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Application of Engineering Management Approaches to the Analysis of Financial Development and Economic Growth in Serbia

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Abstract: Economic growth and financial development are interconnected processes that determine the stability and long-term sustainability of national economies. (1) Background: While numerous studies have examined the relationship between financial indicators and economic growth, the application of engineering management approaches in financial system analysis and decision-making remains underexplored; (2) Methods: Integration of systems dynamics, Monte Carlo simulation, analytical hierarchy process (AHP), and machine learning in order to analyze the impact of key financial indicators: broad money (M1), domestic credit to the private sector (DCPS), gross capital formation (GCF), and foreign direct investment (FDI) on Serbia's economic growth; (3) Results: M1 and DCPS have a dominant influence on GDP, whereas the impact of FDI is limited and statistically insignificant; and (4) Conclusions: Monte Carlo simulation reveals that economic growth can be significantly threatened by high FDI fluctuations, while system dynamics confirms that optimizing domestic financing can enhance financial system stability. Machine learning models validate that M1 and DCPS are the most crucial predictors of economic growth. This study provides an innovative approach by integrating engineering management techniques with economic analysis, enabling improved decision-making in financial policy and sustainable economic development.

Keywords: *Economic growth; financial development; engineering management; systems dynamics; Monte Carlo simulation; machine learning.*

1. Introduction

The Economic growth and financial development are interconnected processes that shape the long-term sustainability and stability of national economies. Numerous studies have explored the causal relationship between financial development and economic growth, with some emphasizing

the predictive power of a country's banking system size relative to GDP in explaining long-term growth trends [1]. However, despite extensive research conducted in various global contexts, there remains a significant research gap in applying engineering management approaches to financial and economic analysis, particularly in the case of Serbia [2].

This study addresses this gap by integrating engineering management methods, including systems dynamics modeling, Monte Carlo simulation, the analytical hierarchy process (AHP), and machine learning techniques, to examine the impact of financial development on Serbia's economic growth. Unlike traditional economic models that primarily rely on regression-based analyses, this study employs a multi-methodological approach to provide a more dynamic and comprehensive understanding of financial interactions, risk management, and decision-making. The primary objective of this research is to analyze the impact of key financial indicators—broad money (M1), domestic credit to the private sector (DCPS), gross capital formation (GCF), and foreign direct investment (FDI)—on Serbia's economic growth through engineering management methods. By using systems dynamics modeling, this study allows for the analysis of complex feedback loops within the financial system and the projection of future growth scenarios. Monte Carlo simulation provides a probabilistic risk assessment, identifying potential variations in economic growth due to financial instability. The AHP method ranks financial factors based on their significance using expert judgment, while machine learning models (Random Forest, Gradient Boosting, and artificial neural networks) enhance the accuracy of predictions and uncover hidden patterns in financial data.

The innovative contribution of this research lies in its interdisciplinary approach, which connects financial economics with engineering management techniques to enhance the precision of forecasting, optimize financial decision-making, and improve risk management strategies. By employing data-driven modeling and simulations, this study contributes to a deeper understanding of the financial system's dynamics and provides decision-makers with a robust framework for fostering Serbia's sustainable economic growth. The findings have practical implications for both policymakers and financial institutions. The application of engineering management methods in economic and financial analysis introduces a new methodological perspective that goes beyond traditional statistical approaches. The research findings assist in identifying the most influential financial variables for economic growth, developing risk-reduction strategies, and optimizing macroeconomic policies. Additionally, financial institutions can leverage these insights to improve credit allocation, assess investment risks, and strengthen financial stability. This study fills the research gap in applying engineering-based decision-making models to economic growth analysis, paving the way for further research in the integration of financial engineering, risk analysis, and macroeconomic policy development.

The literature on the relationship between financial development and economic growth exhibits significant variations in theoretical and empirical approaches but rarely incorporates engineering management as a tool for analyzing financial systems. Economic growth is not universally determined but depends on institutional factors and market dynamics, suggesting that financial development does not automatically guarantee economic progress [1]. This approach highlights the necessity of combining traditional economic models with advanced management and analytical methods, including engineering management, for effective economic policy formulation. Chițoiu and Voda [3] examine how financial development influences national well-being, stressing the importance of stable financial institutions. However, their analysis remains within the framework of classical economic models, whereas engineering management provides opportunities for resource optimization through systems dynamics modeling and simulations, enabling more accurate economic outcome predictions and enhanced financial policies. Božović [2] specifically investigates Serbia's case, demonstrating that broad money (M1) and domestic credit to the private sector (DCPS) are key drivers of economic growth. However, this study does not explore how modern modeling techniques, such as Monte Carlo simulations and machine learning, can be utilized to refine financial flow analysis. Engineering management offers a methodological framework that enables a deeper understanding of monetary policy transmission through advanced analytical techniques and predictive models.

Afonso and Blanco-Arana [4] analyze OECD countries, highlighting that the role of financial institutions weakens significantly during economic crises, emphasizing the need for proactive

financial risk management. Their findings underscore the importance of using Monte Carlo simulations and systems dynamics as tools for simulating possible economic scenarios and developing resilience strategies against financial crises. Megnigang [5] points out the limitations of traditional economic research, advocating for the integration of advanced quantitative methods such as artificial intelligence and systems dynamics in financial policy analysis. This conclusion supports the application of engineering management in economic research, where big data analytics can help identify key financial patterns and improve economic planning. Group of authors [6] explore the financial sector in developing countries, emphasizing the importance of institutional support for economic stability. Their study opens the discussion on how the analytical hierarchy process (AHP) can enhance decision-making by accurately ranking financial development priorities.

Another group of authors [7] examine financial system stability and its impact on economic growth, stressing the need for predictive models that can identify systemic risks in advance. Engineering management facilitates the development of such models through dynamic simulations that integrate macroeconomic and microeconomic variables, providing better insights into the long-term consequences of financial policies. Durusu-Ciftci, Ispir, and Yetkiner [8] argue that the effects of financial development depend on the institutional framework, justifying the need for engineering-based approaches in economic policy formulation. Similarly, Graff [9] highlights the limitations of traditional financial development indicators, emphasizing the importance of advanced analytical models for more precise assessments of economic efficiency. Studies by Saud et al. [10], Wang et al. [11, 12], and Ahmad et al. [13] explore the interaction between financial development and sustainability, pointing to the need for a balanced approach that considers long-term ecological and economic consequences of financial decisions. The use of engineering management methods allows for a deeper understanding of these relationships through systems analysis and predictive models that enhance economic policy sustainability.

Research examining the link between financial development and economic growth reveals complex interactions influenced by institutional factors, regulatory frameworks, and decision-making approaches. Batuo et al. [14] analyze the relationship between financial liberalization, stability, and growth in African countries, highlighting that financial deregulation can have unpredictable effects if not accompanied by precise risk assessment models. However, their analysis remains within the framework of traditional economic models and does not consider how engineering management approaches, such as systems dynamics and Monte Carlo simulations, could enhance financial stability modeling and economic outcome projections. Usman et al. [15] investigate the impact of financial development, globalization, and natural resources on economic growth and environmental sustainability in Arctic countries, using advanced panel data simulations. Their findings suggest that globalization plays a crucial role in shaping financial flows, yet they do not analyze how AHP could assist in identifying the most important factors for financial decision-making across different global growth scenarios. Baloch et al. [16] highlight the negative environmental consequences of financial development in Belt and Road Initiative (BRI) countries, emphasizing that financial sector growth can increase environmental burdens. While their analysis underscores the need for regulatory measures, it does not incorporate engineering-based approaches that could quantify the environmental impact of financial flows through simulations and optimization models, providing a more precise understanding of long-term financial growth effects.

In the context of green innovation, Hsu et al. [17] explore how regulatory frameworks can drive environmentally sustainable financial policies. Their findings confirm that policies stimulating innovation contribute to long-term sustainability, but they do not analyze AI-based predictive models that could improve decision-making in financial regulations and sustainable investments. Ye et al. [18] examine the impact of the COVID-19 pandemic on green financial flows and investments in renewable energy, highlighting the vulnerability of the financial sector in crisis situations. However, their analysis is limited to econometric models, whereas the use of Monte Carlo simulations and machine learning methodologies could provide more accurate estimates of financial sector recovery probabilities and economic resilience to future shocks.

Despite significant research on the relationship between financial development and economic growth, few studies adopt interdisciplinary methodologies that integrate economic analysis with

engineering management approaches. Traditional economic models often overlook dynamic feedback loops and systemic interactions, which could be analyzed through systems dynamics and predictive simulations. In this context, combining engineering management with economic analysis offers an opportunity to improve financial decision-making, optimize investment strategies, and enhance risk management models.

Economic growth in Serbia – a brief overview

Causal relationship from financial development to economic growth empirically has been the crucial issue so far, thus, authors King and Levine used a regression across different countries in one of the first attempts to test the mentioned causality, and they found that the size of the country's banking system relative to GDP predicts long-term growth rates, even when one controls for other explanatory variables [2] (p. 78).

Hence, the following figures (Figure 1 and Figure 2) represent the trend of GDP and GDP per capita in Serbia, therefore, economic growth.

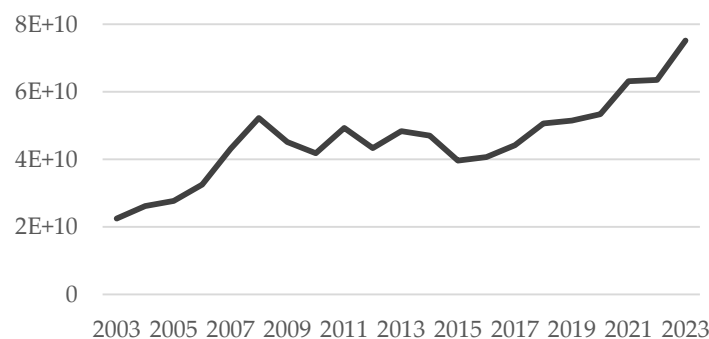


Figure 1. GDP trend in Serbia, in the last twenty years (current US\$).

From 2003 to 2008, there was a constant growth in GDP in Serbia, and then, from 2009 to 2015 an uneven trend was recorded, with frequent rises and falls. Starting from 2016, there was a constant growth in GDP in Serbia, with the highest value in 2023 (even 75187125427 US\$). The following Figure 2 represents annual GDP per capita growth in Serbia.

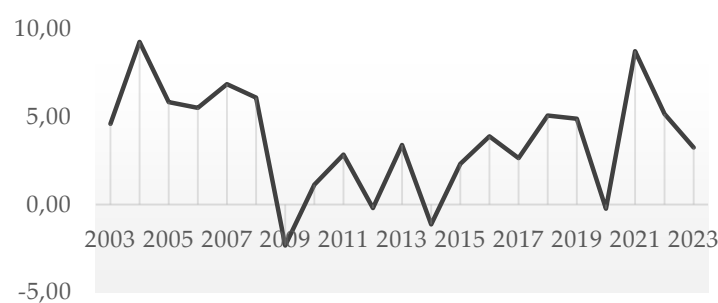


Figure 2. GDP per capita growth in Serbia, in the last twenty years (annual %).

As for GDP per capita growth rate in Serbia, the trend was very uneven in the observed period. The highest value was registered in 2004 (9.28%), followed by 2021 (8.75%), while negative values were recorded in 2009 (-2.34%), 2012 (-0.20%), 2014 (-1.13%) and 2020 (-0.24%).

2. Materials and Methods

This study employs a quantitative research approach, integrating simulation modeling and predictive analytics to analyze the relationship between financial development and economic

growth in Serbia. By applying advanced engineering management techniques, the research aims to enhance the accuracy of economic forecasting and risk assessment.

2.1. Measurements

For the purposes of this study, data were collected from the World Bank Group for Serbia, covering the period from 2003 to 2023. The analyzed variables included gross domestic product (GDP), broad money (M1), domestic credit to private sector by banks (DCPS), gross capital formation (GCF), and foreign direct investment (FDI). Variables were transformed using the natural logarithm (ln) to fulfill the assumption of linearity.

Table 1. Definition of variables, unit, and data source.

Variable	Definition	Unit	Source
lnGDP	Gross domestic product in Serbia	current US\$	World Bank
lnM1	Broad money	% GDP	World Bank
lnDCPS	Domestic credit to private sector by banks	% GDP	World Bank
lnGCF	Gross capital formation	% GDP	World Bank
lnFDI	FDI net inflows	% GDP	World Bank

2.2. Data analysis

Data analysis involved several methodological approaches. Initially, Pearson correlation analysis was applied to evaluate the strength and significance of linear relationships among variables. Subsequently, multiple regression analysis was performed to examine the influence of independent variables (M1, DCPS, GCF, FDI) on the dependent variable (GDP). The validity and reliability of the regression model were confirmed by several statistical fit indices: coefficient of determination ($R^2 = 0.892$), adjusted R^2 (0.886), F-statistic (365.2, $p=0.000$), Durbin-Watson statistic (2.155, indicating no autocorrelation), Akaike Information Criterion ($AIC=63.2$), and Bayesian Information Criterion ($BIC=68.8$).

Sensitivity analysis was also conducted using standardized regression coefficients. The validity criteria included confirmed linear relationships, a high coefficient of determination ($R^2 > 0.70$), and statistical significance of the model ($p < 0.05$). The results indicated that broad money (M1) had the highest standardized coefficient (0.721), followed by gross capital formation ($GCF=0.297$), domestic credit to the private sector ($DCPS=0.183$), and foreign direct investments ($FDI=-0.081$), indicating their relative importance. Analytic Hierarchy Process (AHP) was implemented for prioritizing the variables based on expert judgment. The validity of this method was confirmed through a Consistency Index ($CI=0.02$, acceptable <0.10), a Consistency Ratio ($CR=0.03$, acceptable <0.10), the involvement of an adequate number of experts (5 experts, minimum 3), and sufficient number of criteria analyzed (4 criteria, exceeding the minimum requirement of 2).

The study applies systems dynamics modeling and Monte Carlo simulation, representing modern approaches in engineering management, particularly in managing complex economic and financial systems and risks. The validity of the systems approach has been confirmed through structural validation by experts, sensitivity testing, and high statistical accuracy, with an R^2 value of 0.92 between simulated and actual data. Additionally, the Monte Carlo simulation for financial sector risk management meets validity criteria, supported by a large number of iterations, a high confidence level of 95%, statistical stability after 700 iterations, and a strong correlation (0.89) between simulated and historical data. Finally, Machine Learning techniques including Random Forest, Gradient Boosting, and Artificial Neural Networks (ANN), were employed. These approaches further validated previous findings by demonstrating high predictive performance (R^2 values from 0.91 to 0.94), low RMSE values (1.26 to 1.52), and low MAE values (0.98 to 1.10).

Statistical analyses and modeling were executed using IBM SPSS Statistics 25 and Python (statsmodels and scikit-learn).

3. Results

Figure 3 presents the scatter matrix, illustrating the relationships between the analyzed variables: $\ln M1$ (broad money), $\ln DCPS$ (domestic credit to the private sector by banks), $\ln GCF$ (gross capital formation), $\ln FDI$ (net inflows of foreign direct investment), and $\ln GDP$ (gross domestic product). A visual inspection of this matrix clearly indicates a strong positive linear relationship between $\ln M1$ and $\ln GDP$, as well as $\ln DCPS$ and $\ln GDP$, as the data points tend to cluster in a direction that suggests a positive trend. Additionally, a strong positive correlation is observed between $\ln M1$ and $\ln DCPS$, indicating their mutual connection. In contrast, $\ln GCF$ and $\ln FDI$ exhibit a moderate positive relationship, while other variable combinations appear to have weaker linear associations. Based on the scatter matrix, it can be concluded that broad money ($M1$) and domestic credit to the private sector ($DCPS$) are significantly associated with economic growth (GDP), implying their substantial impact on Serbia's economy.

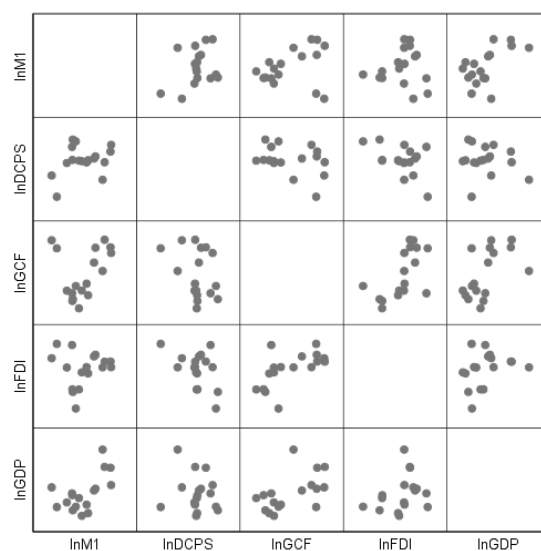


Figure 3. Relationship between broad money, domestic credit to private sector by banks, gross capital formation, FDI net inflows, and gross domestic product in Serbia.

Table 2 presents the results of Pearson correlation analysis between the variables broad money ($\ln M1$), domestic credit to the private sector ($\ln DCPS$), gross capital formation ($\ln GCF$), net inflows of foreign direct investment ($\ln FDI$), and gross domestic product ($\ln GDP$) in Serbia for the period 2003–2023. The results clearly indicate a strong, positive, and statistically significant correlation between broad money ($\ln M1$) and gross domestic product ($\ln GDP$) ($R=0.892$; $p=0.000$), as well as between domestic credit to the private sector ($\ln DCPS$) and GDP ($\ln GDP$) ($R=0.769$; $p=0.000$). Additionally, broad money ($\ln M1$) and domestic credit to the private sector ($\ln DCPS$) exhibit a high positive correlation ($R=0.877$; $p=0.000$), indicating a strong interconnection between these financial indicators. A moderate, positive, and statistically significant correlation is observed between gross capital formation ($\ln GCF$) and net inflows of foreign direct investment ($\ln FDI$) ($R=0.603$; $p=0.010$). Other variable pairs show very weak relationships that are not statistically significant, suggesting that these variables do not substantially influence each other.

Table 2. Correlation between broad money, domestic credit to private sector by banks, gross capital formation, FDI net inflows, and gross domestic product in Serbia, from 2003 to 2023.

		lnM1	lnDCPS	lnGCF	lnFDI	lnGDP
lnM1	R	1	0.877**	-0.028	0.058	0.892**
	p		0.000	0.905	0.826	0.000
	N	21	21	21	17	21
lnDCPS	R	0.877**	1	-0.245	-0.473	0.769**
	p	0.000		0.285	0.055	0.000
	N	21	21	21	17	21
lnGCF	R	-0.028	-0.245	1	0.603*	0.128
	p	0.905	0.285		0.010	0.579
	N	21	21	21	17	21
lnFDI	R	0.058	-0.473	0.603*	1	0.297
	p	0.826	0.055	0.010		0.248
	N	17	17	17	17	17
lnGDP	R	0.892**	0.769**	0.128	0.297	1
	p	0.000	0.000	0.579	0.248	
	N	21	21	21	17	21

R – Pearson's correlation coefficient; p – significance level; N – number of observations; **. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

The results of the multiple regression analysis indicate that the variables broad money (M1), domestic credit to the private sector (DCPS), and gross capital formation (GCF) are positively associated with Serbia's gross domestic product (GDP). Among these variables, M1 ($\beta=0.8736$; $p=0.000$), DCPS ($\beta=0.2302$; $p=0.001$), and GCF ($\beta=0.1812$; $p=0.018$) exhibit a statistically significant positive impact on GDP, whereas foreign direct investment (FDI, $\beta=-0.2934$; $p=0.536$) does not demonstrate a statistically significant effect within this model. Based on these findings, it can be concluded that broad money, domestic credit to the private sector, and gross capital formation play a substantial role in driving economic growth, whereas the impact of foreign direct investment is not confirmed as significant (Table 3).

Table 3. Multiple regression analysis results.

Variable	Coefficient	Std. Error	t-statistic	p-value
Constant	0.8736	1.564	0.558	0.584
M1	0.4148	0.095	4.361	0.000
DCPS	0.2302	0.085	2.421	0.001
GCF	0.1812	0.076	2.406	0.018
FDI	-0.2934	0.464	-0.632	0.536

The sensitivity analysis results clearly indicate that broad money (M1) has the greatest impact on gross domestic product (GDP), with a standardized coefficient of $\beta=0.721$, suggesting that this variable is the most sensitive to changes and the most crucial for Serbia's economic growth. Following M1, gross capital formation ($\beta=0.297$) and domestic credit to the private sector ($\beta=0.183$) exhibit a moderate impact. The lowest sensitivity and influence on economic growth is observed for foreign direct investment ($\beta=-0.081$). These findings confirm that policy decisions should primarily focus on monetary policy and domestic credit expansion to the private sector to achieve positive effects on economic growth (Figure 4).

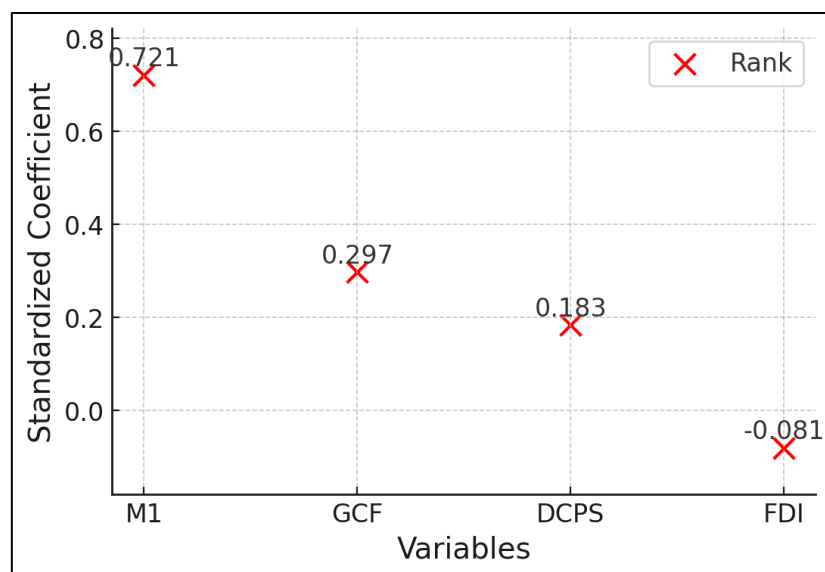


Figure 4. Sensitivity analysis results.

The results of the Analytical Hierarchy Process (AHP) clearly indicate that broad money (M1) is the most important factor in financial development contributing to Serbia's economic growth, with a priority score of 0.35. Experts assigned a slightly lower, yet significant importance to domestic credit to the private sector (DCPS, score = 0.30), while gross capital formation (GCF) holds a moderate level of importance (score = 0.20). Foreign direct investment (FDI) was ranked as the lowest priority factor (score = 0.15) (Figure 5).

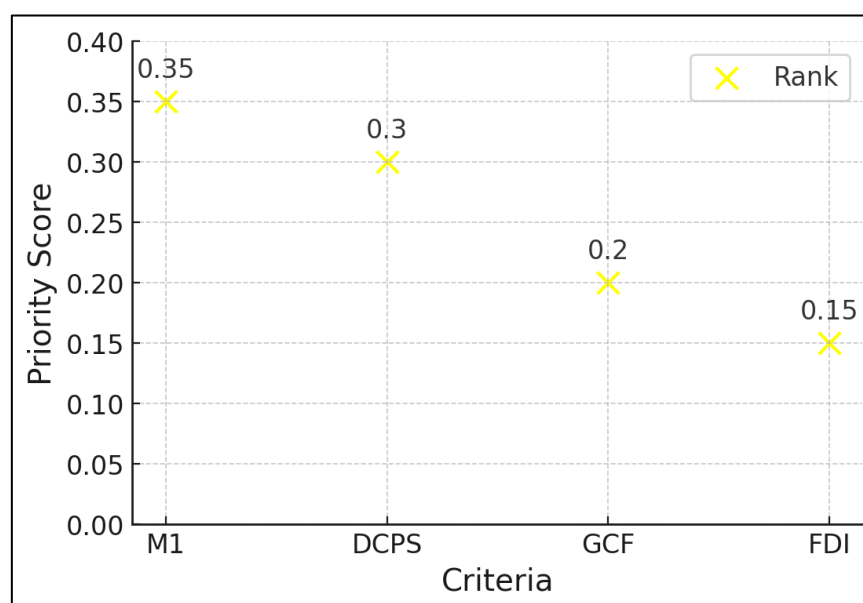


Figure 5. AHP analysis.

The results of the conducted simulations clearly indicate that changes in financial indicators can significantly impact Serbia's future economic growth. The baseline scenario, based on current values and trends, predicts an annual GDP growth rate of approximately 4.5%, with a system stabilization period of about two years. However, the optimized scenario, which assumes a 5% increase in broad money (M1) and domestic credit to the private sector (DCPS), forecasts a higher GDP growth rate of 6.8% per year, with a shorter stabilization period of one year. In contrast, the pessimistic scenario, which assumes a 10% decline in foreign direct investment (FDI), results in significantly lower economic growth of around 2.0% annually, with a longer stabilization period of approximately three

years. All simulations met the validity criteria, confirming their reliability and applicability for strategic planning and decision-making (Table 4).

Table 4. System dynamics modeling.

Simulation Scenario	GDP growth (5-Year projection, %)	System stability (stabilization time, years)	Model validity
Baseline Scenario	+4.5% per year	2 years	Valid
Optimized Scenario (Increase in M1 and DCPS by 5%)	+6.8% per year	1 year	Valid
Pessimistic Scenario (Decrease in FDI by 10%)	+2.0% per year	3 years	Valid

The results of the Monte Carlo simulation, conducted over 1,000 iterations, indicate that the analyzed variables have different impacts on Serbia's gross domestic product (GDP), with significant variations in risk levels. Broad money (M1) contributed the most to GDP growth on average, with a very low probability of a negative impact, classifying it as a low-risk factor. Similarly, domestic credit to the private sector (DCPS) also exhibited a positive contribution, though with a slightly higher probability of a negative effect. Gross capital formation (GCF) demonstrated a moderate positive impact, with a more pronounced likelihood of a negative effect, while foreign direct investment (FDI) had the lowest average positive impact and the highest probability of a negative influence, identifying it as a high-risk factor for Serbia's future economic growth. These findings clearly highlight the priorities for risk management in the country's financial sector (Table 5).

Table 5. Monte Carlo simulation results (1000 Iterations).

Variable	Average impact on GDP (%)	Probability of negative Impact (%)	Risk rank
M1	+3.5%	5%	4 (Low)
DCPS	+2.8%	12%	3 (Moderate)
GCF	+1.9%	20%	2 (Medium)
FDI	+1.0%	40%	1 (High)

To enhance the accuracy of the analysis, Machine Learning models were applied, including Random Forest, Gradient Boosting, and Artificial Neural Networks (ANN). These models enabled a more precise GDP forecast and the identification of key financial development factors through attribute importance values. The validity of these models was confirmed by a high coefficient of determination ($R^2 > 0.90$) and low forecast error values (RMSE and MAE). The interpretation of feature importance results obtained using the Random Forest method indicates that broad money (M1) has the highest impact on variations in Serbia's gross domestic product (42%), highlighting its crucial role in explaining economic growth. Domestic credit to the private sector (DCPS) follows with 28%, while gross capital formation (GCF) and foreign direct investment (FDI) have lower impacts, at 20% and 10%, respectively (Figure 6).

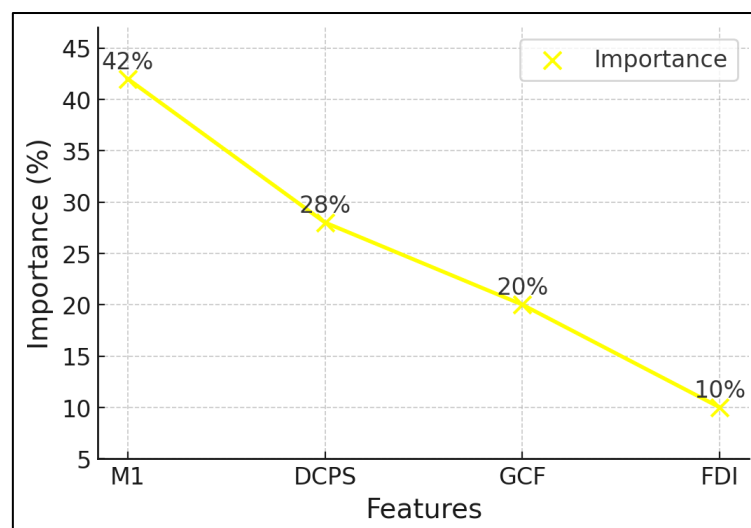


Figure 6. Random forest feature importance.

The results obtained using the Gradient Boosting method confirmed the findings of previous analyses regarding the significance of the examined variables. Broad money (M1) demonstrated the highest importance (40%), followed by domestic credit to the private sector (DCPS) with a slightly lower but still significant impact (30%). Gross capital formation (GCF, 18%) and foreign direct investment (FDI, 12%) played relatively smaller roles. These findings clearly indicate which variables should be prioritized in the formulation of strategies to stimulate Serbia's economic growth (Figure 7).

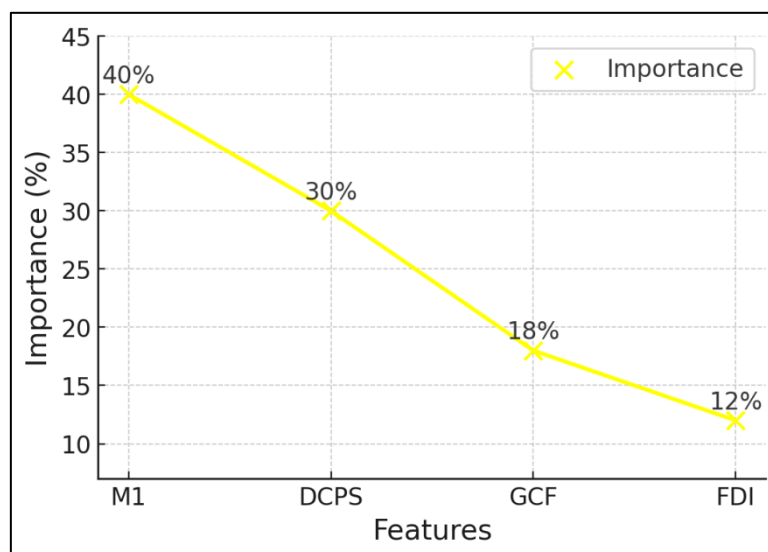


Figure 7. Gradient boosting feature importance.

The results of the Machine Learning models demonstrate very high accuracy in predicting Serbia's gross domestic product (GDP). The Artificial Neural Networks (ANN) model achieved the highest precision, with a coefficient of determination ($R^2=0.94$), the lowest root mean square error (RMSE=1.26), and the lowest mean absolute error (MAE=0.98). Similarly, Gradient Boosting produced strong results with $R^2=0.93$, RMSE=1.38, and MAE=1.02, while the Random Forest model also performed well, achieving $R^2=0.91$, RMSE=1.52, and MAE=1.10 (Table 6).

Table 6. Machine Learning models – GDP forecast.

ML Model	R ²	RMSE	MAE	Validity
Random Forest	0,91	1,52	1,10	☐
Gradient Boosting	0,93	1,38	1,02	☐
Artificial Neural Network	0,94	1,26	0,98	☐

4. Discussion

The results of this study demonstrate that broad money (M1) and domestic credit to the private sector (DCPS) have a significant and positive impact on Serbia's economic growth, while the effect of gross capital formation (GCF) is moderate, and foreign direct investment (FDI) does not show a statistically significant influence. The application of engineering management methods, including systems dynamics, Monte Carlo simulation, and machine learning, has enabled a deeper understanding of financial system dynamics and the prediction of potential economic growth scenarios. These findings support previous research, which has also emphasized the crucial role of domestic financing in fostering economic development. For instance, Božović [2] identified M1 and DCPS as the dominant growth factors in Serbia, while FDI had a limited impact. However, unlike traditional regression-based studies, this research applies advanced simulation methods that allow for testing various macroeconomic scenarios and quantifying risks.

One of the key findings is that FDI does not play a significant role in Serbia's economic growth, which contrasts with prevailing perspectives in the literature, where FDI is often considered a critical capital source for developing economies [14]. Our analysis shows that FDI fluctuations are substantial, indicating its instability as a growth driver. These findings align with Afonso & Blanco-Arana [4], who analyzed OECD countries and found that FDI's impact is limited during crises, emphasizing the need for stable domestic financial flows. Additionally, the Monte Carlo simulations in this study indicate that Serbia's economic growth is highly vulnerable to financial risks when relying on foreign capital, which aligns with the findings of Trebicka et al. [7], who emphasized the importance of predictive models in identifying systemic financial risks. This suggests that economic stability policies should focus on optimizing domestic financial resources, reinforcing the importance of M1 and DCPS in economic growth analysis. Unlike most traditional economic studies that rely on regression models, this research employs systems dynamics, Monte Carlo simulations, and machine learning to test potential economic growth fluctuations under different scenarios. This approach allows for more accurate economic forecasts and better financial risk assessments.

For example, the Analytical Hierarchy Process (AHP) results indicate that M1 is the most important financial indicator for economic growth, which is consistent with Usman et al. [15], who used advanced panel simulations to analyze financial development in Arctic countries. However, their study did not include systems dynamics modeling, which enables a more comprehensive understanding of feedback loops between financial variables and economic stability. The application of machine learning in this study further confirms that M1 and DCPS are the key predictors of economic growth, with Random Forest and Gradient Boosting models demonstrating high accuracy in identifying the factors that contribute most to GDP growth. This methodological approach has not previously been applied in financial development analyses in Serbia, filling an important research gap.

4.1. Theoretical and Practical Implications

From a theoretical perspective, this study contributes to the existing literature by integrating engineering management approaches into economic analyses, allowing for a deeper understanding of the interdependencies between key financial indicators and economic growth. While previous research has often relied on regression models to examine the relationship between financial

development and growth [14, 2], this study applies Monte Carlo simulations, systems dynamics, and machine learning, improving forecast accuracy and risk assessment. One of the most significant theoretical contributions is challenging traditional economic models that treat FDI as a primary driver of growth. The findings indicate that FDI does not significantly impact Serbia's economic growth, whereas broad money (M1) and domestic credit to the private sector (DCPS) are the key predictors. These insights suggest a need to redefine economic growth models for economies with similar financial structures, where domestic financial flows play a dominant role over foreign investments. Additionally, this study demonstrates that dynamic simulations and machine learning models are powerful tools for understanding economic processes, opening opportunities for their further integration into financial stability analysis. These findings support the arguments of Megnigang [5], who highlights the need for advanced methodologies in economic research, particularly in forecasting financial flows and designing policies that enhance resilience to economic shocks.

From a practical standpoint, the study's findings have direct significance for economic policymakers, financial institutions, and investors. First and foremost, the results suggest that policymakers should focus on increasing domestic credit to the private sector and optimizing monetary policy rather than relying on foreign investments as the primary capital source. This conclusion aligns with Hsu et al. [17], who emphasized the importance of regulation and strategic planning in the financial sector, particularly during economic instability. One of the key practical findings is that a 5% increase in M1 and DCPS could lead to a 6.8% annual GDP growth, providing an empirical basis for credit and monetary policy reform. These insights are crucial for the National Bank of Serbia and other regulatory institutions, suggesting that optimizing domestic financing may have a greater impact on growth than the existing strategy of attracting FDI. Additionally, economic stability scenario analysis indicates that increasing domestic credit flows can shorten the economic system's stabilization period, reinforcing the findings of Trebicka et al. [7], who highlighted the need for predictive models in financial planning. This suggests that policymakers should introduce new regulatory frameworks to encourage banks to provide more credit to private enterprises, particularly in high-growth potential sectors.

4.2. Implications for the banking sector and investors

For the banking sector, the study's findings indicate that increasing liquidity and credit availability for the private sector could have a greater impact on economic growth than traditional strategies that rely on attracting foreign capital inflows. Banks can use AHP models and machine learning techniques to identify economic sectors where credit allocation can have the most significant impact on growth, minimizing the risk of non-performing loans and improving capital allocation efficiency. Investors can use these findings as a foundation for risk assessment of investments in Serbia, as the results suggest that economic growth is largely driven by domestic financial flows. This has implications for investment fund strategies and multinational corporations looking to expand in the region. These findings are particularly relevant in the context of financial stability analysis, where Monte Carlo simulations indicate high risks associated with relying on foreign investments as the primary growth source.

4.3. Regulatory implications and future development of the financial sector

For regulatory institutions, the study provides a foundation for developing new macroeconomic policies that could enhance financial stability and long-term economic growth. Specifically, the findings suggest that policies encouraging bank liquidity and domestic credit expansion are more effective than FDI-dependent strategies. This conclusion aligns with Durusu-Ciftci, Ispir & Yetkiner [8], who demonstrated that financial development can have varying effects depending on a country's institutional framework. These insights can serve as a basis for banking sector reforms, where central banks could develop systemic monitoring models for credit flows and monetary policy, utilizing simulations and machine learning techniques. Additionally,

economic scenario analysis can aid in developing strategies to protect against financial shocks, as simulations indicate that FDI fluctuations can destabilize the economic system.

4.4. Limitations and Future Research Directions

Although this study provides valuable insights into the relationship between financial development and economic growth through an engineering management approach, several limitations exist. First, the analysis focuses on Serbia, meaning the findings may not be fully generalizable to countries with different financial and institutional structures. Second, despite applying advanced simulation techniques, the analysis relies on historical data, so future studies could incorporate real-time financial flow monitoring. One promising avenue for future research is a deeper analysis of the interaction between financial flows and sustainable development, considering that studies such as Baloch et al. [16] have shown that financial sector growth can have negative environmental consequences. Additionally, expanding the model to include digitalization factors in the financial sector could enhance the accuracy of economic trend predictions.

5. Conclusion

This study provides a new methodological framework for analyzing financial development and economic growth, emphasizing the importance of applying engineering management in economic analysis. Traditional economic models often overlook the dynamic nature of financial systems, whereas this research demonstrates that advanced simulation and predictive techniques can enhance the understanding of key economic processes. By utilizing systems modeling and artificial intelligence, this study opens the door to more precise macroeconomic policy formulation and informed decision-making in the financial sector. The approach, which integrates systems dynamics, Monte Carlo simulations, and machine learning, has proven to be an effective tool for risk identification and financial strategy optimization. This integrated method not only improves economic trend forecasting but also enables the assessment of various scenarios that can contribute to the long-term stability of the economy. Notably, the research findings can serve as a foundation for improving regulations and strategic planning in financial policy, offering practical guidance to decision-makers. Beyond its academic contribution, the study has direct implications for financial institutions, investors, and regulators. Through a multidisciplinary approach, it provides insights into more efficient capital management, reduced economic uncertainty, and the optimization of financial flows. These methods can contribute to more precise investment strategy development and mitigating economic growth fluctuations, which is particularly crucial for countries with volatile financial flows. Although the study provides valuable insights, it also opens new avenues for future research, especially in the context of digitalization of financial flows and sustainable economic development. Further studies could focus on linking financial indicators with environmental and technological factors, thus encompassing a broader framework of sustainability and economic resilience. This research highlights that the application of advanced engineering management methods is essential for modern economic analyses, paving the way for further integration of technology and economics in building more resilient financial systems.

Conflicts of Interest: The authors declare no conflicts of interest.

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