The valuation of intangible assets and hedonic pricing models

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This paper investigates the use of Lancaster's hedonic pricing model in the valuation of intangible assets owned by firms. It is hypothesised that the presence of intangible assets will lead to higher productivity, that there is a set of characteristics that objectively measures firm productivity, and that the market will "price" the set of these characteristics. Once the "prices" of the characteristics are known, the value of individual intangible assets can be calculated.
The paper investigates the empirical usefulness of this approach by examining US firms over a 5 year period. The results appear to be promising.

Key Words

Intangible assets, hedonic pricing models, valuation

JEL Codes

G10

Introduction

The terms `the new economy' and `intangible assets' are closely linked. Intangible assets have become increasingly important to the continued growth of the modern economy and the welfare of its citizens.

The methods of economic analysis that were successfully applied to economies which were dominated by physical assets sometimes lack efficacy when applied to the new economies. This paper investigates one aspect of economic theory that may be adapted to better cater for the increasing importance of intangible assets; the valuation of intangible assets.

The ability of firms and individuals to value intangible assets correctly is important if economic efficiency is to be achieved. Incorrect valuations will lead to either over- or under-investment, both conditions which would lead to a misallocation of scarce resources.

Fortuitously, the tools for solving the problem are readily at hand. Older schools of economic analysis dealt explicitly with intangible assets; and the hedonic pricing model, that was formulated to encompass neoclassical pricing theory, provides a useful method for comparing the characteristics of intangible assets.

Importance of Intangible Assets in the Economy

The extent to which intangible assets pervade both the public and private sectors of the economy may surprise the casual observer. Nakamura (2001), writing about the US economy states that:

> *"The rate of investment in intangibles, and its economic value, accelerated significantly beginning around 1980. Currently, I estimate that US private gross investment in intangibles is at least $1 trillion. … An intangible investment rate of $1 trillion suggests that US businesses are investing nearly as much in intangibles as they are in plant and equipment. It also suggests that a third of the value of US corporate assets are intangibles." [p.2]*

The World Bank is charged with, amongst other objectives, facilitating economic development of countries. As part of this objective it has undertaken a study into the determinants of wealth of nations (The World Bank, 2006). The findings may be somewhat surprising;

> *"The wealth estimates suggest that the preponderant form of wealth worldwide is intangible capital - human capital and the quality of formal and informal institutions. Moreover, the share of produced assets in total wealth is virtually constant across income groups, with a moderate increase in produced capital intensiveness in middle-income countries. The share of natural capital in total wealth tends to fall with income, while the share of intangible capital rises. The latter point makes perfect sense - rich countries are largely rich because of the skills of their populations and the quality of the institutions supporting economic activity." [p.XIV]*

The sheer size of intangible assets in todays economy is not the only indicator of the importance of intangible assets. Petty (2000) argues that the tools that management must use in the `New Economy' are vastly different from those of the previous decade. There is not only a quantitative change, but an equally large qualitative change to consider. Similar views are advanced by Leif Edvinsson (Edvinsson, 2002), best known as the first Chief Knowledge Officer in the world when he served as Corporate Director for Intellectual Capital, Skandia AFS.

At a national level the design of policy to assist in the creation of intangible assets has recently been given prominence by a number of important policy and research groups. In 2002 the Conference on Research in Income and Wealth of the National Bureau of Economic Research (NBER) hosted a conference that focused on these issues. In a collection of papers and discussions of this conference, the editors emphasize the importance of policy in the following terms;

> *"As the new economy has developed, intangible assets and high-technology investments are playing an increasingly important role. These developments have raised many important*

questions about measurement, including how to treat intangible assets in economic accounts and whether we are accurately measuring newer, high-technology capital. Economic researchers, data-providers, and policy analysts are interested in answering these questions because the answers can lead to better assessments of the economy's long-run pace of economic growth and rate of technological advance, as well as to improved measures of national wealth." [p.1]

The call to better account for the investment in intangible assets in the national accounting system is echoed by Nakamura (1999) and Moulton (2004), amongst others. Work on this problem had commenced earlier under the so-called 'System of National Accounts 1993', or SNA. This was an attempt at international cooperation in solving the difficulties in reporting new aspects of the national accounting under the auspices of the Inter-Secretariat Working Group on National Accounts (which consisted of the Statistical Office of the European Communities, the International Monetary Fund, the Organization of Economic Cooperation and Development, the Statistical Division and regional commissions of the United Nations Secretariat, and the World Bank).

However, the difficulties in implementation remain considerable, especially in regard to intangible assets. Moulton (2004) states the matter thus;

"Because of the substantial data and measurement problems associated with intangible assets other than those already recognized by the SNA, it seems prudent at this point to encourage development of estimates as part of satellite accounts and not immediately add new intangible assets to the core SNA asset boundary. If analysis of data on certain types of intangible assets within the context of satellite accounts demonstrates that they are robust and useful, it may then be appropriate to propose adding them to the core accounts. Data on R\&D and on worker training appear to be better developed than for other intangibles, and serious attention should be given to the research needed for evaluating them as potential fixed assets in the SNA." [p.271]

The increasing importance of intangible assets in economic theory

As a consequence of the increasing importance of intangible assets, there has been an attempt to incorporate such assets into the theoretical models that describe the behaviour of the economic system.

If tangible and intangible assets were similar in all respects, then the relative size of either would be of little interest. Economists, accountants, lawyers, and management theorists have recently begun to explain how these two groups of assets differ from each other. As Michael H. Armacost in the foreword to an influential work by Baruch Lev (2001) states;

"While economists, business people, and policy analysts continue to debate the question of what is `new' about the so-called `New Economy', one important feature of modern economies in the early twenty-first century seems clear: intangible factors are playing an increasingly dominant role in wealth creation. A growing share of economic activity today consists of exchanges of ideas, information, expertise, and services. Corporate profitability is often driven more by organizational capabilities than by control over physical resources, and even the value of physical goods is often due to such intangibles as technical innovations embodied in the products, brand appeal, creative presentation, or artistic content."[p.vii]

Rapid changes in technology over the last few decades have been one of the sources of structural change in modern economies. In order to analyze the 'New Economy' measurements of the changes to the economy are necessary, however data has not been easily available. In his 1994 presidential address to the American Economic Association, Zvi Griliches (1994), who has undertaken considerable work in an attempt to understand economic growth, states the matter thus;

"I will concentrate primarily on the R\&D component of this story - not because it can explain much of the productivity slowdown (it can not), … but because it illustrates rather well the major point I want to make here tonight: that our understanding of what is happening in our

economy (and the world economy) is constrained by the extent and quality of the available data." [p.2]

The reason for this difficulty is not hard to find. Griliches points out that;

> *"What is it about the recent situation that has made matters worse? The brief answer is that the economy has changed and that our data-collection efforts have not kept pace with it. ``Real'' national income accounts were designed in an earlier era, when the economy was simpler and had a large agricultural sector and a growing manufacturing sector. ... By 1990, however, the fraction of the economy for which the productivity numbers are half reasonable had fallen to below one-third. ... Our ability to interpret changes in aggregate total factor productivity has declined, and major portions of actual technical change have eluded our measurement framework entirely." [p.10]*

To reinforce the notion that the distinction between intangible assets and other forms of productive capacity is not trivial consider, the following summary of the proceedings of a conference on Research in Income and Wealth conducted by the National Bureau of Economic Research in 2002 (Corrado2005);

> *"Not surprisingly, no overall consensus emerged from the conference. Because capital measurement issues are difficult and the debate is ongoing, this lack of consensus is consistent with the conference tradition. The statistical, research, and policy communities will be grappling with the difficult issues in measuring capital for some time to come - and the problems associated with defining and measuring intangible assets and measuring high-tech capital will be at or near the top of the list."[p.8]*

Besides problems of measurement, there are additional problems to be considerred in dealing with intangible assets.

- Intangible assets are not often traded on open markets - there are problems associated with imperfect property rights, information asymmetries, and other costs to trading intangible assets.
- The `cost of production' of intangible assets often bears no relationship to the value after completion. Many costly software systems are virtually abandoned after completion; in contrast some brands and reputations are built at very low cost (others at great expense). Any `resource cost' theory of intangible assets seems doomed to failure.
- Classification, measurement and valuation of intangible assets at the firm level is complicated by the manner in which intangible assets are `tightly bound' to other aspects of firm performance.
- The use of an intangible asset by one customer does not necessarily exclude the simultaneous use by another. For example, airline seats can only be used by one passenger at a time, while the brand `Qantas' can be sold to any number of passengers simultaneously without exhausting the available supply.

Pricing financial assets

The Law of One Price is the primary instrument for pricing financial assets.

> *"The Law of One price states that identical goods (or securities) should sell for identical prices. In financial markets the law of one price is thought to hold almost exactly, and is the basis for much of financial economic theory."(Lamont 2003, p.191)*

It is possible to value an asset that is not listed on any market on the basis of its similarity to other traded assets. This methodology forms the basis of the pricing of bonds (which can be decomposed into relatively few characteristics), derivative securities (which often have many more characteristics, often referred to as the `Greeks' since each characteristic is assigned a letter of the Greek alphabet), and also to value the equity of an unlisted firm.

When a valuation of the equity of an unlisted firm is required, the immediate objective is to find `similar firms' whose value is known. The value of the unlisted firm can be estimated from the known value of the firms in the comparable group. The methods of finding comparable firms are numerous. Comparisons are made on the basis of discounted cash flow, `relative valuations' (often based on accounting characteristics), or contingent claims. The method of comparison will often depend on the data that is available to the analyst and on the existence of a group of similar firms. The conventional wisdom in the financial consulting industry is to use all available methods of comparison to `box in' the true value of the firm.

The firm is simply the amalgamation of the various assets that comprise the totality of the firm. The physical assets of a firm can often be valued on a similar basis to the firm itself. For example, in the case of mergers and acquisitions, the value of the subsidiary businesses are valued as `stand alone' units. One of the distinguishing characteristics of intangible assets however is that they are often not separable from the firm itself. Thus, for example, it might not make sense to speak of the `value of the client list' for a successful firm as an asset separate from the firm. The nature of intangible assets is such that there is often no group of assets which have a known value that can be used as a comparison.

This paper proposes an alternative and complementary approach to pricing assets. Hedonic pricing models, based on the work of Kelvin Lancaster and others, have been used successfully to price `bundled' goods for some time. The attributes of the consumer asset `housing' are valued separately and then combined to value any individual property (examples of housing attributes are location, size, and proximity to amenities). The theoretical framework is well developed in particular applications (housing, price indices, and the pricing of public goods), but has not been applied in any significant manner to financial assets. In this study a hedonic pricing model is proposed that allows the `characteristics' of a firm to be priced separately. The value of any asset, including an intangible asset, is comprised of the sum of the values of each of its characteristics. If these characteristics and their values can be identified, then the asset can be valued.

The proposed methodology is thus of a similar nature to other methods for the valuation of financial assets, except only that the method of finding `comparables' is different. The fact that the price of the relevant characteristics is extracted from all the firms in the market (rather than only from those firms placed in the `comparable' group) should, in addition, lead to more efficient estimation of values.

Nor is the proposed method remote form modern portfolio theory, in which all financial assets are reduced to only two characteristics; return and risk. The extension of the capital asset pricing model in the various forms of multi-factor models, and especially the development that followed Fama (1992), form the background to the proposed approach.

Hedonic pricing methods and the valuation of financial assets

There is little reference to hedonic models in the literature that is concerned with the valuation of equities. This seems odd, since the language of investment analysis is peppered with allusions to the characteristics of financial assets.

It is useful to re-state some of the well-known models of equity valuation in terms of an hedonic approach:

The Single Index Model
In the neoclassical model the only characteristics of financial assets are risk and expected return. In a well diversified portfolio the effect of idiosyncratic risk would be eliminated, leaving only systematic risk. The relationship can be specified as follows;

$$E[R_i] = f(Risk_i)$$

where E is the usual expectation operator. Re-stated in words; the expected return on an equity is a function only of the riskiness of the income stream of that equity.

This approach is made more specific by introducing the assumptions of the Capital Asset Pricing Model (CAPM). Under the usual conditions the following empirical relationship can be expected to hold;

$$E[R_i] = R_f + \beta_{i,M}[R_M - R_f]$$

where:
$E[R_i]$ is the expected return on equity *i*
R_f is the return on the risk-free asset
$\beta_{i,M}$ is the correlation coefficient of the returns of equity *i* and the return of the market
R_M is the return on the market.

The Multi-factor Model
There are various problems in the application of the CAPM model. While there have been different attempts to overcome these difficulties, the most influential of these is the approach of Fama and French (1992, 1996). Fama and French extend the model by introducing additional characteristics that represent differing forms of risk. The form of the model used can be expressed as follows;

$$E[R_i] = f(Risk_i)$$

$$(Risk_i) = g(MRP, SMB, HML)$$

where:
MRP is the market risk premium
SMB is the excess return of small capitalization equities over large capitalization equities
HML is the excess return of high book/price equities over low book/price equities.

The equations are estimated by assuming that the system takes the following structural form;

$$R_i = R_f + \beta_{i,M}[R_M - R_f] + \beta_{i,S}SMB + \beta_{i,V}HML$$

where:
the beta's are the sensitivities of the equity to each of the factors.

This formulation of the model has been successfully applied to many different economies, and over many differing periods of time. There is however little theoretical basis for the importance of these particular variables.

A general hedonic model of equity returns
In the most general terms a hedonic model of equity returns can be specified as;

$$E[R_i] = f(Risk_i, C_{1\ldots m})$$

$$(Risk_i) = g(C_{(m+1)\ldots n})$$

where:
C_j represents the *j*'th characteristic of the equity.

The discovery of the characteristics other than risk is really a matter of empirical investigation. This formulation is general enough to provide a model of the return to equity, but imparts no knowledge of which explanatory variables to use. Any of the generally accepted models of equity valuation are seen to be restricted forms of this model.

While the application of an hedonic model to explain equity returns is an important topic, and further investigation into its use is a valid research project, the purpose of this paper is limited to investigating the characteristics that pertain to intangible assets and to discovering their 'shadow prices'.

Quantifying firm characteristics that pertain to intangible assets

Intangible assets are treated differently to tangible assets in the financial reports of a firm's performance. If it were not for this difference, there would be less interest in studying intangible assets. Investors would simply treat intangible and tangible assets as similar when deciding on the future performance (and hence value) of the firm. Managers of firms, who are able to evaluate alternative investments in greater detail, do not usually base investment strategies on a preference (or otherwise) for intangible assets over tangible assets. It is true that the cost of financing an intangible asset may be greater than that of a tangible asset, but this difference is subsumed in the rate at which the future cash flows are discounted. This point has be eloquently made by Webster (1999);

> *"Once it is accepted that investment comprises any present outlay which promises to reap a future reward - the field naturally opens to include all varieties of intangible capital such as the acquisition of knowledge, and the ability to control the firm's internal and external environment by changing the organization, industrial relations systems, labour skills and by enhancing market access and protective rent-producing barriers. Intangible investment activities should not be limited to research and development and commercially successful innovations."[p.20]*

Once the investment decision has been taken, the effect on the financial reports will depend very much on the intangibility of the assets that are to be acquired. Given this asymmetry, the effect of (unreported) intangible assets can be expected to appear as improvements in the operational efficiency of the firm over time. Typically, a single investment in a large intangible asset would initially increase operating expenses (and reduce profitability), and later appear as an increase in profitability (with no matching expenditure). One method that investors adopt in dealing with this problem is to 'rework' the financial accounts of the firm, writing up the expenditure on intangible assets, and then depreciating them over the appropriate period of time. While the methodology is sound, the information needed to reconstruct the financial reports is very onerous and often not available.

An alternative method of dealing with intangible assets is to examine the effect of such intangible assets on the reported results of the firm. Firms that employ larger quantities of intangible assets will have different reported characteristics to firms that do not.

Consider a firm that is about to make a new investment. Since the management of the firm is assumed to act rationally, the investment will add to the value of the firm; i.e. the new investment will yield a non-negative discounted net cash flow. If the discounted cash flow is positive then the firm will be more productive than previously; i.e. the firm will produce a greater income stream per unit of capital employed. The value of the firm's equity will rise as a consequence (it is now more desirable than before the investment).

If there are objective measures of this increase in the firm's efficiency and if these measures can be readily discerned, then there is every reason to suppose that the market for equities would `price' these characteristics of individual firms. An hedonic model would then be the appropriate method to retrieve such `shadow prices', and these prices could be used in the valuation of any proposed asset (tangible or

intangible). Occam's razor would suggest that other methods of valuation are more appropriate for most tangible assets, but that this might be the most efficient approach for intangible assets.

Observations of the performance of a firm derive mainly from the financial reports of the firm. Other sources of information (news releases, interviews with directors, etc.) are important adjuncts, but are not usually sufficient to form an accurate assessment. The aggregated balance sheet and income statements of most publicly traded firms are available. These financial statements of firms have been one of the traditional sources of information for valuing the equity of firms. The use of the ratio of two items from these financial statements has been particular popular.

One ratio that is often considered to be of importance is that of the return earned (or net income) to the average value of shareholders' equity - termed `Return on Equity' (ROE). ROE is a measure of the efficiency with which the firm generates profits from the capital provided by the shareholders. The ROE can be used to compare firms in similar industries. Higher ROE generally equates to higher efficiency, and hence higher growth and profitability.

There are a number of important caveats in using ROE to compare firm productivity;

- If the firms are in different industries ROE may not be a good measure to compare the performance of two firms; some industries have high ROE because they require little or few assets (for example consulting firms) while other industries require large infrastructures (for example firms that generate electrical energy).
- If there are no, or few, barriers to entry firms with high ROE may find that the advantage of higher efficiency will be competed away within a relatively short period of time.
- Firms with high ROE do not necessarily earn higher returns for investors, only if earnings are retained by the firm and are subject to a return greater than the cost of capital to the firm, will the value of the firm increase.

ROE can be analysed by breaking it down into smaller, constituent parts. This methodology has became to be known as DuPont ratio analysis. DuPont ratios were originally used by the DuPont Corporation in 1918 to help analyze the profitability of General Motors (DuPont had by this date acquired 23\% of the equity of General Motors). The usual statement of the DuPont system is as follows:

$$ROE = \frac{Net\ Income}{Equity} = \frac{Net\ Income}{Net\ Sales} \times \frac{Net\ Sales}{Total\ Assets} \times \frac{Total\ Assets}{Equity}$$

where *ROE* = return on equity

The product of the three individual ratios given above is equal to the definition of `return on equity' (i.e. net income/equity), since the common terms `cancel out'. The three ratios however each have a useful and independent interpretation;

- (Net Income / Net Sales) is referred to as the `net profit margin' and is a measure of the ability of the firm to either command relatively high prices for it's products (for example: brand names) or the ability to keep operating costs low (for example: operating efficiencies)
- (Net Sales / Total Assets) is referred to as `asset turnover' and is a measure of the productivity of the assets employed. Total Assets includes both Fixed Assets and Current Assets. Each of these categories of assets may be directly influenced by the existence of intangible assets.
- (Total Assets / Equity) is referred to as `financial leverage' and is a measure of the amount of debt employed by the firm. Return on equity can be increased by increasing borrowing, however this will increase the risk to the holders of equity. This ratio is not expected t be greatly influenced by the mixture of tangible and intangible assets that the firm employs.

The individual ratio used in DuPont Analysis may in turn be decomposed into further components. One such decomposition that has been widely used in the managerial accounting literature is described by Reilly (2000);

> *"Beyond the original DuPont System, some analysts have suggested using an extended DuPont System, which provides additional insights into the effect of financial leverage on the firm and also pinpoints the effect of income taxes on the firm's ROE. Because both financial leverage and tax rates have changed dramatically over the past decade, these additional insights are important." [p.401]*

Many other variations of this system are possible. The simplier form of the DuPont ratios are used in this paper. Further investigation does appear to be warranted.

There has been surprisingly little application of the DuPont ratios to study the effects of intangible assets on corporate performance. Dehning (2002) has studied the question of whether, given that a firm has acquired a competitive advantage from an investment in Information Technology, that advantage can be further decomposed into efficiency gains and profitability gains. A matched-pair research design (comparing companies with a successful IT investment to a direct competitor that enjoyed other comparative advantages) was employed. Using a restricted form of DuPont Analysis (only the Return on Assets is considered), the authors were able to show that;

> *"the IT-enabled competitive advantage shows up in superior returns on assets (ROA), due to a combination of profitability and efficiency, while a competitive advantage not due to IT shows up in superior ROA due only to increased profitability." [p.166]*

The structural model

In order to specify the functional form of a model that may be subjected to empirical test, it is necessary to relate the theoretical model to the data that is available.

Fortunately there is an abundant set of data that relates to DuPont ratios and equity returns. This data is available in the form of both cross-section data (observations of firms at a fixed point in time) and time-series data (observations of the same firm over time). Data sets with both cross-section and time-series components are referred to as TSCS (time-series cross-sectional) data, or more commonly as `panel data'.

Following Matyas (1996), the most general form of the hedonic model of the return on equity, as given by the set of equations above, translates into the following form if panel data is available to estimate the parameters;

$$R_{it} = \beta_{1it} C_{1it} + \cdots + \beta_{Kit} C_{Kit} + u_{it}$$

where:
i is the index for equities, and *t* is the index for time periods
R_{it} is the return on equity *i* in period *t*
β_{1it} is the (unknown) responsiveness of the return on equity *i* to the *k*'th characteristic at time *i*
C_{1it} is the (known) value of the *k*'th characteristic of the *i*'th equity at time *t*
u_{it} are the errors terms, not explained by the model.

While this equation correctly specifies that hypothesised relationships the parameters can not be estimated since the number of parameters exceeds the number of observations. The solution is to impose some structure on the model. Restrictive assumptions can be made about any of the following;

- the selection and properties of the explanatory variables, C_{1it}
- the properties of the residual terms
- the statistical relationship between the residual terms and the explanatory variables.

These assumptions should be formulated so as to conform to the theoretical model that is to be investigated (Matyas, 1996, p.28). In the case at hand the following restrictions are reasonably placed on the model;

1. The explanatory variables are comprised of the characteristics that investors seek in forming a portfolio of equities, and in addition that the usual assumptions of the hedonic model apply. Thus investors care about the mixture of characteristics of the overall portfolio, but not which particular equities these characteristics reside in. This implies that;

   $$\beta_{kit} = \beta_{kt} \forall i$$

   If may be further assumed that investors preference change only slowly (or not at all) over the period examined, then the time period will have no influence either; in which case;

   $$\beta_{kt} = \beta_{k} \forall t$$

2. The full list of characteristics is however not known.

3. The residuals are assumed to be distributed independently of the explanatory variables, to be serially independent, and normally distributed;

   $$u_{it} \sim iid(0, \sigma^2)$$

   This restriction can be modified in many circumstances, but in an initial investigation this rather strong assumption of the structure of the error terms may be justified.

If these assumptions did not include the restriction that the characteristics were not known, then estimation of the model would be straight forward. All the observations could be pooled, and the parameters estimated by ordinary least squares methods. However there is no theoretical reason to specify the characteristics *a priori*, and if the full set of characteristics is not found then the estimates of the parameters will be subject to the well known `omitted variable bias'. Nor would it be possible to correct for this bias without investigating all the possible characteristics that determine the return on equities.

Fortunately it is possible to circumvent the problem of omitted variables in this particular case. Since financial markets have proven to be mostly efficient, it is reasonable to assume that equity prices are unbiased most of the time. Under these conditions, following Fama (1973), it is reasonable to construct a set of portfolios that differ only in respect to one characteristic and to compare the returns of each portfolio. If the portfolio is sufficiently large and fully diversified there should be no difference between the returns of these portfolios UNLESS the characteristics that distinguishes them is, in fact, a valid determinant of equity value.

We have identified three possible characteristics that are related to the presence of intangible assets. In order to test if the equity market places any value on this characteristics, given the assumptions that were made above, the following hypotheses are tested;

1. H_0^1: The characteristic of the firm measured by the ratio of Net Income to Net Sales (i.e. the net profit margin) is not a determinant of the return of the firm's equity.
2. H_0^2: The characteristic of the firm measured by the ratio of Net Sales to Total Assets (i.e. the asset turnover) is not a determinant of the return of the firm's equity.
3. H_0^3: The characteristic of the firm measured by the ratio of Total Assets to Equity (i.e. the financial leverage of the firm) is not a determinant of the return of the firm's equity.

Data

Access to commercial financial databases was not available. All data was gathered from publically available sources. Damodaran (2006) has collected and made available data that is collated from the financial reports of firms. The original sources for the data are:

- Value Line Database
- Morningstar
- Compustat

Damodaran splices the data from the various vendors and calculates the usual financial ratios. The data is published as an Excel spreadsheet. Annual data for approximately 7100 entities (not all of them are firms) were collected for the year ending in 2005 Similar spreadsheets for the previous five years were also available.

A number of problems were encountered when the raw data was examined. It is unlikely that any of these problems (singularly or collectively) will have a significant effect on the estimation of the model.

For each year the net profit margin for each firm is calculated from the information in the data. The average net profit margin for all firms in each SIC code is then calculated. The difference in the net profit margin between each firm and the appropriate SIC mean is calculated.

Yahoo provides a listing of prices for the equity of American firms that are quoted on the major markets. In all cases the daily 'adjusted close' price was collected for each firm in the data set. The data that is collected is the price of the equity on a particular day. Since the return over a discrete period is given by;

$$y_t = \frac{P_{t+1} - P_t}{P_t} = \frac{P_{t+1}}{P_t} - 1$$

where *y* is the periodic compounding rate, *P* is the price and *t* refers to the time period. As prices are available on a daily basis y_t can be approximated by;

$$y_t = ln(P_{t+1}) - ln(P_t)$$

where ln denotes log to the base *e*.

The database of firms that is obtained from Damodaran includes firms which, although public companies, are not listed on an exchange but are traded 'over the counter'. Unfortunately it is not possible to collect prices for these firms from Yahoo. Yet other firms be listed only on minor or regional exchanges only; such firms data could be distorted by illiquidity. Only firms which are listed on;

- NASDAQ
- NSE
- ASE

are retained in the data set. The effect is to remove only a small number of firms.

Empirical results

Each characteristic is considered separately.
Firms are placed in one of five equally sized portfolios, in accordance with the measurement of the characteristic of interest. The monthly returns on each portfolio are calculated, and the portfolios are rebalanced at yearly intervals (since only annual accounting data is available). Differences between

the return on each of these five portfolios is then analysed. Since each portfolio consists of approximately 1600 firms (the number is approximate because for some firms only one or two of the characteristics are available), these portfolios can be expected to be very well diversified indeed. This process is repeated three times, once for each characteristic.

1. Characteristic: Income/Sales

Figure 1 depicts the return of each of the five portfolios over the 5 year period. It is clear that the differences in return are not due to the beta's – since the higher yielding portfolios have lower beta's. There is no reason why the mean returns of these portfolios should be different, other than the fact that the characteristic is valued by investors.

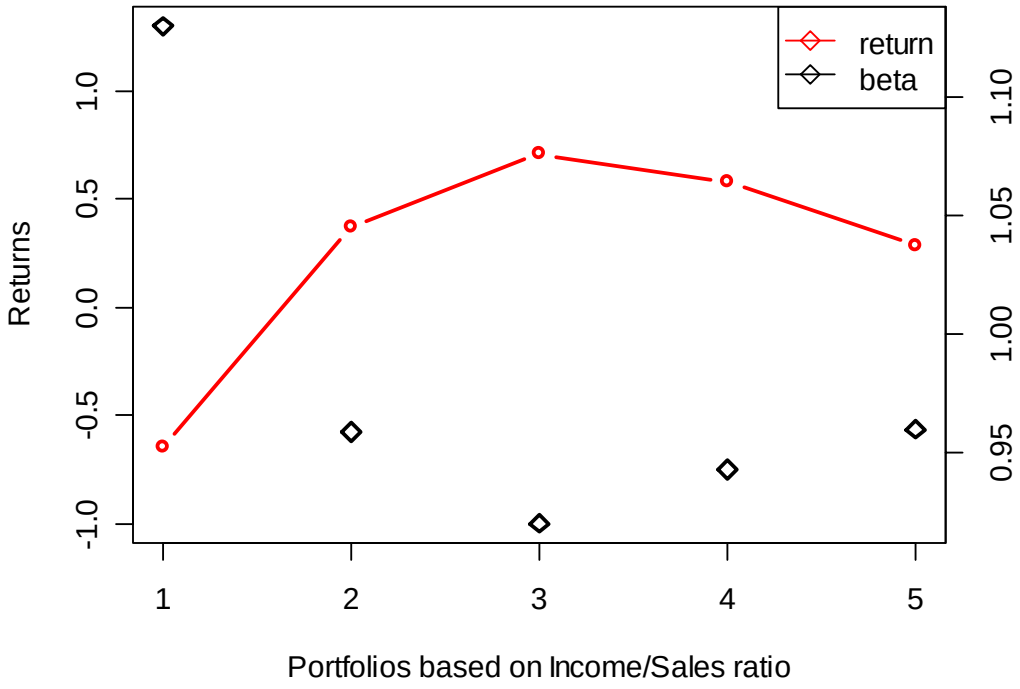


Figure 1: Returns and beta's of portfolios based on Income/Sales ratios

portfolio 1 = very_low
portfolio 2 = low
portfolio 3 = mean
portfolio 4 = high
Portfolio 5 = very_high

The differences in the returns are significantly different in some cases. The Tukey multiple comparison of means is used to test this proposition. These results are presented in Appendix 1. Six of the ten pairs of portfolios show significantly different means at the 95% confidence level. On these results the null hypothesis H_0^1 (that the characteristic of the firm measured by the ratio of Net Income to Net Sales (i.e. the net profit margin) is not a determinant of the return of the firm's equity) can be rejected.

2. Characteristic: Sales/Assets

Figure 2 depicts the return of each of the five portfolios over the 5 year period. It is clear that the differences in return are not due to the beta's – since the higher yielding portfolios have lower beta's. There is no reason why the mean returns of these portfolios should be different, other than the fact that the characteristic is valued by investors.

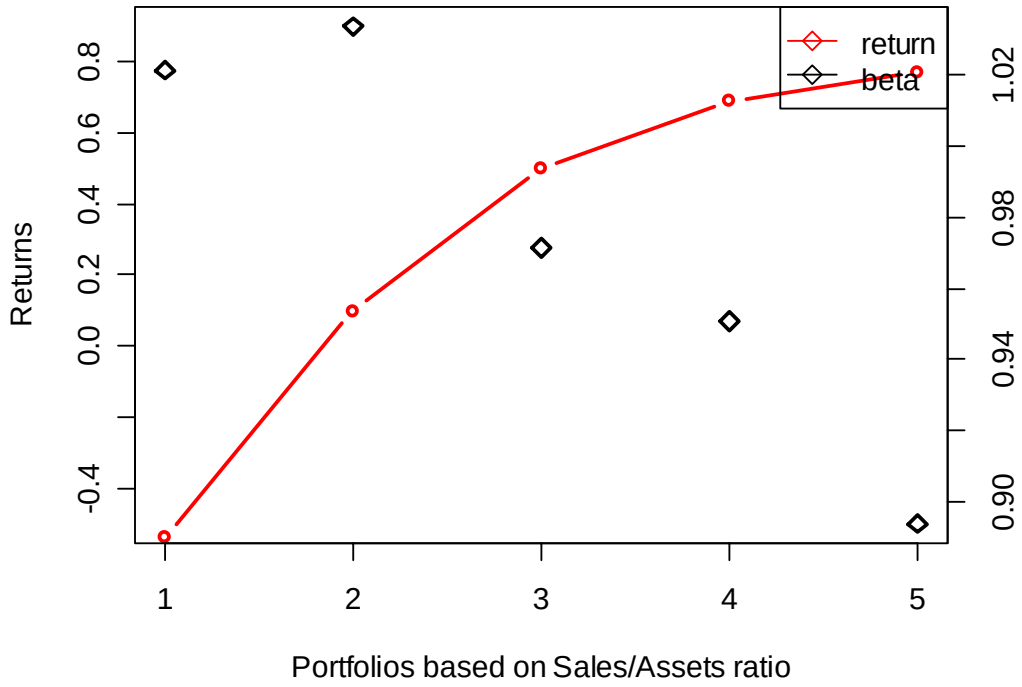


Figure 2: Returns and beta's of portfolios based on Sales/Asset ratios

portfolio 1 = very_low
portfolio 2 = low
portfolio 3 = mean
portfolio 4 = high
Portfolio 5 = very_high

The differences in the returns are significantly different in even more cases than the previous case. The Tukey multiple comparison of means are presented in Appendix 2. Seven of the ten pairs of portfolios show significantly different means at the 95% confidence level. The null hypothesis H_0^2 (the characteristic of the firm measured by the ratio of Net Sales to Total Assets, i.e. the asset turnover, is not a determinant of the return of the firm's equity) can be rejected.

3. Characteristic: Assets/Equity

Figure 3 depicts the return of each of the five portfolios over the 5 year period. There are again significant differences between the returns that are unrelated to the portfolio beta's. The Tukey multiple comparisons of means are presented in Appendix 3. The third null hypothesis is also rejected.

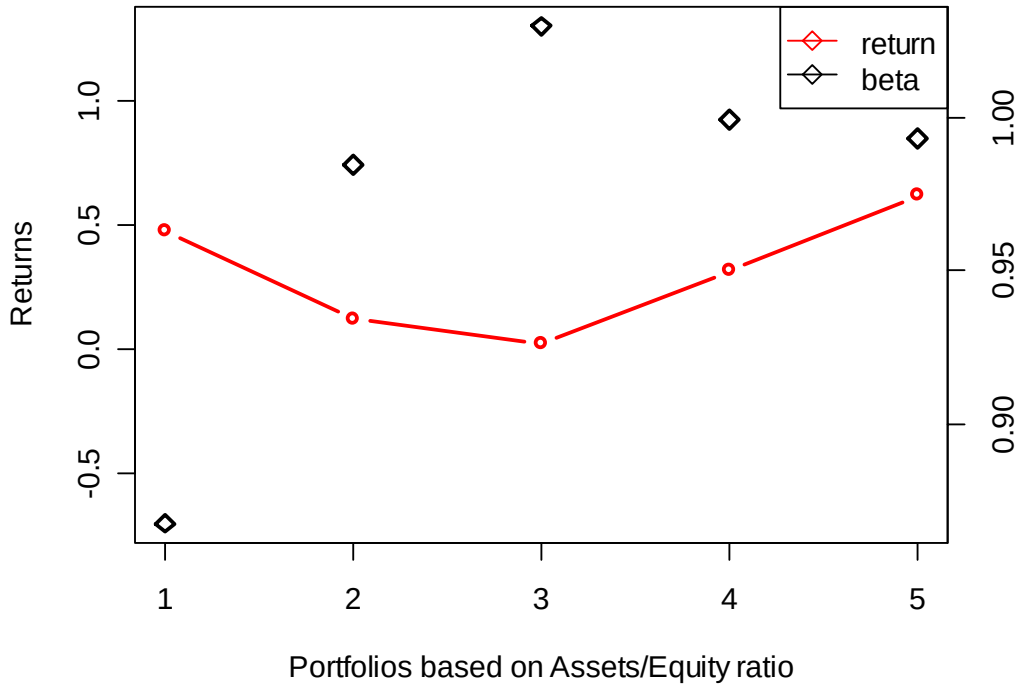


Figure 3: Returns and beta's of portfolios based on Asset/Equity ratios

portfolio 1 = very_low
portfolio 2 = low
portfolio 3 = mean
portfolio 4 = high
Portfolio 5 = very_high

Conclusion

This study investigates an alternative approach to the valuation of intangible assets. Where detailed knowledge of the cash flows that arise from the asset can not be easily quantified, either because of the nature of the assets or because of the remoteness of the observer from the internal records of the firm, the hedonic pricing model provides encouraging results.

At the very least these methods should be considered as one method by which the value of intangible assets can be estimated. As always, additional estimation techniques will add to the robustness of any result.

References:

Baltagi, B. (2001), Econometric Analysis of Panel Data, John Wiley:New York.

Corrado, C., Haltiwanger, J. and Sichel, D. (2005), Measuring capital in the new economy, Vol. 65 of Studies in income and wealth, The University of Chicargo Press.

Damodaran, A. (2006), Dealing with intangibles: Valuing brand names, flexibility and patents. Stern School of Business.

Dehning, B. and Stratopoulos, T. (2002), 'DuPont analysis of an IT-enabled competitive advantage', International Journal of Accounting Information Systems 3, 165–176.

Edvinsson, L. (2002), Corporate Longitude : what you need to know to navigate the knowledge economy, Financial Times Prentice Hall.

Fama, E. F. and French, K. R. (1992), 'The cross-section of expected stock returns', Journal of Finance 47(2), 427–65.

Fama, E. F. and French, K. R. (1996), 'Multifactor explanations of asset pricing anomalies', Journal of Finance 51, 55–84.

Fama, E. and MacBeth, J. (1973), 'Risk, return, and equilibrium: Empirical tests', Journal of Political Economy 81(3), 607–636.

Faria, J., Grosjean, P. and Jelihovschi, E. (2006), 'Tinn-R - GUI/editor for R language and environment statistical computing'.
URL: http://sourceforge.net/projects/tinn-r

Griliches, Z. (1994), 'Productivity, R&D, and the data constraint', The American Economic Review 1, 1–23.

Lamont, O. A. and Thaler, R. H. (2003), 'Anomalies: The law of one price in financial markets', Journal of Economic Perspectives 17(4), 191–202.

Lev, B. (2001), Intangibles: Management, Measurement, and Reporting, The Brookings Institution Washington, D.C.

Markowitz, H. (1952), 'Portfolio selection', The Journal of Finance 7(1), 77–91.
Matyas, L. and Sevestre, P., eds (1996), The Econometrics of Panel Data, Kluwer Academic Pub.:Dordrecht.

Moulton, B. R. (2004), 'The system of national accounts for the new economy: What should change?', Review of Income and Wealth 50(2), 261–78.

Nakamura, L. (1999), 'Intangibles: What put the new in the new economy?', Business Review (Federal Reserve Bank of Philadelphia) Jul/Aug, 3–16.

Nakamura, L. I. (2001), What is the US gross investment in intangibles? (At least) one trillion dollars a year!, Technical report, Federal Reserve Bank of Philadelphia Working Paper No. 01-15.

Petty, R. and Guthrie, J. (2000), 'Intellectual capital literature review: Measurement, reporting and management', Journal of Intellectual Capital 1(2), 155 – 176.

Reilly, F. K. and Brown, K. C. (2000), Investent Analysis and Portfolio Management, The Dryden Press.

The Standish Group International (1996), Unfinished voyages: A follow-up to the CHAOS report, Technical report, The Standish Group International, Inc.

The World Bank (2006), Where is the wealth of nations? Measuring Capital for the 21st Century, The World Bank, Washington, D.C.

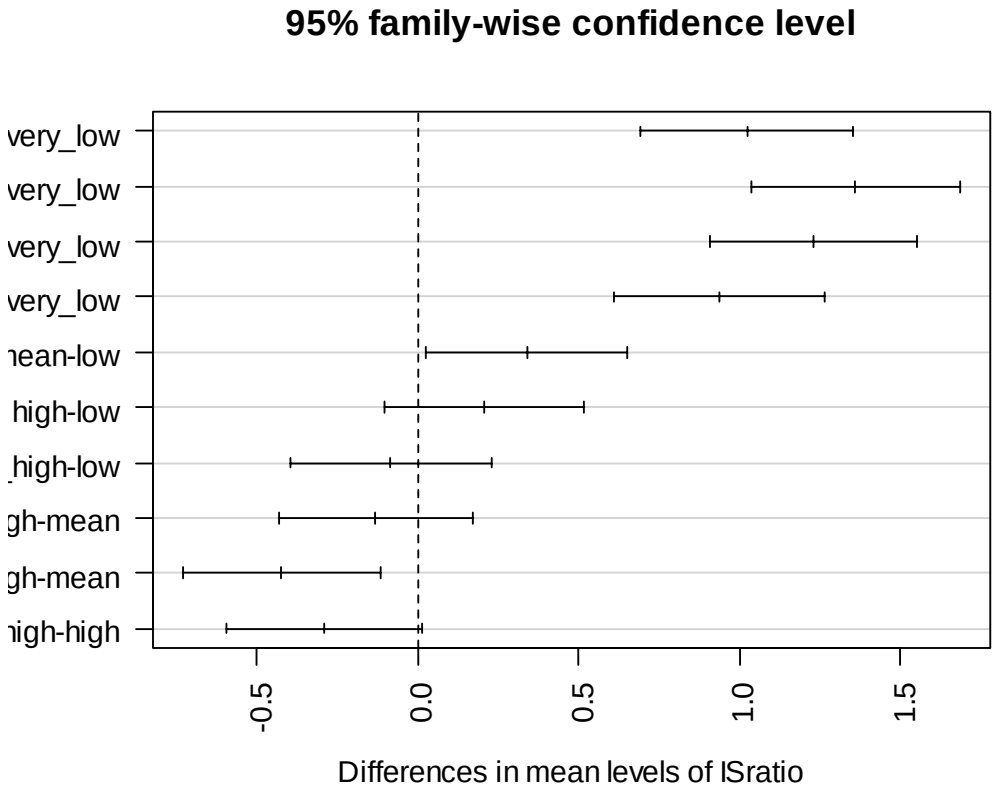
Webster, E. (1999), The economics of intangible investment, New Directions in Modern Economics, Edward Elgar, Cheltenham, UK.

Appendix 1. Income/Sales Portfolios

Results of Tukey multiple comparisons of means

Note:

portfolio 1 = very_low
portfolio 2 = low
portfolio 3 = mean
portfolio 4 = high
Portfolio 5 = very_high



Tukey multiple comparisons of means
95% family-wise confidence level
Fit: aov(formula = Return ~ ISratio, data = C)
$ISratio

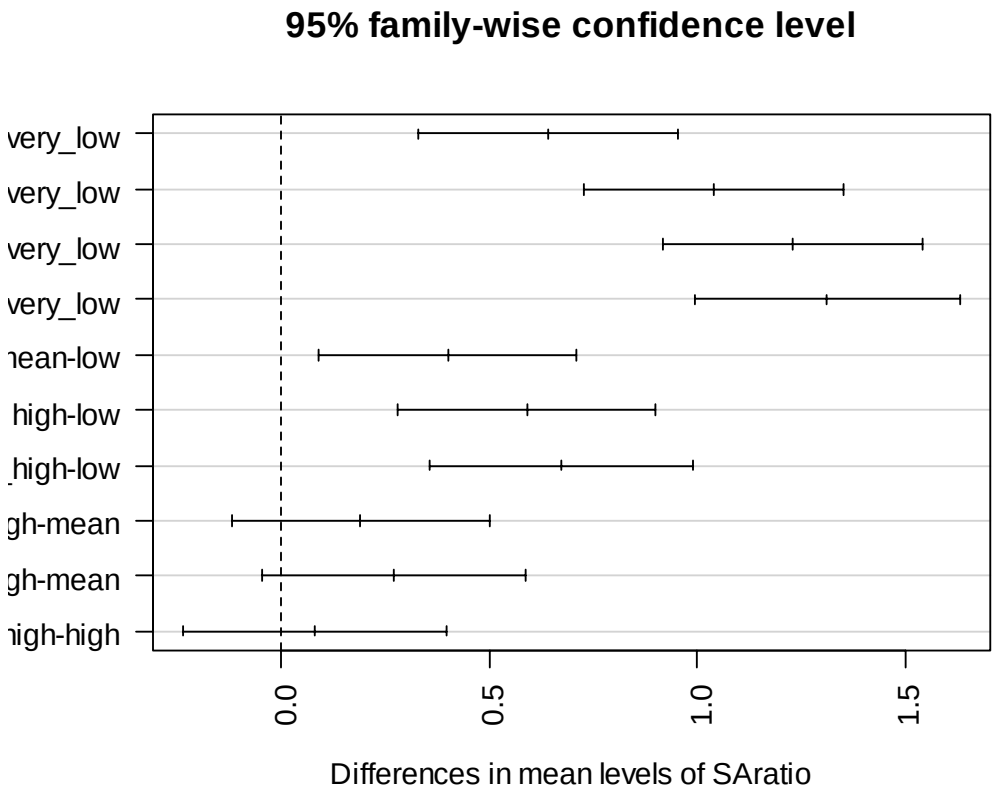
	diff	lwr	upr	p adj
low-very_low	1.02187246	0.69007459	1.35367033	0.0000000
mean-very_low	1.35936991	1.03640803	1.68233179	0.0000000
high-very_low	1.22714270	0.90476131	1.54952409	0.0000000
very_high-very_low	0.93595485	0.61017090	1.26173879	0.0000000
mean-low	0.33749745	0.02659891	0.64839599	0.0255039
high-low	0.20527024	-0.10502525	0.51556573	0.3708480
very_high-low	-0.08591761	-0.39974672	0.22791150	0.9453917
high-mean	-0.13222721	-0.43305580	0.16860138	0.7520178
very_high-mean	-0.42341506	-0.72788716	-0.11894296	0.0013989
very_high-high	-0.29118785	-0.59504414	0.01266843	0.0678013

Appendix 2. Sales/Asset Portfolios

Results of Tukey multiple comparisons of means

Note:

portfolio 1 = very_low
portfolio 2 = low
portfolio 3 = mean
portfolio 4 = high
Portfolio 5 = very_high



Tukey multiple comparisons of means
95% family-wise confidence level
Fit: aov(formula = Return ~ SAratio, data = C)
$SAratio

	diff	lwr	upr	p adj
low-very_low	0.63952467	0.32737537	0.9516740	0.0000002
mean-very_low	1.04082496	0.72829586	1.3533541	0.0000000
high-very_low	1.23038794	0.91808644	1.5426894	0.0000000
very_high-very_low	1.31205257	0.99349624	1.6306089	0.0000000
mean-low	0.40130029	0.09127432	0.7113263	0.0037948
high-low	0.59086327	0.28106673	0.9006598	0.0000020
very_high-low	0.67252790	0.35642697	0.9886288	0.0000001
high-mean	0.18956297	-0.12061625	0.4997422	0.4545072
very_high-mean	0.27122761	-0.04524839	0.5877036	0.1330151

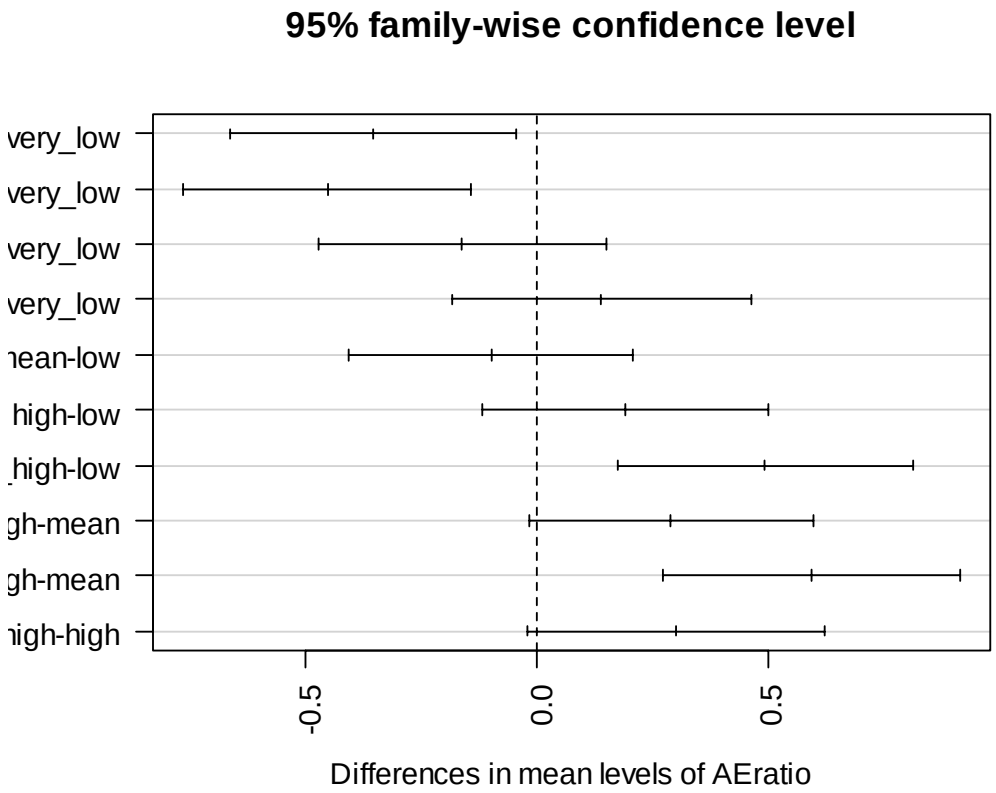
very_high-high	0.08166463	-0.23458660	0.3979159	0.9555677

Appendix 3. Asset/Equity Portfolios

Results of Tukey multiple comparisons of means

Note:

portfolio 1 = very_low
portfolio 2 = low
portfolio 3 = mean
portfolio 4 = high
Portfolio 5 = very_high



Tukey multiple comparisons of means
95% family-wise confidence level
Fit: aov(formula = Return ~ SAratio, data = C)
$SAratio

	diff	lwr	upr	p adj
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very_high-high	0.08166463	-0.23458660	0.3979159	0.9555677