0047	-1.41	
M4 real market growth (366)	0.0078	1.15					0.0159	1.93	*	0.0120	1.45	
M5 major exit (71)	-0.0164	-0.09					-0.3175	-1.56		-0.3484	-1.73	*
M6 major entry (70)	-0.2530	-1.65		-0.2783	-1.88	*	-0.1514	-0.82				
M7 product R&D to sales ratio (132)	-0.0238	-0.64					-0.0033	-0.07				
M8 process R&D sales ratio (137)	0.1666	1.71		0.1446	1.57		0.1258	1.20		0.1224	1.31	
Risk												
R1 industry instability (80)	0.0134	-0.64		0.0129	1.76	*	0.0245	2.55	**	0.0289	3.05	***
R2 immediate customer stability (24)	-0.1649	-1.71	*	-0.1732	-1.69	*	-0.1307	-1.02		-0.1701	-1.40	
Other controls												
C1 Discount rate (451)	-0.4946	-13.72	***	-0.4885	-13.42	***	-0.5558	-11.42	***	-0.5223	-10.81	***
C2 proprietary processes (8)	0.1720	0.84					-0.2185	-0.75				
C3 recent technological change (11)	0.2669	1.62		0.2186	1.36		0.1275	0.61				
C4 Selling price (340)	-0.0002	-0.02					-0.0090	-0.63				
C5 Manufacturing Dummy	-0.4023	-2.66	***	-0.4363	-2.90	***	-	-				
Constant	4.8232	6.29	***	5.0384	8.61	***	4.8814	5.35	***	4.7154	5.64	***
Wald Chi2(23)	224.4300			Wald Chi2(15)	207.9		Wald Chi2(22)	179.3		Wald Chi2(13)	151.1	
Prob > Chi2	0.0000			Prob > Chi2	0.0000		Prob > Chi2	0.0000		Prob > Chi2	0.0000	
Pseudo R2	0.48			Pseudo R2	0.48		Pseudo R2	0.54		Pseudo R2	0.52	
N Obs	645			N Obs	654		N Obs	465		N Obs	469	

Table 2 **Dependent variable = Hurdle for BELOW sample firms ; ols robust estimates; sample=BELOW only**

	(2.1)			(2.2)			(2.3) Manufacturing only			(2.4) Manufacturing only		
	Coefficient	t-ratio	Sig	Coefficient	t-ratio	Sig	Coefficient	t-ratio	Sig	Coefficient	t-ratio	Sig
Managerial Opportunity												
O1 Cash-flow sales (503)	0.0000	0.16					0.0002	1.32		0.0002	1.68	*
O2 % channelled to distribution facility (35)	-0.0037	-1.03					-0.0055	-1.25				
O3 % channelled to retailer (37)	-0.0008	-0.25					-0.0009	-0.24				
O4 high wage cost per employee (487)	0.0003	0.05					0.0014	0.20				
O5 capacity quantum (454)	-0.0082	-2.02	**	-0.0085	-2.17	**	-0.0071	-1.62		-0.0064	-1.46	
O6 ratio of fixed capital to sales (201)	-0.0058	-2.15	**	-0.0063	-2.67	***	-0.0055	-1.67	*	-0.0055	-1.91	*
O7 market leader dominance (336)	0.0000	0.00					0.0001	1.11				
O8 Market share rank (72)	-0.0545	-1.24		-0.0562	-1.37		-0.0631	-1.18		-0.0757	-1.57	
Managerial Motivation												
M1 lifecycle stage (4)	0.2122	1.27		0.1999	1.38		0.0917	0.44				
M2 capacity utilisation (236)	-0.0042	-0.79					-0.0052	-0.89				
M3 % sales from new products (302)	0.0037	0.87					0.0042	0.81				
M4 real market growth (366)	0.0078	0.93					0.0061	0.68				
M5 major exit (71)	-0.1033	-0.51					-0.2923	-1.25		-0.2924	-1.34	
M6 major entry (70)	-0.3352	-1.85	*	-0.3336	-1.91	*	-0.1616	-0.74		-0.1535	-0.74	
M7 product R&D to sales ratio (132)	-0.1010	-2.53	**	-0.0998	-2.79	***	-0.1504	-3.20	***	-0.1258	-3.07	***
M8 process R&D sales ratio (137)	-0.0325	-0.29					-0.0502	-0.35				
Risk												
R1 industry instability (80)	0.0147	1.29		0.0165	1.54		0.0177	1.35		0.0177	1.47	
R2 immediate customer stability (24)	-0.2191	-1.65		-0.1915	-1.53		-0.2658	-1.71	*	-0.2569	-1.84	*
Other controls												
C1 Discount rate (451)	0.3206	7.48	***	0.3255	7.77	***	0.2975	6.43		0.3003	6.71	***
C2 proprietary processes (8)	-0.2435	-1.01					-0.1278	-0.45				
C3 recent technological change (11)	-0.0710	-0.33					-0.1827	-0.75				
C4 Selling price (340)	0.0178	1.27					-0.0074	-0.45				
C5 Manufacturing Dummy	0.1432	0.76										
Constant	5.8681	6.53	***	5.6626	7.30	***	6.8428	6.49		6.6783	9.40	***
F(23,333)	6.33			F(9,354)	14.33		F(22,240)	5.22		F(10,258)	9.74	
Prob > F	0.0000			Prob > F	0.0000		Prob > F	0.0000		Prob>F	0.0000	
R2	0.32			R2	0.31		R2	0.34		0.32		
N Obs	357			N Obs	364		N Obs	263			269	

Table 3 **Dependent variable = Hurdle for ABOVE Sample firms; ols robust estimates; sample= ABOVE firms only**

	(3.1)			(3.2)			(3.3) Manufacturing only			(3.4) Manufacturing only		
	Coefficient	**t-ratio**	**Sig**	**Coefficient**	**t-ratio**	**Sig**	**Coefficient**	**t-ratio**	**Sig**	**Coefficient**	**t-ratio**	**Sig**
Managerial Opportunity												
O1 Cash-flow sales (503)	-0.0003	-2.06	**	-0.0002	-1.93	*	-0.0002	-1.29				
O2 % channelled to distribution facility (35)	0.0268	2.08	**	0.0266	1.96	*	0.0354	1.67	*	0.0383	1.82	*
O3 % channelled to retailer (37)	-0.0047	-1.09		-0.0049	-1.23		-0.0014	-0.25				
O4 high wage cost per employee (487)	-0.0079	-0.77					-0.0215	-1.38		-0.0215	-1.45	
O5 capacity quantum (454)	0.0059	0.80					0.0148	1.64		0.0161	2.00	**
O6 ratio of fixed capital to sales (201)	-0.0043	-1.28					-0.0036	-0.81				
O7 market leader dominance (336)	0.0003	3.03	***	0.0003	2.96	***	0.0003	2.71	***	0.0004	2.94	***
O8 Market share rank (72)	0.2021	2.34	**	0.2068	2.52	**	0.3551	3.21	***	0.3850	3.96	***
Managerial Motivation												
M1 lifecycle stage (4)	0.6752	2.31	**	0.5923	2.37	**	1.1054	2.93	***	1.1382	3.33	***
M2 capacity utilisation (236)	0.0010	0.14		-	-		0.0168	1.71	*	0.0156	1.65	
M3 % sales from new products (302)	-0.0189	-2.61	**	-0.0187	-2.86	***	-0.0114	-1.17		-	-	
M4 real market growth (366)	0.0298	2.27	**	0.0282	2.10	**	0.0511	2.65	***	0.0513	2.70	***
M5 major exit (71)	-0.2587	-0.83		-	-		-0.4438	-1.08				
M6 major entry (70)	1.0987	3.21	***	1.2130	3.49	***	1.2248	2.82	***	1.1366	2.72	***
M7 product R&D to sales ratio (132)	0.1105	1.53		0.1158	1.80	*	0.1467	1.72	*	0.1382	2.05	**
M8 process R&D sales ratio (137)	-0.3114	-2.34	**	-0.2878	-2.31	**	-0.2753	-1.52		-	-	
Risk												
R1 industry instability (80)	0.0119	0.78		0.0118	0.83		0.0159	0.81		0.0155	0.91	
R2 immediate customer stability (24)	-0.2777	-1.38		0.2482	-1.33		-0.4399	-1.64		-0.4420	-1.71	*
Other controls												
C1 Discount rate (451)	1.0453	11.01	***	1.0690	12.53	***	1.1090	9.71	***	1.1531	10.29	***
C2 proprietary processes (8)	0.7914	1.54		-	-		1.0329	1.76		0.9907	1.73	*
C3 recent technological change (11)	-0.2825	-0.91		-	-		-0.0787	-0.20				
C4 Selling price (340)	0.0522	2.30	**	0.0474	2.00	**	0.0662	2.03	**	0.0819	2.72	***
C5 Manufacturing Dummy	1.4219	4.54	***	1.2088	3.79	***	-	-				
Constant	-1.1836	-0.80		-1.2692	-0.96		-3.2859	-3.29	***	-4.4666	-3.80	***
F(23,264)	24.64			F(16,279)	21.55		F(22,179)	26.34		F(15,189)	34.88	
Prob > F	0.0000			Prob > F	0.0000		Prob > F	0.0000		Prob > F	0.0000	
R2	0.61			R2	0.60		R2	0.63		R2	0.63	
N Obs	288			N Obs	296		202			N Obs	205	

7. Discussion of Results for the Separate samples

The relationship between hurdle rates and discount rates: strategists

In the second stage of our empirical analysis, we attempt to unravel the nature of the relationship between hurdle and discount rates, conducting the investigation on the basis of different samples (BELOW for the "strategist" firms, ABOVE for the profit maximising firms). Since our ability to discriminate is less than perfect however, it is important that we still try to control for possible managerial influences in both sample sets.

Table 2 sets out the results for the BELOW sample (interpreted as managerial empire builders under H1 or strategists under H2). Variable sets are identical to Table 1. All estimates are now based on OLS estimators for the hurdle rate (451 – whose definition was discussed above). We report Huber/White robust estimates of variance. Again we report sensitivity tests by considering manufacturing alone, although note here we do not see a significant dummy for manufacturing when the full sample is used.

Our first observation is that in regard to the opportunity set, the fixed capital barrier to entry variables are again significant (equations 2.1 and 2.2) – although this result is weaker for the manufacturing firms alone (equations 2.3 and 2.4).

Turning to motivational factors the key result is that the product R&D to sales ratio is highly significant and negative in all equations – with a rather larger and highly significant coefficient estimated for manufacturing alone. Put differently, product R&D intensity appears to indicate the presence of a real option that encourages firms to set hurdle rates with negative expected return. There is some rather weak evidence that the BELOW sample may act aggressively (loss-making) in the face of major entry. See the impact of variable 70 (major entry) in 2.1 and 2.2. However this was not supported within manufacturing.

Overall, these results – especially the significance of product R&D - do not suggest that the motivation for "over-investment" in this sample is purely of the managerial kind identified by Jensen (1993). Note that in this regard the cash-flow sales ratio was never significant in our tests, although perversely, it appears with a marginally (10%) significant *positive* sign in manufacturing.

Risk factors appear to increase the hurdle rate – with variable 24 (immediate customer stability) lowering it and variable 80 (industry instability) increasing it, but a conventional F-test on their joint significance reveals that they are significant at the 5% level only for equation 2.4[18]

Finally, in regard to controls, the coefficient on the discount rate (robustly determined at around 0.3 in all our equations) suggests that capital market influences on the discount rate have only an attenuated influence on hurdle rates for this sample.

The relationship between hurdle rates and discount rates: profit maximisers

Table 3 examines the relationship between hurdle rates and discount rates for the ABOVE sample. Three key differences between these results and those reported in table 2 stand out:

First we can see that the discount rate – whose coefficient is insignificantly different from unity - in all the experiments - now has a one-for-one impact on the hurdle rate, suggesting that these managers approximate to text-book profit maximisers.

Second, we also note that the free cash flow variable tends to lower the hurdle rate for the full sample. This may be evidence that this group is subject to the "lemons" problem caused by asymmetric information between external financiers and industry. Indeed this putative financial pressure receives some support from the results for the motivation set where actual outcomes in the development of new products (302) lowers the hurdle – at least in the full sample - but R&D commitment to products raises it. Put differently, external capital markets may be able to appraise (highly visible) new products but are unable to appraise R&D devoted to new products as anything other than as a risk factor.

Third, we also see in the motivation set a very strong result for new entry but the response here is now accommodating in contrast with the response reported in Table 2. We have seen from Table 1 that this group of firms has lower scale-related entry barriers and higher capacity utilisation that the strategist group. It also has faster growth and a higher degree of recent technological change. These are classic conditions for accommodating entry to be profit maximising (Besanko, Dranone and Shanley 2000, p.330).

[18] A full set of results for F-tests on the variables we have grouped in Tables 2 and 3 is shown in Table 4 below.

Some significant variables are perversely signed in this set. For example it is hard to understand why firms with sales mediated by distributors (presumably meaning less customer pressure) should have a higher hurdle rate; similarly for the life-cycle variable. It may well be that for this sample such variables should be more properly regarded as controls since we do not have a strong prior of strategic or managerial behaviour for this group of businesses. More surprisingly perhaps, is that we do not find in the first two columns of Table 3 any evidence for the existence of an irreversibility premium: neither our capital intensity nor our capacity quantum variables turned out to be significant in the complete specification for the full sample (3.1), and are not retained in the parsimonious results (3.2). However the manufacturing dummy is highly significant for this group, suggesting that attention should be paid to equations (3.3) and (3.4) where we restrict experiments to cases where the firm is identified as belonging to manufacturing. Most of the results remain robust across equations but some differences need to be noted:

i) Capacity quantum (v454) which we interpret here as a measure of irreversibility (rather than a barrier to entry) now comes out as significant and positive as predicted by the options literature as described above.[19] However, the predicted impact is not large. A one standard deviation change (see Data Appendix) change in this variable produces, on the basis of (3.4) about 1/3 of a percentage point on the hurdle rate.

ii) The positive impact of product R&D on the hurdle rate appears to be strengthened

iii) The cash flow - sales ratio no longer has a negative impact at conventional levels of significance.

Further comparisons

To conclude these results it is useful to consider joint tests of significance on the factors influencing the hurdle rate that we have grouped under the headings of opportunity, motivation and risk. These are shown in Table 4. At least for our preferred (parsimonious) specifications the table shows that both the opportunity and motivational sets are important for both sets of firms; risk factors on the other hand are perhaps surprisingly, statistically significant only for the BELOW sample . However, immediate customer stability is significant on its own at the 10% level and correctly signed for manufacturing, in the ABOVE sample.

[19] The variable was interpreted as a barrier to entry when discussing the behaviour of strategists but is more properly regarded here as an index of sunk cost or irreversibility.

Table 4
F-Tests on Grouped Variables

Equation		Managerial Opportunity	Managerial Motivation	Risk	Other Controls
2.1		F(8,333) = 1.91	F(8, 333) = 1.86	F(2,333) = 2.42	F(5,333) = 12.76
	(Prob>F)	0.0570	0.0635	0.0903	0.0000
2.2		F(3,354) = 5.60	F(3,354) = 5.75	F(2,354) = 2.69	F(1,354) = 60.33
	(Prob>F)	0.0009	0.0008	0.0696	0.0000
2.3		F(8,240) = 2.14	F(8,240) = 1.73	F(2,240) = 2.57	F(4, 240) = 11.34
	(Prob>F)	0.0333	0.0918	0.0783	0.0000
2.4		F(4,258) = 3.40	F(3, 258) = 4.22	F(2, 258) = 3.39	F(1, 258) = 44.98
	(Prob>F)	0.0099	0.0062	0.0353	0.0000
3.1		F(8,264) = 3.84	F(8, 264) = 4.31	F(2, 264) = 1.16	F(5,264) = 40.31
	(Prob>F)	0.0003	0.0001	0.3162	0.0000
3.2		F(5, 279) = 4.75	F(6, 279) = 5.69	F(2,279) = 1.15	F(3,279) = 54.90
	(Prob>F)	0.0003	0.0000	0.3169	0.0000
3.3		F(8, 179) = 5.75	F(8,179) = 4.21	F(2, 179) = 1.50	F(4, 179) = 30.99
	(Prob>F)	0.0000	0.0001	0.2249	0.0000
3.4		F(5,189) = 7.37	F(5,189) = 5.13	F(2,189) =1.73	F(3, 189) = 50.12
	(Prob>F)	0.0000	0.0002	0.1802	0.0000

Overall our results in Table 4 suggest that there are important differences between the BELOW and the ABOVE samples, with the BELOW sample having both the opportunity and the motivation to pursue investments with a strategic value. We find evidence for both H1 and H2, and limited evidence for H3, which is strongest for manufacturing.

Two further F-tests are worth reporting here. Modern option theory suggests that a combination of factors should determine the importance of irreversibility for the investment decision (Chirinko and Schaller 2002) i.e. low growth, low depreciation, high uncertainty plus a limited resale market. In our data set these may respectively be proxied by the variables for real market growth, % sales from new products (negatively), industry instability and capacity quantum. F tests on the joint significance of these variables for equations 3.1 and 3.3 of Table 3 (where all

these variables appear) are significant at 1% and 5% respectively[20]. On the basis of 3.1, a firm in an industry where each of these variables was one standard deviation above (below in the case of % sales from new products) the mean would have a hurdle rate about 1 percentage point above that for a firm at the mean for these variables.

8. Summary and Conclusions

In this paper we have looked at the relationship between hurdle rates and discount rates to infer the influence on investment behaviour of a range of firm characteristics. Beginning with the observation that there are a significant number of firms in our data for whom reported hurdle rates are below discount rates, we argued that this could be explained by managerialism and/or the existence of strategic options. Using a probit analysis we found that indicators of likely managerial and strategic behaviour proved useful to discriminate between firms with hurdle rates below their discount rate, and firms with hurdle rates above their discount rate. Our results confirmed that there is quite striking heterogeneity across firms and that this can be explained in terms of the opportunity and motivation for firms to act strategically.

We then considered the relationship between hurdle rates and discount rates for these two groups of firms, separately.

For the group of strategist firms it appears that barriers to entry and the strategic value of investments explain much of the variation in hurdle rates below discount rates. Proxies for entry barriers such as capital intensity and the lumpiness of investments tend to reduce hurdle rates for a given discount rate. The same is true of a major indicator of strategic opportunity, viz. the intensity of product R&D. Moreover the hurdle rate is less responsive to the discount rate than it is for our second group of firms, which we hypothesise to be classic profit maximisers.

The regression analysis for the second group of firms - which reported hurdle rates above discount rates - revealed some other important contrasts with the strategists. One such contrast is in regard to the response to new entry. There is some evidence of an aggressive response from the strategist sample whereas the profit maximisers tended to pursue an accommodating approach. The other key contrast is in the impact of product R&D which tends to be associated

[20] For equation 3.1 $F(4,262) = 3.42$ (with $Prob>F = 0.0095$); for equation 3.2 $F(4,179) = 2.64$ (with $Prob>F = 0.0331$)

with positive strategic value in our first group of firms (and hence a lower hurdle rate) but with a higher hurdle rate in our second group of firms, perhaps reflecting exposure to risk.

Modern investment theory places a lot of stress on the impact of irreversibility on hurdle rates. Our search for an irreversibility premium had some success, since indicators of risk helped to discriminate between the groups. Also, for our second group we found a positive impact on hurdle rates which emanated from our measure of the size of sunk costs. Moreover, variables noted in the literature as likely to represent the conditions for real options effects to exist, were jointly significant at the 1% (5%) level for all industries (manufacturing). However, on this evidence, the effect may be less important than other factors (such as determinants of the managerial styles of firms) which clearly have a key influence on the ways in which investment projects are evaluated.

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DATA APPENDIX

Summary data are described here according to variable numbers as defined in the text. The only variable not appearing there is v67 – which is a four digit SIC code.

Table A1 presents summary statistics for the variables deployed in the text based on the sub-samples BELOW and ABOVE. Tables A2 and A3 present correlation matrices for these subsamples.

Table A1
Summary Statistics

	BELOW Sample					ABOVE Sample				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
v4	503	2.86	0.48	1	4	449	2.81	0.54	1	4
v8	503	0.20	0.40	0	1	448	0.19	0.39	0	1
v11	484	0.26	0.44	0	1	438	0.28	0.45	0	1
v24	483	1.84	0.65	1	3	437	1.80	0.65	1	3
v35	504	6.14	17.66	0	100	450	5.06	16.53	0	100
v37	504	14.38	27.89	0	100	450	19.18	32.07	0	100
v67(SIC)	297	3228.48	942.12	1455	9999	239	3352.93	885.54	2010	7512
v70	504	0.21	0.41	0	1	446	0.21	0.41	0	1
v71	503	0.17	0.38	0	1	443	0.15	0.36	0	1
v72	505	2.53	1.92	1	10	452	2.71	2.18	1	10
v80	374	10.47	8.65	0.02	40	311	12.24	10.44	0.03	40
v84	400	6.36	10.33	0	95	332	5.26	7.96	0	53
v132	504	1.42	1.88	0	9	452	1.77	2.24	0	9
v137	504	0.50	0.78	0	4	452	0.54	0.83	0	4
v201	505	47.21	32.73	3	170	452	46.03	34.21	3	170
v236	502	75.98	15.98	30	110	452	75.80	16.28	30	110
v302	502	8.48	16.47	0	90.8	446	10.87	19.20	0	99
v336	498	2081.23	1356.00	100	6000	445	2045.27	1397.81	100	6000
v340	504	7.88	6.28	-5	30	452	7.86	6.73	-5	30
v366	502	3.64	10.40	-20	40	452	3.87	11.38	-20	40
v451	505	13.97	2.74	8	20	452	9.99	2.69	2	18
v452	505	9.87	1.90	4	19	452	13.29	3.62	5	20
v454	499	19.31	21.98	0	100	430	17.71	20.33	0	100
v487	501	30.54	15.81	5	95	452	28.52	16.06	5	95
v503	505	186.12	750.08	-3916	2653.2	452	-22.76	1096.45	-6000	3360
mandum	505	0.55	0.50	0	1	452	0.50	0.50	0	1

Table A2 BELOW Sample correlation matrix

	v452	v4	v8	v11	v24	v35	v37
v452	1.00						
v4	0.09	1.00					
v8	-0.15	-0.38	1.00				
v11	-0.05	-0.25	0.40	1.00			
v24	-0.13	-0.19	0.16	-0.01	1.00		
v35	-0.09	0.01	-0.02	0.06	0.05	1.00	
v37	-0.02	0.15	-0.03	-0.11	-0.19	-0.05	1.00
v67	0.14	-0.08	0.07	0.01	0.13	0.00	-0.16
v70	-0.07	-0.13	-0.04	0.01	-0.05	0.03	0.01
v71	-0.11	-0.04	-0.02	-0.01	0.00	0.03	0.03
v72	-0.14	-0.11	0.07	0.06	0.12	-0.02	0.14
v80	0.15	-0.11	-0.04	0.00	0.12	-0.02	-0.08
v84	0.11	0.15	0.00	-0.05	-0.04	-0.01	0.02
v132	-0.19	-0.34	0.30	0.13	0.12	-0.08	-0.10
v137	-0.07	-0.24	0.28	0.14	-0.03	-0.02	-0.13
v201	-0.11	0.00	0.16	-0.02	0.09	-0.13	-0.11
v236	0.04	0.09	0.01	-0.10	-0.05	-0.06	-0.04
v302	-0.04	-0.19	0.11	0.20	0.04	-0.04	0.08
v336	0.06	-0.01	0.18	0.06	-0.07	0.02	-0.10
v340	-0.05	0.06	0.01	0.00	0.01	0.02	-0.09
v366	0.10	-0.22	-0.09	-0.01	0.00	0.02	-0.05
v451	0.46	-0.11	-0.02	0.06	0.01	-0.13	-0.06
v452	1.00	0.09	-0.15	-0.05	-0.13	-0.09	-0.02
v454	-0.06	-0.05	-0.04	-0.02	-0.08	-0.05	0.05
v487	-0.07	-0.22	0.27	0.13	0.18	-0.01	-0.24
v503	0.17	0.09	-0.04	-0.10	-0.04	-0.03	-0.02
mandum	-0.07	-0.01	-0.01	0.06	0.03	0.06	0.03

	v67	v70	v71	v72	v80	v84	v132
v67	1.00						
v70	-0.04	1.00					
v71	-0.10	0.26	1.00				
v72	-0.08	-0.10	-0.06	1.00			
v80	0.34	-0.05	0.00	0.05	1.00		
v84	0.00	-0.06	-0.09	-0.01	-0.15	1.00	
v132	0.17	0.06	-0.07	0.12	0.10	-0.08	1.00
v137	-0.01	0.01	-0.02	0.04	-0.02	-0.03	0.23
v201	-0.17	-0.05	-0.02	0.06	-0.11	0.00	-0.05
v236	-0.05	-0.09	-0.06	-0.12	-0.07	-0.01	-0.19
v302	0.00	0.07	-0.04	0.07	0.09	-0.01	0.32
v336	-0.17	0.09	0.01	-0.24	-0.16	0.13	0.14
v340	-0.11	0.02	0.09	0.00	-0.07	0.00	-0.15
v366	0.17	0.06	-0.06	-0.02	0.11	-0.10	0.12
v451	0.06	0.01	-0.08	-0.04	0.10	-0.04	-0.05
v452	0.14	-0.07	-0.11	-0.14	0.15	0.11	-0.19
v454	-0.16	0.09	0.08	-0.05	-0.17	-0.07	0.03

	v67	v70	v71	v72	v80	v84	v132
v487	0.02	0.03	0.04	0.09	-0.04	-0.08	0.12
v503	0.14	-0.03	-0.02	-0.12	0.06	0.05	-0.10
mandum	-0.41	0.03	0.08	0.00	-0.29	0.13	0.12

	v137	v201	v236	v302	v336	v340	v366
v137	1.00						
v201	0.20	1.00					
v236	0.10	0.16	1.00				
v302	0.19	-0.13	-0.04	1.00			
v336	0.18	0.02	0.07	0.10	1.00		
v340	-0.06	0.08	0.13	-0.07	0.11	1.00	
v366	0.07	-0.02	0.01	0.03	0.05	-0.18	1.00
v451	0.11	0.08	0.08	-0.02	0.11	-0.05	0.16
v452	-0.07	-0.11	0.04	-0.04	0.06	-0.05	0.10
v454	0.16	0.08	-0.03	0.06	0.15	0.00	0.14
v487	0.20	0.27	0.02	-0.05	0.10	0.08	0.00
v503	-0.24	-0.08	0.07	-0.12	0.07	0.04	0.04
mandum	0.01	0.00	-0.10	0.04	0.08	0.01	-0.14

	v451	v452	v454	v487	v503	mandum
v451	1.00					
v452	0.46	1.00				
v454	0.10	-0.06	1.00			
v487	0.02	-0.07	-0.02	1.00		
v503	0.02	0.17	-0.08	-0.01	1.00	
mandum	-0.03	-0.07	0.08	-0.13	0.03	1.00

Table A3
ABOVE Sample correlation matrix

	v452	v4	v8	v11	v24	v35	v37
v452	1.00						
v4	0.11	1.00					
v8	0.23	-0.30	1.00				
v11	0.15	-0.31	0.27	1.00			
v24	-0.12	0.09	-0.03	0.00	1.00		
v35	-0.01	0.04	-0.02	-0.03	0.09	1.00	
v37	0.08	0.15	-0.06	-0.13	-0.09	-0.04	1.00
v67	0.22	-0.09	0.20	0.15	-0.05	-0.01	-0.12
v70	0.06	-0.15	0.07	0.04	-0.04	0.05	-0.12
v71	-0.05	0.04	0.02	0.01	0.02	0.07	-0.06
v72	0.07	0.01	-0.04	-0.05	0.09	-0.02	0.02
v80	-0.04	-0.05	-0.08	-0.05	-0.04	-0.05	0.17
v84	0.06	0.11	-0.16	0.00	0.21	-0.07	-0.18
v132	0.09	-0.19	0.22	0.16	0.19	-0.10	-0.32
v137	-0.05	-0.21	0.19	0.13	-0.03	-0.10	-0.17
v201	-0.06	-0.10	0.21	0.16	-0.01	-0.05	-0.09
v236	0.12	0.08	-0.01	0.10	-0.03	0.13	-0.04
v302	-0.08	-0.28	0.04	0.08	0.05	0.00	-0.09
v336	0.19	-0.12	0.25	0.19	-0.12	-0.11	0.01
v340	0.01	0.19	-0.24	-0.09	0.06	0.02	0.08
v366	0.16	-0.35	0.22	0.21	-0.02	0.01	-0.03
v451	0.66	0.05	0.26	0.23	-0.16	-0.21	0.14
v452	1.00	0.11	0.23	0.15	-0.12	-0.01	0.08
v454	0.05	-0.06	0.07	0.10	0.07	0.15	-0.04
v487	-0.02	-0.04	0.25	0.26	0.00	0.01	-0.01
v503	-0.07	0.24	-0.13	-0.17	-0.01	0.01	0.11
mandum	-0.12	0.06	-0.26	-0.14	0.20	0.01	-0.08

	v67	v70	v71	v72	v80	v84	v132
v67	1.00						
v70	0.03	1.00					
v71	0.10	-0.09	1.00				
v72	0.00	-0.16	0.02	1.00			
v80	-0.08	0.08	-0.10	0.03	1.00		
v84	0.11	0.02	0.12	-0.01	-0.13	1.00	
v132	0.08	0.20	-0.05	-0.14	-0.01	0.28	1.00
v137	0.19	0.18	-0.05	-0.08	0.10	0.00	0.13
v201	-0.24	-0.10	-0.10	0.00	-0.05	-0.09	0.10
v236	0.28	-0.07	0.03	-0.12	-0.04	0.00	-0.13
v302	0.05	0.17	0.11	0.00	0.03	0.17	0.47
v336	0.22	0.02	-0.10	-0.41	-0.03	0.00	0.26
v340	-0.13	0.02	-0.12	0.12	0.07	0.04	-0.21
v366	0.09	0.23	-0.03	-0.06	-0.04	-0.10	0.19
v451	0.39	-0.15	0.07	-0.09	-0.12	0.03	0.03
v452	0.22	0.06	-0.05	0.07	-0.04	0.06	0.09
v454	-0.11	-0.01	-0.01	0.16	-0.04	-0.12	-0.10

	v67	v70	v71	v72	v80	v84	v132
v487	0.09	-0.12	0.05	0.01	-0.07	-0.19	0.19
v503	-0.03	0.10	-0.03	-0.34	-0.04	-0.07	-0.30
mandum	-0.74	0.11	-0.17	-0.12	0.04	0.11	0.14

	v137	v201	v236	v302	v336	v340	v366
v137	1.00						
v201	0.12	1.00					
v236	0.01	-0.04	1.00				
v302	0.05	-0.15	-0.13	1.00			
v336	0.16	0.09	0.15	0.02	1.00		
v340	-0.16	-0.07	-0.04	-0.15	-0.22	1.00	
v366	0.16	0.03	-0.02	0.20	0.20	-0.31	1.00
v451	-0.01	-0.07	0.13	-0.08	0.22	-0.12	0.06
v452	-0.05	-0.06	0.12	-0.08	0.19	0.01	0.16
v454	0.00	0.19	-0.04	-0.07	-0.04	-0.11	0.01
v487	0.12	0.24	0.05	0.05	0.14	-0.16	0.19
v503	-0.20	-0.20	0.17	-0.36	0.13	-0.01	-0.15
mandum	-0.04	0.09	-0.19	0.02	-0.14	0.07	-0.05

	v451	v452	v454	v487	v503	mandum
v451	1.00					
v452	0.66	1.00				
v454	-0.06	0.05	1.00			
v487	0.11	-0.02	0.00	1.00		
v503	-0.02	-0.07	-0.13	-0.23	1.00	
mandum	-0.34	-0.12	-0.05	-0.27	0.10	1.00