

APPLYING THE GOAL PROGRAMMING MODEL TO STRATEGIC PLANNING FOR SUSTAINABLE BUSINESS PRACTICES

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Abstract

Within the provisions of the Paris Agreement (2015), which pertain to the mitigation of the adverse effects of climate change, a series of regulations have been developed prescribing the achievement of net-zero carbon dioxide emissions, recognized as one of the most significant pollutants of countries' natural environments. The transport sector, which is responsible for more than a quarter of all greenhouse gas emissions, is a major generator of harmful gases. For modeling purposes, the performance of Serbia's largest logistics company will be used. By utilizing goal programming techniques, a strategic solution is determined that minimizes deviations from the company's predetermined priority goals. In the event of deviations above or below the established targets, corresponding penalties for deviations are applied. In a sustainable business model, carbon dioxide reduction is prioritized in the goal programming hierarchy. The research indicates that a goal programming model enables the logistics company to minimize deviations, reduce pollution, and optimize operational performance.

Keywords: Sustainable-oriented business model, Environmental protection, Goal programming, Transport Sector.

1 INTRODUCTION

Sustainability constitutes a central element of countries' development strategies, shaped by regulations of European Commission and the Council of the EU [4], and aligned with the United Nations Sustainable Development Goals [12].

The attainment of the Sustainable Development Goals necessitates the active involvement of all social actors, including national governments, civil society, non-profit organizations, and companies from both the public and private sectors [9]. The private sector is increasingly recognized as a key driver in advancing sustainable economic development [2]. The private sector plays a key role in achieving Goal 12 on sustainable consumption and production patterns [13]. Accordingly, the application of the sustainability concept in production, through the rational use and reuse of inputs as well as the responsible consumption of outputs, aligns with sustainable business strategies [10]. Private enterprises are increasingly orienting themselves toward new strategic frameworks consistent with the concept of sustainability [14]. Public and private sector operations seek to enhance performance while reducing environmental pollution [6]. According to the European Environmental Agency (2024), entities within the transport sector represent the dominant source of environmental pollution among EU member states. Historically, greenhouse gas emissions from this sector accounted for 25.9% of total emissions across all other economic sectors during the period from 1990-2022 (EEA, 2024). Moreover, greenhouse gas emissions generated by activities within the transport sector accounted for 33% of total emissions from other economic sectors during the period 1990-2019 (EEA, 2024). In 2022, transport-related activities produced 28.9% of total emissions at the level of the EU-27 member states (27) (EEA, 2024).

Within the transport sector, road transport stands out as the activity that contributes most significantly to environmental pollution across the EU-27 member states. Specifically, road transport activities account for 73.2% of total greenhouse gas emissions generated by the transport sector [5]. Notably, road transport accounts for 21.1% of total greenhouse gas emissions compared to other sectors, measured at the level of EU-27 member states [5]. According to the European Environmental Agency (2024), the implementation and adoption of planned sustainability goals and policies, alongside a series of environmental directives, regulations, and strategies, are expected to ensure a future reduction in environmental pollution. Therefore, through the implementation of objectives outlined in the development strategies of EU-27 member states, a reduction in greenhouse gas emissions is projected at 14.3% by 2030 and 37.1% by 2050 [5].

On the proposal of the European Commission, a series of sustainability-related regulations and directives have been adopted by the European Parliament and the Council of the EU. The "Regulation (EU) 2019/1242" establishes standards for reducing carbon dioxide emissions from heavy-duty vehicles in road transport, while "Regulation (EU) 2019/631" concerns the reduction of carbon dioxide emissions from light commercial and passenger vehicles. Additionally, the "ETS2" mechanism requires logistics companies to pay for fuel based on their emissions, with fuel costs positively correlated to pollutant levels. The "Weights and Dimensions" directive regulates vehicle sizes, while transport emissions are addressed through the "Corporate Sustainability Reporting Directive (2022/2464)" and "Regulation (EU) 2024/1257 (EURO 7)".

2 METHODOLOGY AND DATA SOURCES

To conduct the empirical component of this study and ensure robust results, data were collected from the annual financial reports of companies operating in Serbia's transport sector ("Business Registers Agency"). The selection of transport sector entities is justified by the fact that nearly one-third of total environmental pollution from greenhouse gas emissions originates from transport activities [5]. However, over 70% of greenhouse gas emissions are generated by road transport activities [5]. For this reason, the goal programming model is constructed using the example of the largest freight forwarding company "A", within Serbia's transport sector, which primarily operates in road transport.

The methodological part of this study will be conducted using goal programming. In this approach, a feasible solution is identified as the one that minimizes the deviations from a pre-specified target. Specifically, the model seeks the solution that minimizes the weighted underachievement and overachievement of the goals, where the reference point does not necessarily correspond to an ideal solution [7]. Accordingly, the target or reference point will be represented by the following formula:

$$g = (g_1, g_2, g_3, \dots, g_k) \quad (1)$$

, while the objective function expressed as:

$$f(x) = (f_1(x), f_2(x), f_3(x), \dots, f_k(x)) \quad (2)$$

The objective functions $f_k(x)$ must achieve the pre-specified targets g_k within the model. Target values can be set as the maximum of all functions. The minimum of all functions, a mix of maxima and minima for different functions, or exact values for specific functions [11]. Theoretically, the model aims for a state with no deviations from the set targets, which in most cases is unattainable. Two types of deviations from the established priorities are recognized: underachievement relative to the target and overachievement beyond the target [3]. For a feasible solution ($x \in X$) the overachievement d^+ and underachievement d^- of each goal criterion are determined. The overachievement and underachievement of the goal criteria are defined by the following equations [3]:

$$d_i^+ = f_i(x) - g_i \geq 0 \quad (3)$$

$$d_i^- = g_i - f_i(x) \geq 0 \quad (4)$$

Based on this, the goal programming problem can be formulated as follows:

$$\begin{aligned} \min \sum_{i=1}^k (d_i^+ + d_i^-) \\ f_i(x) - d_i^+ + d_i^- = g_i, i = 1, \dots, k \\ x \in X \\ d_i^+, d_i^- \geq 0 \end{aligned} \quad (5)$$

According to the constructed goal programming model (Expression 5), the overachievement variable d_i^+ in a given constraint (i) takes a coordinate value of -1, while all other coordinates are zero. Conversely, the underachievement variable d_i^- , in a given constraint (i) takes a coordinate value of 1, with all other coordinates being zero [7] and [8].

Within the goal programming method, any deviation from the pre-defined model targets ($g_1, g_2, g_3, \dots, g_k$) incurs a penalty W_i [11]. Penalties for overachievement or underachievement of targets do not necessarily have the same values; they depend on the priority assigned to each goal within the company's business model. If a particular overachievement or underachievement contributes positively to the company's operational optimization, no penalty is applied for that outcome. The penalty for exceeding a target is denoted w_i^+ , while the penalty for falling short of a target is denoted w_i^- [1]. If the condition specified in the model represents the lower bound of the objective function, then the following holds:

$$f_i(x) \geq g_i$$

In this case, for each achieved value of the objective function that exceeds the specified condition, the penalty $w_i^+ = 0$ is assigned, whereas for each achieved value below the specified condition, the penalty $w_i^- > 0$ is applied.

If the condition specified in the model represents the upper bound of the objective function, then the following applies:

$$f_i(x) \leq g_i$$

In this case, for each achieved value of the objective function that is below the specified condition, the penalty $w_i^- = 0$ is assigned, whereas for each achieved value exceeding the specified condition, the penalty $w_i^+ > 0$ is applied.

If the condition specified in the model represents exact fulfillment of the objective function, then the following applies:

$$f_i(x) = g_i$$

In this case, a penalty of $w_i^+ > 0$ is assigned for each overachievement and a penalty of $w_i^- > 0$ for each underachievement [1] and [11].

Based on the above statements, the goal programming model is formulated in the following form:

$$\begin{aligned} \min \sum_{i=1}^k (w_i^+ d_i^+ + w_i^- d_i^-) \\ f_i(x) - d_i^+ + d_i^- = g_i, i = 1, \dots, k \\ x \in X \\ d_i^+, d_i^- \geq 0 \end{aligned} \quad (6)$$

Model conditions are based on financial statement indicators, such as net profit, working capital, liquidity and debt ratios, return on equity, and receivables turnover. Equal penalties are assigned for underachievement and overachievement ($w_i^+ = 1, w_i^- = 1$). The results of the methodological part will provide a model for optimizing business operations while reducing environmental pollution, a key imperative of sustainable business practices.

3 RESULTS AND DISCUSSION

Based on the regulations adopted by the European Parliament and the Council of the EU (2019/631 and 2019/1242), the reduction of harmful environmental emissions is implemented through the calculation of carbon dioxide (CO₂) emissions, exemplified by the largest logistics

service provider “A” within Serbia's transport sector. An examination of the total production factors of company “A” reveals the presence of two types of capital assets, i.e. assets used for service provision. According to publicly available data and regular annual financial statements, company “A” owns two types of transport assets. The first type consists of trucks weighing between 11 and 26 tons, accounting for 90% of the company's total transport fleet. The second type of vehicles consists of trucks under 11 tons, representing 10% of the company's total transport fleet. In Table 1, the total amount of carbon dioxide emitted by the company will be calculated using the emission factor (Ef). The emission factor (Ef) represents the amount of harmful gases emitted per vehicle, fuel unit, and distance traveled (Environmental Protection Agency, US). To obtain robust research results, the emission factor used is standardized according to international databases, such as IPCC (Guidelines for National Greenhouse Gas Inventories), EEA (European Environment Agency), and US EPA (Environmental Protection Agency, US).

Table 1. Calculation of CO₂ emission for company “A”

Ef – 2.68 kg CO₂/L	Vehicles number	Annual fuel consum. (L / km)	Annual fuel consum. (liters)	(CO₂) emiss. calcul.
Vehicles type				
EURO 6 trucks (11-26 t)	202	0.30	2.424.000	6489 (t)
Other transport vehicles (< 11 t)	23	0.12	69.0001	185 (t)
Total	225	-	2.493.000	6676 (t)

Source: Author's calculation based on fleet data from the company website and APR reports.

The results presented in Table 1 indicate that the leading logistics company “A” generated an annual carbon dioxide CO₂ emission of 6676 tons. Examining the company's capital assets structure, type 1 transport vehicles emitted 6489 tons of CO₂ emissions, while type 2 transport vehicles contributed 185 tons of annual CO₂ emissions. Based on regular annual financial statements and the auditor's report for the audited financial statements, published on the website of the Business Registers Agency of Serbia, the contribution of the two types of transport vehicles is calculated in relation to changes in balance sheet items, used as indicators of the company's business performance.

The following section presents company financial indicators, including profitability indicators such as net profit (NP), liquidity indicators such as net working capital (Nws) and current ratio (CR), financial structure indicators such as the financing sources ratio (Fsr), return indicators such as return on equity (ROE), assets turnover indicators such as the receivables turnover ratio (Rtr), human capital indicators measured by the number of employees (TL), and leverage indicators represented by debt ratio (DR). Analysis of business models of leading companies in the logistics sector,

specifically in freight forwarding, indicates that the majority of net profits are generated through the use of type 1 transport vehicles, which dominate international and regional transport. The contribution to net profit from type 2 transport vehicles relates primarily to intra-national distribution. By analyzing the number and type of transport vehicles, their contribution to the company's profit is calculated and estimated (Table 2).

Table 2. Contribution of Transport Vehicle Types to the Net Profit of Company “A” (2023)

Vehicles type	Vehic. Numb.	Net profit by vehicle type	Net profit per transport unit
Type 1 (11 -26 t)	202	374,042 k RSD	1,852 k RSD
Type 2 (< 11 t)	23	41,560 k RSD	1,807 k RSD
Total	225	415,603 k RSD	3,659 k RSD

Source: Author's calculation based on financial statements obtained from the Business Registers Agency of Serbia.

Business operations under contemporary economic conditions require sustainability through environmental protection, while emphasizing the rational perspective that profit remains one of the primary business objectives. In accordance with the regulations and directives of the European Parliament and the Council of the EU, an annual reduction of 4.5% in carbon dioxide emissions is set as the first priority goal, whereas the growth of the company's net profit constitutes the second priority within the goal programming model. The remaining financial indicators from the company's balance sheet are assigned as the third priority within the goal programming model. Table 3 presents the calculation of financial indicators by transport unit, depending on the type of transport vehicle.

Table 3. Calculation of Transport Unit Ratios for Other Financial Indicators (Priority 3) of Company “A”

Vehicles Type	Nws	CR	Fsr	ROE	Rtr	DR
Type 1 (11-26 t)	6785	0.003	0.001	0.035	0.01	0.002
Type 2 (< 11 t)	6621	0.003	0.001	0.034	0.01	0.002

Source: Author's calculation based on financial statements obtained from the Business Registers Agency of Serbia.

Within the third priority objectives, the variable representing the total workforce employed by the leading logistics company “A”, in the Serbian market is included. The number of employees serves as an indicator of the company's market performance. According to publicly available financial statements, the company's profitability growth is accompanied by an increase in total human capital. In 2020, the company employed 1,968 workers, rising to 2,658 employees by 2024 (“Business Register Agency of Serbia”). To maximize profitability while implementing the prescribed reduction of environmental pollution through decreased carbon dioxide emissions, company “A” establishes an additional priority related to workforce size.

The company's objective stipulates that the number of employees should not fall below 2,000. For the application of the goal programming method, a model with three primary priorities is established. The first priority concerns the reduction of harmful gas emissions, i.e., environmental protection, assigning this goal as a first level priority. The second priority is the maximization of the company's profitability under the given market conditions, classifying it as a second level priority. The third goal pertains to a set of financial structure indicators that need to be maintained within specified boundaries, thus constituting a third level priority. If the defined partial goals across all three company priority levels are unmet, the decision-maker assigns weight coefficients of 1 as penalties for deviations. Accordingly, a goal programming model is established to forecast priority attainment.

Table 4. Model formulation and Definition of Target Values

Goals	Coeff. 1 (type 1) <11 (t)	Coeff. 2 (type 2) >11 (t)	Target Values
CO ₂ emissions	32.12	8.04	≤6373 (t)
Net Profit	1852	1807	≥415604 mill. (rsd)
Nws	6785	6621	≥1522898 (rsd)
CR	0.0039	0.0038	≥1
Fsr	0.0010	0.0010	≤0.5
ROE	0.0352	0.0342	≥10.52
Rtr	0.0178	0.0173	≥4.3
DR	0.0028	0.0027	≤0.5
TL	11.84	11.55	≥2000

Source: Author's calculation via “QM for Windows “

By applying the goal programming method using the “Qm for Windows” software, a business model aligned with the principles of sustainability is developed. Specifically, the transport company aims to achieve the objectives of EU regulations, directives, and strategic goals, while simultaneously maximizing profitability and maintaining other financial indicators within the required limits. Table 4 presents the results of the goal programming model.

According to the results presented in Table 4., all business objectives of the company are grouped into three priority levels. The first priority is the reduction of carbon dioxide emissions, in accordance with the applicable regulations and directives of the European Commission, European Parliament, and the Council of the EU. The previously calculated carbon dioxide emissions are reduced from 6,676 tons to 6,373 tons on an annual basis. Thus, the total carbon dioxide emissions of the transport company will be reduced, aligning with the planned 4.5% annual reduction target. Consequently, one of the fundamental requirements of the sustainable development framework is met through the decrease in the company's overall greenhouse gas emissions within a single fiscal year.

Table 5. Results of the Goal Programming Application

Decision variable analysis	Value		
k1 (transport vehicle 1)	189		
k2 (transport vehicle 2)	36		
Priority analysis	Nonachievement		
Priority 1	0		
Priority 2	0		
Priority 3	3.4705		
Constraint Analysis	RHS	d ⁺	d ⁻
Carbon Dioxide Emissions (Environmental Quality)	6373	0	0
Net Profit of the Company (Profitability Indicator)	415604	71.25	0
Net Workin Capital (Nws) (Liquidity Indicator)	1522898	0	0.125
Current ratio (CR)	1	0	0.124
Financing Sources Ratio (Fsr)	0.5	0	0.274
Return on Equity (ROE)	10.52	0	2.621
Receivables Turnover Ratio (Rtr)	4.3	0	0.307
Debt Ratio (DR) (Leverage Indicator)	0.5	0.127	0
Total number of Employees (TL)	2000	657.3	0

Source: Author's calculation via “QM for Windows “

Since the target condition is met, no penalties apply. Maximizing profitability while reducing environmental pollution is set as the second level priority. According to the goal programming results (Table 4), the leading transport company is projected to achieve an annual profit of 415,675 million RSD in 2025, exceeding the required profit level set by the model's target function. In this regard, the company not only meets its planned profitability level but also records an excess of 71.25 million RSD. Through the established model, the first two priorities are achieved, i.e., the required reduction of environmental pollution and protection of the natural environment, along with the maximization of company profitability.

Within the third level of priority, a set of financial performance indicators of the analyzed transport company is specified. The net working capital, serving as an indicator of operational liquidity, is projected to reach a value approximating the target level, with a marginal shortfall of 0.125 units. A target surplus is observed with respect to the debt ratio and total employment. Specifically, the debt ratio is expected to stand at 0.6 remaining within the prescribed boundaries of acceptable financial average. Furthermore, the company is expected to achieve its strategic objectives of maintaining the existing workforce, thereby ensuring that total employment remains about 2000 employees. According to the constructed model, a marginal shortfall of 0.124 units is projected in the value of the current ratio, estimated at 0.88. The liquidity indicator, representing the proportion

between current assets and short-term liabilities, remains consistent with the company's historical performance, indicating stable short-term solvency and efficient working capital management. Regarding the financial structure ratio, a deviation of 0.274 is recorded. Moreover, the model projects a positive return on equity of 7.89 percent, while the company is also expected to achieve a 3.99 ratio between operating revenue and the average accounts receivable balance. Thus, the transport company stays within the defined limits for third level priority goals, and the goal programming results demonstrate a significant annual carbon dioxide reduction of over 4.5%. To meet the first two priority objectives, the fleet is adjusted: heavy-duty trucks are reduced from 202 to 189, and lighter vehicles increased from 23 to 36. Profit exceeds the target by 71.25 million RSD, while key financial indicators remain within prescribed limits and environmental sustainability is maintained.

4 CONCLUSIONS

At the beginning of the new century, a series of regulations and directives were adopted by the European Parliament and Council of Europe, addressing sustainable economic development models for member states and candidate countries of the European Union. The Sustainable Development Goals (SDGs) established by the United Nations have become a key focus within the economic policies of these countries. Achieving economic growth without compromising environmental quality requires the coordinated engagement of government authorities, civil society, private and public sector companies, as well as non-governmental and non-profit organizations [9]. According to reports [5], companies in the transport sector generate one-third of greenhouse gas emissions. Goal programming establishes a model that maximizes sector profitability while reducing carbon dioxide emissions, a leading greenhouse gas. The conclusion is that the company mitigates harmful emissions by strategically modifying the structure of its vehicle fleet. This model emphasizes the need to reduce the share of heavy-duty trucks and increase the use of lighter vehicles with lower fuel consumption per unit of transported goods. The adoption of engines with advanced combustion technologies is proposed to increase energy efficiency and reduce carbon dioxide emissions, aiming to enhance fleet performance in line with modern environmental standards, which contribute to the preservation of the natural environment.

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