The Value Relevance of Enterprise Resource Planning Information

THE VALUE RELEVANCE OF ENTERPRISE RESOURCE PLANNING INFORMATION (ERP)

ABSTRACT: This paper examines whether ERP systems contribute to enterprise value. An ERP Value Relevance Model is developed and tested with data from 60 matched pairs of ERP–adopter/ non–adopter firms.

Two classes of tests are designed: performance relevance and value relevance. Tests of performance relevance show ERP–adopter firms do not achieve significant positive abnormal earnings until year four of the five–year test period. Tests of value relevance show the market responds significantly to ERP adoption in year two only. This early response in the year following the year of adoption suggests a significant early market expectation of these systems. However, this expectation does not appear to translate into a sustained contribution to firm value.

The paper contributes to the question of enterprise value of ERP adoption. The method presented can be adapted to test the value relevance of other innovations in management and technology.

Keywords: Enterprise Resource Planning, Value Relevance, Value Measurement, Value of management and technology innovations

Data Availability: All data are available upon written request and justification.

I. INTRODUCTION

Information technologies are so tightly entwined with the business that "… the influence of IT on decision making is, in many ways, synonymous with the impact of IT on the success or failure of the organization as a whole" (Todd and Benbasat 2000). It is surprising therefore that the value delivered by these investments is considered uncertain (ITGI 2005; Wiseman 1992). The absence of a methodology for measuring the enterprise value of an IT innovation may well be a contributory cause for this uncertainty.

The value of an enterprise resource planning (ERP) system implementation to the firm would appear to derive from a sequential flow of benefits, each flow segment a precursor or prerequisite to the one that follows. They are:

a. integration of fragmented enterprise operations (Ross and Vitale 2000; Jenson and Johnson 1999; Davenport 2000a; Austin et al 1999, 2003);
b. vastly improved synergies of operation (Kelle and Akbulut 2005; Ross and Vitale 2000; Defee and Stank 2005; Austin et al 1999, 2003);
c. greater relevance and reliability of information for knowledge discovery and decision support (Davenport et al. 2001; Holsapple and Sena 2003, 2005; Davenport, Harris, and Cantrell 2004; Bendoly 2003; Li and Zhao 2006);
d. better value–focussed competitive strategies (Lengnick-Hall et al 2004; Davenport 2000a; Lengnick-Hall and Lengnick-Hall 2006; Light 1999); and
e. better design and implementation of strategy execution and content controls (CorVu 2005; Defee and Stank 2005; Lawrie and Cobbold 2004; Muralidharan 2004; Lin, Ping-Yu, and Ping-Ho 2006).

In sum, ERP promises an enterprise–wide rationalization and integration of operations leading to a far–ranging decision support capability able to deliver a more competitive market

posture for the firm. This in turn could be expected to engender significant improvement in earnings and capital market returns.

This paper investigates whether adoption of ERP systems have translated into "shareholder value". The importance of this question lies in the proposition that, if the billions invested in ERP implementations are to be justified from a shareholder perspective, then such justifications must be based on not just the ERP-industry–touted benefits to firm performance alone (Matolcsy, Booth, and Wieder 2005), but also on demonstrable market perceptions that the promised benefits would persist through time.

II. THEORY AND HYPOTHESES

Extensive research shows capital markets respond to earnings (Easton and Harris 1991; Ball and Brown 1968; Lipe 1986; Cheng and Cheung 1993; Lev and Ohlson 1982; Easton, Harris, and Ohlson 1992). Yet there is evidence that earnings signals may contain noise (Collins et al. 1994; Lieber, Melnick, and Ronen 1984). Because of this noise, capital markets assess whether earnings improvements are permanent or transitory (Cheng et al 1996; Kormendi and Lipe 1987). The consistency of earnings/returns correlations points to reported earnings containing information as to the "future benefit"[1] accruing to equity holdings (Ohlson 1979; Garman and Ohlson 1980; Easton 1985; Ohlson 1983; Beaver 1998). While this "benefit" is the stream of expected future equity dividends (Easton 1985), the "clean surplus" relation in financial reporting permits earnings to proxy dividend distributions (Ohlson 1995). Miller and Rock (1985) show that share returns must remain a function of "persistence" i.e. the present value of revisions to future earnings. If ERP implementations result in improved earnings through a quantum and an expected permanency to that quantum, this must reflect in market returns.

Capital markets also respond to signals about the strategic value of an investment (Fama 1970; Ball and Brown 1968; Fama 1991). Furthermore, since markets price earnings quality

(Aboody, Hughes, and Liu 2005; Chan et al. 2006), they may reward the firm for any improvements in earnings quality resulting from an ERP implementation. Improvements in market returns may thus be associated with ERP adoption regardless of the particular timing of the bottom line benefit.

It is therefore posited that any conclusive measure of ERP value must consider long–term capital market effects. Previous research has largely not addressed this (Benco 2004; Hitt et al 2002; Hunton et al 2003; Nicolaou 2004; Poston and Grabski 2000, 2001). The few that address market effects have limited themselves to event/behavioral studies surrounding announcement dates of ERP investment plans (Benco 2004; Hayes et al 2001; Hunton et al 2002).

Kormendi and Lipe (1987) find that the earnings response coefficient (or ERC)[2] that measures the magnitude of a firm's return response to "earnings innovation"[3] is positively correlated with the present value of revisions to expected future earnings (or earnings persistence) from the innovation. Since the revisions themselves are a function of the time series properties of the firm's earnings, the time series persistence of earnings, in effect, informs the ERC.

The "shareholder value" construct underlying this research is defined as the persistence of earnings associated with a current earnings innovation and evidenced by the share price return response to the innovation as measured by the earnings response coefficient[4]. The research question is refined to *whether ERP implementations are perceived in the share market to be significantly associated with earnings innovations with persistence effects*[5] *as measured by the ERC of the ERP–earnings change interaction*.

ERP as Earnings Innovation Agent I: A Shareholder Value Paradigm

The size of a market return is a function of four drivers of shareholder value (Kormendi and Lipe 1987; Ohlson 1995)

i. a decrease to the cost of operations; and/or

ii. an increase to the revenue from operations that

iii. persist/s over time, at

iv. a constant or reducing[6] cost of capital.

From a perspective of strategy execution, the above shareholder value drivers are caused by four structural/ executional cofactors (drivers): (1) capital deepening and process innovation[7] (2) product/process innovation (3) structural improvements to organizational processes—including information processing and decision rights distribution, and (4) improvements in capital utilization[8] (Anderson et al 1994; Kaplan and Norton 1996; Dedrick et al 2003; Defee and Stank 2005; Reichheld and Sasser Jr 1990; Ittner and Larcker 2001; Shank and Govindarajan 1992; Srivastava et al 1998) (Anderson, Fornell, and Lehmann 1994).

ERP as Earnings Innovation Agent II: Transaction Cost Economics

The Transaction Cost Economics Theory (Coase 1988, 1992, 1937; Williamson 1975, 1979, 1981a, 1981b) asserts that to achieve firm growth the firm need to address three limitations to generating cost–effective growth:

1. the rising cost of organizing transactions within the firm;
2. the increasing failure to place factors of production in their best uses; and
3. the rising supply price of factors of production (Coase 1937).

ERP's potential as a catalyst for earnings innovation rest with its ability to reduce these limitations on a continuing basis.

Coase's 1st Limitation – the Rising Cost of Organizing Transactions

A "transaction" means the transfer of a good or service "… across a technologically separable interface (where) *one stage of processing or assembly activity* terminates and

another begins (*italics added*)" (Williamson 1981b). The costs of organizing an extra transaction stems from "planning, adapting and monitoring task completion" (Williamson 1981a). Transaction cost reduction is achieved ".. by assigning transactions to governance structures in a discriminating way" (Williamson 1981a). While Williamson's main focus is on institutional economics, governance structure must also subsume organizational processes (Ratnatunga and Alam, 2007), which turn on physical asset and human asset specificity (Williamson 1981a)[9]. Any technology–driven solution, targeting transaction cost reduction must address the design of organisational processes for configuring tasks and *ipso facto* the consumption of both human and material resources required for those tasks (Williamson 1981a).

Transaction cost reduction involves the integration of work and data flows through efficient and effective business process re–design. The key significance of ERP appears to be its ability to deliver this integration leading to operational synergies. This should yield long–term improvements in productivity and cost savings associated with limitations 1 and 3. Accordingly—

H1: ERP–adopter firms exhibit a lower ratio of selling, general, and administration (SG&A) to Sales Revenue relative to non–adopter firms

Coase's 2nd Limitation – the Increasing Failure to Place Factors in their Best Uses

The failure to place the factors of production where their value is greatest is caused by limitations in human information processing capacity in the face of increasing scale and scope of operations. This renders it difficult to accomplish optimal resource allocation and coordination (Williamson 1979).

Addressing the problem requires quality information that is decision relevant and effective (Ptak and Schragenheim 2004; Kelle and Akbulut 2005; Kilpatrick 1999; Holsapple and Sena 2003; DeLone and McLean 1992).

ERP improves information quality by securing infrastructure integration (Jenson and Johnson 1999; Davenport 2000b; Light 1999; Lee et al. 2002; Redman 1998; Wang and Strong 1996; Xu et al. 2002; Davenport 2000a). It promotes data visibility and consistency across the supply chain promoting effectiveness in resource allocation and coordination (*vide* segments (b) and (c) of the *flow of benefits*). This enables knowledge discovery and decision support (*vide* segment (c)). The evidence for all of this would be ERP's support of the second and fourth drivers of the value paradigm. Accordingly—

H2: ERP–adopter firms exhibit a higher ratio of Sales Revenue to Total Assets Employed relative to non–adopter firms

Coase's 3rd Limitation – the Rising Supply Prices of Factors of Production

Coase (1937) states that with firm growth a point must be reached where "… the supply price of one or more of the factors of production may rise…". While Coase's particular rationalization of the cause remains particular to the pre–information age, presently, it would seem reasonable that higher factor prices would likely remain an inevitable adjunct to increasing complexity. In general, the more complex the firm's operations, the less qualified the available factors and the dearer the price of the adequately qualified. The key to reducing the supply price of factors of production must ultimately remain with the ability to reduce complexities of business process and information flow resulting from task and environmental complexity.

ERP's ability to streamline the supply chain, both internally and externally (*vide* segments (a) and (b) of the *flow of benefits*), would likely alleviate complexity via the streamlining of operations. This would allow for the removal of pockets of information impactedness[10] (Williamson 1973, 1975, 1981a, 1981b) with visible and consistent data (segement (b)). The evidence for this would be ERP's support of the first, third, and fourth drivers of the value paradigm. Accordingly—

H3: ERP–adopter firms exhibit a lower ratio of Operational Expense (SG&A and Finance Charges) to Sales Revenue relative to non–adopter firms

Performance Relevance: ERP's Summary Benefit Relative to Coase's Limitations

From the foregoing theoretical development, ERP would appear to advance the point of "diminishing returns to management" through productivity gains (driver 1) and cost savings (drivers 1 and 4) and through innovative customer value propositions (driver 2) that persist over time (driver 3). The effect should be an improvement in earnings returns. Accordingly—

H4: ERP–adopter firms exhibit a higher ratio of EBIT to Sales Revenue relative to non–adopter firms

H5: ERP–adopter firms exhibit a higher ROA than non–adopter firms

Value Relevance: ERP's Summary Benefit to Shareholders

Persistence (driver 3) would additionally also suggest ERP system implementations lead to shareholder value creation. Accordingly—

H6: ERP implementations are shareholder value relevant

The value relevance hypothesis is extended under the Efficient Markets Hypothesis (Fama 1970) to embrace possible market value effects of perceived improvements to earnings quality consequent to ERP implementations as well as perceived strategic value of ERP adoption independent of any earnings effects. Hypothesis 7 therefore comprises the following sub–hypotheses:

H6A: The coefficient of the interaction between the empirical indicator for the earnings level variable and the empirical indicator for the ERP implementation variable is significantly greater than zero

H6B: The coefficient of the interaction between the empirical indicator for the earnings change variable and the empirical indicator for the ERP implementation variable is significantly greater than zero

H6C: The coefficient of the ERP–implementation empirical indicator is significantly greater than zero

Hypothesis H7A represents the value relevance of ERP–engendered earnings quality improvements. H7B addresses value relevance of ERP–engendered earnings innovation. H7C hypothesizes the strategic value of ERP independent of earnings effects.

III. RESEARCH METHOD

The method uses an event study of ERP adoption. Five years post–adoption performance data for a sample of sixty ERP–adopter firms and a matching control sample of sixty non–adopter firms were used. The method tests for differential performance effects between adopter firms and non–adopter firms for each of five years post–adoption.

Data and Sample Selection

The Factiva news data base supplied ERP adoption–related information. This was supplemented by AspectHuntley's Signal G extracts[11]. AspectHuntley's Annual Reports Online, DatAnalysis, and FinAnalysis databases supplied company financial data and other company–related data. The Securities Industry Research Centre of Asia–Pacific (SIRCA) supplemented with AspectHuntley's FinAnalysis was the source for share price data. The chief source for macroeconomic data was the Australian Bureau of Statistics. This source was supplemented in the main by the database of the Reserve Bank of Australia. Other supplementary sources include the International Monetary Fund's International Financial Statistics service, IFS Online, and the statistics portal for Australia available from the Organization for Economic Cooperation and Development. The National Australia Bank

made available their time series data on capacity utilization rates and business conditions indices.

Collection of ERP–adopter data (for sample selection) spanned the period 1995–2001. Corresponding data for the analysis (i.e. financial data, share price data, macroeconomic data) spanning the five years of post–implementation operations were culled from the periods 1995 through 2005.

Sixty non–adopter firms are matched to the adopter–firm sample. The purpose for the matching is to help bring about a measure of parity between firms across each of the factors known to affect cross–sectional financial performance. The factors in question are risk and earnings growth variability across firms (Alford 1992). Without adequate matching, this variability could be expected to yield differential earnings change residuals that would confound the actual effect on firm performance from ERP adoption.

Matching firms by industry group membership appears an adequate surrogate for risk and earnings growth components, particularly in the matching of larger firms for valuation purposes (Alford 1992; Cheng and McNamara 2000). Since the valuation multiple relates to the magnitude of the share return response, industry group membership is also deemed adequate for matching firms by share return response. As an added control for differential risk, firms are also matched by asset base. The matching criterion adopted was 85–115 percent[12] of the end–of–period total assets of the treatment firm.

Industry group membership is determined in accordance with the General Industry Classification System (GIC). The GIC is significantly better at explaining stock returns, cross–sectional variation in valuation, growth rates, and key financial ratios across groups of homogeneous firms[13] (Bhojraj, Lee, and Oler 2003). GIC leads to lower valuation errors (Weiner 2005). Accordingly, the control (ERP non–adopter) firm is matched to the sample

(ERP–adopter) firm by industry group level of the GIC code supplemented with firm operational asset base wherever feasible.

Three further checks are performed for the effects on differential earnings from (a) changes to accounting policies (b) excessive earnings management practices, and (c) divestiture/ acquisition of major assets. Financial statements are vetted for significant changes to accounting policies and for major divestitures and acquisitions.

Given the sample matches 60 firms that implemented and operated ERP systems with firms that did not in each of five years post implementation, there are a total of 600 data points (firm/years). This translates into over 120 individual firms across five years[14].

Model Development

The information technology literature adopts two key enterprise–level summary measures, Return on Equity (ROE) and Return on Assets (ROA), as empirical indicators of enterprise performance (Hitt and Brynjolfsson 1996; Dehning and Richardson 2002). Of these, ROA is the better measure to represent operational performance as it excludes financial leverage and operating profit leakages whilst impounding financial performance effects of cost/revenue management (i.e. profitability), and asset utilization (i.e. capital efficiency) (Dehning and Richardson 2002; Milbourn and Haight 2005). This follows from ROA being the composite measure of return on sales (ROS) and asset turnover (ATO). While ROS is influenced by cost containment and revenue enhancement, ATO is improved by revenue enhancement and capital efficiency propositions such as capacity utilization (Dehning and Richardson 2002; Milbourn and Haight 2005). ROS is thus directly associated with the 1st and 2nd drivers of the value paradigm whilst ATO links with the 2nd and 4th. ROA can thus be seen as a composite measure that subsumes the 1st, 2nd and 4th drivers of the value paradigm.

The Earnings Change Measure

Toward deriving a *change* variable, a ROA prediction model is initially estimated. The model is designed to represent the firm's *intrinsic performance capacity* as moderated by macro–economic factors that impinge on such capacity, either favourably (in times of growth) or unfavourably (in recessionary periods)[15].

The underlying rationale for the model is that a firm's *realized* ROA impounds its intrinsic earnings *capacity* moderated by environmental variables impacting the industry sector or the economy as a whole (McNamara and Duncan 1995). An estimate of this intrinsic capacity moderated by the latter exogenous factors is necessary for deriving a *base* earnings level prediction for the firm–year preparatory to determining the residual earnings *change* resulting from potential earnings innovations as ERP.

The intrinsic *capacity* derives from the diverse structural and executional drivers of performance (Ittner and MacDuffie 1995; Shank and Govindarajan 1992) that operationalize management 'capability' and other "resource position advantages" (Wernerfelt 1984). The time series persistence of operational earnings is deemed to reflect this capacity. This implies an autoregressive time series ROA prediction model[16].

The key macroeconomic influences are determined with the aid of economic theories of the business cycle[17] (Hall 1990). Theories relating to leading and coincident indicators of the business cycle (Lahiri and Moore 1991) are used to identify business cycle indicator variables[18].

Thirty–five indicators are thus identified and subjected to a principal components analysis with Varimax rotation (Kaiser 1958) to produce a reduced, independent (orthogonal) set of economic factors underpinning the movement in the business cycle. The factors turn out to be a business activity factor, an interest rate factor, and an aggregate profits factor, accounting for a total of 72% of the variance in the factor matrix. These factors are deemed

best represented by the Capacity Utilization Rate, the 3–year Treasury Bond Rate, and the Gross Operating Surplus[19].

The estimation model—

$$ROA = k + \sum_{i=1}^{N} a_i \Delta ROA_{t-i} + b_1 CUR_{t-\delta} + b_2 BRAT_{t-\delta} + b_3 GOS_{t-\delta} + \varepsilon$$

where,

k is an earnings constant

N is the number of periods in the ROA time series

CUR is Capacity Utilization Rate

$BRAT$ is 3–year Treasury Bond Rate

GOS is Gross Operating Surpluses, and

$\delta \geq 0$ is the lagged period

The term $\sum_{i=1}^{N} a_i \Delta ROA_{t-i}$ measures time series earnings persistence[20].

The coefficients of the model are used to predict ROA. The predicted ROA is netted against the actual ROA to derive a measure of earnings change. The change parameter captures the incremental performance[21] for input into a value relevance model towards determining ERP's significance to the market value of the firm.

The Value Relevance Model

A returns–earnings regression model based on the share returns model of Easton and Harris (1991) is developed for the purpose. The model is designed to make for a comprehensive ERP value relevance construct with terms that model (a) earnings change (b) quality of earnings, and (c) ERP strategic value independent of earnings effects.

Accordingly, and after Easton and Harris (1991):

$$\gamma = \beta_0 + \beta_1 x + \beta_2 \Delta x + \theta$$

where

γ is the share return

x is earnings scaled by beginning–period share price

Δx is earnings change scaled by beginning–period price

β_1 and β_2 are earnings response coefficients (ERC), and

θ represents the error term.

Expanding the ERCs to give expression to ERP's interaction with the earnings terms—

$$\gamma = \beta_0 + (\chi_0 + \chi_1 ERP)x + (\delta_0 + \delta_1 ERP)\Delta x + \theta$$

Therefore,

$$\gamma = \beta_0 + \chi_0 x + \chi_1 ERPx + \delta_0 \Delta x + \delta_1 ERP\Delta x + \theta$$

where

ERP is a characteristic variable[22] flagging firm ERP status (1/0)

Since the error term θ may subsume any direct effect of the ERP implementation on share return—

$$\gamma = \beta_0 + \chi_0 x + \chi_1 ERPx + \delta_0 \Delta x + \delta_1 ERP\Delta x + \psi ERP + \theta_0$$

where

the ERP term models the potential strategic value of ERP

In deriving the final functional form of the model, three further considerations are addressed: (a) the form of the earnings variable, (b) the influence of leverage, and (c) the final functional form for the share return dependent variable.

In accordance with the ROA estimator model for deriving the earnings change variable Δx, the earnings variable x is defined as EBIT[23] scaled by beginning–period total assets (rather than NPAT[24] scaled by beginning–period share price[25]). This gives, in effect, the realized (or actual) ROA.

The influence of leverage (financial risk) is implicit in the Easton and Harris (1991) model since the share return is modelled on NPAT, the earnings available to shareholders. In the value relevance model however financial risk needs to be modelled. The indicative leverage measure is the debt/equity measure of capital gearing[26]. The model thus takes the functional form[27]—

$$R_t = \beta_0 + \beta_1 ROA_t + \beta_2 ERP.ROA_t + \beta_3 \Delta ROA_t + \beta_4 ERP.\Delta ROA_t + \beta_5 DER_t + \beta_6 ERP + \theta$$

where,

R_t is the share return at time t

ROA_t is the return on assets (realized) at time t

ΔROA_t is the actual ROA less its predicted value for time t

DER_t is the debt–to–equity ratio at time t, and

ERP is the characteristic variable for ERP adoption/ non–adoption

The functional form of the share return dependent variable in the above model builds upon the Easton & Harris (1991) formulation, which is—

$$R_t = (P_t - P_{t-1} + D_t) / P_{t-1}$$

This completes the value relevance model based on Easton and Harris (1991). The $ERP.\Delta ROA_t$ interaction term gives effect to the value relevance of ERP as agent for earnings innovation. The $ERP.ROA_t$ term represents value relevance of ERP as enhancer of earnings quality. The ERP term assesses the relevance of ERP as a strategic value proposition in its own right.

IV. ANALYSES AND RESULTS

Estimating the ROA Prediction Model

A large proportion of the sample of firms exhibit short time series dimensions for their earnings data[28]. Therefore, and consistent with the theory for control group matching, the matching industry group is used for deriving representative coefficients for the sample firm.

The rationale for this treatment is that firms in each industry group are likely to have similar risk/growth profiles given the commonality of the industry conditions and market expectations experienced by them.

Accordingly, the full functional form of the model to be estimated is specified:

$$ROA_{ji} = k_{ji} + \sum_{i=1}^{N} a_{ji} \Delta ROA_{jt-i} + b_1 CUR_{t-\delta} + b_2 BRAT_{t-\delta} + b_3 GOS_{t-\delta} + \varepsilon$$

where,

ROA_{ji} is Return on Assets for the *j*th firm at time *i*

k_{ji} is the firm/period–specific fixed effect[29] for firm *j* at time *i*

$CUR_{t-\delta}$ is the Capacity Utilization Rate at lag *t-δ*

$BRAT_{t-\delta}$ is the 3yr Treasury Bond interest rate at lag *t-δ*, and

$GOS_{t-\delta}$ is the Gross Operating Surpluses at lag *t-δ*

Panel least squares regressions were initially attempted. The results showed a considerable influence from heterogeneous cross–section fixed effects. Controlling for the firm–specific fixed effects resulted in the lagged earning variables (ROA_{t-1}, ROA_{t-2}) turning significant at $p<.05$. Yet the macroeconomic terms remained insignificant ($p<.05$). This result was inconsistent with evidence that share markets price macroeconomic variables (Chaudhuri and Smiles 2004; Groenewold and Fraser 1997).

Autocorrelation between the lagged dependent variable and the error term is unavoidable in dynamic models (Arellano and Bond 1991; Baltagi 2005). Accordingly, the Generalized Method of Moments/ Dynamic Panel Data Modelling method (GMM/DPD) for estimating was adopted.

While GMM regressions remove cross–sectional fixed effects through first differencing, they also allow for instruments to be specified as substitutes for the first–differenced regressors to control for the latter's correlation with the error term (Arellano and Bond 1991).

Furthermore, where dynamic models with uncorrelated errors can be specified, lagged values of the dependent variable become valid instruments in differenced equations (Anderson and Hsiao 1981; Arellano and Bond 1991). Therefore, subject to the independence of the error variable being satisfied, the GMM panel data modelling approach remains consistent with the autoregressive time–series modelling used in firm earnings prediction (Kormendi and Lipe 1987).

The key assumption underlying GMM estimation therefore is the absence of serial correlation in the error variable. Violation of this key assumption would render the GMM estimator inconsistent (Arellano and Bond 1991), and the results of the estimation therefore invalid. To test for violation of this key assumption, the literature specifies the test of the second order serial correlation of the (first differenced) error term, along with the Sargan test for over–identifying (instrument variable) restrictions (Arellano and Bond 1991; Gaston and Rajaguru 2007). Subject to this latter auxiliary requirement being satisfied together with the standard assumptions for deriving the unbiased least squares estimator, the GMM estimators of the model would result in negligible finite sample biases, as well as smaller variances than those associated with simpler instrumental variable estimators (Arellano and Bond 1991).

A model for the Consumer Services industry group was estimated using GMM/DPD[30]. However, a full two thirds of the industry group firm/year membership needed to be dropped on account of outlier treatment.

Given this excessive variation in the Consumer Services industry group, estimation at the corresponding higher level of the GIC system—the industry sector level—was performed. The estimation for the Consumer Discretionary sector however eventuated with the total number of firm/year observations declining on account of outlier treatment by 68%, a rate nearly identical with that of the Consumer Services industry group. This suggested that, on

average, other industry groups within the Consumer Discretionary sector perform similar to Consumer Services. Similar results were obtained for other sectors of the GIC system.

An excessively high outlier attrition rate raises issues of external validity of the estimation. It appeared that the ASX industry sector membership is not large enough to supply the mass needed to buffer sector variability.

The model is therefore estimated for the entire pool of ASX–listed companies. Even though the ASX level pool is more heterogeneous, there is yet a greater likelihood of deriving usable coefficients from a larger pool[31]. The output of this GMM estimation reveals the following:

Insert Table 1 about here

Insert Table 2 about here

Insert Figure 1 about here

a) The model yields acceptable coefficients at the $p<.10$ level of significance (Table 1) with all assumptions satisfied: Jarque–Bera summary test statistic (0.73) not significant at $p<.10$ (Fig 1), the Sargan test statistic (J-Stat=63.1) not significant at $p<.10$ (Table 1), and the 2nd order autocorrelation of the first differenced residual within the $\pm 1.96/\sqrt{n}$ ACF bound (Table 2).

b) The explanatory power of the model remains high at R sq=0.99, which is not unrealistic for a first–differenced model.

c) The key coefficients within range of the credible with (a) the highest coefficient, ROA(-1), at 0.61, a result that appears to fall within reason in light of the autoregressive earnings function in firms (Kormendi and Lipe 1987), (b) the interest rate term, BOND_RAT(-1), in the negative at -0.16 as would be reasonable to expect, and (c) the capacity utilization rate, CUR(-1), at a not unreasonable 0.21.

d) The only unusual result would appear to be the negative coefficient for the profits term, GOS, at -0.05. This might be explained by the fact that, in an Australian context, the annual wage bargaining in a good year in the business cycle would tend to drive down the following year's earnings result on account of a higher wages award granted relative to a 'bad' year in the cycle. The opposite may not always hold true, or at least, not to the same degree, which may explain, at least in part, the relatively low GOS coefficient. This seeming anomaly points to the need for further investigation, which is beyond the scope of the present research.

The coefficients estimated are applied to predict the ROA for each firm/year of the sample. The ROA residuals extracted represent the empirical measure of earnings change.

Insert Table 3 about here

Insert Table 4 about here

Test of Hypothesis 1

Hypothesis 1 is unsupported for the complete panel across industry sector/years. The two–sample *t*–test of the mean difference between matched pairs is insignificant at $p<.05$ (Table 3).

The *t*–tests of the respective means (Table 4) show that while the mean of the sample of adopter firms is significantly different from zero at $p < .05$, the mean of the control group of non–adopters (*p*–value = .11) is not significant ($p < .05$).

Test of Hypothesis 2

Hypothesis 2 is unsupported (Table 3). The paired two–sample *t*–test for means is insignificant (*p*–value = .49) at $p<.05$, lending strong support to the null hypothesis that there is no significant difference in capacity utilization (asset turnover) between the ERP–adopters and non–adopters. The means of the respective distributions are significantly different from zero at $p<.05$ (Table 4), allowing greater confidence in the result. Together, they lend strong

evidence that ERP adopters do not appear to improve their operational effectiveness relative to non–adopters.

Test of Hypothesis 3

Hypothesis 3 is unsupported for the entire pool of companies across industry sector/years (Table 3). The paired two–sample *t*–test for means is insignificant (*p*–value = .12) at the p<.05 level, lending support to the null hypothesis that ERP–adopters do not attain to a lower operating expense ratio than that of ERP non–adopters. This result is underlined by the means of the adopter and non–adopter samples being different from zero (*p*–value = 0.00, in each case) at *p*<.05 level of significance (Table 4).

Test of Hypothesis 4

Hypothesis 4 is unsupported for the pool of companies across industry sector/years (Table 3). The paired two–sample *t*–test of the mean difference is insignificant at the p<.05 level, indicating insufficient evidence to support that ERP–adopter firms achieve a higher ratio of operating income (EBIT) to sales revenue than non–adopter firms.

Test of Hypothesis 5

Insert Table 5 about here

Hypothesis 5 is unsupported for the entire pool of companies across industry sector/years (Table 3). The paired two–sample *t*–test for mean difference turns out insignificant at *p*<.05 with a *p*–value of .21, indicating wholly insufficient evidence that ERP–adopters achieve a better return on capital employed (return on assets) than ERP non–adopters.

However, when the test is performed on an yearly basis, years 4 and 5 are significant at p<.05 with *t* stats of -1.81 (*p*–value = .04) and -2.19 (*p*–value = .02) respectively (Table 5), indicating that in the later years post–adoption, ERP adopters appear to attain to a better performance relative to capital employed than non–adopter firms.

Test of Hypothesis 6

Insert Table 6 about here

Insert Table 7 about here

Insert Table 8 about here

Sub–hypotheses 6A, 6B & 6C are tested on a yearly basis by means of least squares estimations. With respect to year 1 of ERP adoption (Table 7), all sub–hypotheses remain unsupported at $p<.05$. There is no evidence that ERP is value relevant in the 1st year of adoption.

Insert Table 9 about here

Insert Table 10 about here

In year 2, the ERP–earnings interaction term, ERPX, is positive and significant at $p<.05$ (Table 9). This would suggest, in the context of the smaller (negative) and significant (at $p<.05$) coefficient of the earnings term X, that the market attaches greater credence to, and thus a higher value on the *reported* earnings of ERP adopters over that of non–adopters. It would seem that the earnings of ERP adopters are given a premium value for greater reliability.

The negative coefficient for the ERP characteristic term, ERP, at significance level $p<.05$ (Table 10), would strongly suggest the market views ERP adoption *per se* negatively value relevant. This result appears consistent with the negative result for the ERP–earnings change (ERPCHX) interaction since the market is likely to view ERP adoption most value relevant if it can be seen to improve earnings performance appreciably, rather than merely improve strategic value.

Insert Table 11 about here

Insert Table 12 about here

In year 3, the ERP–earnings change interaction (ERPCHX) is not value relevant, it being not significant (p–value = .77) at the $p<.05$ level (Table 11). The very significant p–values ($p<.01$) of the CHX terms (Tables 11 and 12) underscores the market's apparent lack of confidence in ERP's capacity to deliver improved earnings.

The negative value relevance trend is further confirmed by the ERP–earnings interaction (ERPX) term relative to the earnings level (X) term (Tables 11 and 12). The coefficient of the former turns *negative* while remaining higher than the coefficient of the earnings (X) term, a notable about turn from year 2. It would appear that in year 3, the market begins to view ERP adoption as detracting from the quality of reported earnings as well. The summary conclusion therefore is that ERP adoption is clearly not value relevant to the market in the 3rd year of adoption.

Insert Table 13 about here

Insert Table 14 about here

The weakening trend for the ERP–earnings interactive relation is further underscored in year 4 by the relationship amongst the X terms (Tables 13 and 14) and the ERPX term (Table 13). The coefficient of the ERPX term is not significant even at $p<.05$ while the coefficients of the X terms themselves are significant. This suggests the market no longer associates ERP adoption with earnings quality over and above that of ERP non–adopter firms. The ERP–earnings change interaction term remains insignificant at $p<.05$ as in year 3.

Insert Table 15 about here

Year 5 (Table 15) appears to present an anachronistic result in that while the paired two–sample t–test for means is significant in favour of adopters at $p<.05$ (Table 5, Panel 6), and the t–test of the adopter sample mean residual is positive and significant at $p<.05$ while that of the non–adopters is negative and not significant at $p<.05$ (Table 6, Panel 5), the share

market appears not to accord any value to these very positive results as evidenced by the significance levels of the ERP terms of the regression results for year 5 (Table 15).

Insert Table 16 about here

In sum, it would appear that, despite some limiting evidence of market expectation in adoption year 2, the market is less than enthusiastic of the positive effect of ERP implementations on firm performance. This is particularly evidenced by the earnings change interaction term, ERPCHX, turning out consistently negative or non–significant at $p<.10$, in the context of the consistently positive and significant (at $p<.10$) earnings change term, CHX. Table 16 summarizes the findings for the 3 hypotheses across the 5 years post adoption.

V. DISCUSSION

The test of hypothesis 5, the stronger of the tests of performance relevance, was significant at $p<.10$ level and *negative* in year 3, and significant at $p<.05$ and *positive* in years 4 and 5. The significant and negative result with respect to year 3 corresponds with a finding that ERP adopters performed significantly worse at $p<.01$ in the 2nd year after completion of implementation[32] (Nicolaou 2004). Despite the foregoing however, the general trend in residual ROA is an improving one for ERP adopters that turns significant in the later years of adoption. Year 5 in particular gives significant results for both the paired two–sample test of mean difference, and the *t*–test of the mean. The overall result remains broadly consistent with that of Nicolaou (2004)[33].

The rest of the tests of performance relevance, the tests of hypotheses 1-4, tests the components of ROA. Their lack of significance may have been due to the lack of power or efficiency in the experimental design in that movements in these variables other than from the effects of ERP were not isolated to derive a residual for each corresponding to the ROA residual. Nonetheless, it would appear that survey–based and observational studies in the US manufacturing sector (Mabert, Soni, and Venkataramanan 2003; Stratman 2001) cited in

recent research (Hendricks, Singhal, and Stratman 2007) find little evidence of improvements in operational metrics and costs consequent to ERP adoption. It is possible that the improvement in ROA residuals is related more to the improvement in gross margins from a reduction in the cost of goods sold (COGS), which is offset by the other components of ROA comprised in the tests of hypotheses 1–4. The absence of COGS data from published annual reports during the sample years prevented further enquiry.

This would appear to be of particular interest since COGS is impacted by the supply chain, and ERP–engendered improvements along the supply chain could reduce the cost of goods sold. Nonetheless, given gross margins are subsumed in EBIT, and the latter as well as asset turnover turned out non–significant in this study on a yearly basis as well as on a pooled basis across the 5 years of the study, it is suspected that residuals of ROA components would provide a more representative system of measurement to correspond with a residual ROA computation.

The overall finding from the tests of value relevance (hypothesis 6) is that in general, ERP adoption is not viewed by the market as value relevant across the three value relevance dimensions. The 1st dimension, the subject of hypothesis 6A, tests for the significance of ERP adoption to reported earnings. It effectively addresses the question, "Is ERP adoption significant to market perception of the reliability of the reported earnings of firms?" The answer is in the negative for all years other than year 2.

The 2nd dimension, the subject of hypothesis 6B, tests for the significance of ERP adoption to the abnormal earnings achieved by firms. It addresses the question, "Is ERP adoption significant to market perception of abnormal earnings of firms?" The answer is negative for all years with the exception of year 2.

The 3rd dimension, the subject of hypothesis 6C, tests for the significance of ERP adoption in itself to the value of the firm. It addresses the question, "Is ERP adoption significant in itself to market perception of the value of the firm?"

The significant result in year 2 across all of three dimensions and the non–significant results in the years 3–5 would suggest that the market reacts only when the news of ERP adoption initially permeates the market[34]. This is particularly suggested by the result for the test of hypothesis 6B, the market response to abnormal earning (or residual ROA), which turns out significant at $p<.10$, while the paired two–sample *t*–test for the mean difference of residual ROA between adopters and non–adopters is not significant at $p<.10$.

The market's lack of enthusiasm for ERP adoption is even more striking in years 4 and 5. This is in view of the fact that these are the *only* years that the paired *t*–test for the mean difference of residual ROA between adopters and non–adopters is significant ($p<.05$).

These results would suggest that the market, after a period of initial interest over the presumably hyped–up news of ERP adoption, becomes quickly disillusioned with the lack of evidence of improved performance in the financial results of years 2 and 3[35], and as a consequence does not react to improvements in years 4 and 5. The alternative scenario is that ERP adoption is simply not seen as the cause for the improved results in these years.

The overall findings of this research are broadly consistent with the findings of the only other identified published study of the comprehensive performance effect of ERP adoption over an extended period of 5 years (Hendricks, Singhal, and Stratman 2007). Using an entirely different research design and method, Hendricks et al. find no evidence of abnormal profit performance over the pooled 5–year period of adoption, a finding consistent with the present study. However, in direct contrast to this research, they find abnormal, positive performance for the pooled 2–year implementation period and none for the pooled 3–year

period after. The findings in this study give positive, significant performance in years 4 and 5 and none in the earlier years.

With respect to share returns, they find abnormal, significant, negative returns in the pre–implementation period. This is generally consistent with the findings of this research for year 2, which gives two negative and significant results for ERP's interaction with the ROA residual (hypothesis 6B) and for ERP adoption as a substantive value relevant event in itself (hypothesis 6C). Conversely, they find abnormal, significant, and positive returns in the post–implementation period. They yet conclude that there is no evidence of improvements in performance on the basis that only a statistically insignificant proportion of their sample firms perform better than the median (negative) stock return of the matched portfolio group. Given that their study was conducted on a larger sample of 186 firms drawn from the larger US market, these results would appear to confirm the findings in this research.

This research shows that it is important to derive a true measure of value of an information technology or management initiative, and that it is possible to do so. Specifically, it shows that it is possible to determine the value of an ERP initiative by observing the market's response to the interaction between ERP and ROA on the one hand, and between ERP and the ROA residual on the other. The two interactions give two different perspectives to the market's response: the former speaks to the improvement, if any, to the quality of the earnings reported by the enterprise, while the latter informs the significance of the initiative to the earnings of the enterprise. This information gives meaning to the value estimation of an ERP initiative in a way that no other method can.

The research demonstrates that, in order to understand the true impact of an information system such as ERP, it is first necessary to control for the influence of the economy on performance, and that it is possible to do so.

In financial accounting research, Ball and Brown (1968) pioneered the computation of cumulative residuals for the determination of the share market's response to reported accounting income numbers. No previous research would appear to have attempted to evaluate a residuals method for management accounting numbers[36]. This research demonstrates a residual computation method for ROA and relates the computed residual to share market performance.

It would seem no method has yet been systematically developed to control for the effect of the macro economy on performance. This research demonstrates a method for determining the key macroeconomic factors that affect enterprise performance, and how they may be controlled for in determining a performance result specific to a management or technology initiative. This research contributes to both theory and method relating to macroeconomic influences on firm performance.

Previous research has not attempted to develop a theory for the performance relevance of ERP to enterprise operations. This research develops the theory for ERP's performance relevance by comprehensively qualifying it as a management and organizational innovation that meets the criteria for enterprise continuance implicit in Ronald Coase's monograph, "The Nature of the Firm" (1937). As a consequence, this research makes an original contribution to the theory of ERP.

In business studies in general and information technology management education in particular, there is a general lack of awareness of the importance of determining the proper value of enterprise initiatives. This research underscores the importance of this issue and presents a methodology for evaluating the value relevance of enterprise initiatives. Further, it heightens awareness that major projects cannot but be evaluated in the long–term and gives an appreciation of the length of time that is needed for evaluating the performance effects of IT initiatives.

The broadly similar Hendricks et al. (2007) findings for firms listed in US stock markets offers a measure of generalizability for the findings of this research. The ecological validity of this research may be violated by the inability to derive more firm–specific coefficients for earnings prediction on account of the thinness of the Australian Stock Market. Future research would need to address a larger pool of companies to make for the derivation of more representative coefficients at the firm level.

Figures & Tables

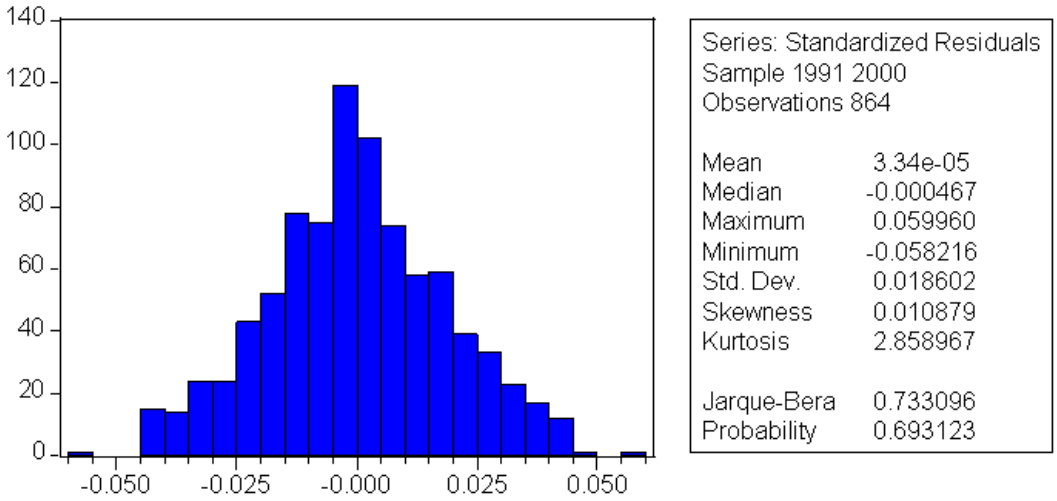

Fig. 1 HISTOGRAM OF RESIDUALS UNDER GMM ESTIMATION
ASX Pool of Companies

Table 1 Generalized Method of Moments Estimation ASX pool of companies				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ROA(-1)	0.608623	0.036041	16.88674	0.0000
CUR(-1)	0.207806	0.034346	6.050323	0.0000
BOND_RAT(-1)	-0.159261	0.026503	-6.009258	0.0000
GOS(-1)	-0.048146	0.007109	-6.772468	0.0000
Effects Specification				
Cross-section fixed (first differences)				
R-squared	0.990000	Mean dependent var		-0.000624
S.E. of regression	0.018634	S.D. dependent var		0.012963
J-statistic	63.06264	Sum squared resid		0.298614
		Instrument rank		55.00000

1. Sargan test for over-identifying restrictions:

H0: Number of Instruments is not over-identified

H1: Number of instruments is over-identified

Test Specification:

Under the null hypothesis that over-identifying restrictions are valid, the J-Statistic is chi-squared distributed with (p-k) df where p = instrument rank, k = estimated coefficients.

Eviews 5.1 Command Specification:

scalar pval = @chisq(J-statistic, df)

where,

df = p - k

Calculation:

df = 55 - 4 = 51

scalar pval = @chisq(63.06264,51) = 0.12

Conclusion:

There is no evidence to support H1.

Over-identifying restrictions remain valid.

Table 2 ACF and PCF under the Generalized Method of Moments Estimation
ASX pool of companies

Date: 08/31/07 Time: 03:39
Sample: 1989 2000
Included observations: 785

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
****|. |	****|. |	1	-0.490	-0.490	189.13	0.000
.|. |	**|. |	2	0.045	-0.257	190.71	0.000
.|. |	*|. |	3	0.017	-0.115	190.93	0.000
.|. |	.|. |	4	0.002	-0.041	190.94	0.000
.|. |	.|. |	5	0.002	-0.007	190.94	0.000
.|. |	.|. |	6	-0.006	-0.004	190.97	0.000
.|. |	.|. |	7	-0.012	-0.022	191.08	0.000
.|. |	.|. |	8	0.013	-0.008	191.22	0.000
.|. |	.|. |	9	-0.000	0.002	191.22	0.000

Note: The bar plots for the autocorrelation function (ACF) and the partial correlation function (PCF) do not print (on export into MS Word). However, the 2nd order correlation of the first differenced residual is within the ±1.96SD / √n as follows:

$$\pm 1.96 / \sqrt{n} = \pm 1.96 / \sqrt{785} = \pm\ 0.069$$

r at lag 2 of the ACF is +0.045

r at lag 2 is inside the ± 1.96SD bound

Table 3 Paired t-Tests: Two samples for means
Years 1-5
Hypotheses 1-5

Observations: 300

	H1		H2		H3		H4		H5	
	N-Adopt	**Adopt.**	**N-Adopt**	**Adopt.**	**N-Adopt**	**Adopt.**	**N-Adopt**	**Adopt.**	**N-Adopt**	**Adopt.**
Mean	13.1	1.3	1.18	1.18	2.1	1.2	-11.96	-0.29	-0.00	0.02
Variance	32381.2	27.8	3.88	.63	142.0	19.0	32365.1	27.0	0.05	0.25
t-stat	1.13		-0.02		1.16		-1.22		-0.81	
P-val	0.13		0.49		0.12		0.13		0.21	

Table 4 t-Tests: Mean
Years 1-5
Hypotheses 1-4

Observations: 300

	H1		H2		H3		H4	
	N-Adopt	**Adopt.**	**N-Adopt**	**Adopt.**	**N-Adopt**	**Adopt.**	**N-Adopt**	**Adopt.**
Mean	13.1	1.3	1.18	1.18	2.1	1.2	-11.96	-0.29
Std Dev	179.94	5.27	1.97	0.79	11.92	4.36	179.9	5.2
t-stat	1.26	4.38	10.35	25.71	3.01	4.82	-1.15	-0.97
P-val	0.11	0.00	0.00	0.00	0.00	0.00	0.13	0.17

Table 5 Paired t-Tests for the difference between ROA residuals Test of Hypothesis H5

Panel 1 Yr 1-5

t-Test: Paired Two Sample for Means years 1-5

	N-Adopt	*Adopt*
Mean	-0.00172	0.023845
Variance	0.052279	0.252229
Observations	300	300
Pearson Correlation	0.029702	
Hypothesized Mean Difference	0	
df	299	
t Stat	-0.81144	
P(T<=t) one-tail	0.208878	
t Critical one-tail	1.649966	
P(T<=t) two-tail	0.417756	
t Critical two-tail	1.96793	

Panel 2 Yr 1

t-Test: Paired Two Sample for Means Year 1

	N-Adopt	*Adopt*
Mean	-0.01681	0.146007
Variance	0.052661	1.005418
Observations	60	60
Pearson Correlation	0.074415	
Hypothesized Mean Difference	0	
df	59	
t Stat	-1.24639	
P(T<=t) one-tail	0.108773	
t Critical one-tail	1.671093	
P(T<=t) two-tail	0.217546	
t Critical two-tail	2.000995	

Panel 3 Yr 2

t-Test: Paired Two Sample for Means Year 2

	N-Adopt	*Adopt*
Mean	-0.0206	-0.06624
Variance	0.06195	0.208676
Observations	60	60
Pearson Correlation	0.001633	
Hypothesized Mean Difference	0	
df	59	
t Stat	0.68014	
P(T<=t) one-tail	0.249538	
t Critical one-tail	1.671093	
P(T<=t) two-tail	0.499076	
t Critical two-tail	2.000995	

Table 5 (cont) **Paired t-Tests for the difference between ROA residuals**
Test of Hypothesis H5

Panel 4
Yr 3

t-Test: Paired Two Sample for Means Year 3

	N-Adopt	*Adopt*
Mean	0.064327	-0.00014
Variance	0.12635	0.008405
Observations	60	60
Pearson Correlation	-0.01321	
Hypothesized Mean Difference	0	
df	59	
t Stat	1.356059	
P(T<=t) one-tail	0.090124	
t Critical one-tail	1.671093	
P(T<=t) two-tail	0.180248	
t Critical two-tail	2.000995	

Panel 5
Yr 4

t-Test: Paired Two Sample for Means Year 4

	N-Adopt	*Adopt*
Mean	-0.02776	0.014248
Variance	0.0144	0.020321
Observations	60	60
Pearson Correlation	0.068614	
Hypothesized Mean Difference	0	
df	59	
t Stat	-1.80834	
P(T<=t) one-tail	0.037826	
t Critical one-tail	1.671093	
P(T<=t) two-tail	0.075651	
t Critical two-tail	2.000995	

Panel 6
Yr 5

t-Test: Paired Two Sample for Means Year 5

	N-Adopt	*Adopt*
Mean	-0.00775	0.025353
Variance	0.003825	0.011314
Observations	60	60
Pearson Correlation	0.113199	
Hypothesized Mean Difference	0	
df	59	
t Stat	-2.1947	
P(T<=t) one-tail	0.016067	
t Critical one-tail	1.671093	
P(T<=t) two-tail	0.032133	
t Critical two-tail	2.000995	

Table 6 t-test of means of the residuals for their difference from zero Test of Hypothesis 6

Panel 1

Yr 1

t-Test: Mean	*Non-adopt*	*Adopt*
Mean	-0.0168	0.146
Standard Deviation	0.2295	1.0027
Hypothesized Mean	0	0
df	59	59
t Stat	-0.5674	1.1279
P(T<=t) one-tail	0.2863	0.132
t Critical one-tail	1.6711	1.6711
P(T<=t) two-tail	0.5726	0.264
t Critical two-tail	2.001	2.001

Panel 2

Yr 2

t-Test: Mean	*N-Adopt*	*Adopt*
Mean	-0.0206	-0.0662
Standard Deviation	0.2489	0.4568
Hypothesized Mean	0	0
df	59	59
t Stat	-0.6409	-1.1232
P(T<=t) one-tail	0.262	0.1329
t Critical one-tail	1.6711	1.6711
P(T<=t) two-tail	0.524	0.2658
t Critical two-tail	2.001	2.001

Panel 3

Yr 3

t-Test: Mean	*N-Adopt*	*Adopt*
Mean	0.0643	-0.0001
Standard Deviation	0.3555	0.0917
Hypothesized Mean	0	0
df	59	59
t Stat	1.4018	-0.0121
P(T<=t) one-tail	0.0831	0.4952
t Critical one-tail	1.6711	1.6711
P(T<=t) two-tail	0.1662	0.9904
t Critical two-tail	2.001	2.001

Table 6 (cont) t-test of means of the residuals for their difference from zero
Test of Hypothesis 6

Panel 4
Yr 4

t-Test: Mean		
	N-Adopt	*Adopt*
Mean	-0.0278	0.0142
Standard Deviation	0.12	0.1426
Hypothesized Mean	0	0
df	59	59
t Stat	-1.7917	0.7742
P(T<=t) one-tail	0.0392	0.2209
t Critical one-tail	1.6711	1.6711
P(T<=t) two-tail	0.0784	0.4418
t Critical two-tail	2.001	2.001

Panel 5
Yr 5

t-Test: Mean		
	N-Adopt	*Adopt*
Mean	-0.0077	0.0254
Standard Deviation	0.0618	0.1064
Hypothesized Mean	0	0
df	59	59
t Stat	-0.9705	1.8463
P(T<=t) one-tail	0.1679	0.0349
t Critical one-tail	1.6711	1.6711
P(T<=t) two-tail	0.3358	0.0698
t Critical two-tail	2.001	2.001

Table 7 Ordinary Least Squares Estimation of Shareholder Value Relevance of ERP information: Year 1

Dependent Variable: Y
Method: Least Squares
Date: 09/14/07 Time: 20:04
Sample: 1 120
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.036622	0.056005	-0.653905	0.5145
X	0.562299	0.522743	1.075671	0.2844
ERPX	0.062745	0.674857	0.092976	0.9261
CHX	0.405226	0.221540	1.829135	0.0700
ERPCHX	-0.325514	0.226920	-1.434490	0.1542
ERP	0.016004	0.077023	0.207777	0.8358
LEV	0.013209	0.005023	2.629601	0.0097

R-squared	0.118757	Mean dependent var	0.042163
Adjusted R-squared	0.071966	S.D. dependent var	0.388684
S.E. of regression	0.374437	Akaike info criterion	0.929777
Sum squared resid	15.84295	Schwarz criterion	1.092380
Log likelihood	-48.78660	F-statistic	2.538003
Durbin-Watson stat	1.860085	Prob(F-statistic)	0.024204

Legend

C	–	Constant
X	–	Earnings
ERPX	–	ERP interaction with earnings
CHX	–	Earnings change
ERPCHX	–	ERP interaction with earnings change
ERP	–	ERP Characteristic term
LEV	–	Leverage term

Table 8 Ordinary Least Squares Regression of Share Returns on Earnings ex. ERP terms: Year 1

Dependent Variable: Y
Method: Least Squares
Date: 09/14/07 Time: 19:57
Sample: 1 120
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.029411	0.040945	-0.718294	0.4740
X	0.533523	0.324360	1.644851	0.1027
CHX	0.096217	0.047365	2.031393	0.0445
LEV	0.013322	0.004976	2.676990	0.0085

R-squared	0.100302	Mean dependent var	0.042163
Adjusted R-squared	0.077034	S.D. dependent var	0.388684
S.E. of regression	0.373413	Akaike info criterion	0.900503
Sum squared resid	16.17474	Schwarz criterion	0.993419
Log likelihood	-50.03018	F-statistic	4.310711
Durbin-Watson stat	1.870691	Prob(F-statistic)	0.006385

Legend

C	–	Constant
X	–	Earnings
CHX	–	Earnings change
LEV	–	Leverage term

Table 9 Generalized Least Squares Estimation of Shareholder Value Relevance of ERP information: Year 2

Dependent Variable: Y
Method: Least Squares
Date: 09/18/07 Time: 01:51
Sample: 1 120
Included observations: 120
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.368496	0.117136	3.145892	0.0021
X	-1.799785	0.896576	-2.007397	0.0471
ERPX	2.752577	0.912936	3.015083	0.0032
CHX	1.890228	0.974434	1.939822	0.0549
ERPCHX	-1.667478	0.978458	-1.704190	0.0911
ERP	-0.355809	0.113493	-3.135084	0.0022
LEV	0.004902	0.008672	0.565299	0.5730

R-squared	0.124287	Mean dependent var	0.180850
Adjusted R-squared	0.077789	S.D. dependent var	0.620545
S.E. of regression	0.595920	Akaike info criterion	1.859143
Sum squared resid	40.12866	Schwarz criterion	2.021747
Log likelihood	-104.5486	F-statistic	2.672960
Durbin-Watson stat	2.119312	Prob(F-statistic)	0.018342

Legend

C	–	Constant
X	–	Earnings
ERPX	–	ERP interaction with earnings
CHX	–	Earnings change
ERPCHX	–	ERP interaction with earnings change
ERP	–	ERP Characteristic term
LEV	–	Leverage term

Table 10 Generalized Least Squares Regression of Share Returns on Earnings ex. ERP terms: Year 2

Dependent Variable: Y
Method: Least Squares
Date: 09/18/07 Time: 02:04
Sample: 1 120
Included observations: 120
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.193158	0.073565	2.625675	0.0098
X	-0.273434	0.435135	-0.628389	0.5310
CHX	0.419069	0.084826	4.940335	0.0000
LEV	0.005539	0.009130	0.606739	0.5452

R-squared	0.047424	Mean dependent var	0.180850
Adjusted R-squared	0.022788	S.D. dependent var	0.620545
S.E. of regression	0.613433	Akaike info criterion	1.893275
Sum squared resid	43.65087	Schwarz criterion	1.986192
Log likelihood	-109.5965	F-statistic	1.925002
Durbin-Watson stat	2.080339	Prob(F-statistic)	0.129378

Legend

C	–	Constant
X	–	Earnings
CHX	–	Earnings change
LEV	–	Leverage term

Table 11 Ordinary Least Squares Estimation of Shareholder Value Relevance of ERP information: Year 3

Dependent Variable: Y
Method: Least Squares
Date: 09/11/07 Time: 02:53
Sample: 1 120
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.107867	0.109695	0.983335	0.3275
X	1.727707	0.680757	2.537921	0.0125
ERPX	-1.764784	0.856300	-2.060942	0.0416
CHX	0.966735	0.161090	6.001229	0.0000
ERPCHX	0.230820	0.784299	0.294302	0.7691
ERP	0.061470	0.094227	0.652366	0.5155
LEV	-0.009655	0.033524	-0.288006	0.7739

R-squared	0.279867	Mean dependent var	0.198297
Adjusted R-squared	0.241630	S.D. dependent var	0.499348
S.E. of regression	0.434854	Akaike info criterion	1.228951
Sum squared resid	21.36809	Schwarz criterion	1.391555
Log likelihood	-66.73705	F-statistic	7.319256
Durbin-Watson stat	2.049463	Prob(F-statistic)	0.000001

Legend

C	–	Constant
X	–	Earnings
ERPX	–	ERP interaction with earnings
CHX	–	Earnings change
ERPCHX	–	ERP interaction with earnings change
ERP	–	ERP Characteristic term
LEV	–	Leverage term

Table 12 Ordinary Least Squares Regression of Share Returns on Earnings ex. ERP terms: Year 3

Dependent Variable: Y
Method: Least Squares
Date: 09/14/07 Time: 15:21
Sample: 1 120
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.199191	0.080593	2.471567	0.0149
X	0.533657	0.348700	1.530416	0.1286
CHX	0.924440	0.155019	5.963379	0.0000
LEV	-0.025546	0.032460	-0.787007	0.4329

R-squared	0.250497	Mean dependent var	0.198297
Adjusted R-squared	0.231113	S.D. dependent var	0.499348
S.E. of regression	0.437859	Akaike info criterion	1.218926
Sum squared resid	22.23958	Schwarz criterion	1.311842
Log likelihood	-69.13554	F-statistic	12.92308
Durbin-Watson stat	1.952757	Prob(F-statistic)	0.000000

Legend

C	–	Constant
X	–	Earnings
CHX	–	Earnings change
LEV	–	Leverage term

Table 13 Generalized Least Squares Estimation of Shareholder Value Relevance of ERP information: Year 4

Dependent Variable: Y
Method: Least Squares
Date: 09/16/07 Time: 01:43
Sample: 1 120
Included observations: 120
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.120037	0.101017	-1.188282	0.2372
X	1.024098	0.459239	2.229988	0.0277
ERPX	1.010216	0.932927	1.082846	0.2812
CHX	0.529705	0.305721	1.732640	0.0859
ERPCHX	0.300698	0.395348	0.760592	0.4485
ERP	-0.012783	0.099481	-0.128501	0.8980
LEV	0.037787	0.038281	0.987103	0.3257

R-squared	0.091621	Mean dependent var	0.033008
Adjusted R-squared	0.043388	S.D. dependent var	0.481480
S.E. of regression	0.470919	Akaike info criterion	1.388301
Sum squared resid	25.05940	Schwarz criterion	1.550905
Log likelihood	-76.29805	F-statistic	1.899569
Durbin-Watson stat	2.096193	Prob(F-statistic)	0.086901

Legend

C	–	Constant
X	–	Earnings
ERPX	–	ERP interaction with earnings
CHX	–	Earnings change
ERPCHX	–	ERP interaction with earnings change
ERP	–	ERP Characteristic term
LEV	–	Leverage term

Table 14 Generalized Least Squares Regression of Share Returns on Earnings ex. ERP terms: Year 4

Dependent Variable: Y
Method: Least Squares
Date: 09/16/07 Time: 00:20
Sample: 1 120
Included observations: 120
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.108594	0.086372	-1.257280	0.2112
X	1.422518	0.427835	3.324922	0.0012
CHX	0.630887	0.205188	3.074676	0.0026
LEV	0.032971	0.036937	0.892624	0.3739

R-squared	0.082201	Mean dependent var	0.033008
Adjusted R-squared	0.058465	S.D. dependent var	0.481480
S.E. of regression	0.467193	Akaike info criterion	1.348617
Sum squared resid	25.31925	Schwarz criterion	1.441533
Log likelihood	-76.91702	F-statistic	3.463131
Durbin-Watson stat	2.081519	Prob(F-statistic)	0.018629

Legend

C	–	Constant
X	–	Earnings
CHX	–	Earnings change
LEV	–	Leverage term

Table 15 Generalized Least Squares Estimation of Shareholder Value Relevance of ERP information: Year 5

Dependent Variable: Y
Method: Least Squares
Date: 09/14/07 Time: 14:12
Sample: 1 120
Included observations: 120
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.171516	0.096786	1.772115	0.0791
X	0.928835	0.467992	1.984722	0.0496
ERPX	-1.790978	1.528363	-1.171828	0.2437
CHX	2.199843	1.081854	2.033400	0.0444
ERPCHX	1.197034	1.637803	0.730878	0.4664
ERP	0.182717	0.198865	0.918799	0.3602
LEV	0.028897	0.028432	1.016360	0.3116

R-squared	0.123268	Mean dependent var	0.354105
Adjusted R-squared	0.076716	S.D. dependent var	0.790071
S.E. of regression	0.759161	Akaike info criterion	2.343356
Sum squared resid	65.12473	Schwarz criterion	2.505960
Log likelihood	-133.6014	F-statistic	2.647966
Durbin-Watson stat	2.020480	Prob(F-statistic)	0.019311

Legend

C	–	Constant
X	–	Earnings
ERPX	–	ERP interaction with earnings
CHX	–	Earnings change
ERPCHX	–	ERP interaction with earnings change
ERP	–	ERP Characteristic term
LEV	–	Leverage term

Table 16 Are Enterprise Resource Planning Information Systems Shareholder Value Relevant?

Value Relevance Hypotheses:

6A *The coefficient of the interaction between the empirical indicator for the earnings level variable and the empirical indicator for the ERP implementation variable* (i.e. ERPX) *is significantly greater than zero.*

6B *The coefficient of the interaction between the empirical indicator for the earnings change variable and the empirical indicator for the ERP implementation variable* (i.e. ERPCHX) *is significantly greater than zero.*

6C *The coefficient of the ERP–implementation empirical indicator* (i.e. ERP) *is significantly greater than zero.*

	YEAR OF ADOPTION				
Hypothesis	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
6A	**Not Supported**	**Supported[1]**	**Not Supported**	**Not Supported**	**Not Supported**
6B	**Not Supported**	**Supported[2]**	**Not Supported**	**Not Supported**	**Not Supported**
6C	**Not Supported**	**Supported[3]**	**Not Supported**	**Not Supported**	**Not Supported**

[1]Coefficient (ERPX) significant and positive at p<.01
[2]Coefficient (ERPCHX) significant and *negative* at p<.10
[3]Coefficient (ERP) significant and *negative* at p<.01

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[1] After the classical valuation model, which states the firm's stock price should equal the present value of expected future benefits (Miller and Modigliani 1961)

[2] The ERC is defined as "… the effect of a dollar of unexpected earnings on stock returns, and typically measured as a slope coefficient in the regression of abnormal stock returns on the appropriately scaled unexpected earnings" (Cho and Jung 1991)

[3] "Earnings innovation" is an estimate of the "new earnings" in the earnings report. This "new information in earnings" is represented as the residual of an autoregressive time series earnings model fitted to the firm's history of earnings (Kormendi and Lipe 1987)

[4] The definition covers both historical time series earnings persistence and any improvements thereto (that may be triggered by ERP adoption) subsumed in the ERC

[5] For the purposes of this paper, the term "earnings innovation" will hence connote "new earnings with persistence effects"

[6] The cost of capital could be expected to fall through a reduction in risk from, among other things, (a) an improvement in the time series persistence of the earnings over and above what is normal to the firm from its past history of earnings—effectively, with an improvement in driver 3, and/or (b) an improvement to the quality of earnings

[7] "Capital deepening" is additional capital invested in labour inputs leading to increased labour productivity. "Process innovation" is technical progress in the production process leading to improved multi–factor productivity. Investment in IT contributes to both labour and multi–factor productivity through more efficient production processes, as well as through promoting faster innovation (Dedrick, Gurbaxani, and Kraemer 2003; Pilat 2004)

[8] From improved forecasting, improved working capital management, superior product design, optimized supply chain, efficient plant layout, reduced order–to–cash cycle times, efficient cash management, and others

[9] Physical assets and human assets are often closely coupled in an unique firm–specific way (Amit and Schoemaker 1993; Conner 1991; Williamson 1975)

[10] "Information impactedness" is the condition attending upon a contract where one of the parties to the contract has access to significant information of strategic import to contract negotiations under circumstances that render it too costly or impractical for the other to secure information parity. Information impactedness is thus an information asymmetry condition that confers unfair advantage to one party over the other (Williamson 1973)

[11] Signal G returns give full text company announcements lodged with the ASX pursuant to the ASX listing rules

[12] Given the limited number of firms listed on the ASX, an 85–115 percent range is considered optimal for size matching. A narrower spread is not found to be supported by the available industry sector mass

[13] Homogeneity is defined by the system of classification. Unlike other classification algorithms commonly adopted in the literature (e.g. SIC and NAICS), the superiority of the GIC derives from the fact that it has been established to meet the needs of investment professionals and not primarily shaped by firms' production technologies (Bhojraj, Lee, and Oler 2003)

[14] The exact number depends on the actual number of matching control group firms that do not retain their comparability with their respective matched treatment group firm continuously over the five–year period. Firms that do not retain their comparability over the five years (due to mergers and divestitures, management changes, conversion to enterprise systems or other firm–specific causes) are substituted with appropriate matching replacements

[15] It is widely reported that the economies of several countries underwent a period of slowed/negative growth during the years straddling the new millennium. In contrast, the mid–90s saw a period of growth. The data for the present study covers the period 1995–2005

[16] After Kormendi and Lipe (1987)

[17] Monetary Theory, Underconsumption Theory, Investment–based Theories, and Cost–Price Theory (Hall 1990)

[18] Business Cycle Theory and Leading/Coincident Indicator Theory has been adopted in the bankruptcy prediction research literature to model macroeconomic indicators of bankruptcy risk (Hol 2007; Rose, Wesley, and Giroux 1982). The choice of these indicators as moderators of *intrinsic performance capacity* is based on the rationale that if macroeconomic factors affect the performance of bankrupting firms, they must *ipso facto* influence firm performance irrespective of the particular financial health status of the firm. This rationale would appear to find corroboration—albeit indirectly—through various capital market studies that report associations between macroeconomic variables and share market performance (Chaudhuri and Smiles 2004; Groenewold and Fraser 1997)

[19] The best choice is determined in accordance with their temporal attribute—coincident indicators being preferred for input into an earnings prediction model designed to predict current performance—subject to their suitability to an earnings prediction context. Accordingly, the 3–year Treasury Bond rate is selected over the consumer price index since an interest rate is deemed to better reflect *intrinsic earnings capacity* by way of its direct influence upon relative capital availability (via cost of capital) for internal investment. (The interest expense itself, being a financing cost that does not affect EBIT for ROA determination, is not considered relevant to *intrinsic earnings capacity*, which is an operating income concept. Instead, interest rates are deemed to moderate business investment and therefore operating profitability)

[20] The specification follows from classical valuation theory (Miller and Modigliani 1961) as theoretically (Miller and Rock 1985) and empirically (Kormendi and Lipe 1987) extended to firm reported earnings

[21] To derive a valid measure of the incremental performance, three further controls are implemented during data collection and analysis. They are for the effects of (a) changes to accounting policies (b) questionable earnings management practices, and (c) divestiture/ acquisition of major assets. Financial statements are required to disclose significant changes to accounting policies (IAS8 of the IASB). Further, an analysis of the cash flow ratios will reveal any excessive earnings management effects (Schwartz and Soo 1996). Since the share market can be expected to discern the quality of reported earnings of the enterprise and penalize firms accordingly with

'below–par' returns (Aboody, Hughes, and Liu 2005; Chan et al. 2006), controlling for these effects during data collection and analysis could have a bearing on the analysis and conclusions

[22] Characteristic variables have been used in the information technology literature to differentiate ERP adopters from non–adopters (Hitt, Wu, and Zhou 2002) as well as in the accounting literature to differentiate earnings and cash flow–related contexts (Cheng, Liu, and Schaefer 1996)

[23] EBIT is Earnings Before Interest and Tax

[24] NPAT is Net Profit After Tax

[25] Since scaling is a measure that controls for heteroscedasticity in the residuals, different scaling parameters on either side of the regression function is not considered material to the result

[26] This is derived from the DuPont model (Penman 1991) as follows: leverage = Assets/Equity = 1 + Debt/Equity = 1 + non–interest–bearing debt/Equity + D/E ratio. The last term represents financial risk (via the numerator representing interest–bearing debt and therefore covenanted liabilities), therefore influencing risk and hence share return response

[27] Leakages are excluded from the model development and would be subsumed in the error term. Besides, the only recurrent leakages are likely to be interest and taxes. Interest, which depends upon level of gearing, is yet incorporated in financial risk term, DER

[28] The inadequacy arises from such things as mergers, privatization, and receivership in addition to listings of relatively recent origin

[29] The subscript i is specified in the constant k_{ji} to capture the possible period–specific effect other than that impounded in the macroeconomic indicator terms in the regression

[30] Eviews v5.1, a program for statistical and econometric analysis and forecasting, is used for the purpose

[31] While the ASX pool would comprise a large enough cross–section, the twelve years earnings and macroeconomic data selected for estimating the model would comprise a limited time series per cross section, a combination that is well suited to panel estimation (Wooldridge 2002). In general, it would appear the time series would need to be of reasonable length, reasonableness dependent upon the number of available observations. Whilst Gaston & Rajaguru (2007) adopt a 20–year period for their study, Arellano & Bond (1991) estimate employment equations using an unbalanced (i.e. unequal number of observations per cross section) panel over a 6 year period. Anderson &Hsiao (1982) show that for fixed time periods, time series regression models yield consistent estimators as the number of cross–sections tends to infinity

[32] The 2nd year after completion in the Nicolaou (2004) study roughly corresponds to the 3rd year of adoption in the present study. The present study treats the year of commencement of ERP adoption as year 1 and Nicolau (2004) finds the average time to completion to be 9.92 months

[33] This study (Nicolaou 2004) uses the differential ROA performance between adopters and non–adopters pre– and post–adoption as the measure of ROA residual

[34] This news, barring any announcements—which are not altogether the norm judging by the limited number of Signal G listings with ERP adoption information filed with the ASX—is likely to be first reported in the annual report of the year of adoption (year 1). Presumably, in year 1 itself, the news does not register in the market given that the significance of this information may not be immediately clear (the market is not likely to have prior knowledge of the significance of ERP adoption). The information likely percolates market thinking in the course of year 2. Further, year 1, being the year of adoption, does not feature a full year of post–ERP–adoption operation, and therefore, ERP adoption is relatively new and need not necessarily be significant to the financial result

[35] The coefficient of the ERP–earnings change interaction term is negative in year 2, indicating that share returns are depressed in consequence of ERP's effect on changed earnings levels of firms. In year 3, the paired

t–test for the mean difference of residual ROA between adopters and non–adopters is significant at $p<.10$ in favour of non–adopters, showing that in year 3, adopters fare significantly *worse* than non–adopters

[36] A residual analysis method has been developed and presented in the context of contingency studies in management accounting (Duncan and Moores 1989). However, it does not appear any method has been *directly* applied to management accounting numbers in the research literature