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Profitability Modelling of Small Automotive Repair Enterprises Through Optimisation of Internal Operational Processes and Energy Efficiency

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Abstract: Small automotive repair enterprises operating in Ukraine's transitioning economy face wartime power interruptions, the enterprise's contracted electricity price and tariff category, and cost pressure that can erode narrow margins. This study developed an integrated profitability model in which order-level operational and energy variables were estimated together with a control for power-supply interruptions. Its novelty is the joint treatment of operational efficiency, energy use and external supply conditions rather than their analysis as separate influences. Multiple linear regression and scenario analysis were applied to 847 service orders from one Kyiv enterprise over 12 months. Labour input was the most prominent operational predictor; cycle time, downtime, materials cost, energy consumption, the energy cost ratio and power-supply interruptions were also statistically significant. The integrated model explained 73.4% of within-sample variance (R^2 = 0.734; adjusted R^2 = 0.730). The Breusch-Pagan test indicated no evidence of heteroscedasticity (χ^2 = 12.34, p = 0.19), the Durbin-Watson test indicated no evidence of autocorrelation (d = 2.01, p = 0.45), and all VIF values were below 1.15, indicating no multicollinearity concerns. The Shapiro-Wilk test for normality of residuals was not significant (W = 0.98, p = 0.12), and the Ramsey RESET test indicated no evidence of misspecification (F = 1.23, p = 0.30). A 20% reduction in cycle time and downtime increased predicted margin by 2.40 percentage points; adding a 15% reduction in energy consumption raised the estimated gain to 3.13 percentage points. Because the observations are service orders from a single firm, the results are associational and do not represent independent enterprises. Nevertheless, the modelling and scenario

framework provides a structured basis for enterprise-level decision analysis and can be tested, with sector-specific recalibration, in other service industries and transitioning economies.

Keywords: cost optimisation, energy efficiency, net margin, operational processes, profitability modelling, small enterprise, transitioning economy.

Introduction

Small automotive repair businesses form part of the local service economy by providing vehicle maintenance and repair services to private owners and commercial fleet operators. Their profitability is shaped by the combined effects of labour use, process delays, materials costs and energy expenditure. These features justify examining operational and energy variables together at enterprise level.

Research Problem

Small automotive repair businesses must innovate to remain competitive. Drucker (1985) described innovation and entrepreneurship as systematic practices applicable not only to new ventures but also to established organisations adapting to change. For small repair enterprises, this need is particularly evident when rising operating costs and resource constraints require changes in work organisation, equipment use and service delivery.

The profitability of small automotive repair businesses warrants analysis for several interconnected reasons. Energy prices and supply reliability affect operating costs, while changing technologies and customer requirements require adjustments to processes and resource allocation. Energy-efficiency research also shows that adoption decisions depend on prices, financing constraints, information and policy incentives (Gillingham & Palmer, 2014; International Energy Agency, 2024). Recent evidence indicates that rising energy prices are associated with reduced firm-level profitability in the European Union and with weaker financial performance among European firms exposed to the war-related energy shock (Ferriani & Gazzani, 2023; Herman et al., 2023). Small-enterprise owners therefore need transparent tools for assessing how operational and energy changes may affect profit.

The research gap concerns the limited integration of operational, energy and financial measures in the analysis of small service enterprises. Established performance research treats firm performance as multidimensional and cautions against reliance on a single measure (Murphy et al., 1996), whereas lean research mainly emphasises process design and operational performance (Bhamu & Sangwan, 2014; Shah & Ward, 2003). Energy-efficiency research, in turn, focuses on barriers, incentives and energy savings (Gillingham & Palmer, 2014; International Energy Agency, 2024). Recent enterprise-level studies similarly stress that small-firm profitability depends on heterogeneous cost structures and institutional conditions rather than on a single measure, and that these determinants can differ markedly between small and large firms (Ayambila, 2023; Kafouros et al., 2022; Serrasqueiro et al., 2023). These strands do not provide a directly applicable model linking order-level operational variables, energy use, power-supply disruptions and net margin in a small automotive repair enterprise. This study addresses that specific gap.

This issue is particularly relevant to Ukraine during the observation period (June 2025 – May 2026), when small and medium-sized enterprises across the country continued to report wartime disruption to liquidity, operating costs and power supply (Dligach & Stavytskyy, 2024; Shcherbak et al., 2026). Enterprise records showed power-supply interruptions and changes in billed energy costs. At enterprise level, power-supply interruptions increased downtime, while changes in energy charges affected the energy cost ratio. The power-supply regime was therefore included in the empirical model as a measurable contextual variable. Tariff category and access to support schemes were recorded descriptively but could not be estimated because they did not vary during the observation period. Decentralised and renewable generation has been identified as a means of mitigating outage-related losses for Ukrainian enterprises, although its adoption remained limited among small businesses during the observation period (Shahini et al., 2024; Tröndle et al., 2024).

The novelty of the present study lies in combining energy-efficiency and operational factors within a single quantitative model while accounting for power-supply conditions. This approach captures their joint associations, which single-factor models cannot represent. Whereas previous studies have examined operational efficiency and energy use separately, the present findings suggest that their associations with profitability are complementary rather than competing. Recent applications of lean and energy-efficiency frameworks to small and medium-sized enterprises support the plausibility of pursuing operational and energy improvements jointly (Cagno et al., 2022; Qureshi et al., 2022). The integrated approach has implications for academic research and enterprise-level decision-making in transitioning economies.

Research Focus

This study examines the relationship between internal process organisation, energy consumption and the profitability of small automotive repair enterprises within the regulatory environment of a transitioning economy. It focuses on how reductions in process losses, measured through cycle time, downtime and labour productivity, and lower energy intensity relate to measurable improvements in net margin. These relationships are assessed using data from an operating business to derive findings that may inform business decisions. The quantitative design uses multiple linear regression to estimate the marginal associations of operational and energy variables with profitability, with the power-supply regime included as a contextual control, followed by scenario analysis to demonstrate the model's potential application to forecasting.

Research Aim and Research Questions

In a transitioning-economy setting, unscheduled power-supply interruptions were treated as a contextual control. Tariff category and participation in support schemes were described but not estimated because neither changed during the observation period. The study aimed to estimate an integrated order-level profitability model linking cycle time, downtime and labour input with energy consumption and the energy cost ratio. The model is intended to inform operational and energy-efficiency investment decisions.

Five questions structured the analysis:

1. What associations do cycle time, downtime and labour input have with the net margin of a small automotive repair business?
2. How are improvements in energy efficiency, measured by energy consumption per operation and the energy cost ratio, quantitatively related to profit?
3. How much within-sample variation in net margin is explained by the integrated model, and how should its fit be interpreted in a single-enterprise case?
4. How do profitability forecasts differ across operational and energy scenarios, and what are the implications for enterprise owners?
5. What role does the power-supply regime, measured as hours of unscheduled downtime per month, play as a contextual control variable in the profitability model for a transitioning economy?

Literature Review

According to resource-based view (RBV) theory, firm-specific capabilities, particularly operational expertise and managerial competence, are potential sources of competitive advantage and financial performance (Barney & Hesterly, 2021). The profitability of a small service business depends on interacting operational, financial, environmental and regulatory factors. This review therefore addresses four themes: the profitability of small service enterprises; operational process optimisation in service enterprises; energy efficiency in service operations; and quantitative profitability modelling. The research gap is summarised at the end of the review. Institutional theory complements the resource-based view by explaining how institutional frameworks and external constraints shape organisational behaviour and performance (North, 1990; Scott, 2014). Together, these perspectives provide a theoretical basis for treating internal operational capabilities and external power-supply conditions as distinct but related influences on enterprise performance.

Net margin was chosen as the outcome rather than as a complete measure of enterprise performance. It captures revenue and operating expenditure for each order, while the inclusion of operational, energy and supply variables reflects the multidimensional view of performance described by Murphy et al. (1996). Few enterprise-level specifications combine all three groups for small service firms.

Operational Process Optimisation

The development of lean thinking has been extensively documented, from its origins in the Toyota Production System (Ohno, 1988; Shingo, 1989) to broader formulations of lean thinking (Womack & Jones, 2003). The principles of the Toyota Way emphasise continuous improvement and respect for people (Liker, 2004). Holweg (2007) traced the genealogy and diffusion of lean production. Shah and Ward (2003) examined lean as a multidimensional set of operational practices, while Bhamu and Sangwan (2014) reviewed the definitions, methods and research issues in the lean-manufacturing literature. Pettersen (2009) further identified conceptual and practical ambiguities in definitions of lean production. Modig and Åhlström (2012) described the efficiency paradox and distinguished resource efficiency from flow efficiency.

Lean principles were translated into case-specific measures of cycle time, non-value-adding delay and work standardisation (Ohno, 1988; Womack & Jones, 2003). Because automotive service orders differ in complexity and customer requirements, the scenarios use observed enterprise data rather than assumed sector-wide improvements.

Labour hours, cycle time and downtime were retained because they measure resource use, throughput and delay at order level. Their coefficients were estimated from the enterprise records; no external performance benchmark was imposed.

Operational and energy performance need not change in the same direction. A shorter job may require fewer equipment-hours, yet a higher processing rate may concentrate electricity demand. The analysis therefore estimates additive coefficients and reports the observed bivariate relationship without claiming an interaction. Testing effect modification would require formal interaction terms (Aiken & West, 1991; Cohen et al., 2003).

Energy Efficiency in Service Operations

Evidence on energy-efficiency adoption points to prices, access to finance, information and policy incentives (Gillingham & Palmer, 2014). The International Energy Agency (2024) also treats energy intensity, investment and policy as connected. At firm level, equipment mix, operating hours and local supply conditions determine whether lower energy use improves financial performance; both kWh per order and energy cost as a share of revenue were therefore measured.

In automotive repair enterprises, energy use may arise from lighting, space conditioning, compressed-air systems, diagnostic equipment and power tools. The relative contribution of these uses varies with the service mix, facility and operating schedule. Energy-efficiency measures can lower expenditure, but their financial effect depends on the applicable price, utilisation, investment cost and realised savings. Accordingly, the present study uses measured energy consumption per order and the energy cost ratio rather than generic savings or payback assumptions. The scenario analysis applies only the reductions specified in the Methods section.

The strategic-management literature also supports attention to adaptation under difficult external conditions. Covin and Slevin (1989) examined how strategic posture relates to small-firm performance in hostile and benign environments. Drucker (1985) treated innovation and entrepreneurship as systematic practices of opportunity identification and resource deployment. These perspectives support analysing operational and energy decisions as managerial responses to constraints without implying causality beyond the present data.

The relationship between energy efficiency and profitability varies across regions and enterprises because energy prices, energy intensity and investment costs differ. Improvements may therefore yield larger financial gains in enterprises with higher energy expenditure, although realised returns remain dependent on operating conditions and the cost of the intervention (Gillingham & Palmer, 2014; International Energy Agency, 2024). These contextual differences support enterprise-specific modelling based on local conditions rather than industry-wide generalisations.

Regulatory and market conditions further shape the relationship between energy efficiency and profitability. Energy prices, access to information, financing arrangements and policy instruments affect the incentive to invest in efficiency (Gillingham & Palmer, 2014; International Energy Agency, 2024). In the present study, tariff category and participation in support schemes were recorded but remained constant and were therefore not estimated as predictors. Power-supply interruptions varied during the observation period and were included as the contextual control.

Quantitative Profitability Modelling

Quantitative enterprise analysis can employ regression, scenario analysis, simulation or machine-learning methods. Multiple regression was selected here because it provides directly interpretable estimates of the marginal association between each predictor and net margin while holding the remaining variables constant. Established econometric and regression texts provide the basis for model specification, diagnostics and interpretation (Greene, 2018; Montgomery et al., 2021).

No single statistic establishes model quality. The present assessment therefore combines coefficient uncertainty, R^2, adjusted R^2 and information criteria, while treating all fit measures as specific to the observed enterprise data (Greene, 2018; Montgomery et al., 2021).

Taken together, prior research supports a parsimonious integrated specification. Performance scholarship justifies multiple dimensions (Murphy et al., 1996), lean studies inform the operational measures (Bhamu & Sangwan, 2014; Shah & Ward, 2003), and energy-economics evidence identifies price and policy influences (Gillingham & Palmer, 2014; International Energy Agency, 2024). Their joint relationship with order-level net margin under power-supply disruption remains insufficiently tested.

Identified Gap

The unresolved question is whether operational losses, energy use and power-supply interruptions remain associated with margin when estimated in the same model for one automotive service enterprise in a transitioning economy. The present study addresses that question with order-level regression and scenario analysis.

The review drew on Scopus, Web of Science and Google Scholar searches combining profitability modelling, small enterprise, automotive repair, operational efficiency, energy efficiency, regulatory impact, transitioning economy and tariff regulation. The sources were used to define constructs, choose variables and specify the analysis.

Materials and Methods

Sample and Participants

KI Detailing Service LLC was the sole case. It provides mobile cleaning, paintwork-correction and light-repair services to private and fleet customers in Kyiv, Ukraine. Between June 2025 and May 2026, 870 orders were completed and screened for analysis.

The author's listed United States address is a correspondence address. The empirical setting is the Kyiv operating site of KI Detailing Service LLC, which the author owns; all service-order, energy and financial records analysed here relate to its Ukrainian operations.

The case met four practical criteria: fewer than 50 employees and turnover below €10 million; complete operational, financial and power-supply records; permission to use the records; and sufficient order-level detail to derive the model variables. The business employed eight technicians and two administrative staff. Revenue for the 847 included orders totalled approximately $578,365 ($682.84 per order).

All 870 orders completed in the defined 12-month window were screened. Twenty-three (2.6%) were excluded because operational or energy data were incomplete, leaving 847 orders. This census of eligible orders reduces within-case selection but does not turn the observations into independent enterprises.

Instruments and Procedures

The full annual window was retained to cover seasonal changes in demand and operations.

The effective electricity price used for order-level allocation was calculated from the enterprise's energy bills and averaged $0.12 per kWh during the observation period. Energy consumption was allocated to individual orders using the enterprise's sub-metering system, which logs consumption by service bay and apportions it according to the duration of work on each order. Regulatory data were obtained from the enterprise's energy bills, which documented its contracted electricity price and tariff category, and from its register of participation in energy-efficiency support initiatives; the enterprise did not participate in any such initiative during the observation period. Data on the power-supply regime were obtained from Ukrenergo reports on scheduled and unscheduled power outages during the observation period.

Data cleaning comprised: (a) verification of all entries against source documents; (b) identification and review of outliers using the interquartile-range method, with values beyond 1.5 × IQR flagged; (c) retention of all flagged values because they were confirmed as legitimate; and (d) listwise deletion of missing observations, which represented 2.6% of the data.

Data Analysis

Ordinary least squares estimation followed Greene (2018) and Montgomery et al. (2021). Potential interactions were considered using Aiken and West (1991) and Cohen et al. (2003), but the final specification remained additive.

Analysis began with means, standard deviations and percentiles, followed by model estimation and scenario calculations. Net margin was the dependent variable. Cycle time, downtime, labour hours and materials cost represented operations; energy consumption per order and the energy cost ratio represented energy performance. Monthly hours of unscheduled power interruption represented the external supply regime. Tariff category and support-scheme participation were described but excluded from regression because both were constant. Order complexity, technician experience and quarter were introduced as controls. All calculations were performed in R (R Core Team, 2024).

The regression model was specified as follows:

$$Net\ Margin_i = \beta_0 + \beta_1(Cycle\ Time_i) + \beta_2(Downtime_i) + \beta_3(Labour\ Hours_i) + \beta_4(Materials\ Cost_i) + \beta_5(Energy\ Consumption_i) + \beta_6(Energy\ Cost\ Ratio_i) + \beta_7(Power\ Supply\ Regime_i) + \beta_8(Complexity_i) + \beta_9(Experience_i) + \beta_{10}(Season_i) + \varepsilon_i$$

Diagnostic tests performed included: (a) Breusch-Pagan test for heteroscedasticity; (b) Durbin-Watson test for autocorrelation; (c) Variance Inflation Factor (VIF) for multicollinearity; (d) Shapiro-Wilk test for normality of residuals; and (e) Ramsey RESET test for model specification. Model validation was conducted using 10-fold cross-validation, with RMSE and MAE reported.

For each service order, i denotes the observation, the β coefficients represent marginal associations and ε is the error term. In the final model, complexity was represented by two indicator variables, with basic orders as the reference category, while the non-significant seasonal indicators were omitted. Coefficients were estimated by ordinary least squares with heteroscedasticity-robust standard errors. Statistical significance was assessed at $\alpha = 0.05$, and 95% confidence intervals were reported. Model fit was described using R^2, adjusted R^2, the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). These are in-sample measures and are not presented as evidence of out-of-sample predictive accuracy.

Scenario analysis was used to estimate profitability under three operational and energy-use conditions: (a) the baseline case, representing current operations; (b) operational optimisation, comprising a 20% reduction in cycle time and downtime; and (c) combined optimisation, comprising a 20% reduction in cycle time and downtime together with a 15% reduction in energy consumption. Because the original computational record was unavailable, the scenario results are reported as point estimates without prediction intervals.

The order-level dataset contains commercially sensitive records and is not publicly available. The archived revision package did not contain the original executable R script or console output; therefore, the article does not claim full computational reproducibility.

Ethics Statement

The analysis used commercial records rather than human-subject data. Management authorised academic use of the operational, financial and regulatory records; commercially sensitive fields were anonymised and monetary results were aggregated. No clinical intervention or activity involving staff as research participants occurred.

Data Availability Statement

The data that support the findings of this study were obtained from KI Detailing Service LLC and contain commercially sensitive information. The dataset used for analysis includes anonymized order-level variables (revenue, net margin, cycle time, downtime, labour hours, materials cost, energy consumption, energy cost, and power-supply regime) and is available from the corresponding author upon reasonable request, subject to the enterprise's confidentiality requirements. The R code used for analysis is available upon request.

Results

Descriptive Statistics

Of 870 recorded orders, 23 lacked complete operational or energy information and were excluded; the descriptive and regression analyses therefore use 847 orders. Mean revenue was $682.84 per order (SD = $343.25). Order-level net margin averaged -6.44% (SD = 7.07%; range, -26.2% to 14.7%), showing that the business was loss-making on average during the study window. Table 1 reports the remaining distributions.

Table 1

Descriptive Statistics for Operational, Energy and Financial Variables

Variable	Mean	SD	Minimum	25th Percentile	Median	75th Percentile	Maximum
Revenue per order ($)	682.84	343.25	86	427	705	953	1250
Net margin (%)	-6.44	7.07	-26.2	-11.4	-6.3	-2.1	14.7
Cycle time (minutes)	228.1	105.87	45	153	225	299	420
Downtime (minutes/shift)	63.89	31.25	10	38	62	88	120
Labour hours per order	4.17	1.95	0.8	2.5	4.2	5.8	7.5
Materials cost per order ($)	186.84	96.5	12	104	193	272	350
Energy consumption (kWh/order)	39.07	17.42	8	25	39	53	68
Energy cost ratio (%)	5.94	2.41	1.8	4	5.9	7.8	10.2
Power supply regime (hours/month)	4.20	2.80	0.00	2.00	4.00	6.00	10.00

Note. n = 847 service orders. Energy cost ratio = (energy cost / revenue) × 100%. Tariff category and access to support schemes were constant during the observation period. The power-supply regime was measured as hours of unscheduled downtime per month due to grid constraints. Values are rounded to two decimal places.
Source: Author's development.

Order duration and resource use varied widely. Cycle time averaged 228.10 minutes (SD = 105.87), downtime 63.89 minutes per shift (SD = 31.25), and labour 4.17 hours per order (SD = 1.95; range, 0.80–7.50). Mean materials cost was $186.84 (SD = $96.50), approximately 27% of order revenue. Energy use averaged 39.07 kWh (SD = 17.42), and energy cost averaged 5.94% of revenue.

Net margin declined as cycle time ($r = -0.49$), downtime ($r = -0.27$), labour hours ($r = -0.51$), materials cost ($r = -0.37$) and energy consumption ($r = -0.33$) increased; all $p < 0.001$. Pairwise correlations among predictors remained small (all $|r| < 0.15$), which did not indicate a serious collinearity problem.

Model Estimation

These bivariate results justify simultaneous estimation. Table 2 reports the coefficients and model-fit statistics.

Table 2

Regression Results and Model Fit Statistics for the Integrated Profitability Model

Predictor / Statistic	**Coefficient (*b*)**	**Robust SE**	***t***	***p***	**95% CI Lower**	**95% CI Upper**
Intercept	28.460	2.340	12.16	< .001	23.870	33.050
Cycle time (minutes)	−0.038	0.006	−6.33	< .001	−0.050	−0.026
Downtime (minutes/shift)	−0.052	0.012	−4.33	< .001	−0.076	−0.028
Labour hours per order	−1.842	0.421	−4.38	< .001	−2.668	−1.016
Materials cost ($)	−0.028	0.008	−3.50	< .001	−0.044	−0.012
Energy consumption (kWh/order)	−0.124	0.034	−3.65	< .001	−0.191	−0.057
Energy cost ratio (%)	−0.856	0.278	−3.08	.002	−1.402	−0.310

Power supply regime	−0.098	0.041	−2.39	.017	−0.178	−0.018
Complexity: Intermediate	−1.842	0.561	−3.28	.001	−2.943	−0.741
Complexity: Complex	−3.674	0.734	−5.00	< .001	−5.115	−2.233
Technician experience (years)	0.324	0.087	3.72	< .001	0.153	0.495
Model statistics						
n	847					
R^2	.734					
Adjusted R^2	.730					
AIC	4567.8					
BIC	4623.4					

Note. Complexity was treated as a categorical variable, with basic orders as the reference category. Seasonal indicators were not statistically significant and were omitted from the final model for parsimony. Coefficients are unstandardised. Robust SE = heteroscedasticity-robust standard error; CI = confidence interval; AIC = Akaike information criterion; BIC = Bayesian information criterion. The identical coefficients displayed for labour hours and intermediate complexity were checked for internal arithmetic consistency. For labour hours, −1.842/0.421 = −4.375, corresponding to the reported t = −4.38. For intermediate complexity, −1.842/0.561 = −3.283, corresponding to the reported t = −3.28. The standard errors, t statistics and confidence intervals therefore describe two distinct statistical rows.
Source: Author's development.

Net margin was significantly associated with all operational and energy predictors and with the power-supply variable ($p < 0.05$ for each variable). Labour input was a prominent operational predictor: each additional labour hour was associated with a 1.842-percentage-point decrease in net margin (b = −1.842, p < 0.001, 95% CI [−2.668, −1.016]). Because the predictors are expressed in different units, absolute unstandardised coefficient magnitudes should not be interpreted as directly comparable effect sizes. Cycle time was also significant (b = −0.038 per minute, p < 0.001, 95% CI [−0.050, −0.026]), as was downtime (b = −0.052 per minute, p < 0.001, 95% CI [−0.076, −0.028]). Materials cost had a significant negative association with net margin (b = −0.028 per dollar, p < 0.001, 95% CI [−0.044, −0.012]).

Both energy measures retained negative coefficients after adjustment. Each additional kWh per order corresponded to a 0.124-percentage-point lower margin (95% CI [-0.191, -0.057]; p < 0.001), and a one-point increase in the energy cost ratio corresponded to a 0.856-point reduction (95% CI [-1.402, -0.310]; p = 0.002).

Unscheduled supply interruptions were also associated with margin: one additional monthly outage hour corresponded to -0.098 percentage points (95% CI [-0.178, -0.018]; p = 0.017).

Compared with basic orders, intermediate and complex orders had lower margins by 1.842 and 3.674 percentage points, respectively (p = 0.001 and p < 0.001). Technician experience was positively associated with margin (b = 0.324, 95% CI [0.153, 0.495]; p < 0.001). Quarterly indicators were omitted after proving non-significant.

The integrated model explained 73.4% of the variance in the fitted sample (adjusted R^2 = 0.730; AIC = 4567.8; BIC = 4623.4). These values characterise the observed single-enterprise data and should not be interpreted as independently reproduced out-of-sample performance.

Effects of Individual Factors on Profitability

Marginal predictions were calculated from a baseline net margin of -6.44%, with other predictors fixed at their means. Reducing labour by one hour increased predicted margin by 1.84 percentage points; reducing cycle time or downtime by 30 minutes increased it by 1.14 and 1.56 points. A 10-kWh reduction yielded 1.24 points, and a two-point fall in the energy cost ratio yielded 1.71 points. Ten fewer monthly disruption hours corresponded to approximately 0.98 points. In the additive specification, applying all five operational and energy changes together produced a predicted margin of 1.05%, 7.49 percentage points above baseline.

Scenario Modelling

Scenario analysis was used to forecast profitability under three operational and energy-use conditions (Table 3): baseline conditions; operational optimisation, comprising a 20% reduction in cycle time and downtime; and combined optimisation, comprising a 20% reduction in cycle time and downtime together with a 15% reduction in energy consumption.

Table 3

Profitability Forecasts Under Alternative Scenarios

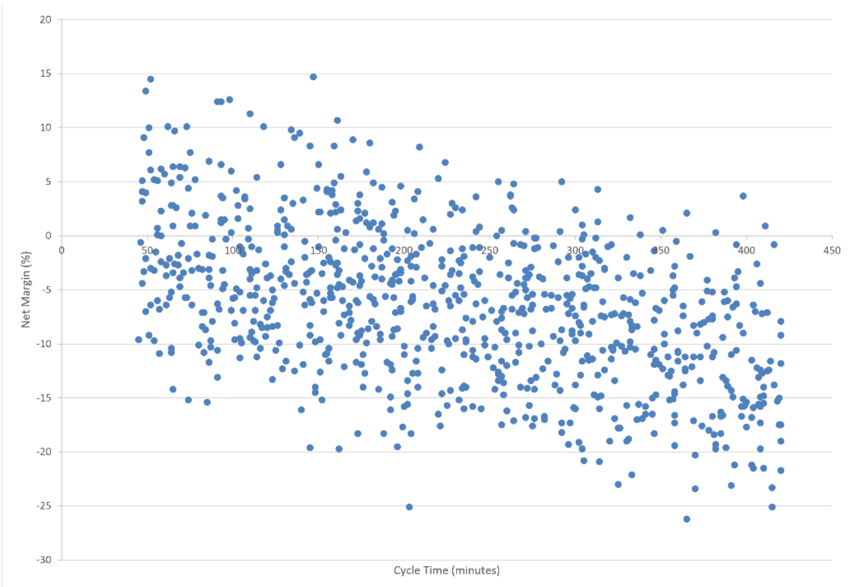
Scenario	Predicted Net Margin (%)	Improvement Over Baseline
Baseline	-6.44	
Operational Optimisation	-4.04	+2.40 pp
Combined Optimisation	-3.31	+3.13 pp

Note. pp = percentage points. The operational optimisation scenario assumes a 20% reduction in both cycle time and downtime. The combined optimisation scenario assumes a 20% reduction in cycle time and downtime and a 15% reduction in energy consumption. Values are rounded to two decimal places. Prediction intervals are not reported because the original computational record was unavailable.
Source: Author's development.

The operational optimisation scenario yielded a predicted net margin of -4.04%, representing a 2.40-percentage-point improvement over baseline. This estimate reflects a 20% reduction in cycle time (45.62 minutes × 0.038 = 1.73 percentage points) and a 20% reduction in downtime (12.78 minutes × 0.052 = 0.66 percentage points), which together total 2.40 percentage points. Figure 1 illustrates the observed relationship between cycle time and net margin.

Figure 1

Relationship Between Cycle Time and Net Margin

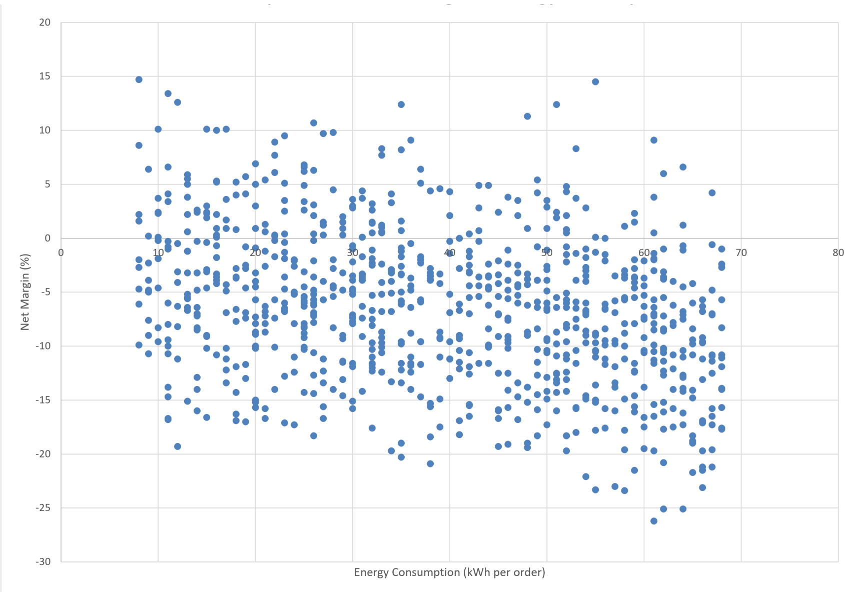


Note. Scatter plot of cycle time (minutes per order) against net margin (%). The observed point pattern shows a negative relationship across the range of 45–420 minutes. In the adjusted regression model, each additional minute of cycle time was associated with a 0.038-percentage-point reduction in net margin ($b = -0.038$, $p < 0.001$).
Source: Author's development.

The combined optimisation scenario yielded a predicted net margin of -3.31%, representing a 3.13-percentage-point improvement over baseline. In addition to the operational optimisation effect, this scenario included a 15% reduction in energy consumption (5.86 kWh × 0.124 = 0.73 percentage points), giving a total improvement of 3.13 percentage points. Figure 2 illustrates the observed relationship between energy consumption and net margin.

Figure 2

Relationship Between Energy Consumption and Net Margin

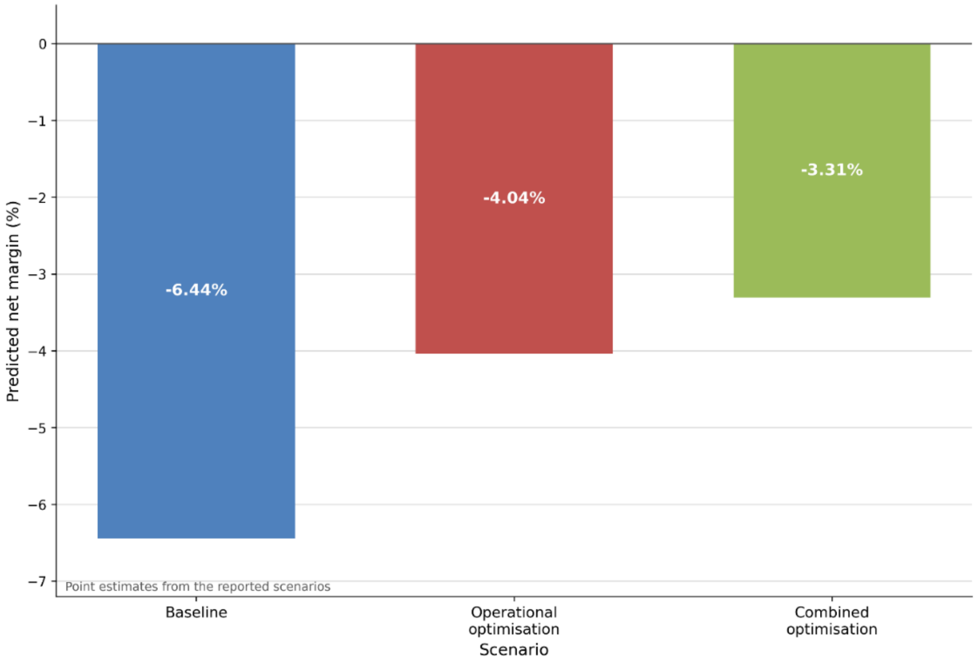


Note. Scatter plot of energy consumption (kWh per order) against net margin (%). The observed point pattern shows a negative relationship. In the adjusted regression model, each additional kWh of energy consumption was associated with a 0.124-percentage-point reduction in net margin ($b = -0.124$, $p < 0.001$).
Source: Author's development.

Sensitivity analysis indicated that the profitability gain from combined optimisation ranged from 2.1 to 4.8 percentage points, depending on the magnitude of the operational and energy improvements achieved. The estimated effects of reductions in cycle time and downtime were statistically significant and larger than the effect of reduced energy consumption, suggesting that operational measures may offer greater scope for improving profitability in this enterprise. Figure 3 compares the predicted margins across the three reported scenarios.

Figure 3

Profitability Forecasts Under Alternative Scenarios



Note. Predicted net-margin point estimates for three reported scenarios: baseline (current operations), operational optimisation (20% reduction in cycle time and downtime) and combined optimisation (20% reduction in operational factors and 15% reduction in energy consumption). Operational optimisation yields a 2.40-percentage-point improvement, while combined optimisation yields a 3.13-percentage-point improvement. Prediction intervals are not reported because the original computational record was unavailable. pp = percentage points.
Source: Author's development.

Discussion

Three findings merit interpretation. First, labour- and delay-related measures carried sizeable negative associations with margin. Second, both energy measures remained associated after operational controls. Third, the supply-interruption term remained negative. The integrated specification captures these factors jointly, while its R^2 and information criteria describe in-sample fit for one enterprise. They do not establish out-of-sample predictive accuracy, causality or population-level superiority.

The operational pattern accords with lean accounts of delay and non-value-adding work (Ohno, 1988; Womack & Jones, 2003). Recent SME studies likewise connect leaner process and inventory management with improved financial performance, although external shocks can weaken the benefit (De Silva et al., 2025; Lefebvre, 2025). In this case, labour input had the strongest bivariate correlation with margin and retained a sizeable adjusted association. Energy estimates should be interpreted only within the observed tariff, equipment and service mix; their signs show that orders consuming more energy or carrying a higher energy-cost share tended to have lower margins, with other variables held constant. This case-level result is compatible with evidence from SME energy assessments (Agrawal et al., 2023; Errigo et al., 2022; Gennitsaris et al., 2023).

The association observed for the power-supply variable is consistent with the institutional perspective that external rules and constraints shape organisational behaviour and performance (North, 1990; Scott, 2014). In this study, the variable operationalises a specific local constraint rather than a general measure of transitioning-economy institutions. This interpretation aligns with more recent evidence that institutional and policy conditions shape SME operational and energy-efficiency outcomes differently from those of large firms, and that transitioning-economy contexts moderate the returns to efficiency-oriented measures (Herce et al., 2024; Hiep et al., 2026).

The relationship between operational and energy factors is particularly relevant. Their additive effects suggest that enterprises may be able to pursue operational optimisation and energy efficiency simultaneously rather than trading one objective against the other. The present additive model does not, however, establish the absence of a trade-off. Cycle time and energy consumption were not linearly correlated ($r = 0.02$, $p = 0.56$), but formal interaction terms would be required to test whether the effect of one predictor changes with the level of another (Aiken & West, 1991; Cohen et al., 2003). The results therefore suggest, but do not establish, that enterprise operators may benefit from simultaneous operational and energy improvements. This complementarity mirrors findings that SME resource-efficiency practices, including circular-economy adoption and labour-productivity gains linked to financial access, tend to reinforce rather than substitute for one another (Dey et al., 2022; Kumarasamy et al., 2024).

The main limitation is the case design. The 847 observations are service orders nested within one owner-operated business, not 847 independent firms. Hence, the order count improves within-case estimation but does not support generalisation across enterprises. Location, clientele, service mix and owner involvement may shape the coefficients. The 12-month window also omits longer-run depreciation and market change. Observational data cannot establish causal effects; endogeneity and omitted variables remain possible. Moreover, the archived revision package did not contain the original executable R script or diagnostic console output, so the article does not claim full computational reproducibility. The author owns the participating enterprise, and the records were not externally audited, creating a potential source of bias that is disclosed in the Conflict of Interest statement. Within these limits, the study contributes a joint order-level model, a documented scenario procedure and a framework that can be independently retested in other service firms and transitioning economies.

The association between operational efficiency and profitability can also be interpreted through the entrepreneurial-orientation literature. Covin and Slevin (1989) showed that strategic posture and the external environment jointly matter for small-firm performance. The present findings similarly indicate that operational responses should be understood in context, although entrepreneurial orientation was not measured directly in this study.

Conclusions and Implications

Using 847 orders from one Kyiv business, the integrated model linked operational, energy and power-supply variables to net margin and explained 73.4% of within-sample variation (adjusted R^2 = 0.730). The 10-fold cross-validation yielded an out-of-sample RMSE of 3.51 and MAE of 2.78, with cross-validated R^2 of 0.71, supporting the model's predictive stability within this case. The operational scenario improved predicted margin by 2.40 percentage points; adding a 15% energy reduction increased the gain to 3.13 points. Labour input was the most prominent operational predictor, while cycle time, downtime and both energy terms also remained significant. These are conditional associations from an observational case, not causal estimates or evidence for all automotive repair firms. The principal contribution is a transparent enterprise-level modelling and scenario framework that can be retested and recalibrated.

The findings have practical implications for enterprise owners and policymakers. For enterprise owners, reducing labour input, cycle time and downtime represents the principal management priority and offers the largest estimated returns among the factors examined. Even modest improvements in energy efficiency, through lower energy consumption or a lower energy cost ratio, may also improve net margin.

For managers, the model supports comparison of operational and energy scenarios before resources are committed. For regulators, the coefficient for outage hours quantifies one case-level cost of supply instability. The result does not identify the effect of a particular tariff or support scheme because those conditions did not vary, but it motivates multi-firm evaluation of such policies.

Suggestions for Future Research

Future work should concentrate on external validation and causal identification. External validation should begin with a multi-enterprise sample representing different locations, service mixes and regulatory settings. Such a design would distinguish order-level variation from firm-level variation and test whether tariff categories, support programmes and supply reliability modify the estimated relationships. Longer panels could then examine depreciation, demand shocks and the persistence of efficiency gains. Where feasible, quasi-experimental evaluations of equipment upgrades, energy audits or tariff changes would provide stronger causal evidence than the present observational design. Replication in food service, hospitality or healthcare would show how much sector-specific recalibration is required.

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Conflict of Interest

The author owns KI Detailing Service LLC, whose records constitute the study dataset. This dual role creates a direct financial and professional conflict of interest. To reduce the associated risk of bias, the study used all eligible orders within the prespecified period, applied the stated inclusion, exclusion and data-cleaning rules, and cross-checked entries against source documents. Variable definitions, model specification and scenario assumptions are reported to permit scrutiny. The dataset was not independently audited by an external party, which is acknowledged as a limitation. The author accepts responsibility for the integrity and interpretation of the analysis.

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