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BIBLIOMETRIC REVIEW OF SYSTEM DYNAMICS APPLICATIONS IN ECONOMICS AND FINANCE

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This paper presents a systematic bibliometric analysis of applications of the system dynamics (SD) methodology in economics and finance, based on 945 Scopus-indexed publications from 1980-2026. The analytical framework combines frequency distribution analysis, thematic classification by author keywords, citation metrics, and keyword co-occurrence analysis. The results demonstrate consistent growth in SD-related publication activity, from 42 papers in 1980–1999 to 353 in 2020–2026. The thematic structure is dominated by Innovation and Technology (262 papers), Construction and Infrastructure (191), and Sustainability (157), while financial applications such as Banking and Credit (17), Capital Structure (15), and Taxation (30) remain significantly underrepresented. Instrumental analysis reveals VenSim as the dominant simulation platform (44 mentions), with Python-based tools virtually absent from the sample (1 mention). The XMILE interoperability standard is not referenced in any abstract within the sample. A classification matrix maps twelve thematic clusters against methodological characteristics, including primary tools, hybrid approaches, validation reporting, and Python integration. Four research gaps are identified and substantiated quantitatively: the limited application of SD in taxation and fiscal regulation, the absence of Python integration in financial SD research, the lack of a micro-to-macro derivation methodology linking enterprise-level stock-flow models to jurisdictional tax dynamics, and the systemic gap between established SD validation protocols and actual reporting practices. The proposed classification matrix and gap identification provide a quantitative foundation for directing future SD research toward underexplored domains of economic and financial analysis.

Keywords: system dynamics, bibliometric analysis, simulation, financial modelling, Scopus, Vensim, research gaps.

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INTRODUCTION

Economics and finance deal with inherently complex systems characterised by feedback loops, nonlinear dependencies, time delays, and threshold effects. Corporate financial flows, tax regulation, investment decisions, and credit markets form interconnected, dynamic structures in which the behaviour of the whole cannot be predicted from the properties of individual components. This complexity demands analytical methods capable of capturing endogenous feedback and simulating system behaviour over time.

System dynamics (SD) is a methodology specifically designed for such challenges. Founded by Jay Wright Forrester in *Industrial Dynamics* [1], SD models complex systems through stocks (accumulations), flows (rates of change), and feedback loops (causal connections that create self-reinforcing or self-correcting behaviour). The mathematical foundation rests on ordinary differential equations (ODE) of the first order, where the state of each stock variable *L(t)* is governed by the integral of its inflows and outflows (eq. 1).

$$L(t) = L(t^0) + \int_{s=t^0}^{t} \big(\text{Inflow}(s) - \text{Outflow}(s)\big) ds \quad (1)$$

In Principles of Systems [2], Forrester formalised four types of variables. LEVEL (stock) variables represent cumulative quantities. RATE variables define inflows and outflows. AUXILIARY variables serve as intermediate calculations. CONSTANT (parameter) variables capture fixed or adjustable model parameters. This taxonomy remains the foundation of all SD implementations, from VenSim to modern Python libraries such as PySD [3].

Forrester's World Dynamics [4] demonstrated that SD scales from micro-level enterprise modelling to macro-level global systems. Sterman [5] provided the canonical five-stage SD procedure: problem articulation, dynamic hypothesis development through causal loop diagrams (CLD), formulation of stock-flow diagrams (SFD), model testing through validation, and policy design through scenario analysis. Bala,

Arshad, and Noh [6] operationalised this procedure both as a six-step methodology of systems thinking (problem identification, system conceptualisation, model formulation, model testing and evaluation, model use, and design of learning/strategy/infrastructure) and as a seven-step operational summary that adds parameter estimation and explicit validation/sensitivity/policy analysis as separate steps, applicable to agricultural, environmental, and socio-economic systems alike.

Sterman [7] assessed SD sixty years after its founding, concluding that its greatest unrealised potential lies in domains where policy feedback and threshold effects are most pronounced. Lane [8] traced SD's foundational pillars across three intellectual neighbours (MS/OR, system science and the social sciences, and problem structuring methods), emphasising the multi-disciplinary heritage of Forrester's Industrial Dynamics. Today, SD operates at the intersection of computational simulation and artificial intelligence (AI). PySD [3] enables SD models to run within the Python ecosystem, integrating with Pandas, NumPy, and machine learning libraries. ChatPySD [9] introduces natural-language interaction with SD models using large language models (LLMs). These developments position SD as an evolving analytical paradigm absorbing advances in data science while preserving its distinctive feedback-oriented epistemology.

Despite this growing relevance, the distribution of SD applications across economic sub-domains remains incompletely covered. Jonsdottir, Johannsdottir, and Davidsdottir [10] conducted a systematic literature review based on the PSALSAR framework, analysing 142 papers (final sample after PRISMA-style screening of 467 Scopus and WoS records and snowballing through Google Scholar) on SD modelling of sustainable business model strategies. They classified simulations into nine strategy categories and demonstrated that SD has been predominantly applied to maximise resource efficiency (Strategy 1, 35% of simulations), with sustainability stewardship, functionality-delivery, and circular-loop strategies gaining momentum since 2016 and 2020. However, the review does not cover SD applications in corporate financial management, banking regulation, or taxation. Furthermore, the methodological rigour of SD publications varies considerably, and the extent to which researchers adhere to established validation protocols, such as the twelve tests proposed by Senge and Forrester [11] or the formal classification by Barlas [12], remains an open empirical question.

Among the 945 Scopus publications matching the specified query, only 12 are classified as review articles, and none systematically address SD in financial management or taxation. This absence constitutes an objective research gap confirmed by the bibliometric data itself. The present study addresses this gap through a systematic analysis that maps the thematic landscape, evaluates methodological practices, and identifies underexplored domains. The study contributes a classification matrix that maps thematic clusters against methodological characteristics and identifies four research gaps, substantiated quantitatively.

RESEARCH METHODOLOGY

The study employs a bibliometric analysis based on an export from the Scopus database. The complete search query used was

KEY ("System Dynamics" Simulation) AND (LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON"))

The search was executed on April, 2026, yielding 968 records. After filtering for publications explicitly addressing SD methodology (verified through the presence of "system dynamics" in Author Keywords, Title, or Abstract), the analytical sample comprises 945 publications covering 1980–2026.

The Scopus request export provides structured data across ten fields, as follows: Authors, Title, Year, Source title, Cited by, DOI, Author Keywords, Abstract, Document Type, and Affiliations. Data completeness exceeds 90% for all fields, with Author Keywords available for 95.6% and DOI for 90.7% of records in the 945 SD-specific sample (94.8% Author Keywords completeness in the unfiltered 968-record set). The analytical sample of 945 SD-specific publications comprises 685 journal articles (72.5%), 211 conference papers (22.3%), 36 book chapters (3.8%), 12 review articles (1.3%), and 1 retracted record (0.1%). The unfiltered 968-record query returns 701 articles, 216 conference papers, 36 book chapters, 13 review articles, 1 book, and 1 retracted record; the difference (23 records) corresponds to non-SD simulation studies removed by the filtering procedure described below.

The analytical toolkit includes Python (Pandas, matplotlib). Thematic categorisation is based on rule-based keyword matching against predefined domain-specific term lists applied simultaneously to Author Keywords, Title, and Abstract. A publication is assigned to a cluster if at least one of its defining terms is found; publications may appear in multiple clusters. Hybrid publications were detected through

keyword matching for "agent-based," "agent based," "discrete event," "discrete-event," and "hybrid" in abstracts and keywords. Validation practice was assessed by matching "validation," "sensitivity analysis," and "calibration" in the same fields. Citation metrics (total, mean, median) provide a quantitative assessment of impact. Keyword co-occurrence analysis enumerates the most frequent Author Keywords that appear together in the same publication.

The research objectives are as follows.

First, to determine publication dynamics and geographic distribution.

Second, to classify thematic directions through keyword-based clustering.

Third, to evaluate the instrumental base and validation practices.

Fourth, to identify research gaps and propose a classification matrix as the principal result.

The SD-specific filtering procedure requires explanation. The raw Scopus query returns 968 records, of which 23 do not contain the term "system dynamics" in any of the three text fields (Author Keywords, Title, Abstract). These publications mention "simulation" in the context of discrete-event, Monte Carlo, or agent-based simulation, without reference to the system dynamics methodology. Excluding them yields 945 records that constitute the analytical sample. This filtering ensures that all quantitative results (cluster sizes, tool counts, validation frequencies) reflect publications genuinely related to SD methodology rather than general simulation research indexed under Business and Economics.

Limitations include the following. Scopus does not fully cover Ukrainian and other non-English-language publications. The keyword matching approach may produce both false positives and false negatives, although the large sample size mitigates these concerns. Thematic categorisation allows multiple group assignments per publication, so the group-related sizes do not sum to N = 945. The validation analysis relies on abstract-level text matching and may underestimate actual adoption of validation practices. Also, the limitation of this study is its reliance on the Scopus subject-area classification at the source-journal level. SD-based economic and financial studies published in journals classified outside BUSI/ECON (in Computer Science, Engineering and Control Systems, or Environmental Science and so on) are systematically excluded from the 945-record sample, which therefore represents a conservative lower-bound estimate of SD penetration into economics and finance.

During the preparation of this manuscript, the authors used Claude Opus 4.7 (Anthropic) and Grammarly as auxiliary tools for language proofreading, scientific text editing, and refinement of the Python analytical code. These tools were employed exclusively for technical assistance and did not contribute to the conceptualisation, research design, data interpretation, or scientific conclusions of this study.

RESULTS OF THE BIBLIOMETRIC ANALYSIS

The 945 SD-specific publications span 47 calendar years (from 1980 to 2026) with a cumulative citation count of 23,100, a mean of 24.4 citations per paper, a median of 7, and a maximum of 577. Publication dynamics demonstrate consistent growth (Fig. 1) – the period 1980–1999 produced 42 publications, 2000–2009 yielded 143, 2010–2014 reached 181, 2015–2019 generated 226, and 2020–2026 accounts for 353 records (37.4% of the sample). The earliest SD publication in the Business and Economics intersection dates to 1980; prior to 1995, annual counts remained below 5.

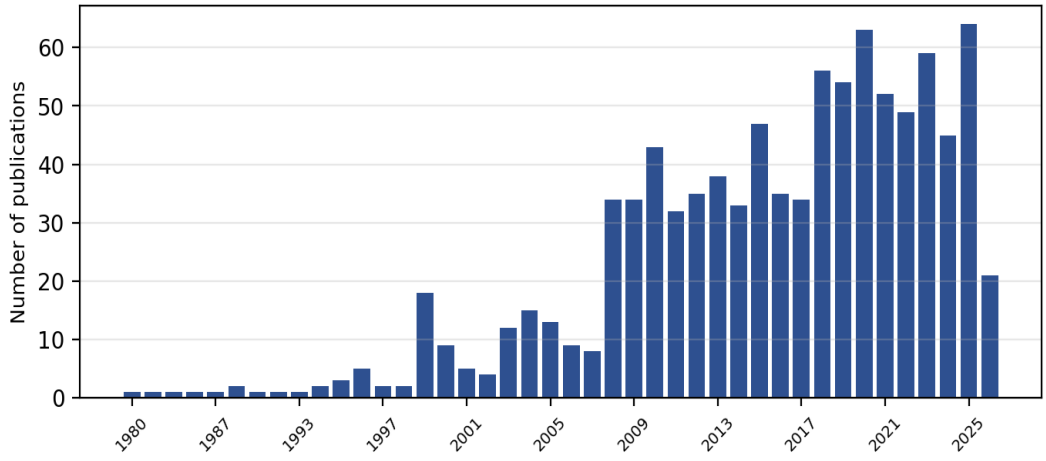

Fig. 1. Publication dynamics of SD research in Business and Economics
(Source: Scopus request, 1980–2026, N = 945; for 2026 data cover January-April only).

Geographically, paper-level country presence (a paper is counted once for each country represented among its authors' affiliations) places China first (207 records), followed by the United States (160), the United Kingdom (114), Germany (45), Italy (43), Australia (40), the Netherlands (36), India (31), Iran (29), and Colombia (27) and others. When multiple affiliations per paper are counted as separate occurrences, China rises to 419 and the United States to 279. Ukraine is represented by 4 publications.

Thematic classification identifies twelve top-level clusters with pronounced imbalance (Fig. 2). Innovation and Technology constitute the largest cluster (262 publications), driven by research on neural network integration with SD [13], digital platform competition dynamics [14], and Industry 4.0 implementation through CLD-based frameworks [15].

Construction and Infrastructure follow with 191 papers, reflecting extensive SD applications in project management, rework cycles, and public-private partnership (PPP) life-cycle financial modelling, where Castelblanco et al. [16] demonstrated how stock-flow diagrams can assess multidimensional flexibility alternatives for toll road concessionaires under traffic uncertainty. Sustainability and environmental, social, and governance (ESG)-related research accounts for 157 publications, with the partially overlapping Circular Economy cluster comprising 72 papers. The two clusters share publications because circular-economy strategies are typically framed within sustainability rhetoric.

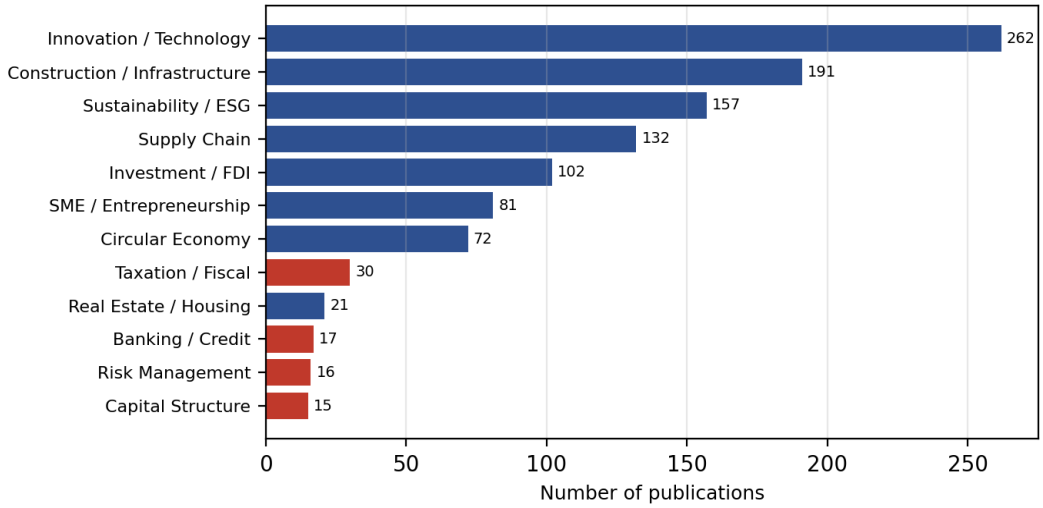

Fig. 2. Thematic clusters of SD research in Business and Economics

Supply chain management (132 papers) includes research on inventory oscillations and the cash-flow bullwhip effect, in which Badakhshan et al. [17] integrated SD simulation with genetic algorithms to simultaneously optimise the bullwhip effect, cash-flow variability, and total supply chain cost through the Beer Distribution Game framework. Investment and foreign direct investment (FDI) analysis (102) covers both micro-level appraisal and macro-level flow modelling. At the lower end, financial sub-domains are notably underrepresented. Taxation and fiscal policy account for only 30 publications. Within the Business and Economics subject areas under the specified query, only one clearly SD-based tax-behaviour study was identified – Merkulova, Bitkova, and Kononova [18]. Additional SD models of tax policy exist outside this subject area scope, including Liu et al. [19] who developed an SD simulation of sugar-sweetened beverage taxation with revenue recycling for childhood obesity prevention in the Journal of the Operational Research Society, and Rokhmawati et al. [20], who simulated carbon tax impact on manufacturing competitiveness in Indonesia. Banking and Credit (17), Risk Management (16), and Capital Structure (15, including the firm value maximisation model by Khan, Qureshi, and Davidsen [21]) collectively comprise around 5% of the sample.

This distribution reveals a paradox. Financial systems with inherent feedback loops (interest rate – investment – output – tax revenue – fiscal policy), time delays (investment maturation, regulatory lag), and threshold effects (default triggers, capital adequacy ratios) possess precisely the properties SD was designed to analyse. Yet the methodology has been predominantly applied to supply chains and construction. One plausible explanation is institutional: financial researchers have relied on econometric and computable general equilibrium (CGE) approaches, while SD developed its community around operations research and environmental journals. This pattern is consistent with the systematic review by Jonsdottir et al. [10], who showed that SD business model simulations cluster around resource-efficiency and circular-economy strategies, with financial and social-pillar dimensions remaining underrepresented.

The geographic distribution of thematic clusters reveals additional patterns. Chinese affiliations dominate construction and circular-economy research, reflecting policy-driven research agendas related to urbanisation and environmental regulation. US and UK affiliations are distributed more evenly across clusters. European researchers (Germany, the Netherlands, Finland) show a stronger presence in research on supply chain and platform dynamics. Ukraine is represented by 4 publications in the sample, spanning insurance modelling, quality-of-life simulation, educational competitiveness, and tax behaviour, demonstrating a diverse yet limited contribution to the international SD discourse.

The top 20 author keywords (excluding "system dynamics", "simulation", and their morphological variants ("system dynamics model", "system dynamics modelling/modeling", "system dynamics simulation", "scenario simulation", "simulation modeling/modelling", "modeling", "modelling") confirm these priorities. The most frequent are "supply chain" (29), "supply chain management" (22), "sustainability" (22), "policy simulation" (20), "project management" (18), and "discrete event simulation" (DES, 18). The presence of "agent-based modelling" (ABM, 12) and "hybrid simulation" (10) signals the growing trend toward multi-method approaches. Beyond Forrester's paradigm, formal models of dynamic discrete distributed systems in computer science (e.g., Broy's interaction-stream model [22]) share the term "dynamic systems" yet operate with a different mathematical apparatus (state machines and channel-based composition rather than stock-flow integral equations). This terminological adjacency justifies the strict SD-keyword filtering applied above (Section 2). Financial terms such as "investment," "cash flow," or "tax" do not appear among the top 20 keywords, further confirming the marginal status of financial applications in the SD research landscape.

The BUSI/ECON subject-area filter narrows the sample by source-level classification rather than by article content, so several SD studies fall outside the 945-record set despite their direct economic relevance. One such case is Kozlovskyi et al. [23], who modelled the impact of labour-migrant policy on economic growth under COVID-19 in a journal indexed under Environmental and Social Sciences. The study illustrates the sustainability and social pillar potential of SD beyond the boundaries imposed by Scopus subject classification.

Among the 945 SD-specific publications, 12 are classified as review articles (1.3%); the unfiltered 968-record set contains 13 reviews, of which one was removed by SD-specific filtering. None of these reviews systematically addresses SD applications in financial management or taxation. This scarcity of review literature is significant — despite SD's maturity (over 60 years since Forrester's foundational work), systematic assessments of SD's penetration into specific economic domains remain rare, which reinforces the motivation for the present study.

Keyword co-occurrence analysis (Table 1) reveals structural connections between thematic domains, excluding "system dynamics", "simulation", and their morphological variants.

The most frequent co-occurrence pairs involve discrete-event simulation with agent-based simulation (4 co-occurrences) and discrete-event simulation with hybrid simulation (3 co-occurrences), confirming that multi-method approaches serve as methodological connectors. Supply chain and bullwhip effect form a tightly connected pair (3), as do project management and rework (3). Financial terms do not appear among the top co-occurrence pairs, confirming their isolation from mainstream SD discourse.

Instrumental analysis reveals VenSim as the dominant platform, with 44 mentions, followed by STELLA/iThink (18), AnyLogic (11), Powersim (9), and several mentions of MATLAB/Simulink, R language, and Python/PySD. This distribution is largely determined by the functionality and cost of these tools (Table 2).

The XMILE (XML Interchange Language for System Dynamics) standard [24] defines an XML schema for representing stocks, flows, auxiliaries, and their interconnections in a platform-independent format. The OASIS XMILE 1.0 specification organises models around the elements of model container, variables (stocks, flows, auxiliaries with equations), simulation specifications (time step, integration method), graphical views (SFD layout), and styling. Eberlein and Chichakly [24] argue that this XML-based standard enables archiving, replicability, and cross-tool analysis of SD models. STELLA/iThink natively uses XMILE; VenSim exports to XMILE alongside its .mdl format; PySD [3] reads both. AnyLogic and MATLAB do not support XMILE, limiting cross-platform reproducibility. Not a single abstract in the 945-publication sample mentions XMILE, confirming that model interoperability remains a theoretical possibility rather than a reporting norm. For the R ecosystem, Duggan [25] developed an open-source framework integrating SD with the deSolve package, complementing the Python/PySD pipeline.

Table 1.

Top keyword co-occurrence pairs (SD-specific, N = 945, excluding "system dynamics" and "simulation")

Keyword 1	Keyword 2	Co-occurrences
agent-based simulation	discrete-event simulation	4
business simulation	model transparency	3
project management	rework	3
bullwhip effect	supply chain	3
agent-based modeling	discrete-event simulation	3
discrete-event simulation	hybrid simulation	3
discrete event simulation	hybrid simulation	3
mining	recycling	3
interactive learning environments	learning	3
agent-based modeling	anylogic	2
computer simulation	forecasting	2
complexity	feedback	2
capacity	project	2
policy combination	policy simulation	2
china	policy simulation	2

The cost structure (Table 2) is relevant for understanding adoption patterns.

Table 2.

SD simulation tools: functionality and cost comparison

Tool	Key functionality	Cost (indicative)*	XMILE compliance
VenSim	Full SD (CLD, SFD, SyntheSim, sensitivity)	From USD 169 (PLE free for education)	Export to XMILE; native .mdl
STELLA/ iThink	Full SD + storytelling, web publishing	From USD 699/year	XMILE native format
AnyLogic	SD + ABM + DES multi-method	From USD 1,200/year (PLE free)	No XMILE support
Powersim	Full SD + optimization	From USD 495	Partial XMILE
MATLAB/ Simulink	Block-diagram, control systems	From USD 2,350 + toolboxes	No XMILE support
R (deSolve)	Open-source SD via packages	Free (open-source)	No XMILE; custom code
Python/PySD	Open-source, reads .mdl and XMILE	Free (open-source)	XMILE + .mdl import

* based on data from official websites as of early 2026

VenSim PLE (free for educational use) and the open-source Python/PySD stack are the most accessible options. Commercial licenses for AnyLogic and STELLA range from USD 699 to USD 1,200 per year, while MATLAB requires USD 2,350+ for toolboxes. VenSim's dominance in the bibliometric sample is likely due to its combination of full SD functionality, a free educational license, and community support. The VenSim–PySD combination via the .mdl format represents the most viable integration path for researchers seeking both visual model construction (VenSim) and programmatic analysis (Python), yet this combination appears in only 1 publication.

Among 945 publications, 94 combine SD with ABM or DES, and 62 explicitly use the term "hybrid." This trend has intensified since 2018, reflecting growing recognition that complex economic systems often require multi-paradigm modelling. Hybrid approaches concentrate on supply chain and construction clusters, with virtually no presence in financial or taxation applications. Bala et al. [6] characterised systems thinking as a formalised methodology that integrates problem definition, dynamic hypothesis, modelling, and policy analysis to understand and manage complex dynamic systems. A description applicable regardless of whether the modelling paradigm is pure SD or hybrid, which positions the methodology as natively compatible with the multi-paradigm shift documented above.

Validation practices reveal a gap between SD theory and applied research. Forrester and Senge [11] proposed 12 tests to build confidence in SD models. Barlas [12] formalised the classification into structure-oriented and behaviour pattern tests. Bala et al. [6] further systematised these into three operational categories (tests of model structure, tests of model behaviour, and tests of policy implications), providing a unified teaching and research standard. Schwaninger and Groesser [26] operationalised these protocols for quality assurance in their chapter in the Encyclopedia of Complexity and Systems Science. However, based on the authors' Scopus text search, only 32 of 945 abstracts and author keywords (3.4%) mention "validation," 29 (3.1%) reference "sensitivity analysis," and 6 (0.6%) mention "calibration." Ruutu et al. [14] exemplify best practice by documenting the VenSim version, time step (0.0625), and integration method (Euler), and by conducting extreme conditions and sensitivity tests — yet such transparency remains exceptional. McGarvey and Hannon [27] provided a systematic introduction to dynamic modelling for business management, emphasising that SD's feedback-oriented perspective is particularly powerful for understanding how managerial decisions interact with market dynamics over time — a description directly applicable to tax compliance and corporate decision-making under regulatory change.

4. Classification Matrix and Research Gaps

The principal result is the classification matrix (Table 3) mapping twelve thematic clusters against methodological characteristics.

Gap 1 concerns SD in taxation and fiscal regulation. Within the Business and Economics subject areas, only 30 of 945 publications address taxation. Merkulova et al. [18] remains the sole SD-based tax-behaviour study in this scope. Liu et al. [19] in public health and Rokhmawati et al. [20] in energy policy expand the application to specific tax instruments. These works demonstrate SD's applicability to fiscal analysis, yet international tax reform initiatives (e.g. OECD's global minimum corporate tax reform establishing a 15% rate) have not been addressed through SD, despite its inherently feedback-driven structure.

Gap 2 addresses Python integration. Despite 94 publications employing hybrid approaches, only 1 mentions Python. The potential of PySD [3] for automated multi-scenario runs and sensitivity analysis remains unexploited in financial applications.

Gap 3 identifies the missing micro-to-macro derivation. Enterprise-level SD models such as the six-LEVEL model in [28] (Capital, Long-Term Assets, Investment Level, Cash Flow, Short-Term Liabilities, and Long-Term Liabilities) operate at the firm level. Macroeconomic tax models typically use computable general equilibrium (CGE) frameworks. The methodological bridge between stock-flow architecture at the corporate level and jurisdictional models of tax burden dynamics is not represented in the 945-record SD-specific Scopus sample under BUSI/ECON subject areas.

Gap 4 concerns validation. Only 32 of 945 publications mention validation, and the protocols of Forrester-Senge [11] and Barlas [12] are absent from abstracts. This gap has not been quantified in prior reviews.

Table 3.

Classification matrix of SD approaches in economics and finance

Cluster	Primary tool	Hybrid SD, ABM/DES	Validation reported	Python	SD procedure
Innovation / Technol.	VenSim, AnyLogic	Frequent	Moderate	Rare	Partial
Construction	VenSim	Occasional	Moderate	None	Partial
Sustainability	VenSim, STELLA	Occasional	Low	None	Partial
Supply Chain	VenSim, AnyLogic	Frequent	Moderate	None	Full
Investment / FDI	VenSim	Rare	Low	None	Partial
SME / Enterprise	VenSim	Rare	Low	None	Partial
Circular Economy	VenSim, STELLA	Occasional	Low	None	Partial
Taxation / Fiscal	VenSim	None	Very low	None	Partial
Real Estate	VenSim	Rare	Low	None	Partial
Banking / Credit	VenSim, Powersim	Rare	Low	None	Partial
Risk Management	VenSim	Rare	Low	None	Partial
Capital Structure	VenSim	None	Very low	None	Minimal

The authors' own research trajectory complements the Scopus 945-record sample and demonstrates evolution within the SD paradigm. Kuzheliev, Zherlitsyn, and Zhytar [29] formalised dynamic relationships between financial indicators (published in a Ukrainian journal not indexed in Scopus). Zherlitsyn, Galaieva, and Mandra [28] developed a six-LEVEL enterprise SD model in Vensim (CIBMEE 2021 conference proceedings, also outside Scopus indexing). Mints, Zherlitsyn et al. [30] extended SD to household welfare under crisis conditions, indexed in Scopus but outside the BUSI/ECON subject filter applied in this query. This progression (from firm-level financial dynamics to enterprise stock-flow modelling and household welfare simulation) points toward jurisdictional-level tax dynamics modelling, addressing Gaps 1 and 3.

CONCLUSIONS

System dynamics, founded by Forrester [1; 2; 4] and pedagogically systematised by Sterman [5], remains an actively growing methodology in business and economics, with publication volumes increasing from 42 papers in 1980–1999 to 353 in 2020–2026. The method's core architecture — stocks, flows, feedback loops, and time delays, formalised through Forrester's four-variable taxonomy (LEVEL, RATE, AUXILIARY, CONSTANT) and Sterman's five-stage procedure — provides a natural representation of economic complexity.

The XMILE standard [24], designed for cross-platform interoperability, is natively supported by STELLA/iThink and partially by VenSim and PySD [3], but is not referenced in any of the 945 abstracts. VenSim dominates the instrumental landscape (44 mentions); Python-based tools appear in 1 publication. The open-source trajectory (PySD, ChatPySD [9], R packages [25]) offers reproducibility and AI integration that the SD community has not yet adopted at scale.

The thematic structure is markedly uneven. Innovation/Technology (262), Construction (191), and Sustainability (157) dominate, while Taxation (30), Banking (17), and Capital Structure (15) collectively represent less than 7%. This imbalance is significant given that financial systems possess the feedback-driven, delay-intensive, threshold-sensitive properties SD is designed to analyse. This pattern is consistent with the systematic review by Jonsdottir et al. [10], in which SD business model simulations were shown to cluster around resource-efficiency and circular-economy strategies, while financial and social-pillar dimensions remain underrepresented.

Four research gaps are quantitatively substantiated. The limited application of SD in taxation (Gap 1), the absence of Python integration in financial SD (Gap 2), the missing micro-to-macro derivation linking enterprise stock-flow models to jurisdictional tax dynamics (Gap 3), and the systemic gap between validation protocols and reporting practice (Gap 4) define priority directions for future investigation.

The practical implications extend beyond academic interest. For researchers, the classification matrix provides a structured overview of where SD has been applied and where opportunities remain. For journal editors and reviewers, Gap 4 highlights the need for more rigorous reporting standards for validation. For practitioners and policymakers, the finding that SD has been underutilised in taxation and financial regulation suggests that this simulation methodology could provide insights into the dynamic consequences of regulatory interventions currently assessed only through static models.

The classification matrix (Table 3) provides a structured navigation tool for the SD research landscape. Future work will address Gaps 1 and 3 through SD simulation of jurisdictional tax reform dynamics, extending the stock-flow architecture from [28] to jurisdictional-level modelling.

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БІБЛІОМЕТРИЧНИЙ ОГЛЯД ЗАСТОСУВАННЯ МЕТОДУ СИСТЕМНОЇ ДИНАМІКИ В ЕКОНОМІЦІ ТА ФІНАНСАХ

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У цій статті представлено систематичний бібліометричний аналіз застосувань методології системної динаміки (СД) в економіці та фінансах, заснований на 945 публікаціях, індексованих у Scopus, за 1980–2026 роки. Аналітична структура поєднує аналіз розподілу частот, тематичну класифікацію за ключовими словами авторів, метрики цитування та аналіз спільної появи ключових слів. Результати демонструють стабільне зростання публікаційної активності, пов'язаної з СД, з 42 статей у 1980–1999 роках до 353 у 2020–2026 роках. У тематичній структурі домінують Інновації та технології (262 статті), Будівництво та інфраструктура (191) та Сталий розвиток (157), тоді як фінансові застосування, такі як Банківська справа та кредит (17), Структура капіталу (15) та Оподаткування (30), залишаються значно недостатньо представленими. Інструментальний аналіз показує, що VenSim є домінуючою

платформою моделювання (44 згадки), тоді як інструменти на основі Python практично відсутні у вибірці (1 згадка). Стандарт сумісності XMILE не згадується в жодному рефераті у вибірці. Матриця класифікації відображає дванадцять тематичних кластерів за методологічними характеристиками, включаючи основні інструменти, гібридні підходи, звітність про валідацію та інтеграцію Python. Визначено та кількісно обґрунтовано чотири прогалини в дослідженнях: обмежене застосування SD в оподаткуванні та фіскальному регулюванні, відсутність інтеграції Python у фінансових дослідженнях SD, відсутність методології мікро- та макро-виведення, яка б пов'язувала моделі потоків запасів на рівні підприємства з динамікою юрисдикційних податків, а також системний розрив між усталеними протоколами валідації SD та фактичною практикою звітності. Запропонована матриця класифікації та ідентифікація прогалин забезпечують кількісну основу для спрямування майбутніх досліджень SD на малодосліджені області економічного та фінансового аналізу.

Ключові слова: системна динаміка, бібліометричний аналіз, моделювання, фінансове моделювання, Scopus, Vensim, прогалини в дослідженнях.