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Bohdan DOROSH, PhD Student
ORCID ID: 0000-0002-8642-5071
e-mail: bogdandorosh@gmail.com, dorosh_b@nubip.edu.ua
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine

OVERCOMING CONSTRAINTS AND EXPLORING BEHAVIORAL INSIGHTS INTO THE SAMUELSON MULTIPLIER-ACCELERATOR MODEL

Background. ***This article critically examines the limitations of traditional macroeconomic modeling, with a particular focus on the dynamic stochastic general equilibrium (DSGE) models and their predecessors. By scrutinizing their shortcomings in predicting and comprehending economic crises that are highlighted in numerous research papers and addressing contemporary challenges, the article calls for a fundamental revision of these models. To overcome their limitations, the article puts forward a novel approach that integrates insights from behavioral economics and incorporates real-life agents into macroeconomic models aiming to contribute to the advancement and refinement of macroeconomic modeling.***

Methods. ***The paper centers its analysis on Samuelson's multiplier-accelerator model, a prominent framework in macroeconomics, highlighting its inherent deficiencies and proposing potential improvements through the application of behavioral economics insights.***

Results. ***By dissecting the model's core assumptions, such as the consumption function, private investment, and government spending, the article argues for the integration of real agents with bounded rationality, 'animal spirits', expectations of future income, consumer sentiment, and segmentation of households and firms into distinct categories. By adopting a more realistic representation of human behavior, macroeconomic models can provide more accurate forecasts and better policy guidance.***

Conclusions. ***The article states that the incorporation of behavioral factors into macroeconomic models is indispensable for advancing our understanding of complex economic phenomena. By incorporating a more nuanced and realistic representation of economic agents and their decision-making processes, these models can overcome their existing limitations and contribute to the development of more robust and effective economic policies.***

Keywords: ***macroeconomic modeling, Samuelson's multiplier-accelerator model, agent-based modeling, behavioral economics, animal spirits, economic growth.***

Background

Over the past three decades, dynamic stochastic general equilibrium models (DSGE models) have been the prevailing framework in macroeconomic modeling. These models are rooted in the principle of rational expectations and equilibrium and continue to be extensively utilized by macroeconomists as well as research departments of central banks in most developed countries with market economies. To date, the vast majority of macroeconomic studies rely on DSGE models or their antecedents, such as the theory of real business cycles (RBC), the Goodwin growth cycle model, Samuelson business cycles, Keynesian economics, and various other methodologies.

DSGE models, along with their predecessors that were partially supplanted by DSGE models, have demonstrated inadequacies in both practical and theoretical dimensions (Talavyrya, Dorosh, & Pintsak, 2023). Particularly during crises, these models have proven insufficient in predicting and providing the necessary understanding for a swift recovery from such phenomena. DSGE models were unable to predict the 2007-2008 Global Financial Crisis and did not help public officials navigate through it. They have failed to fulfill the essential functions expected of well-developed macroeconomic models. A key objective of any macro model is its capacity to furnish vital information during profound economic downturns, which have been recurring events throughout history, and to offer guidance on appropriate responses to these downturns. Ideally, a macro model should anticipate such crises rather than merely informing us about the precise growth rate of the economy (e.g., 3% or 5%). Given that deep economic recessions give rise to heightened unemployment and increased consumer prices, critically affecting a significant portion of the population (Stiglitz, 2018), addressing these concerns becomes paramount.

As we enter the third decade of the 21st century, humanity confronts a multitude of new challenges and uncertainties lying ahead. In recent years alone, the world has encountered an unprecedented series of events, including russia's war against Ukraine in the heart of Europe, the global outbreak of the coronavirus pandemic, the profound societal shifts associated with digital transformation, the pressing issue of climate change, the complexities of global migration and refugee crises, the demographic challenges, and numerous other significant concerns. It is crucial to thoroughly study and comprehend these phenomena to formulate appropriate responses, as they exert a profound impact not only on the economy and business cycles but also on the well-being of a majority of the world's population. In our assessment, it is not only impractical but also detrimental to rely on modeling methods that have proven ineffective in practice when seeking solutions to such intricate questions.

Hence, the search for solutions to contemporary challenges through macroeconomic modeling is a pressing concern. Behavioral economics emerges as a promising avenue to address these challenges by introducing real-life agents into existing models, departing from the abstract realm of theoretical constructs. Alternatively, it offers the possibility of developing entirely new agent-based models. Both approaches have considerable potential and are advocated by the scientific community. An evident shift in the paradigm of macroeconomic thinking is already underway, characterized by increasing and more profound integration with microeconomics. Within this evolving landscape, behavioral economics assumes a pivotal role (Akerlof, 2002). Several national banks around the world including the Federal Reserve System, the European Central Bank, and the Bank of England are already developing agent-based models that are based on behavioral economics insights. We believe that the trend will continue, and more countries will develop such models in the future.

Literature review. Over the past three decades, a considerable number of scholars, including Nobel laureates

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in economics, have devoted their efforts to examining the efficacy of DSGE models and their predecessors in macroeconomic modeling. Their research has included critical analysis, suggestions for improvement, and proposals for alternative model frameworks. In general, there is a broad consensus among researchers that macroeconomic modeling has been grappling with an existential crisis for approximately 15 years. As S. Storm (Storm, 2021) points out, it is widely acknowledged that the classical form of DSGE models should be phased out, yet consensus has not been reached regarding the precise type of models that should supplant them. Consequently, DSGE models persist in active use.

D. Vines and S. Wills (2018, 2020) advocate for the continued utilization of DSGE models but propose significant modifications to enhance their effectiveness. In a recent paper, they outline several key adjustments to the models. These modifications include emphasizing financial contradictions, imposing limitations on the application of rational expectations, incorporating heterogeneous agents, and identifying more appropriate representative agents (Vines, & Wills, 2018). Building upon their previous work, they propose a more radical transformation in a subsequent paper. Their proposal involves commencing simulations with simpler models, ideally represented as two-dimensional sketches, to elucidate the underlying mechanisms responsible for the existence of multiple equilibrium points. These identified mechanisms would then be integrated into broader DSGE models through a novel framework of multi-equilibrium synthesis (Vines, & Wills, 2020).

Following the global financial crisis of 2008, there has been a substantial increase in the number of researchers highlighting the limited applicability of DSGE models in macroeconomic modeling. Many of these scholars advocate for a complete replacement of DSGE models with alternative frameworks. Notably, Joseph Stiglitz expresses his skepticism, stating that mainstream DSGE models do not qualify as sound theory. He argues that a robust theoretical framework should be grounded in the actual behavior of firms, households, and the functioning of markets (Stiglitz, 2018). J. Stiglitz (2018) emphasizes that models lacking the ability to replicate and explain real-world economic phenomena are ill-suited for practical macroeconomic modeling. In his view, an appropriate model should be built upon the actions of real agents, incorporating microfoundations, rather than relying on fictional hyperrational beings, which are seldom observed in real economic behavior. As economics is a behavioral science, this perspective holds significant relevance.

A. Korinek (Korinek, 2018) acknowledges certain positive attributes of DSGE models, including their universal applicability, although he expresses criticism regarding this aspect. However, he emphasizes that these models tend to oversimplify intricate social interactions, reducing them to a limited set of variables and relationships. Furthermore, they often impose constraints that are in direct contradiction with findings from microeconomic research.

In conclusion, a growing body of research argues for the partial or complete replacement of outdated DSGE models with agent-based models that incorporate microfoundations. This viewpoint is supported by influential works by G. Akerlof, D. Colander et al and D. Gatti et al. (Akerlof, 2002; Colander et al., 2008; Gatti et al., 2018), among others. Our previous paper provides a comprehensive examination of the key developments and issues associated with agent-based models (Talavyrya, & Dorosh, 2021). While there have been promising advancements in agent-based modeling, a significant challenge remains in the limited adoption of such models by central banks, despite initiatives such as the European Central Bank's efforts to develop such a model. It is important to bridge the gap between research and practical implementation to leverage the potential benefits of agent-based models in guiding policy decisions and understanding complex economic dynamics.

Samuelson's model of business cycles, also known as the Hansen–Samuelson model (Samuelson, 1939), was developed by Samuelson himself as a tribute to the influential economist Alvin Hansen, whose work inspired Samuelson during the model's construction. Although the model's primitiveness stems from its sole consideration of the demand side, it nonetheless offers valuable insights into the dynamics of business cycles within national economies (Barros, Ortega, 2019). However, the original form of the model, dating back to 1939, possesses inherent limitations and has since become outdated. Consequently, numerous new variations of Samuelson's model have emerged over the past two decades alone, with at least 15 works reevaluating the model's foundational assumptions. Noteworthy contributions include the works of I. Dassios and A. Zimbidis, M. Barros and F. Ortega, F. Tramontana and L. Gardini, P. Piiroinen and S. Raghavendra (Dassios, & Zimbidis, 2014; Barros, & Ortega, 2019; Tramontana, & Gardini, 2021; Piiroinen, & Raghavendra, 2019), among others. In addition, elements of behavioral economics have been integrated into Samuelson's model by (Westerhoff, 2006) and (Westerhoff, & Franke, 2012).

Research gap and the aim of the article. Despite the prevalence of DSGE models in macroeconomics, there is a broad consensus among scientists that profound changes are needed in macroeconomic modeling. Much of the criticism stems from conceptual shortcomings observed in DSGE models. These include the reliance on the hyper-rationality of agents, the assumption of general equilibrium, homogeneity, the pursuit of a generalized solution to all problems, and other related factors. However, there has been relatively limited research focused on examining specific instances of DSGE models or their predecessors to identify and address their inherent deficiencies. Our primary aim is to address this research gap by conducting an extensive analysis of the limitations present in macroeconomic models, with a particular focus on Samuelson's multiplier-accelerator model. We intend to provide a comprehensive examination of these shortcomings and propose potential enhancements to the model utilizing insights from behavioral economics. By incorporating behavioral factors into the framework, we aim to contribute to the advancement and refinement of macroeconomic modeling.

Methods

Using the classical Hansen–Samuelson model (Samuelson, 1939) as a basis for analyzing business cycles, which serves as an antecedent to pure DSGE models, our objective is to highlight the principal limitations associated with this model type. We aim to delve deeper into the underlying assumptions formulated by Samuelson, illustrating why they are not in line with contemporary scientific trends, which are mainly related to the inclusion of real agents in the models. Furthermore, we attempt to propose possible modifications to this model drawing on the research of behavioral economists and incorporating a more comprehensive representation of real agents. Through these efforts, our goal is to enhance the model's applicability in today's world and align it with modern scientific advances mainly related to behavioral economics.

Results

The birth of modern business cycle theory can be attributed to the introduction of the Samuelson multiplier-accelerator model in 1939. This model, created by Samuelson, combined the innovative Keynesian multiplier analysis with the well-established principle of acceleration. While several key components of Samuelson's model remain relevant, scholars frequently point to two significant shortcomings. First, the model fails to replicate long-term business cycles accurately. Second, empirical observations indicate that the model's parameter values lead to an unstable trajectory of national income. Additionally, F. Westerhoff (Westerhoff, 2006) asserts that the model does not meet expectations.

Samuelson multiplier-accelerator model is based on the following assumptions (Samuelson, 1939):

1. ***National income*** Y_t at the time *t* can be written as the sum of three components: consumption, C_t, induced private investment, I_t, and government spending, G_t:

$$Y_t = C_t + I_t + G_t.$$

2. ***Consumption function*** C_t at the time *t* depends on the value of last year's national income (only on it) and on the marginal propensity to consume, modeled by the parameter *a*, where 0 < *a* < 1:

$$C_t = aY_{t-1}.$$

3. ***Private investment*** I_t at the time *t* depends on changes in consumption compared to the previous period and on the accelerator (acceleration coefficient) *b*, where *b* > 0. So, by substituting the corresponding values into the formula, we get that I_t depends on the change in national income:

$$I_t = b(C_t - C_{t-1}) = ab(Y_{t-1} - Y_{t-2}).$$

4. ***Government spending*** G_t at the time *t* is a constant:

$$G_t = \underline{G}.$$

Therefore, the national income is determined using the following linear equation of the second order:

$$Y_t = \underline{G} + a(1+b)Y_{t-1} - abY_{t-2}.$$

Several researchers have suggested diverse modifications to the classical model, asserting that their relevant versions outperform the original. These alterations include the incorporation of monetary factors, capital borrowing constraints, reserve formation challenges, business expectations, welfare growth considerations, the inclusion of lagged variables, and cross-country consumption correlations. It is important to note that our objective is not to present an "ideal" version of the model, but rather to demonstrate why Samuelson's original model does not match contemporary scientific discourse in the field of economics, particularly behavioral economics. Furthermore, we aim to suggest ways to improve the model, acknowledging that it may not be the sole correct framework.

Baros and Ortega (2019) summarize the key issues with Samuelson's model discussed in the literature. The model can't generate a sustainable trajectory for national income when actual parameter values (as opposed to theoretical assumptions) are used within the system of equations. While the authors may not fully agree with this assertion found in the literature, they correctly identify a fundamental drawback of Samuelson's model: when actual values are incorporated, it fails to yield the expected outcomes. During his lifetime (1915–2009), Samuelson acknowledged the limitations of his model, characterizing it as "a purely marginal analysis that should be applied to the study of small fluctuations" (Piiroinen, & Raghavendra, 2019). Thus, even the Nobel Laureate did not assert the model's infallible reliability in the long run, leaving room for improvement by other researchers.

Our analysis of the model commences with a focus on Assumption 2, which pertains to the consumption function. We accept Assumption 1, stating that in a closed economy, national income can be simplified as the sum of consumption, investment, and government spending. It is worth noting that Samuelson incorporated Keynes's consumption function from his influential work, "General Theory of Employment, Interest and Money" (Keynes, & Krugman, 2007). According to J. Keynes, individuals annually consume a portion of their income based on past earnings, including autonomous consumption. However, this simplistic view of human behavior fails to account for the findings of numerous empirical studies conducted by behavioral economists. These studies show that economic agents exhibit bounded rationality, rendering Keynes's assumption unreliable and unsuitable for modeling real-world outcomes, as opposed to theoretical ones. As early as 1955, Herbert Simon, a future Nobel laureate in economics, pointed out the limitations of fully rational decision-making, emphasizing that individuals lack the requisite knowledge and computational abilities (Simon, 1955). It is important to clarify that bounded rationality does not imply complete irrationality or a lack of logical thinking. Research by Daniel Kahneman and his colleagues reveals that individuals endeavor to make sound decisions using simple heuristics that have proven useful in the past (Kahneman et al., 1982). Not all decisions are irrational and not all people make impractical decisions all the time. However, it would be a very challenging task to find an individual who has never made at least one economic mistake.

Preceding the advent of behavioral economics, Keynes's works, including his analysis of the consumption function, faced criticism from numerous scholars. Among them, Milton Friedman, a prominent figure, argued that the Keynesian multiplier was not only misguided but fundamentally flawed. Regarding the consumption function specifically, (Friedman, 2018) introduced his concise formulation known as the "permanent income hypothesis," which differentiates between permanent and temporary income within the model. Expanding on this topic, (Bilik, & Kok, 2020) provide a comprehensive overview of at least 27 distinct variations and investigations related to the consumption function. We agree with the critics of the Keynesian multiplier stating that human decision-making is much more complex than simply spending a fixed percentage of their income all the time.

It is important to clarify that we do not advocate for the simultaneous implementation of all the following recommendations, as it could excessively burden the model. Rather, these suggestions serve as potential ways to modernize the traditional Samuelson model and impart agent-like characteristics to it. Drawing on the insights and advances of behavioral economics, we put forth the following proposals to enhance the realism of the consumption function, considering practical conditions:

- ***Incorporate expectations of future income instead of relying solely on past income to determine current consumption.*** Numerous studies have explored how individuals form their consumption decisions based on either their past income or their expectations for future periods. However, it is important to note that there is no consensus

on this issue, with proponents of both approaches. For instance, (Carroll, 1994; Pounder, 2009) present contrasting perspectives on this topic. M. Friedman (Friedman, 2018), on the other hand, posits that individuals consume according to their anticipated long-term incomes, but his assumption relies on the hypothesis of rational behavior. In our proposed approach, we suggest incorporating a blend of these approaches without excessively burdening the model, rather than completely discarding the original version.

- ***Segment economic agents into distinct groups based on characteristics such as age, gender, education level, place of work, and place of residence.*** This approach aligns with empirical studies that highlight notable differences in consumption patterns among various groups of individuals and shed light on their focus on past incomes versus expectations about future incomes (Borella, Moscarola, & Rossi, 2011). For instance, (Gustman, & Stafford, 1972) conducted a study demonstrating that students who anticipate higher-paying employment after graduation tend to exhibit higher levels of consumption during their academic years. While it is essential to capture relevant heterogeneity in consumption behavior, it is crucial to strike a balance to avoid excessive complexity in the model, which could limit its practical usefulness. Therefore, we propose incorporating the distribution of individuals into one or a limited number of groups within the consumption function, ensuring that the selected categorization adequately captures meaningful distinctions.
- ***Incorporation of consumer sentiment, which refers to a statistical measure of the overall economic outlook as perceived by consumers.*** This measure considers individuals' attitudes regarding their current financial situation, short-term economic health, and long-term growth prospects. Consumer sentiment is widely recognized as a valuable economic indicator, and several indices such as CCI, CB, and MSCI are calculated to assess it in countries like the United States. Recent studies have demonstrated the significant influence of consumer sentiment on consumption (Gillitzer, & Prasad, 2018) and have shown that consumer sentiment indices can serve as effective predictors of consumption (Dees, & Brinca, 2013). To minimize the data collection burden on scientists and practitioners, we recommend integrating existing consumer sentiment indices into the model. For countries where such indices are not available, the development of analogous measures can be accomplished through surveys conducted among citizens. By incorporating consumer sentiment, the model will capture the influence of public perception and expectations on consumption behavior, offering a more comprehensive representation of real-world dynamics while avoiding excessive data collection requirements.

Assumption 3 of Samuelson's model is that private investment depends on the change in consumption in past periods multiplied by the accelerator. In other words, changes in national income lead to the acceleration of investment. Samuelson, like Keynes before him, borrowed this principle of acceleration from the American scholar John Clark (Fiorito, 2001). Economic growth, as reflected in GDP expansion, is commonly linked to a phase of prosperity characterized by positive advancements in the business sector. These include augmented profits, heightened sales, improved cash flow, and increased utilization of existing capacity. Such favorable settings often foster elevated profit expectations and enhanced business confidence, stimulating enterprises to engage in expansionary endeavors like constructing new facilities, and buildings, and investing in additional machinery. However, it is important to note that the said assumption predominantly relies on past changes in consumption, disregarding the fact that real-world businesses also base their investment decisions on anticipated prospects. Hence, incorporating considerations of expected future conditions becomes crucial for a more comprehensive understanding of investment behavior in the actual economy.

The investment decision-making process in firms is commonly guided by the assessment of future returns, often through techniques like discounting future cash flows and analyzing payback periods. Firms typically set high hurdle rates to ensure that expected returns on capital expenditure meet certain thresholds. However, extensive research suggests that investment decision-making is subject to subjective factors, with "animal spirits" or intuitive judgments playing a significant role. A survey of Australian firms conducted by (Lane, & Rosewall, 2015) found that investment decision-making often involves subjective elements, where "animal spirits" or "gut feeling" exert a notable influence on capital expenditure decisions. Given the inherent challenges in accurately forecasting future cash flows, even opportunities with promising quantitative prospects are often rejected due to various constraints. These constraints encompass strategic considerations, heightened risk aversion, limitations imposed by higher-level management or global parent companies, resource constraints for project implementation, and shareholder perceptions (Lane, & Rosewall, 2015).

As with Assumption 2, behavioral economics is used for the following proposals to enhance the investment function's realism:

- ***Incorporating expectations of national income, rather than relying solely on past income.*** Since businesses are operated by human agents, they tend to exhibit similar behavioral patterns. While there is no definitive evidence that all businesses rely exclusively on future expectations when making investment decisions, it is widely recognized as a common practice to assess investment potential by forecasting future cash flows, rather than relying solely on past performance (Kruschwitz, & Löffler, 2006). Building upon this notion, Westerhoff and Franke proposed a similar approach by categorizing firm managers' expectations into extrapolative and regressive categories. Extrapolative expectations drive increased investment during economic upswings and decreased investment during downturns, assuming the continuation of the current trend in national income. Conversely, regressive expectations lead to increased investment when national income falls below the long-run equilibrium value, and reduced investment otherwise, as they anticipate a return to this equilibrium (Westerhoff, & Franke, 2012). To enhance the realism of the investment function and align it with behavioral economics, we suggest adopting a similar approach of incorporating future expectations into investment decision-making. This approach acknowledges the dynamic nature of business behavior and the role of expectations in shaping investment choices.
- ***Segmenting firms based on their size, ownership structure, and industry is essential, as their investment behaviors exhibit significant variations***. Similar to individuals, firms adopt different investment approaches depending on factors such as size, ownership, and industry characteristics. Extensive academic research supports this

notion, particularly highlighting the diverse behaviors observed during economic downturns. For instance, (Audretsch, & Elston, 2002) analyzed 719 German firms from 1961 to 1989. Their findings revealed that medium-sized firms face greater liquidity constraints in their investment decisions than the smallest and largest firms. This suggests that the specialized infrastructure in Germany aimed at supporting small businesses has achieved a certain level of success in alleviating liquidity constraints. Furthermore, Asker, Farre-Mensa and Ljungqvist (2011) examined data from approximately 250,000 firm-years, encompassing both public and private firms, during the period 2001–2007. Their research indicated that publicly traded companies exhibit lower investment levels and demonstrate less responsiveness to changes in investment opportunities compared to comparable privately held firms. This disparity is particularly pronounced in industries where stock prices strongly correlate with current earnings. Therefore, to account for the heterogeneity in firm behaviors, we propose incorporating the segmentation of firms into one or a limited number of groups within the investment function. This approach ensures that the chosen categorization captures meaningful distinctions, similar to the approach used for individuals in the model.

- ***The incorporation of the "animal spirit" concept into the investment decision-making process.*** Coined by (Keynes, 1936) and widely adopted by behavioral economists, the term "animal spirits" is used to explain deviations from rational behavior (Westerhoff, 2010). Akerlof and Shiller (2008) demonstrated how animal spirits played a significant role in driving the global financial crisis of 2008. As previously mentioned, "animal spirits" or "gut feelings" have a substantial impact on capital expenditure decisions, making it a key factor to consider in the modeling process (Akerlof, & Shiller, 2008). To incorporate this concept into the model, we propose distinguishing companies based on their management approach. Although it may be challenging to apply this approach to every company in the economy, estimating the proportion of each management type can be accomplished by analyzing publicly listed and selected private companies over an extended period. By considering the influence of "animal spirits" through the characterization of management approaches, a more realistic representation of investment decision-making can be achieved, aligning with insights from behavioral economics.

Assumption 4 of Samuelson's model is that government spending is constant at *t*. As government spending includes both consumption and investment, all the recommendations made for those functions can be applied to government spending as well. Politicians often make decisions not on a rational basis, but to satisfy the expectations of their voters and/or to keep their donors under their scope. There are lots of examples of such behavior, for example, Biden's Student Debt Relief Plan or 1,000 UAH aid for fully vaccinated Ukrainian citizens that could have been spent only on cultural needs like books, theatres, or museums, investment tax credits for tech companies (Lubkovskyi, & Dorosh, 2017), or participatory budgeting to satisfy the most active voters (Dorosh, 2019a, 2019b). Additionally, the government spending structure can vary significantly during different economic and election cycles (Brender, & Drazen, 2013).

Westerhoff and Franke (2012) proposed a trend-offsetting strategy for modeling government spending which implies that the government increases its spending when national income decreases, and vice versa. We agree that such an assumption can be made and is a much better predictor of government spending as usually during the crisis the elected officials try to spend much more to prevent catastrophic consequences. Examples are financial measures after a large natural disaster, global financial crisis, COVID-19, or other pandemics and wars.

Discussion and conclusions

The prevailing macroeconomic modeling framework, represented by dynamic stochastic general equilibrium (DSGE) models and their predecessors, has shown significant limitations in both practical and theoretical dimensions. These models, rooted in the principles of rational expectations and equilibrium, have proven inadequate in predicting and understanding economic crises and providing guidance for appropriate responses. As we face a multitude of new challenges and uncertainties in the 21st century, relying on modeling methods that have shown ineffectiveness in practice becomes impractical and detrimental.

Behavioral economics emerges as a promising way to address contemporary challenges in macroeconomic modeling. By introducing real-life agents and departing from the abstract constructs of traditional models, behavioral economics offers the possibility of enhancing existing models or developing entirely new agent-based models. This approach is consistent with the evolving paradigm of macroeconomic thought, characterized by deeper integration with microeconomics and the inclusion of behavioral factors.

A substantial body of research advocates for the partial or complete replacement of outdated DSGE models with agent-based models that incorporate microfoundations. Nobel laureates and influential economists have criticized the shortcomings of DSGE models and emphasized the need for models grounded in the actual behavior of firms, households, and markets. Moreover, modifications proposed by researchers, such as incorporating financial contradictions, relaxing assumptions of rational expectations, and introducing heterogeneous agents, highlight the quest for more realistic and robust modeling frameworks.

Within this context, our research aimed to address the limitations present in macroeconomic models by conducting a comprehensive analysis of Samuelson's multiplier-accelerator model, a predecessor to DSGE models. By examining the underlying assumptions and comparing them with contemporary scientific trends, we identified shortcomings in the model's ability to replicate long-term business cycles and generate stable trajectories for national income. These limitations, coupled with the advancements in behavioral economics, motivate us to propose potential enhancements to the model by incorporating insights from behavioral economists and representing real agents more comprehensively.

In our analysis, we focused on the consumption function, private investment, and government spending assumptions of Samuelson's model, highlighting the inadequacy of assuming hyper-rationality and bounded rationality of economic agents. Empirical studies in behavioral economics have shown that economic agents exhibit bounded rationality, making it necessary to depart from assumptions of fully rational decision-making. Drawing upon the insights from behavioral economics, among others we suggested incorporating expectations of future income and segmenting economic agents (both individuals and firms) into distinct groups based on relevant characteristics and incorporating

the 'animal spirits' concept to enhance the realism of the consumption function.

This study has potential limitations. Access to the data needed for the altered model may be challenging and even unavailable for some countries. The expertise of the staff largely determines the quality of the data collected. For further validation, the model needs to be tested using national statistical and empirical data.

Macroeconomic modeling requires a paradigm shift that embraces behavioral economics and incorporates insights from microeconomics. The limitations of DSGE models and their predecessors necessitate the exploration of alternative frameworks that provide a more accurate understanding of economic phenomena and guide appropriate policy responses. By incorporating behavioral factors and enhancing existing models or developing new agent-based models, we can contribute to the advancement and refinement of macroeconomic modeling, enabling a better understanding of contemporary challenges and facilitating informed decision-making for a prosperous future.

References

Akerlof, G. & Shiller, R. (2008). *Animal spirits*. Princeton University Press, Princeton.

Akerlof, G.A., 2002. Behavioral macroeconomics and macroeconomic behavior. *American Economic Review*, 92(3), 411–433.

Asker, J., Farre-Mensa, J., & Ljungqvist, A. (2011). Comparing the investment behavior of public and private firms. (No w17394). *National Bureau of Economic Research*.

Audretsch, D.B., & Elston, J.A. (2002). Does firm size matter? Evidence on the impact of liquidity constraints on firm investment behavior in Germany. *International Journal of Industrial Organization*, 20(1), 1–17.

Barros, M.F. & Ortega, F. (2019). An optimal equilibrium for a reformulated Samuelson economic discrete time system. *Journal of Economic Structures*, 8(1), 1–10.

Bilik, M. & Recep, K.Ö.K. (2020). A Comparative Study on Consumption Functions: The Case of the European Union. *Ege Academic Review*, 20(3), 167–178.

Borella, M., Coda Moscarola, F. & Rossi, M. (2011). (Un)Expected Retirement and the Consumption Puzzle. *Empirical Economics,* 47, 733–751. http://doi.org/10.1007/s00181-013-0760-z

Brender, A., & Drazen, A. (2013). Elections, leaders, and the composition of government spending. *Journal of Public Economics*, 97, 18–31.

Carroll, C.D. (1994). How does future income affect current consumption? *The Quarterly Journal of Economics*, 109(1), 111–147.

Colander, D., Howitt, P., Kirman, A., Leijonhufvud, A. & Mehrling, P. (2008). Beyond DSGE models: toward an empirically based macroeconomics. *American Economic Review*, 98(2), 236–240.

Dassios, I. & Zimbidis, A. (2014). The classical Samuelson's model in a multi-country context under a delayed framework with interaction. *Dynamics of continuous, discrete and impulsive systems. Series B: Applications & Algorithms*, 21, 261–274.

Dees, S. & Brinca, P.S. (2013). Consumer confidence as a predictor of consumption spending: Evidence for the United States and the Euro area. *International Economics*, 134, 1–14.

Dorosh, B. (2019a). The Models of Application of the Participation Budget: the European Experience and Prospects of Application in Ukraine. *Business-Inform*, 2(493), 58–63 [in Ukrainian]. [Дорош, Б.Й. (2019). Моделі застосування бюджету участі: європейський досвід і перспективи застосування в Україні. *Бізнес-Інформ*, № 2]. http://nbuv.gov.ua/UJRN/binf_2019_2_10]

Dorosh, B. (2019b). *The role of control in shaping dialogue in participatory budgeting: case study of the city of Kyiv*. (Master's thesis, Nord universitet), Master's thesis in Business, Nord universitet. http://hdl.handle.net/11250/2621136

Fiorito, L. (2001). John Maurice Clark's Contribution to the Genesis of the Multiplier Analysis (with some unpublished correspondence). *History of Economic Ideas*, pp. 7–37.

Friedman, M. (2018). *Theory of the consumption function*. Princeton University Press.

Gatti, D.D., Fagiolo, G., Gallegati, M., Richiardi, M., & Russo, A. (Eds.). (2018). *Agent-based models in economics: A toolkit*. Cambridge University Press.

Gillitzer, C. & Prasad, N. (2018). The effect of consumer sentiment on consumption: Cross-sectional evidence from elections. *American Economic Journal: Macroeconomics*, 10(4), 234–269.

Gustman, A.L. & Stafford, F.P. (1972). Income expectations and the consumption of graduate students. *Journal of Political Economy*, 80(6), 1246–1258.

Kahneman, D., Slovic, S.P., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge university press.

Keynes, J.M., & Krugman, P.R. (2007). *The General Theory of Employment Interest and Money*. Houndmills Basingstoke Hampshire: Palgrave Macmillan.

Korinek, A. (2018). *Thoughts on DSGE Macroeconomics: Matching the Moment, But Missing the Point*? In Toward a Just Society (pp. 159–173). Columbia University Press.

Kruschwitz, L., & Löffler, A. (2006). *Discounted cash flow: a theory of the valuation of firms*. John Wiley & Sons.

Lane, K., & Rosewall, T. (2015). Firms' investment decisions and interest rates. *RBA Bulletin*, 1–7.

Lubkovskyi, S., & Dorosh, B. (2017). Investment tax credit as an instrument for the harmonization of private and public interests. *Securities Market of Ukraine,* № 5, 6 [in Ukrainian]. [Лубковський, С., & Дорош, Б. (2017). Інвестиційний податковий кредит як інструмент гармонізації приватних та суспільних інтересів. *Ринок цінних паперів України*, № 5, 6].

Piiroinen, P.T., & Raghavendra, S. (2019). A Nonsmooth Extension of Samuelson's Multiplier-Accelerator Model. *International Journal of Bifurcation and Chaos*, 29(10), 1930027.

Pounder, L. (2009). Consumption response to expected future income.

Samuelson, P.A. (1939). Interactions between the multiplier analysis and the principle of acceleration. *The Review of Economics and Statistics*, 21(2), 75–78.

Simon, H.A. (1955). A behavioral model of rational choice. *The quarterly journal of economics*, 69(1), 99–118.

Stiglitz, J.E. (2018). Where modern macroeconomics went wrong. *Oxford Review of Economic Policy*, 34(1-2), 70–106.

Storm, S. (2021). Cordon of conformity: Why DSGE models are not the future of macroeconomics. *International Journal of Political Economy*, 50(2), 77–98.

Talavyrya, M., & Dorosh, B. (2021). Development of macroeconomic models based on behavioral economics: issues and further research. *Zemleustriy, kadastr i monitorynh zemel*, (4), 18–26.

Talavyrya, M., Dorosh, B., & Pintsak, S. (2023). Prospects for the further development of macroeconomic modeling based on its historical evolution. *Geopolitics of Ukraine: History and Present*, 1(30), 96–106 [in Ukrainian]. [Талавиря, М., Дорош, Б., & Пінцак, С. (2023). Перспективи подальшого розвитку макроекономічного моделювання на основі історичного досвіду його еволюції. *Геополітика України: історія і сучасність*, 1(30), 96–106].

Tramontana, F., & Gardini, L. (2021). Revisiting Samuelson's models, linear and nonlinear, stability conditions and oscillating dynamics. *Journal of Economic Structures*, 10(1), 1–15.

Vines, D. & Wills, S. (2018). The rebuilding macroeconomic theory project: an analytical assessment. *Oxford Review of Economic Policy*, 34(1-2), 1–42.

Vines, D. & Wills, S. (2020). The rebuilding macroeconomic theory project part II: Multiple equilibria, toy models, and policy models in a new macroeconomic paradigm. *Oxford Review of Economic Policy*, 36(3), 427–497.

Westerhoff , F.H. (2006). Samuelson's multiplier–accelerator model revisited. *Applied Economics Letters*, 13(2), 89–92.

Westerhoff, F. (2010). An agent-based macroeconomic model with interacting firms, socio-economic opinion formation and optimistic/pessimistic sales expectations. *New Journal of Physics*, 12(7), 075035.

Westerhoff, F. & Franke, R. (2012). Agent-based models for economic policy design: two illustrative examples. *BERG Working Paper Series,* No 88.

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Богдан ДОРОШ, асп.
ORCID ID: 0000-0002-8642-5071
e-mail: bogdandorosh@gmail.com, dorosh_b@nubip.edu.ua
Національний університет біоресурсів і природокористування України, Київ, Україна

ПОДОЛАННЯ ОБМЕЖЕНЬ ТА ВВЕДЕННЯ ПОВЕДІНКОВИХ АСПЕКТІВ У МОДЕЛІ МУЛЬТИПЛІКАТОРА-АКСЕЛЕРАТОРА САМУЕЛЬСОНА

В с т у п . ***Критично розглянуто обмеження традиційних макроекономічних моделей, з особливим акцентом на динамічних стохастичних моделях загальної рівноваги (DSGE) та їхніх попередниках. Вивчаючи їхні недоліки в прогнозуванні та осмисленні економічних криз, висвітленні у численних наукових публікаціях, а також у вирішенні сучасних викликів, доведено необхідність фундаментального перегляду цих моделей. Для подолання їхніх обмежень запропоновано новий підхід, який інтегрує ідеї поведінкової економіки та долучає реальних агентів у макроекономічні моделі з метою сприяння розвитку та вдосконаленню макроекономічного моделювання.***

М е т о д и . ***У центрі аналізу розглянуто модель мультиплікатора-акселератора Самуельсона, у якій досліджено притаманні їй недоліки і запропоновано потенційні покращення за допомогою застосування поведінкової економіки.***

Р е з у л ь т а т и . ***Розглядаючи основні припущення моделі, такі як функція споживання, приватні інвестиції та державні видатки, аргументовано доведена необхідність інтеграції реальних агентів з обмеженою раціональністю, тваринними інстинктами, очікуваннями майбутнього доходу, споживчими очікуваннями та сегментацією домогосподарств і підприємств на окремі категорії. Завдяки більш реалістичному відображенню людської поведінки макроекономічні моделі можуть надавати точніші прогнози і давати кращі політичні вказівки.***

В и с н о в к и . ***Включення поведінкових факторів у макроекономічні моделі дуже необхідне для поглиблення нашого розуміння складних економічних явищ. Завдяки більш детальному та реалістичному зображенню економічних агентів та їхніх процесів прийняття рішень ці моделі можуть подолати існуючі обмеження та сприяти розробці більш надійної та ефективної економічної політики.***

К л ю ч о в і с л о в а : ***макроекономічне моделювання, модель мультиплікатора-акселератора Самуельсона, агентне моделювання, поведінкова економіка, тваринні інстинкти, економічне зростання.***

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