Empirical Failure Prediction of UK Construction Industry Developers and Contractors

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INTRODUCTION

Since Beaver's 1966 study pioneering failure prediction modelling techniques using financial ratios, business failure prediction has developed into a major research area within corporate finance. In 2015, 252,000 of 2.67m active UK businesses across the economy failed, a rate of 9.4%. The UK construction industry experienced a failure rate of 9.3% - 31,000 failures.

The economic importance of the construction industry in the UK is evident in it's contribution of £103 billion in GVA (6.5%) to the economy 2014, employing approximately 2.1 million people (6.2% of total UK employment) in 2015 (ONS).

DATA SOURCE AND FORMATION OF SAMPLE

The Financial Analysis Made Easy (FAME) source was used to identify some 20,685 UK construction industry firms. To avoid sample selection biases, every firm-year for which data are available is sampled separately.

Please refer to *UK Construction Industry Business Models - Empirical failure prediction of Developers and Contractors with use of financial accounts* BSc Disseration for full sample selection and cleaning methods.

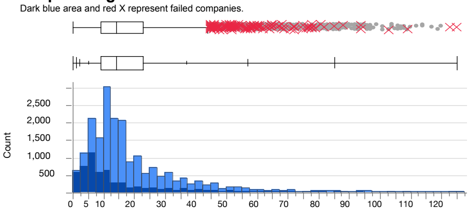
SAMPLE CHARACTERISTICS

Table 1 - Size & age for SIC codes

	Size (count)					Age (years)		
SIC Code	Large	Medium	Small	Micro	Total	Mean	Median	Std Dev
41100	93	628	1,292	1,207	3,220	18	14	15
41 (excl. 41100)	233	773	1,166	1,866	4,038	20	15	17
42 (all codes)	97	359	298	367	1,121	22	17	16
43 (all codes)	288	1,434	2,049	6,690	10,461	17	13	13
64203	39	96	27	0	162	16	10	18
Total:	750	3,290	4,832	10,130	19,002			
% of All:	3.9%	17.3%	25.4%	53.3%	100.0%			

Graph 1 - Age Distribution

Dark blue area and red X represent failed companies.



MODELLING TECHNIQUES

Lasso (Least Absolute Shrinkage and Selection Operator) regression analysis methods are applied to select predictor variables. During the computation of a Lasso regression, a penalty is applied to the regression coefficients given by the following equation:

$$\hat{\beta}^{lasso} = \operatorname{argmin}_{\beta}\left\{\frac{1}{2}\sum_{i=1}^{N} -LogLikelihood(\beta{:}y_i) + \lambda\sum_{j=1}^{p}|\beta_j|\right\}$$

where $\sum_{j=1}^{p}|\beta_j|$ is the penalty; λ is the tuning parameter; N is the number of rows; and p is the number of variables.

Lasso penalties apply to strongly correlated variables where the less available variables are penalised more and subsequently removed. Lasso methods are forms of machine learning processes, replacing the need for manual and more subjective factor analyses procedures, commonly used to determine what combinations of variables lead to models that are both powerful and parsimonious.

Logistical Regression. Predicting a binary outcome (failed or non-failed) requires the applicaiton of logistical regression models. The general form of a logistic regression equation: $\ln\left(\frac{\rho}{1-\rho}\right) = \beta_0 + \beta_1 + \cdots + \beta_n$

where the equation for calculating probability is: $\rho = \frac{e^{\beta_0+\beta_1+\cdots+\beta_n}}{e^{\beta_0+\beta_1+\cdots+\beta_n} + 1}$

Interpretability. Lasso regression and Logistic regression model outputs are not comparable and may only be analysed in isolation in terms of their magnitude, direction and statistical significance. Odds ratios are used for comparision of individual effects, with values over 1 suggesting an increased likelihood of failure with unit increases of the predictor.

LIMITATIONS

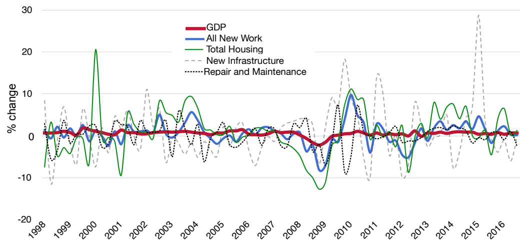
- **Annual accounts data and biases:** Lack of data coverage for micro and small firms result in under-sampling bias towards medium and large firms. Different types of financial information is subject to publication under the Companies Act, 2006, depending on firm size. Further research is suggested in order to specify prediction models which are more applicable to micro and small firms and account for their specific credit risks.
- **Binary classification of failure:** Although this study attempted to provide an objective definition of failure defined, different stages of failure have not been taken into consideration. The use of a linear classification rule (binary outcome: failed or non-failed) does not truly reflect the complex nature of the failure process.
- **Classification of business models:** The application of 2 digit SIC codes is an imperfect method for classifying business models. Further study is required to classify firms in groups according to their business models based on other measures, through clustering onncepts on important conceptual continuums such as: *make / buy* ratios, e.g. turnover to number of employees, cost of sales to remuneration; ratios related to receivables and payables; ratios identifying the financial structures; and more detailed 3-5 digit SIC code classifications.
- **Missing data:** Further work on data cleaning and missing data imputation is required in order to improve the predictive power of models (Ooghe and Balcaen, 2002). These approaches are most applicable where data can be considered as *missing at random*.

Full BSc Disseration - bit.ly/2kxl3KU

DEFINITION OF FAILURE

"Situations in which a company cannot pay lenders, preferred stockholders, suppliers, etc. or a bill is overdrawn, or the company is bankrupt according to law". (Ahn et al., 2000, p. 65)

Graph 2 - GDP Change v CI Output Change [Seasonally adjusted]



CATEGORIES OF UK CONSTRUCTION FIRMS

- **Main contractors** (SIC 41 - buildings, 42 - civil engineering) - Tier 1 contractors, who respond to demand to construct buildings and linear infrastructure. Volatile demand reduces their ability to maintain capacity or market share. Main contractors often act as the project and construction *manager*, subcontracting most of the works, as a means to protect against market volatility. Tier 1 firms tend to own only limited plant and equipment (forms of fixed asset) as most is leased, and directly employ small number of manual workers relative to turnover (Ball et al., 2000).
- **Specialist contractors** (SIC 43 - sub-contractors, Tier 2, 3 and lower level of supply chain) - these are *direct specialist contractors* (Ive and Gruneberg, 2000) who undertake work on numerous projects simultaneously, and thus achieve diversification across markets. Sub-contractors' key role is to work for the main contractors in the capacity of the *installer of* materials/plant/equipment often providing the labour.
- **Developers** (SIC 41100) - these are the customers of contractors output, commissioning the construction of buildings (such as residential, retail and industrial) and infrastructure. Developers' main role is to buy land and develop the site (Ive and Gruneberg, 2000).

Defining characteristics of construction contractors:

- Overoptimism about revenues arising from often applied percentage-of-completion method to forecast revenues on construction projects.
- High inventory ratio as contractors typically process large volumes of materials and supplies in comparison to other industries.
- Low level of fixed assets, in comparison to other firms which possesses land (such as developers), factories, equipment (including construction plant hire firms) or other durable assets, main contractors tend to have a larger portion of assets as current assets - trade debt and stock & WIP.
- High reliance on current liabilities arising from contractors use of short-term loans (Abidali and Harris, 1995) and business-to-business credit (Ive and Murray, 2013) to make payments for material, equipment, and labour.

DEVELOPERS

All models are of high reliability with minimum generalised R^2 of 71.4%. In years 2012 and 2014 the odds ratios for interest cover ratio (C5) are 0.765 and 0.885 respectively, indicating (with strong statistical significance) that a unit increase in interest cover ratio would reduce chances of failure by 76.5% and 88.5% respectively. In other words, the more profit a firm generates to pay interest, the lower are the chances of insolvency (Barkham, 1997). Developers have significantly lower interest cover ratios (C3) than other types of firms, resulting from more intensive use of debt to finance the purchase and long term ownership of land. A developer takes much longer to turnover over thier assets when compared to a contractor, often taking many years from purchase of land, through development and to final sale, so long term finance is essential.

- From the odds ratios for equity multiplier (LL3) for year 2009 it is evident that the more assets are financed by shareholders funds, the less likely such a firm was to fail (Arditi et al., 2000). The importance of shareholders funds as a source of finance is further supported when looking at return on shareholders funds (P4). In 2009, profitability helped finance operations and reduced likelihood of failure by around 25%.
- It is seen from 2012 and 2014 models, the older a firm is, the less likely it is to fail. This supports that with age a firm becomes more experienced in managing its finances. There is also an important auto correaltion here that with age of firm, comes growth and hence size - the larger a firm is the more likely it is to survive.

Table 3 - Summary of Odds Ratios for Models

	Odds Ratios for Logit Fit Models												
	Developers			Main Contractors			Sub-contractors			Civil Engineering			
	2009	2012	2014	2009	2012	2014	2009	2012	2014	2011	2012	2014	Count
L1	•	•	•	•	•	•	0.000	0.000	•	0.496	•	•	3
L2	•	•	•	∞	•	•	•	0.000	0.000	•	•	0.000	4
L3	•	0.412	•	∞	•	•	•	0.224	•	•	•	•	3
L4	•	0.000	•	0.000	•	•	•	•	∞	•	3.038	•	4
L5	•	•	∞	0.000	•	0.000	∞	∞	•	•	0.013	∞	7
L6	0.000	∞	•	•	∞	∞	•	•	•	•	•	•	4
C1	•	•	•	0.014	•	•	∞	•	0.000	•	•	•	3
C2	•	•	1.001	•	1.000	1.000	1.001	•	•	•	•	•	4
C3	∞	∞	∞	•	•	0.001	0.000	•	∞	0.000	•	0.000	8
C4	•	•	•	0.971	•	•	•	1.003	•	•	•	•	2
C5	•	0.765	0.885	0.980	•	•	0.309	•	0.934	•	•	•	5
C6	•	0.605	•	•	•	•	•	•	•	•	•	1.557	2
C7	•	0.308	•	1.220	•	•	•	•	1.402	•	•	•	3
C8	1.194	0.799	•	1.010	0.907	0.957	0.939	1.019	1.006	0.939	0.997	•	10
C9	•	0.651	0.943	1.028	•	•	•	1.023	•	0.847	•	0.918	6
C10	•	0.816	•	•	•	1.040	•	1.110	•	•	•	1.133	4
C11	•	0.000	•	•	0.000	0.000	•	∞	•	0.000	0.000	∞	7
E1	•	1.233	•	0.985	•	•	1.003	0.999	•	•	•	1.008	5
E2	•	0.001	•	∞	∞	•	∞	∞	•	0.040	•	•	6
E3	•	•	•	0.001	•	•	0.000	0.001	∞	•	•	•	4
E4	•	•	0.989	0.942	0.982	•	0.950	•	•	•	•	0.813	5
E5	•	1.451	•	0.704	•	1.120	1.625	1.133	0.049	•	•	•	6
LL1	•	•	•	0.001	∞	•	0.000	•	•	•	•	•	3
LL2	•	0.000	•	•	•	•	0.000	0.000	∞	∞	•	•	5
LL3	0.920	•	•	•	0.000	•	0.000	1.711	•	•	1.091	•	5
LL4	0.000	0.000	∞	0.000	1.697	1.947	0.000	0.000	0.000	•	•	•	9
LL5	0.000	0.000	•	0.000	•	•	0.000	0.000	0.000	∞	∞	•	8
P1	•	∞	•	0.000	•	0.000	0.000	0.000	∞	•	•	•	6
P2	2.618	0.000	•	∞	•	•	•	•	0.000	•	•	•	4
P3	•	0.000	•	∞	0.000	•	∞	•	0.000	•	0.119	•	6
P4	0.245	∞	•	•	•	∞	•	•	•	•	•	0.719	4
P5	•	•	•	•	•	•	•	•	•	0.472	•	0.587	2
P6	•	∞	•	•	∞	0.307	•	∞	∞	•	0.193	•	6
Age	•	0.209	0.699	1.032	0.820	1.092	•	0.859	•	0.695	0.610	•	8
Count	8	23	8	22	12	13	19	20	16	10	9	11	
R^2	75.7%	71.4%	80.0%	68.0%	78.5%	85.5%	66.1%	60.1%	73.0%	64.4%	70.1%	57.9%	

Table 4 - Summary of P-values of Variables for Models

	P-values (Statistical Significance) of Coefficients for Logit Fit Models												
	Developers			Main Contractors			Sub-contractors			Civil Engineering			
	2009	2012	2014	2009	2012	2014	2009	2012	2014	2011	2012	2014	Count
L1	•	•	•	•	•	•	0.00	0.04	•	0.77	•	•	3
L2	•	•	•	0.06	•	•	•	0.01	0.01	•	•	0.00	4
L3	•	0.01	•	0.01	•	•	•	0.43	•	•	•	•	3
L4	•	0.10	•	0.10	•	•	•	•	0.00	•	0.54	•	4
L5	•	•	0.03	0.18	•	0.07	0.00	0.05	•	•	0.06	0.00	7
L6	0.01	0.01	•	•	0.00	0.00	•	•	•	•	•	•	4
C1	•	•	•	0.03	•	•	0.03	•	0.00	•	•	•	3
C2	•	•	0.00	•	0.01	0.00	0.01	•	•	•	•	•	4
C3	0.00	0.01	0.00	•	•	0.01	0.07	•	0.00	0.03	•	0.05	8
C4	•	•	•	0.23	•	•	•	0.83	•	•	•	•	2
C5	•	0.04	0.01	0.36	•	•	0.00	•	0.00	•	•	•	5
C6	•	0.02	•	•	•	•	•	•	•	•	•	0.23	2
C7	•	0.07	•	0.05	•	•	•	•	0.10	•	•	•	3
C8	0.09	0.16	•	0.49	0.01	0.05	0.04	0.18	0.83	0.05	0.59	•	10
C9	•	0.00	0.40	0.28	•	•	•	0.49	•	0.00	•	0.05	6
C10	•	0.02	•	•	•	0.21	•	0.03	•	•	•	0.02	4
C11	•	0.01	•	•	0.00	0.00	•	0.21	•	0.00	0.00	0.03	7
E1	•	0.06	•	0.01	•	•	0.26	0.51	•	•	•	0.27	5
E2	•	0.04	•	0.01	0.12	•	0.00	0.11	•	0.01	•	•	6
E3	•	•	•	0.00	•	•	0.00	0.03	0.00	•	•	•	4
E4	•	•	0.10	0.13	0.11	•	0.11	•	•	•	•	0.01	5
E5	•	0.23	•	0.02	•	0.00	0.12	0.70	0.00	•	•	•	6
LL1	•	•	•	0.04	0.12	•	0.08	•	•	•	•	•	3
LL2	•	0.01	•	•	•	•	0.01	0.01	0.00	0.00	•	•	5
LL3	0.01	•	•	•	0.12	•	0.08	0.76	•	•	0.41	•	5
LL4	0.07	0.15	0.40	0.18	0.93	0.45	0.22	0.10	0.06	•	•	•	9
LL5	0.07	0.15	•	0.18	•	•	0.22	0.09	0.06	0.16	0.00	•	8
P1	•	0.01	•	0.01	•	0.00	0.01	0.11	0.00	•	•	•	6
P2	0.03	0.01	•	0.34	•	•	•	•	0.00	•	•	•	4
P3	•	0.01	•	0.01	0.00	•	0.00	•	0.04	•	0.54	•	6
P4	0.00	0.01	•	•	•	0.06	•	•	•	•	•	0.14	4
P5	•	•	•	•	•	•	•	•	•	0.67	•	0.12	2
P6	•	0.00	•	•	0.00	0.49	•	0.41	0.02	•	0.06	•	6
Age	•	0.00	0.01	0.42	0.00	0.13	•	0.05	•	0.00	0.00	•	8
Count	8	23	8	22	12	13	19	20	16	10	9	11	
R^2	75.7%	71.4%	80.0%	68.0%	78.5%	85.5%	66.1%	60.1%	73.0%	64.4%	70.1%	57.9%	

FACTORS AND VARIABLES

Selection of factors has commonly been dependent upon the following criteria: popularity, priority, cash-flow concept, relevancy and independence (Altman, 1968; Beaver, 1966; Sun et al., 2014).

Table 2 - Quantitative factors and variables

Factor / • Variable	Construction industry Relevance (* - Balance sheet ** - Profit & loss *** - Cash flow statement; ° - derived from other variables ⁺ - variable limited to ≥ 0 as core accounting principle)
Liquidity	Liquidity concerns the short-term financial position, covering firm expenses arising from material suppliers, sub-contractors and employees. This indicates to what extent financial obligations can be met without liquidating non-liquid assets (Horta *et al.* 2012; Horta & Camanho 2013). Inability to meet liabilities may lead to insolvency. A relatively high liquidity is required for construction firms as cash availability is vital for projects execution (Alaka *et al.*, 2016). Although liquidity factors might be poor predictors as an *early warning signs* (Altman, 1984), they are effective for near-immediate and immediate predictions.
	• (L1) *Current Ratio*⁺ = Current Assets* ÷ Current Liabilities* • (L2) *Liquid Ratio*⁺ = Liquid Assets° ÷ Current Liabilities*, where Liquid Assets = Current Assets - Inventory. • (L3) *Current Liabilities to Net Assets Ratio*⁺ • (L4) *Working Capital to Total Assets Ratio*⁺, where Working Capital = Current Assets* - Current Liabilities*. • (L5) *Liquid Assets to Total Assets Ratio*⁺ • (L6) *Receivables to Current Assets Ratio*⁺.
Cash Flow	The success of a construction firm depends on the success of projects within it's *portfolio* of works: therefore to be more solvent, a reasonable size of the firm's cash flow should be employed in operations and a reduced cash flow in investment (Arditi *et al.* 2000; Chen 2012). Additionally, *retentions* are held back from final and fill payment for potential omissions and/or defects in delivered work at various levels of the supply chain. Therefore, firms, from whom retentions are held (i.e. main contractors and sub-contractors), may find it difficult to recover expenses and record a profit before completion of works. A cash flow plan for operations is necessary to avoid extreme leverage (i.e. abnormal debt level), being cash strapped or having a negative cash flow, all of which risk the survival of the construction firm (Kale & Arditi 1999).
	• (C1) *Cash Flow Ratio* = Operating Cash Flow** ÷ Current Liabilities* • (C2) *Current Liquid Ratio* = 365 × ((Current Liabilities* - Liquid Assets) ÷ Operating Cash Flow***) • (C3) *Cash Flow Return on Total Assets* = Operating Cash Flow*** ÷ Total Assets* • (C4) Operating *Cash Flow to Debt Ratio* • (C5) *Interest Cover Ratio* = Profit before Interest and Tax** ÷ Interest Paid**. • (C6) Free Cash Flow to Operating Cash Flow Ratio • (C7) *Working Capital Needs to Working Capital Ratio* • (C8) *Receivables to Payables Ratio*⁺ • (C9) *Days' Receivables*⁺ = 365 x Receivables* ÷ Turnover* • (C10) *Days' Payables*⁺ = 365 x Payables* ÷ Turnover* • (C11) *Accruals to Current Liabilities Ratio*⁺
Efficiency	Efficiency indicates how well management use assets and leverage to generate output (Edum-Fotwe *et al.*, 1996; Thomas Ng *et. al.* 2011; Bal *et. al.* 2013). Construction activity is characterised as generating significant variable operating expenses, which becomes especially problematic for firms when they *'need to shrink and expand in cycle with the job market and competitive conditions'* (Arditi *et al.* 2000). The inability to manage down overheads can contribute to insolvency. Activity ratios demonstrate the management's ability to turn a firm's assets into cash (Ng *et al.* 2011), which in turn may be helpful in reducing insolvency risks.
	• (E1) *Working Capital Turnover*⁺ = Turnover** ÷ Working Capital*(Current Assets* - Current Liabilities*) • (E2) *Total Assets Turnover*⁺ = Turnover** ÷ Total Assets* • (E3) *Current Assets Turnover*⁺ = Turnover** ÷ Current Assets* • (E4) *Fixed Assets Turnover*⁺ = Turnover** ÷ Fixed Assets* • (E5) *Net Assets Turnover*⁺ = Turnover** ÷ Net Assets*
Leverage	Leverage ratios indicate long term solvency and therefore may be used as early warning signs (Horta *et al.* 2012). As construction works are paid for only when completed, contractors are exposed to high debt (leverage) as they may be required to pay their sub-contractors and suppliers before they themselves receive a payment; these debts make construction firms more likely to fail (Arditi *et al.*, 2000).
	• (LL1) *Total Liabilities to Net Assets Ratio*⁺ • (LL2) *Debt Ratio*⁺ = Total Liabilities ÷ Total Assets • (LL3) *Equity Multiplier*⁺ = Total Assets* ÷ Shareholders Funds* • (LL4) *Long Term Liabilities to Capital Employed Ratio*⁺ • (LL5) *Shareholders Funds to Capital Employed Ratio*⁺
Profitability	Insufficient profit is amongst the most common reasons for failure of construction firms (Arditi *et al.*, 2000). In part resulting from extremely aggressive bidding (pricing), based on far from accurate estimates and the *one-off* and *custom-made* nature of many construction projects. The higher the profitability of a firm is, the more solvent it is (Alaka *et al.*, 2016).
	• (P1) *Profit Margin* = Profit before Interest and Tax** ÷ Turnover* • (P2) *Operating Profit Margin* = Operating Profit** ÷ Turnover** • (P3) *Return on Total Assets (ROTA)* = Profit before Interest and Tax** ÷ Total Assets* • (P4) *Return on Shareholders Funds (ROSF)* = Profit after Interest and Tax** ÷ Shareholders Funds* • (P5) *Return on Working Capital* = Profit before Interest and Tax** ÷ Working Capital* • (P6) *Return on Capital Employed (ROCE)* = Profit before Interest and Tax** ÷ Capital Employed

MAIN BUILDING CONTRACTORS

Overall, all three models are highly reliable with minimum generalised R^2 of 68.0% in the year 2009. From odds ratios, for years 2012 and 2014 - an increased value for current liquid ratio (C2), indicating an increased likelihood of failure. This may be explained by considering the case when operating cash flow is reduced (leading to higher current liquid ratio) suggesting a weaker financial ability to cover liabilities.

- Models suggest that an increase in receivables to payables ratio (C8) would reduce risk of insolvency. Increases in receivables or a decrease in payables indicate lower risk of insolvency, resulting from increases in working capital (current assets - current liabilities) suggesting a better ability to finance the firm operations (Kenley, 2003).
- The more efficiently a firm can generate turnover from total assets (E2), the less likely it was to fail. With odds ratios of 0.942 in 2009 and 0.982 in 2012, this variable has a stable effect, but was not selected by the Lasso for the year 2014. Instead, in 2014 net assets turnover (E5) was selected, indicating with strong statistical significance that a unit increase in net assets turnover would increase risk on insolvency by a factor of 1.120 (a 12% increase in risk of insolvency). Increases in turnover alongside reductions in total assets can make it more difficult for firm to secure debt without adequate collateral.
- In years 2009 and 2012, the low odds ratios for profit margin is witnessed, with strong statistical significance (p-values of 0.008 and 0.000) indicating that increased profitability would greatly decrease insolvency risk.

CONCLUSIONS

Through analysis of 12 models (1 for each 4 types of firms within their sub-industries over 3 time periods) the following conclusions are reached:

- **Time dimension of failure:** Different variables are prioritised by the Lasso technique for predicting failures at different periods, potentially reflecting market conditions. A unified model applied over the business cycle without regard to time dependent effects of failure (including unique events such as the GFC) will lead to sub-optimal predictions as echoed by (Balcaen and Ooghe, 2006). It should be noted that some predictors (C3, E2, C8, LL4, P3) were selectedby the Lasso technique more often than others, contributing consistently to the power of models in varying periods. Changes in exogenous factors such as the competitive nature of the market, sectoral changes in the use of technology and the different phases of the business cycle clearly influence which variables are best able to predict failure (Wood and Piesse, 1987).
- **Specific business model characteristics:** There is noticable consistency in the range of variables selected by the Lasso technique for predicting failures within the different business model types. This suggests the underlying differences in the economic characteristics between business models are reflected in the prediction models (Chava and Jarrow, 2004; Kaplinski, 2008). For example, profitability related variables were infrequently selected for civil engineering contractors. Other factors seem more important for their businesses, for example the proportion of accruals within their current liabilities (C11). The age variable was selected for all 3 models for main contractors indicating the importance of managerial and operational strategy experience within the *buy* business model, where work is sub-contracted and managed rather than completed *in-house*.

The overarching finding concerns success in identifying common factors of failure through the application of artificial intelligence methods of predictor selection, particularly Lasso approaches. This method proved particularly valuable when considering the predictive capability of large numbers of financial ratios. More specifically, a key finding concerns the notable variance in predictor selection through time, as well as observing their relevance change as much within sub-industries as between them.

Please refer to BSc Dissertation for full list of references.