 e-ISSN 2786-8958
ISSN-L 2616-7107

Research Article

UDC 330.36.01
JEL: C02, C63, E12, E60, H20

TAX FACTORS OF ECONOMIC DYNAMICS: ANALYSIS BASED ON THE MODIFIED IS–LM MODEL

Tamara Merkulova *
V. N. Karazin Kharkiv National University,
Kharkiv, Ukraine
ORCID iD: 0000-0002-3507-5593

Tetiana Bitkova
V. N. Karazin Kharkiv National University,
Kharkiv, Ukraine
ORCID iD: 0000-0001-6287-0392

Olena Nikolaeva
V. N. Karazin Kharkiv National University,
Kharkiv, Ukraine
ORCID iD: 0000-0002-1105-7227

Tetiana Stetsenko
V. N. Karazin Kharkiv National University,
Kharkiv, Ukraine
ORCID iD: 0000-0003-3836-4785

*Corresponding author
E-mail: tamara.merkulova@karazin.ua

Received: 28/12/2025
Revised: 04/03/2026
Accepted: 16/03/2026
Published: 30/03/2026

DOI: 10.61954/2616-7107/2026.10.1-11

Background. Taxation is a fundamental instrument of macroeconomic policy, and its influence across various economic and social domains remains one of the most significant subjects of research. Particular attention is devoted to examining the capacity of taxation to regulate economic cycles, shape dynamic processes, and affect the market equilibrium of an economic system. The development of dynamic models of economic equilibrium incorporating endogenous tax factors as a methodological foundation for macroeconomic policy constitutes a significant research objective.

Purpose. This study examines the impact of taxation indicators on macroeconomic dynamics within the dynamic IS–LM framework, incorporating endogenous taxes, mathematical and simulation analyses of oscillatory conditions, and assessment of the influence of tax variables on dynamic regimes.

Findings. This study presents a modified IS-LM model with endogenous taxes, demonstrating the potential influence of taxation on the type of dynamics of economic systems, particularly the exit from the fluctuation zone and vice versa. The theoretical analysis of the model consists of two stages: 1) mathematical analysis of the tax parameter's influence on the type of dynamics of the economic system, and 2) simulation analysis based on the System Dynamics concept. As a result of the first stage, mathematically justified bounds for the tax rate were obtained, which determine its potential (in combination with other parameters) to reflect the diversity of economic systems. In particular, it is shown that for certain values of other model parameters, the transition from fluctuations is possible with both a high tax burden (e.g. above 50%) and a low one (e.g. 20% or below).

Implications. The simulation model developed using the System Dynamics concept demonstrates the possibility of analysing feedback loops that include key variables of the model, revealing reinforcing or balancing mechanisms within closed chains of endogenous variables, and of multivariate calculations and analysis of the impact of various combinations of exogenous parameters on selected response functions (GDP or Interest rate) with the subsequent development of regression meta-models.

Keywords: Business Cycles, IS-LM Model, Fiscal Policy, Market Equilibrium, System Dynamics.

e-ISSN 2786-8958
ISSN-L 2616-7107

1. Introduction.

The impact of taxation on economic system dynamics and equilibrium is crucial for macroeconomic policy, which explains the continuing scientific and practical interest in this topic. Tax instruments are actively used to achieve various socio-economic goals, including supporting certain types of production, stimulating investment activity, redistributing income, and reducing inequalities (Villani & Viscolo, 2021).

The impact of taxation on the behaviour of economic agents (producers and consumers) ultimately results in changes in the macroeconomic proportions and dynamics, including their composition, growth rates and stability. Research on the impact of taxation on macroeconomic equilibrium is essential for determining the boundaries and limitations of tax policy in the economy and predicting changes in its properties.

One of the fundamental results of macroeconomic equilibrium research is the well-known IS-LM model, which helps explain the endogenous cycles of an economic system and the influence of factors that can serve as instruments for macroeconomic policy (Panzaru et al, 2025).

The particular significance of the IS-LM model for economic science and the interest it generates are as follows:

1. It represents the dynamics and potential for achieving equilibrium simultaneously in two markets – those of goods and capital.

2. Oscillatory dynamics are viewed as an internal, endogenous property of the economic system.

3. The model describes a variety of dynamics, not only oscillatory but also monotonically increasing and decreasing, clearly representing the dependence of the type of dynamics on the combination of the values of the economic system's parameters.

These features of the model make it a valuable tool for analysing macroeconomic policy, of which tax policy is a key component.

This study aims to analyse the impact of indicators reflecting taxation (tax variables) on macroeconomic dynamics using the dynamic IS-LM model.

This objective involves the following: modification of the dynamic IS-LM model with endogenous taxes; mathematical and simulation analysis of the conditions of oscillatory dynamics; analysis of the impact of tax variables on the type of dynamics.

2. Literature Review.

2.1. Evolution of the IS-LM Model: From Static Equilibrium to Dynamic Analysis.

The first formulation of the IS-LM model was proposed by Hicks (1937) and subsequently developed in both theoretical and applied (model approval) aspects (Gali, 1992; Smith, 1982). The model has many modifications designed to account for new factors affecting the dynamics of the economic system (Tu, 1994).

Despite its criticism, limitations, and new theoretical approaches, this model remains, as noted by Von Holle (2024), the most important interpretation of Keynesian theory. It remains a fundamental result of economic theory and an instrument of macroeconomic policy (De Cesare & Sportelli, 2005; Gali, 1992; Neamtu et al., 2005; Smith, 1982; Vergés, 2024; Zhou & Li, 2008).

The model has been used to analyse monetary policy. For example, it can point to a study (King, 2000) that shows how the choice of monetary policy rules and monetary shocks can influence macroeconomic fluctuations. Das et al. (2024) investigated environmentally friendly economic growth and the impact of fiscal and monetary policy within the IS-LM model framework.

The model has several significant assumptions and limitations that have been and are the subject of criticism; however, that it is constantly evolving and adapting to new challenges (Li & Wu, 2015; Young & Zilberfarb, 2001).

A surge of interest in this model is associated with its dynamic versions, which describe complex nonlinear behaviour, different types of equilibrium, and stability. Complex dynamics appear in the model due to the inclusion of lag variables (Altar, 2008; Neamtu et al., 2005; Zhou & Li, 2008).

New versions of the IS-LM model have been proposed based on the dynamic stochastic general equilibrium (DSGE) approach (a new paradigm of Keynesian models) (Fritsche and Größl, 2010).

Bazán Navarro and Benazic Tomé (2022) introduced adaptive inflationary expectations into the model, identified conditions for structural instability, and presented examples of locally stable dynamics and a degenerate Hopf bifurcation.

2.2. Fiscal Policy Effects in IS-LM Framework.

Among recent research, note the works by Potrafke (2025), Muslim et al. (2024), Varghese and Saxena (2025), and Wu and Xie (2025), which examine the relationship between fiscal policy and economic sustainability. De Cesare and Sportelli (2005) evaluated the new types of dynamics that emerge due to tax lags. Panzaru et al. (2025) show that deferred taxation, in which tax revenues depend on past income, can destabilise the system, leading to cycles and even chaotic fluctuations. Neamtu et al. (2005) consider types of behaviour such as Hopf bifurcation and limit cycles, which are observed as a result of tax lags introduced into the model.

Thus, on the one hand, despite the extensive research on the influence of taxes on economic processes, this issue is insufficiently discussed in the context of market equilibrium. On the other hand, in IS-LM model studies, attention is mainly focused on the analysis of complex dynamic effects arising from specific tax factors, such as tax lags. This creates a research gap related to the general problem of the impact of all tax instruments on dynamics and equilibrium.

Therefore, taxation should be represented by the most general indicators that characterise it as a whole, and these indicators should be incorporated into the model.

In this study, it is assumed that all taxes can be divided into two groups:

1) Depend on income (income taxes, value-added taxes, etc.).

2) Not directly dependent on income (property taxes, for example).

Accordingly, taxation is represented in the model by two generalised variables: the share of taxes in income (the first group) and the exogenous tax rate (the second group). The proposed modification of the IS-LM model, which considers the mentioned variables, allows us to analyse the impact of these common taxation indicators on the type and equilibrium of the economic system.

3. Methodology.

3.1. A Modified IS-LM Model with Endogenous Taxes.

A modification of the well-known dynamic IS-LM model of a closed economy is introduced based on the following assumptions.

1. GDP grows depending on excess demand, defined as the excess of investments (I) over savings (S):

$$\dot{Y} = h(I - S), \tag{1}$$

where $h > 0$ – proportionality coefficient (constant for regulating the “speed” of income).

2. The interest rate varies depending on the excess demand for money:

$$\dot{r} = m(L - M), \tag{2}$$

where L – the demand for money, M – the supply of money, $m > 0$ – the constant of interest rate adjustment.

3. Investments are linearly dependent on the interest rate:

$$I = I_0 - \alpha r, \alpha > 0, \tag{3}$$

I_0 – exogenously given level of investment.

4. Savings are given as follows:

$$S = Y - C - G\ , \tag{4}$$

where C – household consumption, G – government expenditure (exogenous variable).

5. Consumption assumptions: consumption (C) is closely related to after-tax income (Y–T).

$$C = C_0 + c_1(Y - T), \quad 0 < c_1 < 1 \tag{5}$$

6. Taxes are linearly related to income:

$$T = T_0 + qY,\ 0 < q < 1 \tag{6}$$

where T_0 – tax revenues that are not directly related to income (property taxes).

 e-ISSN 2786-8958
ISSN-L 2616-7107

7. The demand for money is determined by income and the interest rate *L(Y, r)*, with demand increasing with income and decreasing with the interest rate. The relationship *L(Y, r)* is considered to be linear:

$$L(Y,r) = kY - \beta r, \quad (7)$$

where k *and* β – positive constants.

The first term (kY) characterizes business demand for money, the second one ($-\beta r$) is speculative demand, determined only by the interest rate.

3.2. System Dynamics Simulation Framework.

The modified model in matrix form looks like:

$$\begin{pmatrix} \dot{Y} \\ \dot{r} \end{pmatrix} = \begin{bmatrix} -h(1-c_1(1-q)) & -\alpha h \\ km & -\beta m \end{bmatrix} \begin{pmatrix} Y \\ r \end{pmatrix} + \begin{pmatrix} h(G_0+I_0+C_0-c_1T_0) \\ mM \end{pmatrix} \quad (8)$$

The matrix of this system of differential equations is:

$$A = \begin{bmatrix} -h(1-c_1(1-q)) & -\alpha h \\ km & -\beta m \end{bmatrix}$$

It determines the type of economic dynamics. The presence of fluctuations depends on the sign of the characteristic equation of the matrix A:

$$\Delta A = [h(1 - c_1(1-q)) - m\beta]^2 - 4km\alpha h \quad (9)$$

A negative value of the discriminant of this indicator $\Delta A < 0$ means that the dynamics of income and interest rates will be oscillatory, i.e. provided:

$$[h(1 - c_1(1-q)) - m\beta]^2 < 4hmk\alpha \quad (10)$$

Non-oscillating trajectories are obtained under the condition $\Delta A \geq 0$:

$$[h(1 - c_1(1-q)) - m\beta]^2 \geq 4hmk\alpha \quad (11)$$

Consider the influence of the tax parameter q on these conditions.

Condition (5) will be fulfilled for the corresponding values of the parameter q:

$$B - \frac{2\sqrt{mkh\alpha}}{hc_1} < q < B + \frac{2\sqrt{mkh\alpha}}{hc_1}, \quad B = \frac{m\beta - h(1-c_1)}{hc_1} \quad (12)$$

Theoretically, the tax coefficient ranges from zero to one ($0 < q < 1$), but in fact, this interval is smaller, since too high (close to 0.8, for example) or too low values close to 0) are only theoretically permissible, but unrealistic.

If condition (12) lies within the realistic interval of tax coefficient values, non-oscillations are possible when the coefficient increases and decreases.

4. Results.

4.1. Mathematical Conditions for Oscillatory Dynamics.

The derived boundaries for the tax coefficient become clearer with a concrete parameter cases.

Case 1. A numerical example is provided for the following parameters: β = 0.4; α = 0.01; k = 0.3; c_1 = 0.8, m = 1.2; h = 1. Both limits of condition (12) for such values are within the permissible interval 0.2< q < 0.5. Consequently, increasing the tax rate to 50% or higher or decreasing it below 20% eliminates fluctuations.

However, one or both constraints of condition (12) may extend beyond the permissible ranges. For example, changing the value of parameter β by 0.2 moves the left boundary of condition (12) into the unacceptable zone: $-0.1 < q < 0.2$. In this case, fluctuations will appear if the tax rate is less than 20%. Consequently, a decrease in the speculative component of demand in the money market, that is, a decrease in the β parameter, expands the zone of non-fluctuating dynamics and narrows the possibilities for regulating it through taxation. Various combinations of model parameters determining the limits of condition (12) define a range of tax coefficient values over which oscillations occur. In some instances, non-oscillatory dynamics are impossible for any parameter value.

Case 2. Consider an economy with the following parameters: β = 0.4; α = 1; c_1 = 0.8, k = 1, m = h = 1. With these values, condition (12) falls outside the permissible range of the tax coefficient: -2.25< q < 2.75. This means that, with these parameters, it is impossible to change the oscillatory type of system dynamics (a stable focus) by varying the parameter values (Fig. 1).

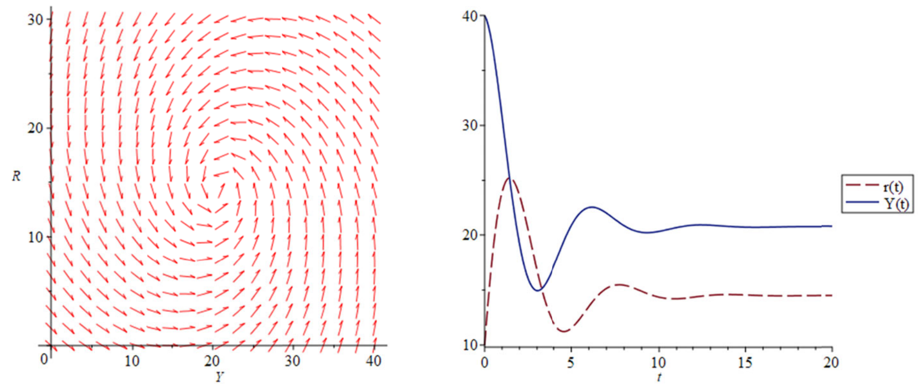

Fig. 1. Dynamics of the Economic System (*Y(0)* = 40, *r(0)* = 10).

4.2. Simulation Implementation of the Modified IS-LM Model.

The use of a simulation approach enables multivariate calculations based on different combinations of model parameters, analysis of feedback loops for various endogenous variables, and the construction of regression meta-models based on statistics generated by the simulation model.

The proposed model is based on the System Dynamics simulation concept and was developed using Vensim PLE software. The structural model is presented in Fig. 2. The model operators correspond to Equations (1–6) and (8).

The analysis of the feedback loops involving the key model variables *Y(t)* and *r(t)* shows that, along with short positive feedback (self-reinforcing) loops, both variables are included in longer negative feedback loops that provide a balancing effect (Fig. 3, 4).

This is a second-order model, that is, it has more than one level variable; therefore, there are one-step delays in the negative feedback loops due to the rate-level coupling. Delays in negative feedback loops generate instability. From a theoretical perspective, the proposed simulation model can demonstrate teleological (goal-seeking) trajectories, such as exponential decay or damped oscillations.

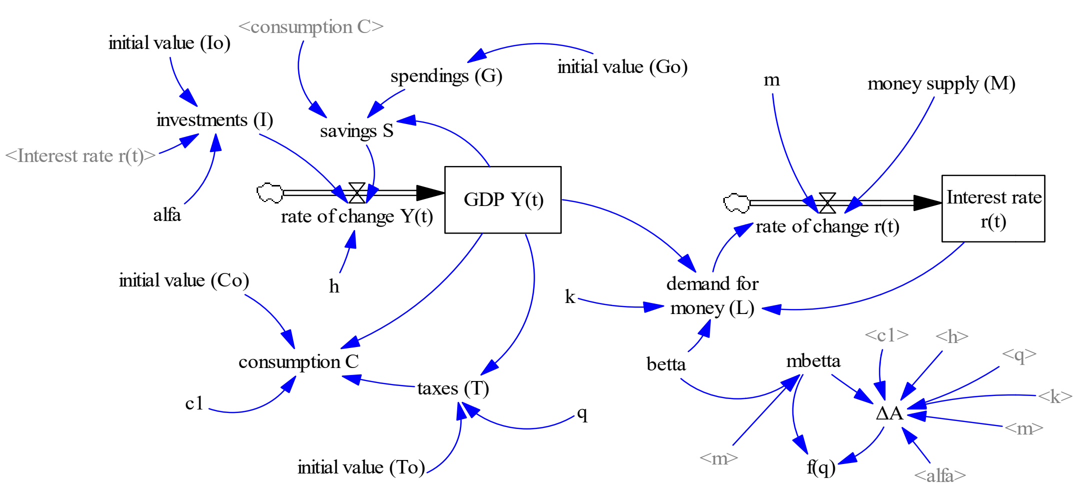

Fig. 2. Structural System-Dynamic Model.

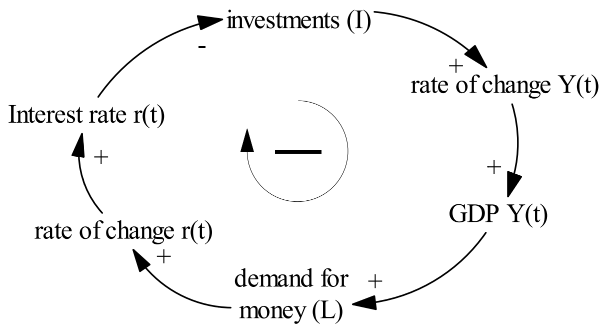

Fig. 3. The Longest Negative Feedback Loop for *Y(t)* and *r(t)*.

The simulation results are presented in Figures 4 and 5. They correspond to the conditions of Case 1 and confirm the theoretical conclusion that for ΔA > 0, the range of variation of the tax parameter q within the limits from 0.2 to 0.5 ensures non-oscillatory dynamics.

Based on the simulation results, the dependence of the equilibrium values of Y(t) on the interest rate can be established as follows: $Y(r) = 16.616 + 1.335 \cdot r$ ($R^2 = 1$; $F = 15958034.8$). All coefficients are statistically significant. Exceeding the specified interval of *q* leads to oscillatory dynamics (Fig. 6).

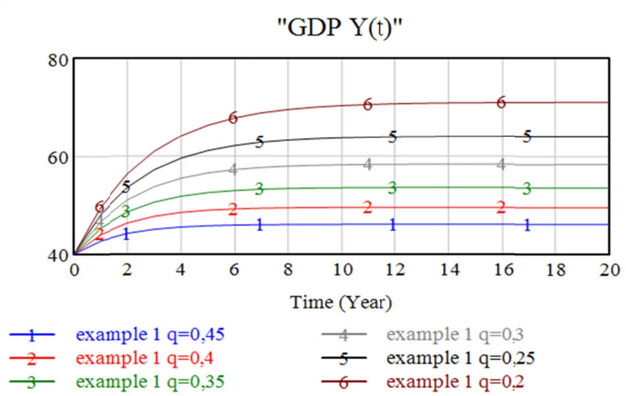

Fig. 4. Dynamics of *Y(t)* for Tax Parameter Values From 0.2 to 0.5.

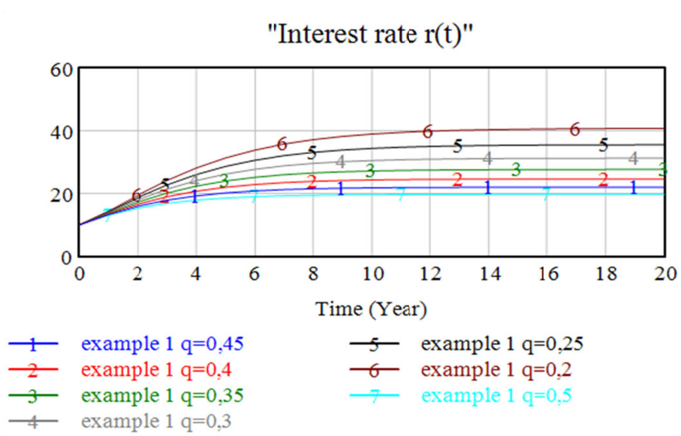

Fig. 5. Dynamics of *r(t)* for Tax Parameter Values From 0.2 to 0.5.

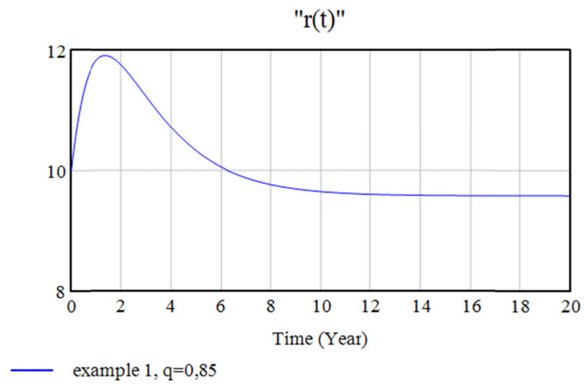

Fig. 6. Dynamics of the Interest Rate for the Value of the Tax Parameter q=0.85.

For Case 2, ΔA < 0, and for q = 0.5, oscillatory dynamics can be obtained, and the smaller the value of the tax parameter, the greater the amplitude of the oscillations and the longer their duration in the transitional process (Fig. 7, 8). Dependence of equilibrium values r on parameter q: *r(q)* = 22.589 – 7.724*q (R^2= 0.996; F = 578.9; all coefficients are statistically significant).

Dependence of the equilibrium values *Y(q):* 14.09–3.24*q (R^2 = 0.998; F = 449.586; all coefficients were statistically significant). By planning experiments with the simulation model and processing their results, it is possible to develop more complex regression meta-models that link endogenous variables with various combinations of exogenous controlled parameters.

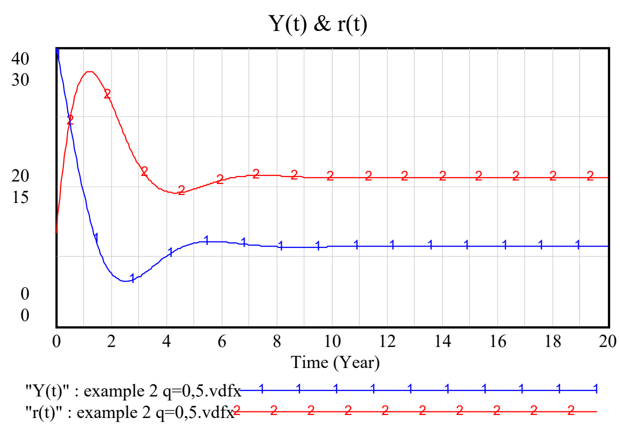

Fig. 7. Dynamics of *Y(t)* and *r(t)* under the Conditions of Case 2 at *q*=0.5.

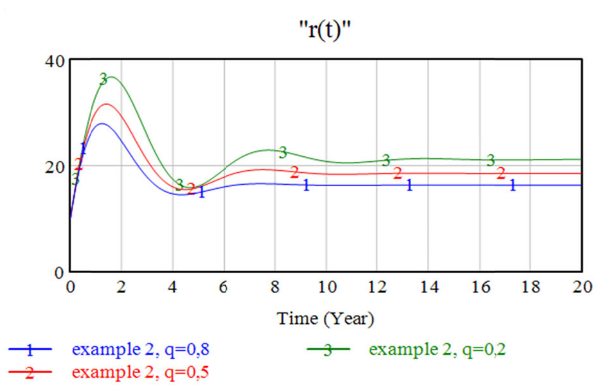

Fig. 8. Interest Rate Dynamics under Case 2 for varying *q*.

5. Discussion.

When comparing the results of this study with those of other studies in this area, the following can be noted. Unlike other studies that focus on analysing the complex dynamic effects arising from specific tax factors, this study models taxation using two generalised variables: the tax share in income and the exogenous tax rate. In addition, the simultaneous use of analytical and simulation approaches enables a significant expansion of the analysis scope through the model experiments.

Firstly, the IS-LM model is primarily a conceptual model, which determines its significance for economics by serving as the basis for applied models. The modification presented here represents a significant step toward the practical use of this model.

Secondly, the examples provided employ tax rate values that are close to realistic (0.3–0.4), as well as some extreme values (e.g., 0.2, 0.5, and higher), which are unlikely but possible from a practical standpoint.

The range of tax coefficient values that determine the type of dynamics is set by the other model parameters, reflecting the absolute dependence of the tax policy on the state of the economy. This means that there are no quantitative estimates of tax parameters adequate for any economic system, but the analysis conducted provides some rules for finding them.

In this study, the proposed modification has limitations beyond those of the IS-LM model, whether theoretical or applied. The tax coefficient is assumed to be constant, whereas in the real economy, it changes, especially over the long term. This assumption limits the practical significance of the results to the short term, during which the tax rate can be relatively stable.

6. Conclusions.

This study explores the implementation of tax parameters within the classical IS-LM market equilibrium model. In general, the analysis confirms the extensive potential of the IS-LM model for interpreting the dynamics of economic systems.

Taxation is one of the most important instruments of countercyclical policy, and its inclusion in the model shows that, using its parameters, one can influence the equilibrium and the type of dynamics, bringing the economy out of the oscillation zone and vice versa. The results can be used to conclude the possibilities and limitations of tax policy based on actual parameter estimates.

The theoretical analysis of the modified IS-LM model consists of two stages: a mathematical analysis of the limitations of the tax variable (tax coefficient) and a simulation analysis of feedback loops and types of dynamic behaviour.

Consequently, mathematically justified double-sided bounds on the tax coefficient were obtained. They depend on all the model parameters (seven in total), resulting in a wide variety of combinations that reflect the diversity of economic systems.

The simulation model developed using the System Dynamics concept demonstrates the possibility of 1) analysing the feedback loops that include key variables of the model, revealing reinforcing or balancing mechanisms and closed chains of endogenous variables; and 2) multivariate calculations and analysis of the impact of various combinations of exogenous parameter values on selected response functions, with the subsequent development of regression meta-models.

The results are used to conclude the possibilities and limitations of tax policy based on the actual parameter estimates. The theoretical results should be further tested in real-world scenarios. In addition, the System Dynamics concept used to construct the simulation model represents an effective and promising methodology and offers a perspective for developing the IS-LM model with additional factors.

Conflict of Interest Statement.

The authors declare that there is no conflict of interest.

Funding Disclosure.

This research received no external funding.

e-ISSN 2786-8958
ISSN-L 2616-7107

REFERENCES

Altar, M. (2008). A Dynamic IS-LM Model with Adaptive Expectations. SSRN. http://dx.doi.org/10.2139/ssrn.1150178

Bazán Navarro, C. E., & Benazic Tomé, R. M. (2022). Structural stability analysis in a dynamic IS-LM-AS macroeconomic model with inflation expectations. International Journal of Differential Equations, 2022, 1–21. https://doi.org/10.1155/2022/5026061

Das, R. C., Chatterjee, T., & Ivaldi, E. (2024). Revisiting policy combinations under IS–LM–EE framework introducing capacity utilization. Quality & Quantity, 58(1), 903–932. https://doi.org/10.1007/s11135-023-01676-x

De Cesare, L., & Sportelli, M. (2005). A dynamic IS-LM model with delayed taxation revenues. Chaos, Solitons, and Fractals, 25(1), 233–244. https://doi.org/10.1016/j.chaos.2004.11.044

Fritsche, U., & Größl, I. (2010). New Keynesian DSGE Models and the IS-LM Paradigm (IMK Working Paper, No. 1/2010). Hans-Böckler-Stiftung, Institut für Makroökonomie und Konjunkturforschung (IMK). https://nbn-resolving.de/urn:nbn:de:101:1-201101312792

Gali, J. (1992). How well does the IS-LM model fit postwar U.S. data? The Quarterly Journal of Economics, 107(2), 709–738. https://doi.org/10.2307/2118487

Hicks, J. R. (1937). Mr. Keynes and the "Classics": A Suggested Interpretation. Econometrica, 5, 147-159. https://doi.org/10.2307/1907242

King, R. (2000) The New IS-LM Model: Language, Logic, and Limits. Economic Quarterly, Federal Reserve Bank of Richmond, 86, 45-103.

Li, H., & Wu, X. (2015). IS-LM paradigm in macroeconomics: A survey and evaluation. Theoretical Economics Letters, 05(02), 296–303. https://doi.org/10.4236/tel.2015.52035

Muslim, M., Bata Ilyas, M. F. G., & Sani, A. (2024). Linking fiscal policy to economic stability through financial sustainability. Vifada Management and Social Sciences, 2(2), 36–55. https://doi.org/10.70184/yessman2024

Neamtu, M., Opris, D., & Chilarescu, C. (2005). Hopf bifurcation in a dynamic IS-LM model with time delay. In arXiv [math.DS]. https://doi.org/10.48550/ARXIV.MATH/0511322

Panzaru, C., Belea, S., & Jianu, L. (2025). Delayed taxation and macroeconomic stability: A dynamic IS–LM model with memory effects. Economies, 13(7), 208. https://doi.org/10.3390/economies13070208

Potrafke, N. (2025). The economic consequences of fiscal rules. Journal of International Money and Finance, 153, 103286. https://doi.org/10.1016/j.jimonfin.2025.103286

Smith, G. (1982). Flexible policies and IS-LM dynamics. Journal of Macroeconomics, 4(2), 155–178. https://doi.org/10.1016/0164-0704(82)90119-7

Tu, P. N. V. (1994). Dynamical systems: An introduction with applications in economics and biology (2nd ed.). Springer. https://doi.org/10.1007/978-3-642-78793-5

Varghese, L., & Saxena, S. P. (2025). Assessing the Global Research Landscape on Fiscal Sustainability (1976–2023): A Scopus-Based Bibliometric Analysis. Asian Journal of Managerial Science, 14(2), 53–65. https://doi.org/10.70112/ajms-2025.14.2.4314

Vergés, J. (2024). Deconstructing the macroeconomics' IS-LM model: Its assumptions and simplifications. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4688399

Villani, S., & Viscolo, M. (2021). Taxation of global commons as a tool to reduce economic inequalities and strengthen the resilience of tax systems. In The Palgrave Handbook of Climate Resilient Societies (pp. 2253–2278). Springer International Publishing. https://doi.org/10.1007/978-3-030-42462-6_88 von Holle, V. (2024). The theory of the IS-LM curve and the IS-LM model. In New Economic Theory (pp. 87–106). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-45136-3_6

Wu, J. C., & Xie, Y. (2025). Unconventional monetary and fiscal policy. Review of Economic Dynamics, 56(101259), 101259. https://doi.org/10.1016/j.red.2024.101259

Young, W., & Zilberfarb, B.-Z. (Eds.). (2001). IS-LM and modern macroeconomics (2000th ed.). Springer. https://doi.org/10.1007/978-94-010-0644-6

Zhou, L., & Li, Y. (2008). A generalized dynamic IS-LM model with delayed time in investment processes. Applied Mathematics and Computation, 196(2), 774–781. https://doi.org/10.1016/j.amc.2007.07.008