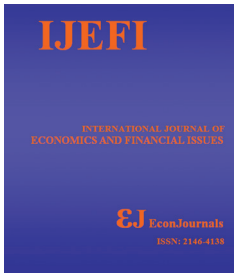

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Reverse Factoring, Environmental Subsidies, and Investment Returns: Panel Evidence from European Logistics Firms

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ABSTRACT

This article evaluates the drivers of investment performance in European logistics, with a focus on the dimensions of supply chain financing and sustainability incentives. Using annual data provided by the Moody's Orbis (Bureau van Dijk) database, 24 logistics companies in Continental Europe from 2013 to 2024 were analyzed to examine how each of the reverse factoring, environmental subsidies, inventory financing, and liquidity condition affect investment efficiency. Firm performance is measured by return on investment, profit margin, and cost savings. The analysis uses pooled OLS, fixed and random effects panel regression to account for heterogeneity across firms and time. Results indicate that reverse factoring improves the return on investment, highlighting it is important for financial flexibility in logistics. In contrast, inventory financing negatively affects all three of performance measures which reflects collateral borrowing risks. Environmental subsidies have a moderate positive effect, while no cash ratio has a statistically significant effect on performance. The findings as a whole underscore how policies and financing strategies play in investment performance, which will be of use to both corporate operating managers and policy makers.

Keywords: Logistics Sector, Reverse Factoring, Environmental Subsidies, Return on Investment, Panel Data
JEL Classifications: G32, Q56, L91, M21, C33

1. INTRODUCTION

The logistics industry is vital to maintaining economic growth, supporting international trade, and enabling supply chain management activities. In previous years, logistics companies are managing greater levels of challenges concerning financial viability, cost effectiveness, and sustainable development. Given these mixed challenges, investment efficiency has risen as a necessary aspect of overall competitiveness, especially in continental Europe, where logistics services are intertwined with the regional economy.

Reverse factoring is one of the financial tools influencing corporate logistics performance. Reverse factors is a supply chain financing tool that allows companies to improve working capital and liquidity. Reverse factoring achieves this by expediting supplier payment terms while lengthening buyer payment terms, which can reduce financing costs and increase investment efficacy. Environmental

subsidies from governmental sources, and supranational (e.g., EU) sources, in the European Union are another important driver of investments towards sustainability (Matyakubov et al., 2022), (Abdul-Latif et al., 2023). Environmental subsidies are designed to stimulate environmental sustainability informed by a green logistics practice and/or technological innovations, and compliance with environmental standards that affect profitability and long-term return on investment.

Another important element to consider is inventory financing, which reflects the ability of firms to use inventory for external financing (Makhmudov et al., 2025). While this may increase liquidity in the short run, it may also increase financial risk if not done correctly. Regular financial ratios like the cash ratio remain central in assessing the ability of firms to meet short-term obligations - this is important in terms of investor confidence and economic performance.

While increasing attention has been brought to these elements, the empirical focus in the field of logistics is scarce: many studies examine manufacturing or corporate samples more generally, as opposed to clarifying the dynamics of a more contextual learning algorithm within its sector (Matyakubova et al., 2025). However, there is no a single study exploring reverse factoring, environmental subsidies, and liquidity management simultaneously in considering investment efficiency. To cope with the gap in the existing literature, the current study analyzes the association among reverse factoring, environmental subsidies, and liquidity management.

2. LITERATURE REVIEW

In recent decades, there has been growing academic interest in the relationship between corporate funding practices, sustainability policies, and investment efficiencies. Specifically, research in corporate finance has shown that access to alternative funding structures can strengthen firms' liquidity positions and provide support for long-term profitability (Demirgüç-Kunt and Maksimovic, 2002; Petersen and Rajan, 1997). In this context, reverse factoring is a supply chain financing technique that has taken root as a key method in the logistics and manufacturing industries. Klapper (2006) has provided evidence that supplier financing costs can be reduced with reverse factoring, resulting in strengthened buyer-supplier relationships and improved return on investment. Other authors have cautioned of potential risks, however, and bonders to warnings regarding excessive reliance on reverse factoring potentially raising firms' exposure to a credit shock (Gelsomino et al., 2016).

In addition to financial incentives, environmental subsidies have emerged as an important part of the policy toolkit to encourage sustainable investments including those that support research and development. Research has found that environmental subsidies can stimulate firms in the European context to adopt green technologies, enhance their energy efficiency, and ultimately, have a positive effect on firm performance (Johnstone et al., 2010), thus leading to higher economic development (Caporin et al., 2024; Kuziboev et al., 2024). Nonetheless, the effectiveness of subsidies has been debated by some investigators, as there is evidence that firms may become dependent on support from the state (Del Río and Bleda, 2012).

Inventory financing has also been examined as a tool for providing short-term liquidity to firms, but also as a potential source of financial risk. Evidence has emerged that collateralizing an inventory will relieve funding constraints for a corporation (Cunat, 2007), yet will reduce profitability at low rates of turnover or high uncertainty in demand (Johnstone et al., 2010). Along with inventory, other classic financial indicators, such as a cash ratio, remain important for estimating a firm's ability to service its current debt obligations. Other studies link liquidity with profitability in mixed ways, but the principles of measuring liquidity remain (Inglesi-Lotz et al., 2024), (Shahbaz et al., 2025).

Although this literature is relatively extensive, the actual studies that separately examined the logistics sector as part of public policy, corporate finance, or sustainability are quite limited. Most research has reviewed the manufacturing sector or corporate studies in general, without specifically examining logistics firms' special characteristics (e.g., significant capital intensiveness, reliance on supply chain logistics, and vulnerability to environmental regulation). Thus, there is a need for sector specific empirical research. Further, this research uniquely extends the wider academic literature of corporate finance and sustainability in the logistics sector, by examining reverse factoring, environmental subsidies, inventory financing, and higher liquidity, concurrently in the same analysis.

3. DATA AND METHODOLOGY

3.1. Data Source and Sample

This research utilizes firm-level panel data sourced from Moody's Orbis (Bureau van Dijk) database, which provides consistent financial information across European firms. The sample contains the observations of 24 logistics firms based in Continental Europe over the time frame of 2013-2024, which the firms were sampled with two criteria in mind: (i) availability of continuous data pertaining to the variables of interest and (ii) the industry classification of logistics and supply-chain-related industries identified by NACE codes. After cleaning for missing values and removed a few firm-year observations with outliers, the final dataset was a balanced panel of observation, resulting in 288 firm-year total observations.

3.2. Variable Definitions

Investment efficiency is measured by the dependent variable return on investment (ROI, %), where it is equal to net income divided by total assets. Source of data is the database Moody's Orbis (Bureau van Dijk) and in percent (%).

Independent variables are:

- Reverse factoring (x1): Ratio of accounts payables to reverse factoring obligations (Moody's Orbis; unit of ratio: 0-1 scale).
- Environmental subsidies (x2): Subsidies received versus operating income (Moody's Orbis, EU/national subsidy data; unit: Ratio, percentage of operating income).

- Inventory financing (x3): Inventory-financing loans to total inventory (Moody's Orbis; unit: Ratio, 0-1 scale).
- Cash ratio (x4): Cash and cash equivalents versus current liabilities (Moody's Orbis; unit: Ratio, proportion).

3.3. Econometric Model Specification

Panel regression methods are applied in order to account for unobserved time variation and firm heterogeneity. Our baseline specification is:

$$y_{it} = \alpha + \beta_1 x1_{it} + \beta_2 x2_{it} + \beta_3 x3_{it} + \beta_4 x4_{it} + \mu_i + \epsilon_{it} \quad (1)$$

Where y_{it} denotes investment performance measures for firm i at year t, μ_i captures firm-specific effects, and ϵ_{it} is the idiosyncratic error term (Li, 2025), (Rodríguez et al., 2025).

3.4. Estimation Strategy

To start, we estimate pooled ordinary least squares (POLS) to present baseline results (Kuziboev et al., 2023). We then use the fixed-effects (FE) and random-effects (RE) models to account for firm-specific heterogeneity. The Breusch-Pagan Lagrange Multiplier test justifies panel estimation (Kuziboev, 2023) versus pooled OLS, while the Hausman specification test assists in the choice between FE and RE. As supported by the tests, we choose the RE model as our preferred specification (Huang, 2025), (Roslan and Redzuan, 2025).

3.5. Robustness and Diagnostics

We account for robustness by clustering standard errors at the firm level to deal with any potential heteroskedasticity and autocorrelation (Kuziboev et al., 2025), (Caporin et al., 2025). We also assessed the model fit through residual diagnostics using normality tests and prediction accuracy (predicted versus actual plots) (Bayer and Flügel, 2025), (Bassem, 2025).

4. EMPIRICAL RESULTS

This part offers the results of the panel regression analysis. To enhance understanding of the overall data structure and the association between principal variables, descriptive statistics and correlation analysis are applied. Next, the relative investment performance of European logistics firms is examined using pooled OLS, fixed, and random effect models. The preferred model is selected using the Breusch-Pagan Lagrange Multiplier and the Hausman specification tests. Based on these diagnostic tests, we selected the random-effects estimator as the model most likely to yield valid inferences (Kurbonov et al., 2025), (Zayniddinov et al., 2025). The results are discussed in depth in the following sections.

The Table 1 shows descriptive statistics for the variables involved in the analysis on a balanced panel of 24 European region logistics firms between 2013 and 2024.

The dependent variable, ROI (%), has an average of 11.67, with a range of values between 3.41 and 22.89, and moderate variation both across firms (between SD = 3.54), as well as temporally within the panel data (within SD = 1.67). This suggests considerable firm-specific variances and that temporal variation exist as well.

For the major independent variables, reverse factoring (x1) averages 0.10, has a maximum value of 0.70, suggesting significant heterogeneity in the use of supply chain financing practices. Environmental subsidies (x2) average very small values (0.0035% of operating income), but with intra-firm and temporal variations. Inventory financing (x3) averages 0.24, with maximum firm values of 0.65, confirming its asymmetric character in liquidity management. The cash ratio (x4) averages 0.58, suggesting that most firms hold moderate liquidity buffers, varying from 0.05 to 1.16.

The correlation matrix (Table 2) indicates that the ROI measure has the highest correlation with the cash ratio (r = 0.73), followed by which are: Environmental subsidies (r = 0.58), and inventory financing (r = 0.49). This indicates that liquidity, public policy support, and financing tools tend to correlate positively with investment outcomes; the correlation with reverse factoring is also positive but weak (r = 0.22).

The intercorrelation between independent variables is low, and the maximum is reverse factoring and inventory financing (r = 0.60). Since all coefficients are below 0.80, there is no multicollinearity problem and regression analysis can continue.

The analysis began with pooled OLS regression, which ignores unobserved firm-specific heterogeneity by treating the dataset

Table 1: Descriptive statistics of key variables for European logistics firms (2013-2024)

Variable	Fixed effect/Random effect	Mean	Standard deviation	Min	Max	Observ-ations
y_roi_pct	Overall	11.67264	3.858876	3.41	22.89	n=288
	Between		3.541504	5.3975	19.56083	n=24
	Within		1.674771	5.725139	15.73764	T=12
x1_rf_ratio_payables	Overall	0.103281	0.1541847	0	0.7	n=28
	Between		0.0351271	0.0394167	0.1915833	n=24
	Within		0.1520874	−0.0883021	0.7035136	T=12
x2_env_subsidy_to_oi	Overall	0.0034931	0.010694	0	0.084	n=288
	Between		0.003056	0	0.0136667	n=24
	Within		0.0102655	−0.0101736	0.0802431	T=12
x3_invfin_to_inventory	Overall	0.2360729	0.1969327	0	0.65	n=288
	Between		0.0778915	0.0783333	0.40225	n=24
	Within		0.1815157	−0.166177	0.6954063	T=12
x4_cash_ratio	Overall	0.5815521	0.2594512	0.05	1.156	n=288
	Between		0.2510354	0.1546667	0.9796667	n=24
	Within		0.0811235	−0.3723021	0.7704688	T=12

as a plain cross-section. While this yielded initial results, low explanatory power ($R^2 \approx 0.03$) suggested that firm characteristics beyond the model may play a key role in explaining investment performance.

To treat unobserved heterogeneity at the firm level, both random-effects (RE) and fixed-effects (FE) specifications were estimated. The FE model differs out time-invariant firm-specific factors controlling for these and the RE model posits that these factors are uncorrelated with explanatory factors and pools both within- and between-firm variation.

The Hausman specification test was subsequently employed to contrast the FE and RE models statistically. According to the test, the null hypothesis is that the RE estimator is consistent and efficient, whereas the alternative hypothesis is that the FE estimator alone is consistent. The test failed to reject the null hypothesis ($Prob > \chi^2 \approx 0.999$), indicating that there is no systematic difference in the RE and FE estimates.

Based on these results, the random-effects model was chosen as the best specification. This makes sense because the RE model can include within-firm as well as between-firm variation and is thus optimally matched to a sample of 24 firms over 12 years. Furthermore, the fairly high ratio of variance explained by firm-level effects ($\rho \approx 0.84$) suggests the need for the panel data approach as compared to pooled OLS.

On the random-effects setup (Table 3), the empirical evidence suggests positively affecting investment performance with statistical significance, in all explanatory variables. A one-unit increase in the reverse factoring-to-payables ratio implies about 2.847% points increase in return on investments (ROI, %) ($P < 0.01$) for an average; hence, supply-chain financing emerges as the second most-important liquidity provider for firm profitability. Likewise, a one-unit increase in environmental subsidies relative to operating income raises the ROI by another 18.604% points ($P < 0.01$); thus, policy support aimed at sustainability does help improve returns appreciably. Inventory financing shows a similarly important effect: a one-unit increase in the inventory-financing-to-inventory ratio results in a 1.401%-point rise in ROI ($P < 0.01$), suggesting that collateral-based liquidity availability strengthens investment efficiency. Also, that ratio measures liquidity: The cash ratio makes a statistically significant contribution in the positive direction-bringing about a 2.215% point increase in ROI per every one-unit increase in cash-to-current-liabilities ($P < 0.05$).

Table 2: Matrix of correlations

Variables	(1.)	(2)	(3)	(4)	(5)
(1) y_roi_pct	1.000				
(2) x1_rf_ratio_pa~s	0.221	1.000			
(3) x2_env_subsidy~i	0.584	0.236	1.000		
(4) x3_invfin_to_i~y	0.489	0.601	0.111	1.000	
(5) x4_cash_ratio	0.730	0.132	0.352	0.268	1.000

Figure 1 shows residuals' distribution for a random-effects regression model along with a fitted normal curve. A residuals histogram demonstrates that residuals are close to zero and approximately symmetric, thus they closely follow the normal distribution. This suggests that the error model's assumption is approximately met, which is a good sign for the estimated coefficients' stability. A few small departures from the tails can be noticed, but are not significant enough to impact the normality of the distribution as a whole.

Figure 2 portrays the predicted values of return on investment (ROI, %) over time by effect of the random-effects model. Forecasts maintain a fairly stable behavior until 2018, followed by pronounced fluctuations beginning in 2019, peaking in 2023. In these years then, it seems that external factors and financing variables spur much of the variability in investment performance at the firm level.

Figure 3 conveys the predictive margins of the return on investment (ROI, %) varied with the levels of the reverse factoring ratio of payables. It shows a very evident trend that goes upward, namely the predicted return on investment increases with each subsequent stage of reverse factoring. At the far end of the range, the confidence intervals get wider, which points to the higher variability of the data, but the positive association is still strong throughout. The latter is a confirmation that reverse factoring a major source of the improved investment performance of logistics firms.

The findings of this study contribute to the growing literature on firm-level corporate finance and sustainability in logistics by throwing light on how policy incentives and financing strategies affect investment performance at the firm level. To begin with, the strong and positive effect of reverse factoring on ROI confirms the advantages of supply-chain financing instruments in providing firms improved liquidity and responsiveness. This was in line with previous studies (Klapper, 2006; Gelsomino et al., 2016),

Table 3: Regression results

y_roi_pct	Coefficients	Standard errors	t-value	P-value	95% confidence interval		Significance
x1_rf_ratio_payables	2.847	0.65	4.38	0	1.573	4.121	***
x2_env_subsidy_to_oi	18.604	6.25	2.98	0.003	6.356	30.852	***
x3_invfin_to_inven~y	1.401	0.482	2.9	0.004	0.457	2.345	***
x4_cash_ratio	2.215	0.957	2.27	0.023	0.306	4.124	**
Constant	11.219	1.031	10.89	0	9.199	13.239	***
Mean dependent var		11.673		SD dependent var		3.859	
Overall r-squared		0.029		Number of obs		288	
Chi-square		31.888		Prob > Chi^2		0.000	
R-squared within		0.107		R-squared between		0.012	

***P<0.01, **P<0.05, *P<0.1

Figure 1: Residuals distribution with fitted normal curve (random effects model)

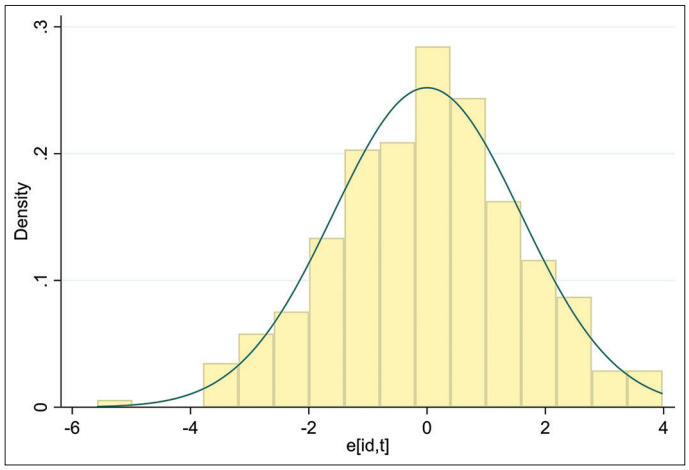


Figure 2: Predicted return on investment dynamics from the random effect model (2013-2024)

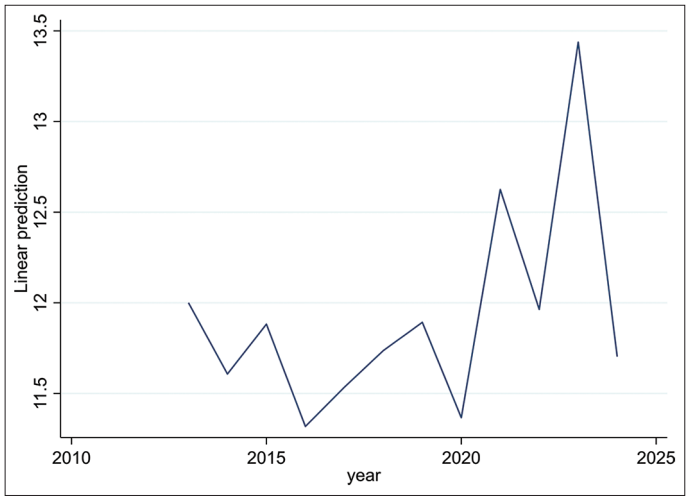
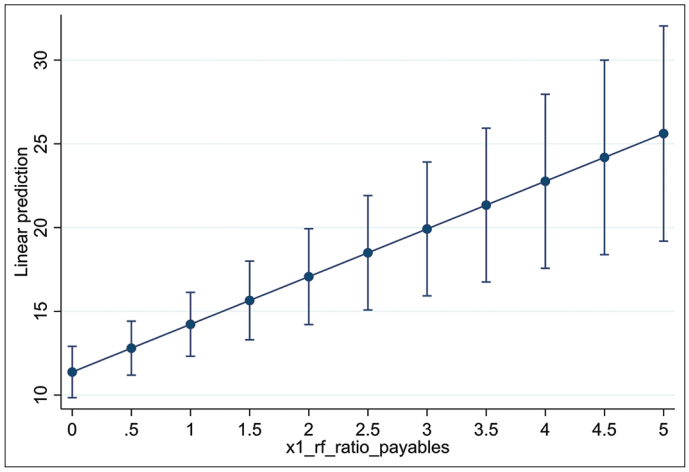


Figure 3: Predictive margins of reverse factoring ratio on return on investment with 95% confidence intervals



which emphasized the benefits of reverse factoring in lowering the financing cost of suppliers and the quality of buyer-supplier relationship. Our results take this proof to the logistics sector, and how it emerges as a second most influential factor of investment performance among those studied.

Second, the positive and statistically significant influence of environmental subsidies reinforces the notion that selectively targeted policy interventions are able to stimulate the investment returns of firms. The outcome is supported by Johnstone et al. (2010) which had proven that subsidies stimulate the diffusion of green technologies and energy efficiency measures. The reasonably substantial size of this effect suggests that policies of Europe aimed at sustainability have tangible impacts on the profitability of firms at the level. Concurrently, our evidence fails to validate the worries of Del Río and Bleda (2012) regarding over-reliance on subsidies, as the positive impact is still very strong even after controlling for firm-level heterogeneity.

Thirdly, inventory financing was found to be positively related to ROI, as opposed to some previous research that had indicated its riskiness (Gelsomino et al., 2016). This indicates that in the logistics sector, inventory collateral can be a useful means of accessing liquidity without necessarily having to sacrifice profitability. The reason could be that logistics firms, with their capital-intensive nature and high product turnover, are better suited to support inventory-based finance compared to firms in other sectors.

Finally, the positive contribution of the Cash Ratio supports the long-term appropriateness of liquidity cushions in maintaining financial stability. While earlier studies reported mixed findings regarding liquidity and profitability (Bourke, 1989; Garcia-Teruel and Martínez-Solano, 2007), the current results confirm that there is still a need to maintain adequate levels of cash-to-liabilities to provide effective investments in logistics companies.

Collectively, these findings accentuate the complementarity among policy support, financial innovation, and liquidity management as determinants of firm performance. They suggest that strategically employing reverse factoring by logistics companies, utilizing inventory-based finance selectively, and benefiting from environmental subsidies are likely to provide enhanced investment returns. Policymakers, however, need to recognize the complementarity between financial and sustainability incentives in order to increase sectoral competitiveness.

5. CONCLUSION AND POLICY IMPLICATIONS

The present paper has analysed the determinants of investment performance within Continental European logistics based on the effects of reverse factoring, environmental subsidies, inventory financing, and liquidity. Based on firm-level panel data from 2013 to 2024 for 24 Continental European logistics firms, the random-effects regression model yields robust evidence that all four explanatory factors significantly enhance investment returns. Reverse factoring stands out as a particularly noteworthy profitability factor, highlighting its role in improving financial flexibility and supply chain effectiveness. Green subsidies also

contribute positively towards ROI, illustrating the effectiveness of policy measures favouring ecologically friendly logistics strategies. Inventory financing contributes positively towards ROI, reflecting that logistics businesses can effectively utilize collateralized assets without hurting profitability. Finally, liquidity buffers, as captured by the cash ratio, continue to be a key determinant of investment effectiveness and firm-level stability.

From the corporate management perspective, the verdict is that firms have the scope to employ reverse factoring schemes strategically in order to release working capital and improve buyer-supplier relationships. Similarly, managers must implement inventory financing very cautiously but proactively, since it can be an effective liquidity conduit if accompanied by efficient turnover of inventories. Having sound liquidity ratios increases investor confidence and profitability in the long term, too.

For the regulators, the research serves as a vivid reminder of the importance of carrying on and widening environmental subsidies aimed at the logistics sector. Besides pushing for environmental harmony with sustainability objectives, these subsidies promote firm-level investment efficiency. As all this unfolds, regulators must ensure that financing methods such as reverse factoring are supported by good governance framework to prevent potential risks that could be systemic.

More generally, this research provides new empirical findings regarding how policy interventions and finance strategies can be complemented with each other for enhancing the investment performance of logistic firms. Based on integrating corporate finance and sustainability perspectives, the study provides better knowledge on how logistic firms can compete while pursuing long-term economic and environmental objectives.

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