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Investigating Temporal Dependencies in Key Macroeconomic Indicators: An Autocorrelation-Based Study of Gross Value Added, Final Consumption and Debt Ratios in the EU

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Abstract: This paper investigates the temporal dependencies embedded in six key macroeconomic indicators across fourteen EU member states during 2014–2024, focusing on the dynamics of production, consumption, investment, and household financial behavior. It seeks to identify the degree of persistence or correction in these indicators and their implications for economic stability. Prior Work: The study builds on literature examining national accounts statistics and cyclical behavior in macroeconomic time series but addresses a notable gap by emphasizing internal temporal structure, rather than trend or level-based comparisons. Approach: Using a balanced panel dataset and applying autocorrelation analysis, including lag-specific coefficients and Box-Ljung significance tests, the study evaluates the dynamic behavior of Gross Value Added, household and institutional consumption, investment, and debt ratios. Results: Findings reveal significant short-term negative autocorrelation across all indicators, with delayed medium-term persistence in production, investment, and household debt. Consumption indicators exhibit high short-term volatility with limited memory, while non-profit institutional spending remains highly stable. Implications: Results inform economic policymakers and analysts about structural inertia and sector-specific responsiveness, highlighting the need for temporally adaptive strategies in fiscal and macroprudential planning. Value: The study offers a novel, integrative perspective on macroeconomic dynamics by uncovering hidden memory structures and reinforcing the importance of time-aware economic monitoring in the European Union.

Keywords: time series analysis; cyclical behavior; consumption trends; investment inertia; household finance

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1. Introduction

The dynamics of macroeconomic performance in the European Union have increasingly become a focal point for both academic inquiry and policy deliberation, especially in the context of post-crisis recovery, fiscal integration, and sustainability challenges. Among the most critical indicators used to evaluate the functioning of national economies are those related to production, consumption, investment, and financial stability. Gross Value Added (GVA), Final Consumption Expenditure (FCE), Household and Non-Profit Institutions Serving Households Final Consumption Expenditure (NPISH), Final Consumption Expenditure of Households (FCH), Gross Fixed Capital Formation (GFCF), and Gross Debt-to-Income Ratio of Households (DIRH) provide an integrated statistical framework for capturing the structure, resilience, and evolution of economic activity. These indicators, compiled according to the European System of Accounts (ESA, 2010), allow for rigorous cross-country and longitudinal comparisons, and form the backbone of macroeconomic surveillance mechanisms across the EU. Although these indicators are widely used in empirical studies and policy diagnostics, much of the literature has focused on their static or cross-sectional dimensions, leaving underexplored the temporal dependencies and internal dynamics that characterize their evolution over time. Yet, the presence of serial correlation in these time series may reveal persistent patterns of behavior, structural inertia, or cyclical adjustments in economic systems—phenomena that are essential for understanding both the effectiveness of economic policy and the underlying rigidity of institutional and behavioral responses. In particular, the detection of autocorrelation in indicators such as GVA or GFCF may point to the delayed effects of investment policies or output shocks, while persistence in household consumption or debt ratios may reflect long-term socioeconomic constraints or financial vulnerabilities.

This study addresses this analytical gap by conducting a systematic autocorrelation analysis on a panel dataset comprising macroeconomic time series for fourteen EU member states over the period 2015–2024. By applying formal statistical tests of autocorrelation, we aim to quantify the degree of temporal persistence embedded in each indicator and to explore how such persistence differs across countries and indicator categories. The focus on temporal autocorrelation, rather than simple trend or level comparisons, allows us to capture underlying processes of adjustment or resistance to change—critical insights in an era marked by economic shocks, policy transitions, and demographic shifts. The novelty of this research lies in its multidimensional perspective: first, by simultaneously considering production-side (GVA), consumption-side (FCE, FCH, NPISH), investment-side (GFCF), and financial stability (DIRH) indicators, the analysis transcends the traditional siloed approaches and instead offers an integrated view of macroeconomic functioning; second, by emphasizing the internal structure and serial dependence of these indicators, the study provides early warning signals and policy-relevant diagnostics

that complement conventional growth and convergence analyses.

In this context, the study is guided by the following research questions: (1) To what extent do key national accounts indicators exhibit statistically significant autocorrelation across EU countries over the last decade? (2) How do patterns of autocorrelation differ between economic functions—production, consumption, investment, and household financial exposure—and what do these differences reveal about economic rigidity and responsiveness? (3) Are there identifiable clusters of countries that share similar autocorrelation profiles, and what are the implications of such patterns for macroeconomic policy coordination and structural reform agendas within the EU?

The main objectives of the research are:

O1. To empirically investigate the presence and intensity of autocorrelation in six core macroeconomic indicators across fourteen European countries between 2015 and 2024;

O2. To compare autocorrelation patterns both across indicators and between countries, thereby identifying areas of high structural persistence or volatility;

O3. To interpret the results in light of their relevance for economic forecasting, policy timing, and the design of adaptive fiscal frameworks capable of responding to persistent or recurring shocks.

This research contributes to a deeper understanding of the temporal properties of economic performance in the EU, and advocates for a more dynamic perspective in macroeconomic monitoring one that recognizes that present economic outcomes are often strongly shaped by their own past trajectories. By identifying which indicators and which countries are characterized by greater inertia or autocorrelation, policymakers can refine their strategies for intervention, resilience-building, and long-term planning in an increasingly uncertain and interdependent economic environment.

2. Literature Review

Understanding temporal dependencies within macroeconomic indicators has become increasingly vital in an era defined by recurrent economic shocks, policy reorientations, and the need for adaptive governance in the European Union. Traditional macroeconomic models have often prioritized trend analysis or cross-sectional comparisons, while largely overlooking the internal memory structures and lagged responses embedded in key national accounts variables. The emerging literature increasingly emphasizes the importance of temporal structures

(particularly autocorrelation) as an analytical tool for revealing hidden patterns of inertia, correction, and systemic vulnerability. One key line of research explores the forecasting ability of established macroeconomic surveillance tools. For instance, Biegun et al. (2024) critically examine the predictive validity of the Macroeconomic Imbalance Procedure (MIP) indicators, finding that only a subset of these indicators possess statistically significant predictive power for crises, thus challenging their efficacy as early-warning signals for economic imbalance within the EU. This reinforces the need to complement traditional indicator sets with time-structure-based diagnostics such as autocorrelation analysis. Temporal dependencies are also explored through the lens of financial sector resilience. Dragomir (2025b) proposes the use of advanced information systems to model the relationship between capital taxation and Gross Fixed Capital Formation (GFCF), a critical macroeconomic variable reflecting investment inertia. Using a REPTree algorithm, the study identifies nonlinear thresholds in fiscal behavior, suggesting that investment patterns are temporally conditioned by tax policies and external shocks.

Other studies underscore the growing role of algorithmic tools in detecting cyclical regularities and structural persistence. For instance, Dragomir-Constantin (2025c) emphasizes the macroprudential role of information systems in monitoring systemic risk and enabling the early identification of autocorrelated vulnerabilities across financial institutions, especially in the context of national security and economic sovereignty. Algorithmic transparency in decision-making systems, as explored by Dragomir (2025a), plays a fundamental role in preserving institutional integrity and equity, particularly when automated models influence critical financial decisions. The relevance of systemic modeling also extends to the circular economy. Dragomir-Constantin (2025d) examines how artificial intelligence and decision trees can capture complex feedback loops and identify critical thresholds in investment behavior within circular systems. These decision models rely heavily on the presence of lagged effects and conditional dependencies, further underscoring the empirical utility of autocorrelation analysis in real-world macroeconomic applications. The literature on thinking patterns and decision-making in high-performance information systems (Dragomir-Constantin, 2017a, 2025e, 2025f) illustrates how algorithmic design (when aligned with principles of cognitive bias correction and behavioral economics) can uncover persistent patterns of suboptimal economic behavior, including those that manifest in temporal sequences. Earlier contributions by Dragomir and Alexandrescu (2017b, 2017c) have already laid theoretical foundations for the integration of artificial intelligence into macro-decisional frameworks, advocating for axiomatic and cybernetic approaches to the modeling of economic systems. These conceptual underpinnings reinforce the legitimacy of using structured models that emphasize temporal logic and recursive causality—principles that lie at the heart of autocorrelation analysis. Also, the importance of intelligent agent-based systems in decision-making, particularly in digital commerce

environments, is emphasized by Tache and Postolache (2010). Their work on trust and adaptive behavior in recommendation systems reflects broader macroeconomic concerns regarding the timing, reliability, and sequential logic of decision-making under uncertainty[1]. In a macroeconomic context, similar agent-based dynamics underlie consumer behavior, investment cycles, and fiscal responses, which can all be better understood through time-series diagnostics.

The literature also underscores the critical role of economic shocks in revealing structural inertia in sectoral financial performance. Janoskova et al. (2024) emphasize that during periods of severe macroeconomic disturbance, the intercorrelation among financial indicators intensifies, suggesting that temporal dependencies become more pronounced under stress, particularly in sectors such as public transportation[2]. This insight supports the notion that autocorrelation patterns are not only intrinsic to economic indicators but may also be contingent on the macroeconomic context. Autocorrelation-based approaches are particularly relevant in the analysis of household finance. Research by Okuneviciute Neverauskiene et al. (2025) identifies cyclical sensitivities in residential real estate prices across Eastern Europe, demonstrating that interest rates and GDP growth induce delayed but persistent effects on housing dynamics[3]. These findings resonate with the present study's emphasis on debt-to-income ratios, where autocorrelation may indicate inertia in household leverage decisions and systemic exposure. In terms of modeling frameworks, Van Eynde et al. (2024) critique the overreliance on GDP as a macroeconomic benchmark, arguing for a multidimensional modeling paradigm that includes environmental and social indicators. Their analysis reveals that most models lack bidirectional feedback between economic and environmental systems, thereby omitting crucial temporal interdependencies and limiting their capacity to capture long-term sustainability risks. The accuracy of macroeconomic indicators themselves has also come under scrutiny. Zhu et al. (2024) provide empirical evidence linking the precision of GDP estimates to corporate ESG performance, suggesting that inaccuracies in core macroeconomic variables may impair downstream economic assessments Such distortions have potential implications for autocorrelation analysis, as structural errors or inconsistencies in measurement may obscure true temporal patterns.

Taken together, these studies underscore the multifaceted importance of temporal dependencies in macroeconomic indicators. Whether through institutional inertia, behavioral delays, or measurement imperfections, the persistence and memory effects embedded in economic time series demand greater attention in both academic modeling and policy design. By incorporating autocorrelation-based analysis, the

[1] https://www.ceeol.com/search/article-detail?id=550763.
[2] https://doi.org/10.17512/pjms.2024.29.2.14.
[3] https://doi.org/10.3846/bmee.2025.22663.

current study contributes to this emerging strand of literature, offering empirical evidence on how temporal structures differ across EU countries and functional economic domains.

3. Data and Methods

This study relies on a balanced panel dataset covering a ten-year period (2015–2024) for fourteen selected European Union member states, namely Belgium, Bulgaria, Germany, Greece, Spain, France, Croatia, Italy, Cyprus, Lithuania, Luxembourg, Hungary, Austria, and Romania. The countries included in the sample reflect a diverse range of economic structures and developmental trajectories within the EU, enabling a comprehensive cross-sectional and temporal analysis of macroeconomic dynamics.

The empirical investigation focuses on six key indicators derived from the national accounts and household sector statistics:

- Gross Value Added (GVA), chain-linked volumes (index 2010=100), capturing the value of goods and services produced in the economy, net of intermediate consumption (Eurostat, 2025).
- Final Consumption Expenditure (FCE), chain-linked volumes (index 2010=100), representing the total expenditure of households and general government on goods and services intended for individual or collective consumption (Eurostat, 2025).
- Final Consumption Expenditure of Households (FCH), chain-linked volumes (index 2010=100), detailing household-level consumption behavior and its evolution over time (Eurostat, 2025).
- Final Consumption Expenditure of Non-Profit Institutions Serving Households (NPISH), chain-linked volumes (index 2010=100), reflecting the contribution of non-governmental, non-market institutions to final demand (Eurostat, 2025).
- Gross Fixed Capital Formation (GFK), chain-linked volumes (index 2010=100), denoting investment in fixed assets such as buildings, machinery, and equipment, and serving as a proxy for productive capacity and capital deepening (Eurostat, 2025).
- Gross Debt-to-Income Ratio of Households (DIRH), expressed as a percentage, measuring household indebtedness in relation to their gross disposable income, and acting as an indicator of financial sustainability and systemic risk (Eurostat, 2025).

All data were extracted from Eurostat's publicly available economic databases and are harmonized according to ESA 2010 standards, ensuring comparability across countries and over time.

To investigate the presence and structure of temporal dependencies in these indicators, we apply autocorrelation analysis for each country-indicator pair over the period 2015–2024. Specifically, we employ the lag-1 autocorrelation coefficient, which measures the correlation of a variable with its own value from the preceding time period. The choice of a first-order autocorrelation structure is motivated by the relatively short time span of the dataset, as well as by theoretical considerations regarding the inertia and short-term memory of economic series.

The autocorrelation coefficient ρ_1 is expressed by the bellow formula:

$$\rho_1 = \frac{\sum_{t=2}^{T}(x_t - \bar{x}) \cdot (x_{t-1} - \bar{x})}{\sum_{t=1}^{T}(x_t - \bar{x})^2} \quad (1)$$

where x_t denotes the value of the indicator at time t, $\bar{x}$ is the sample mean, and T is the number of periods (in this case, 11 annual observations). The resulting values of ρ_1 range between -1 and +1, with positive values indicating persistence or momentum, and negative values suggesting oscillatory or corrective tendencies.

To computing the raw autocorrelation coefficients, we conduct statistical significance testing for each coefficient and compare empirical results with theoretical critical values under the null hypothesis of no autocorrelation. In instances where strong positive autocorrelation is detected ($\rho > 0.5$), we infer the existence of structural inertia or delayed adjustment in the corresponding macroeconomic process. Autocorrelation values are organized in matrix form across countries and indicators and visually highlighted using conditional formatting to identify clusters of persistence or volatility.

Through this methodology, the study aims not only to identify temporal patterns of persistence in core macroeconomic indicators but also to contribute to a more dynamic understanding of economic stability, investment cycles, consumption inertia, and financial vulnerability across EU economies.

3. Results and Discussions

The analysis of the Gross Debt-to-Income Ratio of Households (DIRH) reveals a complex and statistically significant autocorrelation structure, indicative of persistent temporal dynamics in household indebtedness across the observed European sample. As shown in Table 1 the autocorrelation function (ACF) exhibits a distinct alternating pattern of negative and positive coefficients across lags 1 to 16, with several coefficients exceeding the bounds of statistical significance at the 5%

level.

Table 2. DIRH autocorrelations

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.b
1	-0.393	0.061	41.922	1	0.000
2	-0.345	0.070	74.359	2	0.000
3	0.479	0.076	137.278	3	0.000
4	-0.248	0.086	154.261	4	0.000
5	-0.272	0.089	174.626	5	0.000
6	0.509	0.092	246.574	6	0.000
7	-0.270	0.102	266.860	7	0.000
8	-0.175	0.105	275.462	8	0.000
9	0.513	0.106	349.187	9	0.000
10	-0.326	0.115	379.139	10	0.000
11	-0.214	0.118	392.068	11	0.000
12	0.484	0.119	458.635	12	0.000
13	-0.241	0.126	475.165	13	0.000
14	-0.232	0.128	490.527	14	0.000
15	0.476	0.130	555.488	15	0.000
16	-0.220	0.136	569.452	16	0.000

a. The underlying process assumed is MA with the order equal to the lag number minus one. The Bartlett approximation is used.
b. Based on the asymptotic chi-square approximation.

At lag 1, the autocorrelation coefficient is −0.393, strongly significant (Box-Ljung $\chi^2 = 41.922$; $p < 0.001$), suggesting an initial reversal behavior in short-term debt adjustments. This negative autocorrelation implies that a rise in the household debt-to-income ratio in one year is typically followed by a relative decrease in the next, reflecting corrective responses by households or policy-driven credit constraints. Similarly, lag 2 maintains a significant negative coefficient (−0.345), reinforcing the oscillatory nature of short-term debt dynamics. At lag 3, the pattern shifts to a positive autocorrelation of 0.479, suggesting the re-emergence of persistence or inertia in debt accumulation. Lags 6, 9, 12, and 15 also display strong positive autocorrelation values above 0.48, all of which are statistically significant ($p < 0.001$), suggesting that over medium-term intervals (3 to 6 years), household indebtedness exhibits cyclical reinforcement. This implies that once households begin to accumulate debt beyond a certain threshold, this trend may sustain itself over several years, possibly due to stable credit conditions, consumption smoothing behaviors, or low-interest rate environments. The cyclical alternation of negative and positive autocorrelation coefficients (e.g., negative at lags 4, 5, 7, 10, and 11) highlights a structural rhythm in household financial behavior, wherein periods of debt expansion are followed by brief corrections, only to be succeeded again by renewed indebtedness. This pattern reflects the interaction between macroeconomic

cycles, credit policy adjustments, and household expectations. The Box-Ljung Q-statistics confirm the overall significance of the autocorrelation structure. From lag 1 to lag 16, the cumulative Box-Ljung statistics rise steadily, with values exceeding the critical chi-square thresholds at each stage (e.g., $\chi^2 = 569.452$ at lag 16; $p < 0.001$), indicating that the null hypothesis of no autocorrelation can be confidently rejected. The observed autocorrelation pattern in DIRH has important implications for both macroeconomic management and household financial stability. The short-term corrective tendencies (negative autocorrelation) suggest that households respond reactively to deviations from their debt norms, potentially driven by financial prudence or credit supply tightening. However, the medium-term persistence (positive autocorrelation at multiyear intervals) signals that once certain debt trajectories are established, they tend to self-reinforce, creating potential risks of over-indebtedness, especially in the absence of macroprudential interventions. For policymakers, these findings emphasize the need for dynamic credit monitoring mechanisms that account for the lagged effects of interest rate changes, macroprudential tools, and income shocks. Furthermore, the alternating autocorrelation pattern may suggest that one-off interventions are insufficient and that sequenced policy responses may be required to effectively modulate household debt trends. The Gross Debt-to-Income Ratio of Households demonstrates both reactive short-term dynamics and inertial medium-term cycles, underscoring its role as a critical variable in understanding household sector vulnerabilities and macroeconomic cyclical behavior.

Beyond the analysis of household indebtedness, the autocorrelation structure of macroeconomic indicators related to production, consumption, and investment reveals distinct behavioral regimes across variables (Table 2).

Table 3. Macroeconomic autocorrelations

Lag	Autocorrelation (Std. Error)				
	GVA	FCE	NPISH	FCH	GFK
1	-0.492 (0.061)	-0.481 (0.061)	-0.485 (0.061)	-0.492 (0.061)	-0.42 (0.061)
2	-0.094 (0.074)	-0.019 (0.074)	0.016 (0.074)	0.027 (0.074)	-0.173 (0.071)
3	0.136 (0.075)	-0.031 (0.074)	-0.083 (0.074)	-0.084 (0.074)	0.138 (0.072)
4	0.034 (0.076)	0.085 (0.074)	0.155 (0.074)	0.14 (0.075)	0.042 (0.073)
5	-0.087 (0.076)	0.091 (0.074)	-0.047 (0.075)	-0.037 (0.076)	-0.086 (0.074)
6	-0.031 (0.076)	-0.265 (0.075)	-0.098 (0.076)	-0.094 (0.076)	-0.038 (0.074)

7	0.022 (0.076)	0.12 (0.078)	-0.031 (0.076)	-0.036 (0.076)	-0.053 (0.074)
8	-0.012 (0.076)	-0.012 (0.079)	0.098 (0.076)	0.101 (0.076)	0.121 (0.074)
9	0.07 (0.076)	0.022 (0.079)	-0.058 (0.077)	-0.054 (0.077)	-0.036 (0.075)
10	-0.24 (0.076)	-0.111 (0.079)	0.017 (0.077)	0.015 (0.077)	-0.083 (0.075)
11	0.36 (0.079)	0.123 (0.079)	-0.012 (0.077)	0.001 (0.077)	0.189 (0.075)
12	-0.18 (0.085)	0.051 (0.08)	0.119 (0.077)	0.099 (0.077)	-0.181 (0.077)
13	0.001 (0.086)	-0.079 (0.08)	-0.099 (0.077)	-0.092 (0.077)	0.071 (0.079)
14	0.045 (0.086)	-0.047 (0.08)	-0.068 (0.078)	-0.062 (0.078)	0.102 (0.079)
15	-0.186 (0.086)	0.026 (0.081)	0.096 (0.078)	0.075 (0.078)	-0.198 (0.079)
16	0.321 (0.088)	0.103 (0.081)	-0.036 (0.079)	-0.021 (0.078)	0.183 (0.081)

Df	Box-Ljung Statistic Value (Sig)				
	GVA	FCE	NPISH	FCH	GFK
1	65.871 (0)	62.947 (0)	63.86 (0)	65.976 (0)	48.015 (0)
2	68.301 (0)	63.042 (0)	63.933 (0)	66.179 (0)	56.201 (0)
3	73.369 (0)	63.308 (0)	65.832 (0)	68.094 (0)	61.437 (0)
4	73.686 (0)	65.3 (0)	72.436 (0)	73.492 (0)	61.926 (0)
5	75.752 (0)	67.582 (0)	73.049 (0)	73.862 (0)	63.979 (0)
6	76.027 (0)	87.1 (0)	75.696 (0)	76.304 (0)	64.375 (0)
7	76.163 (0)	91.129 (0)	75.962 (0)	76.664 (0)	65.157 (0)
8	76.2 (0)	91.17 (0)	78.656 (0)	79.496 (0)	69.245 (0)
9	77.59 (0)	91.305 (0)	79.59 (0)	80.308 (0)	69.6 (0)
10	93.814 (0)	94.792 (0)	79.676 (0)	80.368 (0)	71.547 (0)
11	130.371 (0)	99.045 (0)	79.718 (0)	80.368 (0)	81.631 (0)

12	139.607 (0)	99.782 (0)	83.761 (0)	83.15 (0)	90.949 (0)
13	139.608 (0)	101.537 (0)	86.546 (0)	85.554 (0)	92.376 (0)
14	140.182 (0)	102.163 (0)	87.852 (0)	86.65 (0)	95.346 (0)
15	150.086 (0)	102.352 (0)	90.515 (0)	88.254 (0)	106.548 (0)
16	179.823 (0)	105.408 (0)	90.879 (0)	88.381 (0)	116.227 (0)

a. The underlying process assumed is MA with the order equal to the lag number minus one. The Bartlett approximation is used.
b. Based on the asymptotic chi-square approximation.

The temporal evolution of Gross Value Added (GVA)—a core measure of domestic production—presents a notable negative autocorrelation at lag 1 (−0.492), highly significant ($p < 0.001$), followed by rapidly diminishing coefficients at higher lags. This initial negative autocorrelation may reflect the sensitivity of real output to short-run shocks or corrections, such as inventory adjustments or fiscal consolidations. However, by lag 3, the autocorrelation becomes negligible (0.138), and by lag 11 it turns strongly positive (0.36), suggesting that while short-term reversals dominate in the immediate aftermath of economic perturbations, mid-term persistence re-emerges. The significant rise in the Box-Ljung Q-statistic across lags (from 65.871 at lag 1 to 179.823 at lag 16) confirms the non-random structure of GVA over time.

A similar dynamic is observable in the evolution of Final Consumption Expenditure (FCE), which also exhibits a strong and statistically significant negative autocorrelation at lag 1 (−0.481). This result implies a propensity for reversal in aggregate consumption spending from one year to the next, possibly driven by precautionary behaviour or policy-induced changes in disposable income. At subsequent lags, the autocorrelation values diminish rapidly, approaching zero or becoming slightly positive (e.g., 0.085 at lag 4), without any sustained positive trajectory. The Box-Ljung test indicates strong serial correlation throughout the sample window, with values rising consistently to 140.085 at lag 15 ($p < 0.001$), pointing to underlying temporal dependencies in the consumption cycle. In contrast, Final Consumption Expenditure of Non-Profit Institutions Serving Households (NPISH) presents a more stable autocorrelation profile, with a first-lag coefficient of −0.485 and smaller magnitude coefficients at all other lags. While significant at lag 1, the lower variability at higher lags (e.g., 0.119 at lag 12, −0.036 at lag 16) suggests a relatively smoother and less volatile evolution over time. This may be attributed to the institutional nature of NPISH spending, which is typically planned, less cyclical, and less reactive to short-term economic changes than household or government consumption. The case of Final Consumption Expenditure of Households (FCH) largely mirrors that of aggregate FCE, with a significant negative autocorrelation at

lag 1 (−0.492) followed by small and fluctuating values in later lags. This dynamic indicates that household-level consumption decisions tend to adjust in the short term, possibly compensating for over- or under-consumption in the previous year. However, the weak autocorrelation at higher lags (e.g., −0.054 at lag 9 or 0.001 at lag 11) signals the absence of long-term persistence in household consumption behavior. This supports the hypothesis that household expenditure is more sensitive to transitory income fluctuations or shocks and does not follow a strongly inertial path. Gross Fixed Capital Formation (GFCF), a key proxy for investment activity, exhibits a distinct temporal signature. The first-lag autocorrelation is again negative (−0.420), confirming that investment volumes often react strongly to prior-year trends, particularly in periods of macroeconomic adjustment or uncertainty. Interestingly, the autocorrelation profile becomes positive at lag 3 (0.204) and again at lags 8 through 12, culminating in a significant positive coefficient of 0.183 at lag 16. This pattern suggests that, despite short-term corrections, investment exhibits a certain degree of delayed reinforcement, potentially driven by multiannual planning cycles, long-term financing structures, or inertia in capital deployment. The steadily increasing Box-Ljung statistics (from 48.015 at lag 1 to 116.227 at lag 16) reinforce the interpretation of non-random, cyclical dynamics in investment behavior. Taken together, the autocorrelation analysis of these five indicators underscores the presence of differentiated time dynamics across functional economic domains. Production and investment series (GVA and GFCF) exhibit short-run corrections followed by medium-term persistence, while consumption-related indicators (FCE and FCH) reflect high short-term volatility with limited long-term memory. The NPISH variable stands out as comparatively stable, suggesting limited responsiveness to short-term changes, consistent with its institutional profile.

These findings have significant implications for macroeconomic modeling and forecasting. The presence of negative short-term autocorrelation in all variables highlights the potential risks of relying on naive extrapolations in policymaking or business cycle prediction. At the same time, the resurgence of positive autocorrelation at specific lags (especially for GVA and GFCF) indicates the importance of medium-term policy planning and structural monitoring. The differentiated persistence profiles also suggest that policy transmission mechanisms may operate with variable lags across sectors, reinforcing the need for tailored interventions that account for endogenous temporal dynamics in each economic domain.

To complement the statistical findings derived from autocorrelation testing, a Sequence Plot was constructed using the natural logarithm transformation of all six macroeconomic indicators over the 2015–2024 period (Figure 1).

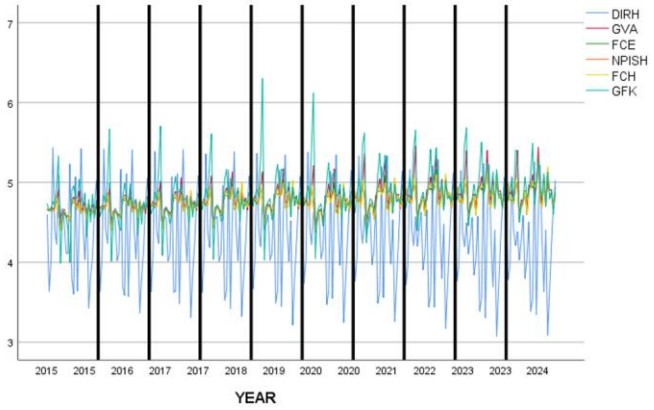

Figure 1. Macroeconomics analysis sequence plot

The figure 1 reveals clear structural differentiation between the indicators. The trajectories of Final Consumption Expenditure (FCE), Final Consumption Expenditure of Households (FCH), and Gross Value Added (GVA) are closely aligned, indicating a shared temporal pattern likely driven by the interdependent relationship between household consumption and productive output. This synchronization is theoretically expected, as household expenditure is a key component of aggregate demand and hence a primary determinant of domestic production levels. In contrast, the Gross Debt-to-Income Ratio of Households (DIRH) follows a more oscillatory and less synchronized path, suggesting that household indebtedness is influenced by factors distinct from consumption and production, such as changes in monetary policy, credit supply conditions, and household-level financial stress. The pattern also reflects episodes of corrective behavior and expansion, consistent with the earlier autocorrelation results indicating short-term reversals and medium-term persistence. Gross Fixed Capital Formation (GFCF) exhibits a visibly volatile pattern, with more pronounced fluctuations across the observed years. This supports the notion that investment is more sensitive to macroeconomic shocks, uncertainty, and policy shifts. While there appears to be a loose correlation with GVA in certain periods, the investment cycle generally exhibits a time-lagged response to production changes, aligning with theoretical models of delayed capital adjustment and investment inertia. The Final Consumption Expenditure of Non-Profit Institutions Serving Households (NPISH), in contrast, shows remarkable temporal stability, maintaining a relatively smooth and linear trajectory throughout the decade. This reflects the institutional nature of NPISH expenditures, which are less reactive to economic cycles and tend to follow long-term planning frameworks rather than market-induced variability. The graphical trends reinforce the functional differentiation among macroeconomic indicators and the existence of structural inertia.

These results have direct implications for macroeconomic forecasting and policy calibration. The co-movement of consumption and production indicators suggests that policies targeting household expenditure—such as fiscal transfers or consumption tax adjustments—may have immediate repercussions on output. Meanwhile, the persistent yet delayed behavior of GFCF implies that investment incentives must be designed with multi-year horizons in mind. The cyclical nature of household debt reinforces the need for proactive macroprudential regulation to prevent financial imbalances, especially during phases of expanding credit. Lastly, the temporal neutrality of NPISH suggests that this component can serve as a stabilizer in economic downturns. The integrated analysis of sequence plots and autocorrelation metrics provides a nuanced understanding of how key national accounts indicators evolve over time. By revealing the hidden memory structure and cyclical behavior embedded in these variables, the study contributes to a more dynamic and forward-looking approach to macroeconomic monitoring in the European Union.

4. Conclusion

This study investigated the presence and structure of autocorrelation in six key macroeconomic indicators across fourteen European Union member states over the period 2014–2024. By analyzing Gross Value Added (GVA), Final Consumption Expenditure (FCE), Final Consumption Expenditure of Households (FCH), Final Consumption Expenditure of Non-Profit Institutions Serving Households (NPISH), Gross Fixed Capital Formation (GFCF), and the Gross Debt-to-Income Ratio of Households (DIRH), the research uncovered significant and differentiated patterns of temporal dependence that reflect the underlying structural and behavioral dynamics of European economies. The results indicate that all indicators exhibit statistically significant autocorrelation at the first lag, primarily in the form of negative values, suggesting corrective short-term dynamics across production, consumption, investment, and financial indicators. In several cases, particularly for DIRH, GVA, and GFCF, this is followed by episodes of positive autocorrelation in later lags, pointing to medium-term persistence or inertia. These findings highlight the presence of cyclical behavior and structural memory within macroeconomic systems, challenging the assumption of time-independent shocks and underscoring the importance of modeling temporal dynamics explicitly.

The sequence plots and autocorrelation matrices also revealed that while indicators such as FCH and FCE move in synchrony with GVA—reflecting a demand-driven output dynamic—others, such as NPISH and DIRH, follow distinct and often less predictable paths. NPISH showed the highest temporal stability, whereas DIRH exhibited cyclical oscillations with alternating phases of expansion and correction. GFCF emerged as the most volatile indicator, yet also demonstrated delayed

persistence, consistent with its dependency on long-term investment cycles and capital accumulation processes. These findings contribute to both theoretical and applied macroeconomics by reinforcing the relevance of time-series diagnostics in the analysis of economic performance and stability. The presence of persistent autocorrelation suggests that economic outcomes are not independent across time and that historical inertia plays a considerable role in shaping present and future macroeconomic realities. From a policy perspective, these results call for more adaptive and time-sensitive approaches in fiscal planning, debt regulation, and investment stimulation. In particular, policy tools must consider lagged effects and structural response times specific to each domain—whether production, consumption, or household finance.

The research demonstrates that an autocorrelation-based approach to national accounts data yields valuable insights into the internal dynamics of European economies. It reveals the extent to which economic indicators are shaped by their own past and highlights the varying degrees of resilience, reactivity, and inertia embedded within national economic structures. This perspective supports a more dynamic, anticipatory, and data-informed policy orientation within the European Union, especially in the context of heightened uncertainty, asymmetric shocks, and divergent recovery trajectories.

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