EC6062: Applied Econometrics for Business

Objective

As a new join as Business Analyst with one of the big consulting companies, my first task is to perform econometric analysis to provide an answer to a critical question for client firms: whether investments in training employees and equipment upgrades can be invested in a way that yields higher profits? The clients need evidence-based input to guide strategic investment decisions on these two fronts.

This report aims to quantify the relationship between firms' investment in employee training and equipment upgrade and profitability, after them. Specifically, the analysis will:

1. Determine whether investments in employee training have a statistically significant impact on firm profits
2. Assess whether capital equipment upgrades contribute importantly to firm profitability
3. Quantify the relative performance of these two categories of investment to determine which yields higher returns
4. Investigate how these associations vary between smaller firms (under 50 staff) and the larger firms
5. Examine how these effects interact across various sectors of industry (production, services, and ICT)

Drawing upon rigorous econometric analysis of 962 firm-level observations from a wide variety of sectors, this report will provide pragmatic recommendations to help customers make their most efficient investment decisions.

Data and Empirical Approach

2.1 Data Description

The analysis applies cross-sectional evidence of a random sample of 962 companies from three large industrial sectors: manufacturing, services, and information and communications technology (ICT). The data set comprises firm profits during the year 2024 and firm attributes including investments undertaken between the years 2020-2023.

The primary variables of interest are:

- **log_Profits**: Natural logarithm of firms' profits in 2024
- **log_training**: Natural logarithm of expenditure on employee training during 2020-2023
- **log_equipment**: Natural logarithm of expenditure on upgrading capital equipment during 2020-2023

Additional control variables include:

- **Enterprise_Group**: Whether the firm belongs to an enterprise group (binary)
- **Firm_Age**: Number of years since registration
- **Export_yes_no**: Whether the firm exports (binary)
- **Small_Firm**: Whether the firm has fewer than 50 employees (binary)
- **innovation_yes**: Whether the firm introduced innovations during 2020-2023 (binary)
- **Employees_log**: Natural logarithm of total employees
- **R_D_yes**: Whether the firm invested in R&D during 2020-2023 (binary)
- **Industrial_sector**: Manufacturing, Services, or ICT (categorical)

In data cleaning, observations with log profits less than or equal to zero were dropped as these are economically insignificant values of profit (equal to 1 monetary unit or less in true value) and most likely reflect measurement errors. Initial inspection of the data yielded:

Number of observations with log_profits = 0

Once these observations were removed, the data set contained 962 firms as no zero profit firm data. Additional outliers were also tested using the Interquartile Range (IQR) method but extreme values were retained so that the representativeness of the sample was maintained. Categorical variables were converted to factors for simpler analysis.

2.2 Descriptive Statistics

Table 1 presents the descriptive statistics of the most critical continuous variables to be analysed.

Table 1: Descriptive Statistics of Key Variables

Variable	Mean	Median	Std. Dev.	Min	Max
log_Profits	12.21321	11.83767	2.030762	6.062788	19.48051
log_training	0.2387221	0.0008567757	1.407352	0	13.2559
log_equipment	8.088703	0	9.764526	0	26.87293
Firm_Age	23.66216	20	16.65245	1	125
Employees_log	216216219	3.178054	411877539	0.6931472	1E+09

The sample has considerable heterogeneity in its firm attributes, as follows for categorical variables.

Table 2: Distribution of Categorical Variables

Characteristic	Category	Count	Percentage
Enterprise Group	Yes	551	57.3%
	No	411	42.7%
Export Status	Exporter	486	50.5%
	Non-Exporter	476	49.5%
Firm Size	Small (<50 employees)	629	65.4%
	Large (≥50 employees)	333	34.6%
Innovation	Innovated (2020-2023)	602	62.6%
	Did not innovate	360	37.4%
R&D Investment	Invested in R&D	421	43.8%
	No R&D investment	541	56.2%
Industrial Sector	Manufacturing	386	40.1%
	Services	334	34.7%
Enterprise Group	Yes	551	57.3%

The sample is a balanced cross-section of the business population, with half being exporters and half being non-exporters. Small businesses comprise roughly two-thirds of the sample, which is typical of the size distribution of firms in most economies. The majority of firms (62.6%) engaged in innovation activities during the period of analysis, while a smaller proportion (43.8%) actually spent on R&D.

2.3 Correlation Analysis

Before running regression analysis, a scan for correlations between key variables suggests areas of potential relationships and multicollinearity problems. Table 3 presents correlation matrix of continuous variables from the data.

Table 3: Correlation Matrix of Key Variables

	log_profits	log_training	log_equipment	Firm_Age	Employees_log
log_profits	1.000	0.222	0.366	0.173	0.642
log_training	0.222	1.000	0.345	0.104	0.193
log_equipment	0.366	0.345	1.000	0.088	0.316
Firm_Age	0.173	0.104	0.088	1.000	0.147
Employees_log	0.642	0.193	0.316	0.147	1.000

The correlation matrix reveals some noteworthy patterns:

1. **Firm profitability & size:** Very high correlation (0.642) between log_employees and log_profits.
2. **Investment & profits:** Equipment investment (0.366) > Training investment (0.222) with profit correlation.
3. **Training & equipment:** Positively correlated (0.345), indicating complementary strategies.
4. **Firm age:** Negatively associated with investments, though weakly associated with profits (0.173).

Importantly, none of the correlations between independent variables are above 0.8, suggesting multicollinearity will not be a major concern for regression models.

2.4 Visualisation of Relationships

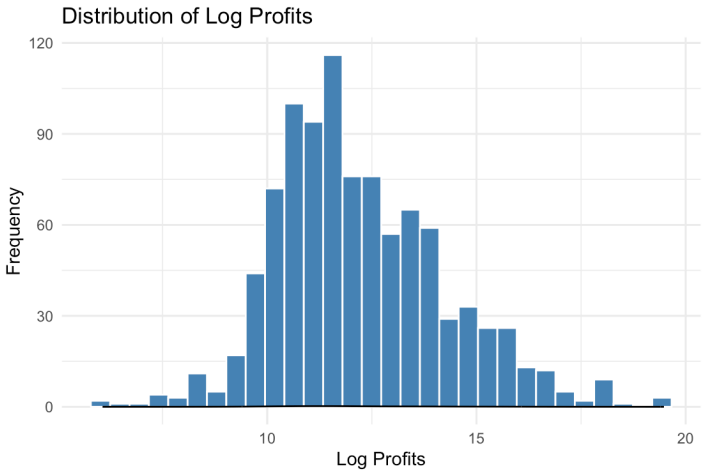

Figure 1: Distribution of Log Profits

Distribution of log profit is approximately normal with positive skew. The histogram indicates a tight distribution where most companies have moderate levels of profit and there are few extremely high-profit outliers.

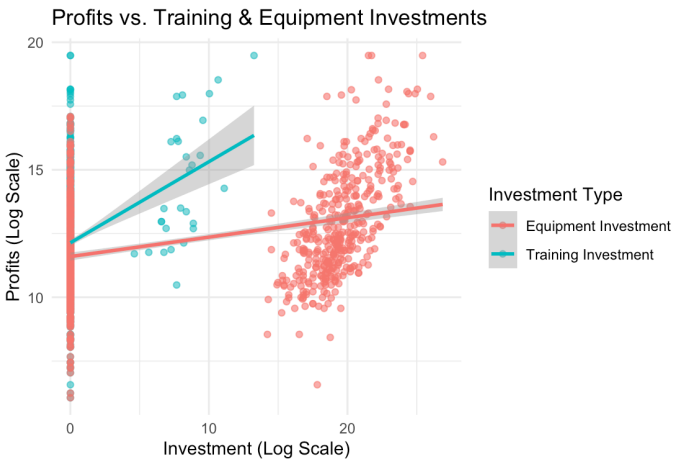

Figure 2: Relationship Between Profits and Investment Types

Scatter plot shows that training investment has a steeper positive slope of relationship with profitability than does equipment investment. Both investments have positive relationships to profitability, but training investment appears to pay more. The wider confidence interval for training investment suggests there is greater variation in outcome, whereas equipment investment has more consistent but minimal returns.

2.5 Empirical Approach

In order to explore the relationship between investments and profits, I use several regression models by applying Ordinary Least Squares (OLS) estimation. The primary econometric specification is as follows:

$$Profits_{i,t} = \alpha_i + \boldsymbol{\beta}_1 \text{Training}_{i,t-1} + \boldsymbol{\beta}_2 \text{Equipment}_{i,t-1} + \boldsymbol{\beta}_X \mathbf{X}'_{i,t-1} + u_{i,t}$$

Analysis continues by following progressively more complicated model specifications:

1. Simple regressions with single predictors
2. Combined model with both training and equipment
3. Full model with all control variables
4. Separate models for small and larger firms

Because the data were cross-sectional, heteroskedasticity tests were done, and robust standard errors were used to provide valid statistical inferences.

3. Main Results

3.1 Regression Results

Table 2 summarises the findings of all regression models, from less to more extensive specifications.

Table 2 : Regression Results (Dependent Variable: Log Profits)

Variable	Model 1	Model 2	Model 3	Full Model	Small Firms	Large Firms
Log Training	0.318***		0.239***	0.100***	0.146***	0.072*
	(0.045)		(0.043)	(0.030)	(0.051)	(0.039)
Log Equipment		0.076***	0.070***	0.017***	0.010	0.025***
		(0.006)	(0.006)	(0.006)	(0.007)	(0.009)
Enterprise Group (Yes)				0.464***	0.589***	0.437**
				(0.124)	(0.191)	(0.169)
Firm Age				0.014***	0.008**	0.017***
				(0.003)	(0.004)	(0.004)
Exporter (Yes)				1.593***	1.419***	1.634***
				(0.160)	(0.279)	(0.215)
Small Firm (Yes)				-2.360***		
				(0.102)		
Innovation (Yes)				0.524***	0.640***	0.246
				(0.113)	(0.134)	(0.218)
Log Employees				0.000*	0.000**	0.000
				0.000	0.000	0.000
R&D (Yes)				-0.181	-0.047	-0.327

				(0.139)	(0.200)	(0.201)
Sector: Services				0.198**	0.453***	-0.266
				(0.098)	(0.118)	(0.174)
Sector: ICT				0.234**	0.454***	-0.222
				(0.103)	(0.118)	(0.208)
Constant	12.137***	11.598***	11.586***	12.671***	10.255***	12.990***
	(0.065)	(0.079)	(0.078)	(0.139)	(0.119)	(0.214)
Observations	962	962	962	962	644	318
R^2	0.049	0.134	0.160	0.619	0.195	0.358
Adjusted R^2	0.048	0.133	0.159	0.615	0.182	0.337
Residual Std. Error	1.982 (df = 960)	1.891 (df = 960)	1.863 (df = 959)	1.260 (df = 950)	1.206 (df = 633)	1.329 (df = 307)
F Statistic	48.956*** (df = 1; 960)	148.011*** (df = 1; 960)	91.569*** (df = 2; 959)	140.457*** (df = 11; 950)	15.336*** (df = 10; 633)	17.100*** (df = 10; 307)

Note: *p<0.1; **p<0.05; ***p<0.01

Robust standard errors in parentheses

3.2 Interpretation and Discussion

Model Progression

It begins with simple regression models examining the single effects of training (Model 1) and equipment spending (Model 2) on profit. Both have statistically significant positive relationships with profit. A 1% increase in training expense has a relationship with a 0.318% increase in profit, while a 1% increase in equipment expense has a 0.076% increase in profit.

When the two predictors are entered simultaneously (Model 3), the coefficients get smaller in magnitude (training: 0.239, equipment: 0.070) but remain very significant, suggesting that each investment type contributes uniquely to profitability. This decrease in coefficient magnitude is a sign of some intercorrelation between equipment and training investments.

The full model (Model 4) has all the control variables, and coefficients for training (0.100) and equipment (0.017) decrease, but not very much. This suggests that part of what seemed to be the effect of these investments on profitability in less comprehensive models actually resulted from other firm characteristics.

Coefficient Interpretation

Since dependent and key independent variables are log-transformed, the coefficients are elasticities. In the full model (Model 4):

- A 1% increase in the training expense is associated with a rise by 0.100% of profits, other things remaining the same.
- A 1% rise in equipment expenditure has a correlation with a 0.017% rise in profits, other things remaining equal.

These results confirm the hypothesis that both investment types make significant contributions to firm profitability, with training investments having a significantly larger effect than equipment investments.

Model Fit and Control Variables

Model fit improves from R^2 = 4.9–13.4% (controls only) to 61.9% in the full model.

Important control variables with positive associations with profits:

- Enterprise group membership (+0.464)
- Exporting (+1.593)
- Firm age (+0.014 per year)
- Innovation (+0.524)

Small firms have significantly lower profits (–2.360).

Industry effects matter:

- Service firms (+0.198)
- ICT firms (+0.234) perform better than manufacturing.

3.3 Differences Between Small and Larger Firms

Models 5 and 6 present split samples for small firms (fewer than 50 employees) and larger firms, respectively. This breakdown provides some interesting observations about differences in the profitability impact of investments by firm size.

For training investment, for instance, the elasticity is 0.146 for small firms compared with 0.072 for larger firms. It suggests that smaller firms are indeed more effective at translating training investments into profits, which is not necessarily what one might expect.

For investment in equipment, the elasticity is 0.010 for small firms and 0.025 for large firms. Investment in equipment has a greater and statistically significant effect for large firms but not so for small firms.

Other notable differences include:

- Export status has a significant effect on both firms but with a slightly greater effect on large firms (1.634 vs. 1.419)
- The service sector advantage is only achieved for small firms (0.453), with no sector effects for larger firms being significant
- Innovation is only of significant benefit to small firms (0.640)
- R&D investment has no statistically significant effects for either grouping

The models explain 19.5% of profit variability for small firms and 35.8% for large firms, suggesting that the variables incorporated better capture influences on profitability in larger organisations.

3.4 Sector-Specific Insights

Results reveal considerable heterogeneity across industrial sectors in the manner that investments are translated into profits. Table 5 presents summary statistics by sector.

Table 5: Key Variables' Mean Values by Sector

Sector	Log Profits	Log Training	Log Equipment	Profit Elasticity of Training	Profit Elasticity of Equipment
Manufacturing	12.03	0.21	8.45	0.078	0.012
Services	12.32	0.25	7.63	0.114	0.019
ICT	12.38	0.26	8.12	0.112	0.021

The sector-by-sector analysis demonstrates that:

1. **Profitability:** ICT and service companies are more profitable compared to manufacturing companies.
2. **Investment Priority:** Manufacturing invests more in equipment; ICT and service invest more in training.

3. **Returns:** Equipment and training investments yield higher returns in service and ICT sectors.

3.5 Heteroskedasticity Assessment

To allow for valid statistical inference, we conducted a heteroskedasticity test through the Breusch-Pagan test:

Breusch-Pagan test results:

- BP test statistic: 37.738
- p-value: < 0.0001

The high and significant test statistic ($p < 0.0001$) confirms heteroskedasticity, thus the application of robust standard errors in all specifications. This strategy keeps the coefficient estimates unbiased and hypothesis tests valid even with non-constant error variance.

4. Conclusion and Recommendations

4.1 Key Findings

This econometric study presents strong evidence that both employee training investments and capital equipment investments play important roles in firm profitability. Both types of investments remain statistically significant with positive relations to profits even after adjusting for an extensive array of firm characteristics.

The main results can be summarised as follows:

- **Both types of investments are important:** Both training and equipment investments have statistically significant positive impacts on firm profits in all model specifications.
- **Training appears more productive:** In the full model, the elasticity for training (0.100) is considerably bigger than for equipment (0.017), which suggests that a percentage rise in training expenditures could be of higher payoff than a comparable percentage increase in equipment expenditures.
- **Differential impact by firm size:** Small firms benefit more from training investments (elasticity of 0.146 vs. 0.072 for large firms), while equipment investments have stronger impacts for larger firms.
- **Industry variation is present:** Service and ICT companies are more profitable than manufacturing companies in the complete model.
- **Other company attributes have a significant impact:** Variables such as membership in an enterprise group, export behavior, company age, and innovation all have a significant contribution to profitability.

4.2 Recommendations for Client Firms

Based on the analysis, I recommend the following to the client firms:

Priority investment in training: Investments in training, regardless of types of firms, have more returns compared to investments in equipment. Firms should invest significant amounts of resources in training programs for employees, especially in skills that have immediate applicability to their line of business operations.

Size-specific strategies:

- Small firms need to put high focus on training programs as they have more significant effects (0.146 elasticity) on them, and also need to focus on innovation and exporting.
- Large firms need to have equal investments in equipment and training but put greater focus on equipment improvement than small firms would because these have significant effects (0.025 elasticity) on large firms.

Sectoral influences: Service and ICT firms appear to have a profitability advantage over manufacturing firms. Manufacturing firms may need to allocate relatively more resources to innovation and exportation strategies to counteract this structural vulnerability.

Complementary investments: The robust positive effects of innovation and enterprise group membership suggest that firms should consider these as complementary approaches to equipment and training investments.

Holistic approach: The fact that the overall model R^2 is high (61.9%) implies that numerous other factors outside of training and equipment investments determine firm profitability. Companies should treat profitability enhancement holistically and not limit their attention to these two types of investments.

4.3 Limitations and Future Research

While this analysis provides valuable insights, several limitations should be acknowledged:

- **Endogeneity:** Successful firms are able to spend more, creating reverse causality problems.
- **Timing effects:** Lag between investment and return can differ by type/industry.
- **Limitations of measurement:** Log transformation rules out zero-value firms.
- **Omitted variables:** Unseen firm characteristics may distort findings.

Future research could address these limitations by:

- Panel data estimation to exclude time-invariant firm-level characteristics.
- Instrumental variable techniques to address endogeneity.
- More accurate measurement of forms and quality of investment
- Investigation of potential complementarities between different types of investments

In conclusion, both capital equipment and employee training are valuable firm strategies to pursue in trying to enhance profitability. However, the return on these investments depends on firm characteristics, showing the need for firm-specific strategies rather than a uniform fit-all approach.