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Convergence Trends in Euro Economies: Financial Crisis Recovery and the COVID-19 Pandemic

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Abstract: The configurative comparative method, Dynamic Pattern Synthesis (DPS) is used to replicate previous research into the impact of the euro on economic convergence. The DPS method ensures a forensic examination of the diverse variable patterns that influence cluster memberships. As with previous research conclusions, there are multiple patterns of convergence and divergence. Consistent clusters across the time periods compared are Germany, the Netherlands, Luxembourg, and Ireland; Slovakia and Estonia; Italy, Spain, and Slovenia; and Portugal and Greece. The variable patterns most likely to influence cluster definitions are differences in GDP per capita, productivity, and investment, although there are other differing variable patterns that influence specific smaller cluster memberships and the consistency of memberships over time. Externalities undermine nominal convergence. An example is the divergence of the experience of consumer inflation between 2016 and 2022. Nevertheless, some convergence in long-term interest rates is achieved. There is also divergence in the real convergence target of GDP per capita. As regards structural changes, productivity differences widen, and investment as a percentage of GDP converges during COVID-19. The theoretical implications are that the complex dynamics between collaboration, competitive markets, and global instabilities makes convergence unlikely. Real convergence, such as reducing the distribution differences of GDP per capita, is only likely to be possible over many decades, and needs considerable government interventions. Complex systems theory informs us that limits to convergence are inevitable in dynamic systems where events bring unplanned divergences.

Keywords: convergence; Dynamic Pattern Synthesis; complex systems; euro; cluster analysis

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1. Introduction

The aim of our research is to examine the comparative trajectories of major euro based national economies and their degree of convergence following recent global events. Its objectives are, firstly, to reevaluate convergence in euro economics as impacted by the most recent global and European events, and secondly to add value to existing convergence research by progressing the conceptual understanding of economic convergence as a dynamic and multivariate phenomenon that can be situated in a complex economic and social systems environment. Our research is influenced by a previous study published in this journal in 2016 (Haynes and Haynes 2016) that commented on changes to euro member countries from 2002 to 2013. The new research in this article examines the later period 2015 to 2021, as national economies seek to stabilise after the financial crisis of 2008 that started in the United States due to unsustainable lending for property and that amplified into an international credit crisis and loan defaults including international bank failures. The European debt crisis of 2009–2010 followed and resulted in a number of countries who share the euro being unable to manage their government deficits. This led to the relaxation of nominal convergence targets for these deficits. Long-term interest rates diverged across euro members, as the cost of borrowing became more severe in the worst-affected countries.

Subsequently, Brexit, a political crisis caused in 2016 when the British electorate voted in a referendum to leave the European Union and the single market, resulted in economic policy challenges for euro members. This impact was reduced to some extent because Britain had not joined the European single currency, despite it being a major trade partner with the eurozone. The COVID-19 pandemic had a large economic impact on euro countries, causing a reduction in demand and global supply disruptions.

The methods used in this research are not an exact replication of the previous research, but nevertheless are influenced by the technical approach and data sources used in the previous study. Exact replication is not possible because the 2016 research used a first emerging multimethod of configurative analysis to examine the complex dynamics of interactive macroeconomic variables. At that time the multimethod had not reached its concluding integrated research design. The method has since been further developed and applied (Haynes 2017). It is still embedded in cluster analysis but contains some unique and novel features that borrow from other comparative configurative approaches. In combination these have been referred to and practiced since 2017 as Dynamic Pattern Synthesis (DPS) (see Haynes 2017; Haynes and Alemna 2023). Such methods examine comparative configurations of cases, like countries, and how they evolve in their similarity and difference over time, as they often experience dynamic changes as a result of operating in a complex systems environment (Bicket et al. 2020).

Examining whether countries that share the euro are converging their economies is a high priority because of the explicit public policy goal of the European Commission and Central Bank to achieve convergence via the implementation of a single currency area. There has been considerable discussion and debate about exactly what type of convergence the single currency is aiming to achieve. Is the goal to achieve similar and stable market conditions across the member countries with convergence of so called 'nominal' indicators like interest rates, inflation, deficits, and debts? Or is convergence a political economic vision that has social policy goals like a greater similarity of per capita income in all countries and structural benefits like shared low unemployment and advanced productive economies (Buti and Turrini 2015)? Both policy goals are important. A complex view of convergence needs to incorporate a wide range of indicators.

This research paper adds original value to the existing literature about European economic convergence by examining the impact of recent events like Brexit and COVID-19, but also because it continues theoretical innovation with methods that allow a multivariate definition of convergence that can be juxtaposed and applied with real world dynamics and economic complexity.

2. Background Literature and Research Context

The theoretical framework applied in this paper to define convergence remains close to the theoretical definition used in the 2016 research paper (Haynes and Haynes 2016). In this study, we do not seek an explanation of convergence from one single dependent variable, such as GDP growth per capita, or investment as a percentage of GDP, although these are important policy goals. Instead, we examine convergence as a multivariate phenomenon where similarity is evidenced in multiple variables concurrently. A more detailed account of the theoretical basis and methodological history important to measuring economic convergence is contained in the introduction to the previous 2016 paper (op cit.). Our theoretical approach in this paper continues to be founded on the importance of a concurrent and combined convergence of several macroeconomic variables.

This is a multivariate definition of convergence and one that seeks evidence of cluster groupings of similar countries, where different variable patterns are likely to be associated with evidence of the similarity of several groups of countries in different cluster groupings, but where there is also likely to be contrasting clusters with different variable characteristics (Caputo and Forte 2015; Irac and Lopez 2015). For convergence to be evidenced, over time one would expect the distribution and standard deviation of a collection of variables to be reducing (sigma convergence, Young et al. 2008), but also that the number of dissimilar

clusters would be reduced, with a lower number of cluster groupings, with more shared similarity across clusters, than previously. This takes a convergence analysis further than the assumption that the less developed economies of the euro can 'catch up' with the more developed economies, such as Germany and Luxembourg, as a result of the euro currency launch in 2002 (beta convergence, Barro 1991; Dvoroková 2014). Likewise, it focuses on a more holistic approach to convergence than seeking to see how all countries perform relative to the single previously best performing country (delta convergence). Our dynamic approach is closer to the idea of 'club convergence' where the complicated nature of countries and macroeconomics implies it makes sense to look at their similarities and differences as dynamic patterns of sub-groupings (Cavallaro and Villani 2021).

What is illuminated further in the theoretical underpinning of our research about country and regional convergence and divergence since 2016 (Haynes and Alemna 2022; Alemna et al. 2021; Taylor et al. 2021) is the pivotal influence that complexity theory (complex adaptive systems) and configurative comparative methods have on how longitudinal comparisons of countries are considered (Bicket et al. 2020, 2021).

Some of the key influences of complexity theory on economic and policy systems that makes them difficult to evaluate and predict are well argued in a seminal guidance document produced for the UK Treasury and its policy-makers and researchers (Bicket et al. 2020). The components in the economic and social system, like consumers and organisations, are not static elements but are able to learn and evolve, so they adapt and change their behaviour to operate strategically in market conditions (Rosser 1999). This results in the emergence of new and changing market behaviour (Beinhocker 2007). Such originality is one reason for the unexpected effects of policy where historical policies such as raising central bank interest rates or central bank purchasing of government debt (Quantitative Easing) may have less impact over time.

Likewise, the impact of independent variables on dependent variables is often nonlinear, with an unstable relationship that defies future prediction. Policy-makers face 'decision making under fundamental uncertainty' (Arthur 2021, p. 143). Complex systems like economies, are nevertheless, not in conditions of chaotic instability in all historical periods and certain relationships between policies and their outcomes do become stable in specific contexts related to limited time and space (Arthur 2013). The difficulty is knowing when these stable patterns will break down, and if they will interact and combine in such a way as to produce 'tipping points' of more dramatic economic and social change, such as those seen in the 2008 financial crisis and the COVID-19 pandemic. One cause of relative stability is 'path dependency', as complex systems are always to some extent influenced by their history (Cilliers 1998; Greener 2005). Key historical decisions in government policy, such as how independent the banking and legal systems are from the political process, may determine the boundaries and limits of how much an economic system and its performance can change, even while some other aspects and details do continue to behave dynamically and with uncertainty. In short, economic evaluation and forecasts are more similar to the science of weather forecasting than the science of tidal timetables. Unlike the precise predictability of tidal timetables, weather forecasting is only highly accurate in a given locality and for short time scales. Tides are static, while the weather is highly dynamic.

Complexity theory has a growing influence on economics and economic policy-making (Haynes and Alemna 2022). The major methodological impacts in economics are, firstly, the use of Agent Based Modelling (ABM), where theoretical models are given some core mathematical rules to demonstrate how complex patterns emerge over future periods of time (Hommes 2006; Tesfatsion 2006). Often ABMs reveal that, as the external environment changes, the dynamics shift, as do the resulting emergent patterns. Secondly, ecological economics has located complexity-informed macroeconomics firmly into an interdisciplinary toolbox that includes environmental science, and other disciplines and sub disciplines (Plummer and Armitage 2007). It uses a whole range of methods to model such complex systems and their most likely outcomes. Ecological economics includes qualitative theorising about systems behaviours and mixed methods where quantitative models

and descriptions are also employed alongside qualitative analysis. There is currently less evidence of the importance of configurative comparative models in applied economics that demonstrate the use of complexity theory to explain economic systems, but configurative methodological approaches to explaining social and economic complexity have become more influential in politics, sociology, and business studies. Configurative methods offer a perspective on complex causalities like equifinality (where different conditions are associated with a single outcome) and multifinality (where the same conditions are associated with different outcomes). Configurative comparative methods therefore offer a realistic method for finding the challenging dynamic patterns that complexity theory argues are vital to understand. The centrality of using these methods to evaluate a complexity-informed policy agenda, and the desire of policy-makers to find better methods for designing policies that are relevant to the complex systems they work with, is well argued by Bicket et al. (2020) in their seminal research for the UK Treasury and Civil Service.

This paper therefore seeks to demonstrate a realistic and complexity-informed approach to convergence using a configurative approach. It applies a multivariate approach to convergence that can encompass overlapping definitions of convergence as discussed in the methodology section.

3. Methodology

Our multivariate and complex approach to measuring convergence is influenced by previous conceptual definitions. Nominal convergence is evidenced by exploring progress on European Bank and Commission economic policy goals, for example reducing consumer price inflation and stabilising interest rates. Real convergence seeks evidence that the economic benefit is impacting social goals, such as reductions in differences in income and wealth (GDP per capita) (Marelli and Signorelli 2010; Siljak 2015). Structural convergence examines the sectorial similarities (technology and productivity) and the macroeconomic environment (formation of the working population and level of investment). In contrast, a multivariate approach informed by DPS allows the possibility to reflect on a combination of these aspects of the macroeconomy and their potential interconnectivities across different working definitions of convergence. Such a multivariate, longitudinal approach allows researchers to explore the complexity in the euro macroeconomic system and to begin to explain recent evolutionary trends in economic patterns of convergence and divergence.

The comparative configurative method used in this paper to model complexity is DPS (Bicket et al. 2020). The contemporary version of DPS used to model convergence is taken from the 2nd edition of the DPS manual (Haynes and Alemna 2023). This uses an exploratory approach to cluster analysis, where the researcher can visualise the relationships between variable patterns and cases, before making an informed decision on the optimal number and memberships of clusters to use for a final model. This is an alternative to using the orthodox algorithm approach to clustering matrices, where the researcher relies on a computer-based model to create groupings and does not easily have an informed view of the basis for how these different groups are formed. In addition, research has shown that using different clustering algorithms with the same dataset can result in the outcome of different cluster groupings (Blashfield 1976; Blashfield and Aldenderfer 1988; Pastor 2010).

With DPS exploratory cluster analysis, the first stage is similar to the first component of automated and orthodox computer-based cluster modelling. Case based associations are calculated using the squared Euclidean difference and then a pairing of the most similar cases in a case-by-case matrix are used to find the most valid mix of clusters. The matrix gives a dissimilarity score where the highest scoring pair represents the maximum dissimilarity with other cases. Conversely the lowest scoring pair of cases is the most similar pair. Next, in an orthodox approach, the mathematical method for combining cases into clusters larger than pairs proceeds on the basis of using an algorithm that finds the best combination of cases into clusters. For this second stage, numerous different mathematical algorithms are offered in any suitable available computer software, and they will produce different cluster patterns. We argue for the use of an alternative simple

and transparent approach to this second stage that promotes the researcher having the maximum awareness of which variables are contributing to the different cluster patterns (Haynes and Alemna 2023).

Using the table of squared Euclidean differences, the process starts by identifying the lowest scoring pair of cases to represent the most similar pair. This forms the root of cluster 1. The next lowest pair, if the cases are different to the first, forms the start of cluster 2. The process continues to search for unique pairs on this basis. Cases whose pattern has already been allocated to a pair will be added to their best fit group, because they cannot form a new unique pair in the continuing process. The technique ends when all cases are allocated to a cluster. This approach is designed to maximise the distance and differentiation between clusters, rather than to find one principal cluster with the best fit of similarity for the whole population of cases. What results is a list of cases and clusters that can then be checked using conventional data tables to see exactly what variable patterns are validating the membership of each cluster. In other words, different clusters are likely to be validated by different variable patterns. The variable tables analysis for each cluster allows the researcher to see the potential overlap between clusters and where two or more clusters could be argued to be combined into a single cluster for the sake of parsimony.

As with all forms of computer-based and orthodox cluster analysis, there is usually more than one possible combination of pairs into larger clusters that is potentially valid for answering the research questions in use. In other words, clustering is rarely mutually exclusive and fuzzy cluster groupings are likely. For example, some single cases can potentially be argued to be located in two or more different clusters on the basis of different variable patterns. Likewise, clustering can be hierarchical. While greater levels of similarity are evidenced for smaller cluster groupings, it is possible that some degree of reduced similarity is still evidenced as a valid combination of cases when small clusters are converged together into a bigger cluster. The researcher must find the best evidence for making the most effective argument about which boundaries and level of cluster membership is most valid for each case (Haynes and Alemna 2023). This may be influenced by previous research and evidence from the literature.

Dynamic Pattern Synthesis exploratory cluster analysis uses tables that compare countries' variable scores, and the resulting clusters come from the first stage analysis of pairs and groups. These tables are analysed to observe where similar variable patterns are associated with the cluster membership. Microsoft Excel 'heat maps' are used for this purpose. In particular, above and below mean average scores shared by all members of a cluster are identified. The researcher can then reach an informed judgement about the most valid number of clusters for a given research question and its analysis, and show the variable data evidence to justify their decision.

Three data periods are compared (2016, 2019, and 2022), to see to what extent clusters, and the variable patterns that define them, remain consistent over time. It is then possible to take an overview of the evidence for longitudinal multivariate patterns of similarity and difference with regard to whether a convergence of countries is taking place, or not, over given time periods.

The following macroeconomic variables (with sources) are analysed for the three years of interest (long name–abbreviated name). The choice of variables is influenced by considerations about what is reliable and valid in major secondary macroeconomic datasets and associated research studies, including the European Commission's own research on economic convergence. The data allows for some coverage of nominal, real and structural aspects of convergence. We have also stayed close to the choice of variables used in our previous research about convergence in countries sharing the euro (Haynes and Haynes 2016).

- Harmonised indices of consumer prices—HICP (Eurostat);
- Long term interest rates—LTIR (Eurostat);
- Government current account, balance of payments—GovCA (Eurostat);
- Gross domestic product per capita, Euros—GDPCap (Eurostat)l;
- Gross government debt as a percentage gross domestic product—GrossDebt (Eurostat);

- Percentage of adult population in employment—workingpop (Eurostat);
- Import to export ratio—IEratio (Eurostat);
- Population change, including migration, as a percentage of population—PopC (Eurostat);
- GDP growth, annual percentage change—GDP (Eurostat);
- Productivity—Prod (Eurostat);
- Consumer confidence—Confid (OECD);
- Investment as a percentage of GDP—Invest (Eurostat).

There is missing data for Estonia's long term interest rate in 2016. This is because Estonia's government did not issue bonds from its central bank at that point in its economic development. All data analysis is computed with Microsoft®Excel (version 2310). Figure 1 is computed using the Microsoft®Excel add on NodeXL, as developed by the Social Media Research Foundation (https://nodexl.com/ as accessed on 22 May 2023).

4. Results

There are two types of tables used in the results. The first type used in Tables 1, 3, and 5 show the clusters that result from an exploratory cluster analysis for each of the selected years. The 'heat map' shows the variable patterns for each variable across the distribution and its impact on each cluster. Green shading indicates scores that are high in the distribution and red indicates scores that are low in the distribution. Light green scores are above the mean and orange scores are below the mean. Yellow scores are close to the central tendency. Distributional statistics for each variable in relation to the 19 countries are shown at the bottom of each table. Where a cluster shares above or below mean scores, these are indicated in bold text. This allows the reader to see the key variable patterns that are associated with each cluster membership.

The second type of table construction is used in Tables 2, 4, and 6 and shows a cluster similarity matrix from the first stage of the exploratory cluster analysis. This similarity matrix helps to inform the researcher about whether to merge similar clusters in the stage two analysis. The stage two column in Tables 1, 3, and 5 therefore indicates the final cluster model for each year of data analysis.

4.1. 2016 Data

Table 1 shows the variable patterns and cluster formation for 2016 data. In cluster 1, Germany, Luxembourg, and the Netherlands share above-average government current accounts, GDP per capita, working populations, import–export ratios, population change, productivity, and consumer confidence. There are below-average scores for long-term interest rates and gross government debt and investment.

Cluster 2, which comprises of Cyprus, Italy, Slovenia, and Spain, the countries share above-average working-age populations, but their population change is at average and below. Consumer prices, GDP per capita, and investment are below-average.

Cluster 3 comprises of Estonia, Latvia, Lithuania and Slovakia. Its members share below-average scores for long-term interest rates (missing data for Estonia, but commercial rates at that time indicate a good cluster fit), GDP per capita, gross government debt, import–export ratios, population change, and productivity.

Cluster 4 is a pairing of Finland and France, which share characteristics for seven variables. They share above-average scores for: consumer prices, productivity, and investment, and below-average scores for long-term interest rates, government current accounts, working population, and import–export ratios.

Cluster 5 is a disparate grouping that only shares two variable patterns, below-average long-term interest rates and above-average investment. Cluster 5 has strong pairs. The first pair, Austria and Belgium, share variable patterns of above or below-average scores for seven variables. In addition, Ireland and Malta share seven such patterns. As a result, the cluster is split into two pairs (cluster 5a and cluster 5b).

Table 1. Countries and macroeconomic variable patterns 2016.

Country	Code	HICP2016	LTIR2016	GovCA2016	GDPCap2016	GrossDebt2016	Workingpop2016	IEratio2016	PopC2016	GDP2016	Prod2016	Confid2016	Invest2016	Cluster Stage 1	Cluster Stage 2
Germany	DEU	100.4	**0.09**	**8.6**	**35,100**	**69.0**	**70.7**	**1.2**	**5.6**	2.2	**106.1**	**−0.2**	**20.3**	1	1
Luxembourg	LUX	100.0	**0.25**	**4.8**	**78,500**	**19.6**	**71.1**	**1.18**	**16.2**	5.0	**175.7**	**−5.1**	**17.3**	1	1
Netherlands	NLD	100.1	**0.29**	**7.1**	**36,300**	**61.9**	**74.8**	**1.15**	**4.6**	2.2	**110.7**	**0.3**	**20.0**	1	1
Cyprus	CYP	**98.8**	3.77	−4.2	**24,900**	103.2	**77.0**	0.99	**2.9**	6.6	87.9	−5.6	**18.0**	2	2
Italy	ITA	**99.9**	1.49	2.6	**28,000**	134.8	**73.0**	1.12	**1.1**	1.3	108.3	−16.4	**17.2**	2	2
Slovenia	SVN	**99.9**	1.15	4.8	**23,600**	78.5	**71.8**	1.13	**0.5**	3.2	81.1	−13.4	**17.4**	2	2
Spain	ESP	**99.7**	1.39	3.2	**25,900**	102.7	**72.4**	1.1	**1.9**	3.0	102.1	−4.9	**18.0**	2	2
Estonia	EST	100.8		1.2	**21,700**	**10.0**	71.3	**1.06**	**0.8**	3.2	**73.3**	−1.4	24.4	3	3
Latvia	LVA	100.1	**0.53**	1.6	**18,600**	**40.3**	75.2	**1.02**	**−6.2**	2.4	**65.7**	−13.1	19.3	3	3
Lithuania	LTU	100.7	**0.90**	−1.1	**21,500**	**39.7**	70.7	**1.02**	**−10.5**	2.5	**71.9**	−0.6	19.9	3	3
Slovakia	SVK	99.5	**0.54**	−2.7	**20,700**	**52.3**	69.5	**1.03**	**0.7**	1.9	**77.4**	−7.4	21.0	3	3
Finland	FIN	**100.4**	**0.37**	**−2.0**	31,200	68.0	**55.9**	**0.97**	3.1	2.8	**108.3**	0.5	**22.7**	4	4
France	FRA	**100.3**	**0.47**	**−0.5**	29,800	98.0	**63.9**	**0.97**	−0.3	1.1	**115.5**	−8.7	**21.8**	4	4
Austria	AUT	101.0	**0.38**	2.7	36,600	82.8	67.7	1.07	7.5	2.0	117.9	−5.4	**23.1**	5a	5
Belgium	BEL	101.8	**0.48**	0.6	33,800	105.0	77.6	1.02	2.4	1.3	131.0	−9.7	**23.3**	5a	5
Ireland	IRL	99.8	**0.74**	−4.2	49,800	74.3	68.7	1.15	5.2	2.0	177.6	2.7	**35.8**	5b	1
Malta	MLT	100.9	**0.89**	−0.6	27,600	54.7	77.9	1.1	19.2	3.4	96.5	3.4	**22.7**	5b	1
Greece	GRC	100.0	**8.36**	−1.7	**19,100**	**180.5**	**61.4**	**0.98**	**1.0**	**−0.5**	**73.8**	−60.0	**11.0**	6	6
Portugal	PRT	100.6	**3.17**	1.2	**22,000**	**131.5**	**69.5**	**1.03**	**−0.8**	**2.0**	**78.0**	−7.8	**15.5**	6	6
Mean		**100.2**	**1.40**	**1.1**	**30,774**	**79.3**	**70.5**	**1.07**	**2.9**	**2.5**	**103.1**	**−8.0**	**20.5**		
Median		100.1	0.64	1.2	27,600	74.3	71.1	1.06	1.9	2.2	102.1	−5.4	20.0		
St. Dev.		0.6	1.94	3.5	13,557	40.7	5.4	0.07	6.4	1.5	31.0	13.4	4.8		

Finally, the pairing of Greece and Portugal forms cluster 6. They share above-average scores for long-term interest rates and gross government debt, and below-average scores for GDP per capita and working population, import–export ratios, population change, GDP change, productivity, and investment.

The stage one (Table 1) analysis has already decided the issue that cluster five was not homogeneous with only two within-cluster shared variable patterns.

Table 2 shows that clusters 1 and 5b have the most shared variable patterns with four shared variable characteristics. This provides evidence that these clusters can be combined in stage two (see final column, Table 1). Several clusters share three variable patterns: clusters 1 and 5a, clusters 3 and 6, clusters 4 and 5a, and clusters 4 and 5b. Clusters 3 and 6 have numerous within-cluster score patterns to evidence their heterogeneity. For this reason, they are not combined in stage two. Similarly, clusters 4 and 5b have as much heterogeneity if left as separate pairs, rather than being combined. The pairs therefore become clusters 4 and 5 in the final model (cluster stage two).

Table 2. Cluster similarity matrix, stage 1, 2016.

Cluster	1	2	3	4	5	5a	5b	6
1	x	2	2	2	1	3	4	1
2	2	x	1	0	0	0	0	1
3	2	1	x	2	1	1	2	3
4	2	0	2	x	2	3	3	2
5	1	0	1	2	x	2	2	0
5a	3	0	1	3	2	x	2	1
5b	4	0	2	3	2	2	x	0
6	1	1	3	2	0	1	0	x

Number of shared variable patterns per cluster pair. Row and column headers in bold text identify the clusters from Table 1.

The macroeconomic situation in 2016 provides evidence of indicative trends emerging across different clusters of eurozone countries, reflective of their diverse economic patterns and fiscal health. Cluster 1, encompassing Germany, Luxembourg, and the Netherlands, exhibits strong economic stability with higher GDP per capita and favourable government current account balances. This stability can be attributed to strong industrial bases, competitive export sectors, and prudent fiscal policies (Baldwin and Wyplosz 2015). As regards monetary policy, these countries benefit from low long-term interest rates, indicative of favourable lending conditions and investor confidence. Conversely, Greece and Portugal (cluster 6) faced fiscal challenges with the highest government debt levels. This fiscal distress could be rooted in austerity measures post the financial crisis and structural issues like high unemployment rates and rigid labour markets. These challenges are mirrored in their high long-term interest rates and lower consumer confidence, signalling financial market concerns (Buti and Carnot 2012). Moreover, the import to export ratios in these countries are lower compared to cluster 1, possibly reflecting trade imbalances and competitiveness issues. Labour market indicators reveal higher employment rates in clusters 2 and 5, depicting healthier labour conditions, whereas productivity levels are notably higher in cluster 4 and 5, implying better economic efficiency. Noteworthy is the investment environment in cluster 5b (Ireland and Malta), where higher investment as a percentage of GDP suggests a favourable climate for capital formation, driven by favourable tax regimes and open economic policies. The different economic conditions across and within clusters highlight the varied economic narratives within the eurozone, where tailored policy measures are imperative to address the distinct economic circumstances and challenges inherent in each cluster and country.

4.2. 2019 Data

Table 3 shows the variable scores and patterns for clusters derived to represent similarity using the 2019 data. Cluster 1 comprises Estonia, Lithuania, and Malta. This cluster has above-average scores for consumer prices, government current accounts, import–export ratios (average and above-average scores), GDP change, and consumer confidence. It shares below-average scores for GDP per capita, gross national debt, and productivity.

Germany, Luxembourg, and the Netherlands form cluster 2. Their cluster has above-average scores for consumer prices, government current accounts, GDP per capita, import–export ratios, and productivity. It shares below-average scores for long-term interest rates, gross national debt, GDP change, and investment.

Cluster three comprises of Italy, Slovenia, and Spain. Above-average scores are shared for government current accounts, working population and import–export ratios. Below-average scores are evidenced for consumer prices, GDP per capita, consumer confidence, and investment.

Latvia and Slovakia are a paring that forms cluster 4. They share ten variable patterns. Above average for consumer prices and working population, and below average for long-term interest rates, government current accounts, GDP per capita, gross government debt, import–export ratios, population change, GDP change, and productivity.

Cluster 5 is the largest cluster with a membership of Cyprus, France, Greece, and Portugal. They have above-average scores for long-term interest rates and gross national debt, and below-average scores for consumer prices, government current accounts, GDP per capita, and import–export ratios.

Austria and Finland are a pair that form cluster 6. They share above-average scores for GDP per capita, productivity, consumer confidence, and investment, and below-average scores for long-term interest rates, gross national debt, working population, import–export ratios (average and below-average), population change, and GDP change.

Belgium and Ireland form cluster 7. They share above-average GDP per capita, working population, productivity, and investment, and below-average scores for long-term interest rates, government current accounts, and population change.

Table 3. Countries and macroeconomic variable patterns 2019.

Country	Code	HICP2019	LTIR2019	GovCA2019	GDPCap2019	GrossDebt2019	Workingpop2019	IEratio2019	PopC2019	GDP2019	Prod2019	Confid2019	Invest2019	Cluster Stage 1	Cluster Stage 2
Estonia	EST	**110.5**		**2.4**	**25,800**	**8.5**	75.0	**1.06**	4.1	**3.7**	**77.8**	**0.1**	25.4	1	1
Lithuania	LTU	**109.5**	0.31	**3.5**	**26,400**	**35.8**	72.8	**1.07**	3.9	**4.6**	**79.3**	**0.7**	21.4	1	1
Malta	MLT	**105.5**	0.67	**9.1**	**32,100**	**40.3**	81.0	**1.11**	40.4	**7.0**	**97.0**	**6.6**	20.5	1	1
Germany	DEU	**105.5**	**−0.25**	**8.2**	**37,900**	**59.6**	72.3	**1.14**	3.7	**1.1**	**103.8**	−3.7	**21.4**	2	2
Luxembourg	LUX	**105.9**	**−0.12**	**3.4**	**78,700**	**22.4**	76.8	**1.21**	16.6	**2.3**	**157.6**	−2.3	**17.4**	2	2
Netherlands	NLD	**105.8**	**−0.07**	**6.9**	**39,700**	**48.5**	76.8	**1.14**	6.2	**2.0**	**107.0**	−8.4	**21.3**	2	2
Italy	ITA	103.2	1.95	**3.3**	**30,200**	134.1	**77.3**	**1.11**	0.7	0.5	105.7	**−12.9**	**18.0**	3	3
Slovenia	SVN	105.1	0.28	**5.9**	**27,800**	65.4	**75.6**	**1.11**	7.8	3.5	82.8	**−15.0**	**19.6**	3	3
Spain	ESP	104.3	0.66	**2.1**	**28,500**	98.2	**76.2**	**1.09**	9.6	2.0	98.5	**−13.2**	**20.0**	3	3
Latvia	LVA	**108.5**	**0.34**	**−0.6**	**21,700**	**36.5**	**78.2**	**0.99**	**−1.8**	**2.6**	**69.2**	−2.8	23.2	4	4
Slovakia	SVK	**106.3**	**0.25**	**−3.3**	**22,100**	**48.0**	**75.9**	**1.00**	**0.7**	**2.5**	**73.6**	−10.5	21.5	4	4
Cyprus	CYP	100.8	**1.07**	**−5.6**	**29,100**	**90.8**	80.5	**0.99**	10.0	5.5	86.0	−7.1	19.0	5	5
France	FRA	105.0	**0.94**	**0.5**	**33,100**	**97.4**	68.0	**0.97**	0.8	1.8	117.7	−11.4	23.5	5	5
Greece	GRC	102.5	**2.59**	**−1.5**	**20,600**	**180.6**	63.5	**0.96**	3.3	1.9	69.3	−3.9	10.7	5	5
Portugal	PRT	103.7	**0.76**	**0.4**	**24,600**	**116.6**	75.5	**1.01**	4.3	2.7	76.4	−8.3	18.1	5	5
Austria	AUT	107.0	**0.06**	2.4	**39,400**	**70.6**	**70.5**	**1.06**	**4.6**	**1.5**	**115.2**	**−3.3**	**24.9**	6	2
Finland	FIN	103.6	**0.13**	−0.3	**34,200**	**64.9**	**60.8**	**1.01**	**2.8**	**1.2**	**105.5**	**−4.2**	**23.8**	6	2
Belgium	BEL	107.8	**0.19**	0.1	**36,800**	97.6	**79.6**	1.01	**5.0**	2.3	**129.1**	−13.2	**24.3**	7	2
Ireland	IRL	101.7	**0.33**	−19.8	**59,300**	57.0	**75.7**	1.11	**6.5**	5.4	**188.2**	−5.0	**54.3**	7	2
Mean		**105.4**	**0.56**	**0.9**	**34,105**	**72.3**	**74.3**	**1.06**	**6.8**	**2.8**	**102.1**	**−6.2**	**22.5**		
Median		105.5	0.32	2.1	30,200	64.9	75.7	1.06	4.3	2.3	98.5	−5.0	21.4		
St.Dev.		2.5	0.70	6.1	13,611	40.8	5.2	0.07	8.9	1.7	30.0	5.5	8.2		

Table 4 provides the evidence for deciding whether clusters are similar enough to converge. The researchers here are interested in clusters that share 4 or more variable patterns.

Table 4. Cluster similarity matrix, stage 1, 2019.

Cluster	1	2	3	4	5	6	7
1	x	3	3	4	1	2	5
2	3	x	3	4	2	5	3
3	3	3	x	2	2	0	1
4	4	4	2	x	3	4	4
5	1	2	2	3	x	1	1
6	2	5	0	4	1	x	5
7	5	3	1	4	1	5	x

Number of shared variable patterns per cluster pair. Row and column headers in bold text identify the clusters from Table 3.

Cluster 6 and 7 share five variable characteristics. Above-average scores for GDP per capita, productivity, and investment, and below-average scores for long-term interest rates and population change.

There is an important relationship between clusters 2 and 6 that share five variable patterns. These are below-average scores for long-term interest rates, gross government debt, and GDP change, and above-average scores for GDP per capita and productivity. Cluster 6 is therefore merged into cluster 2.

In addition, there are four shared patterns between clusters 4 and 6. These are below-average scores for long-term interest rates, gross government debt, import–export ratio, population change, and GDP change. Only three of these specific patterns are also shared with cluster 2. Cluster 4 also shares four variable patterns with clusters 1, 2, and 7, but it does have much internal homogeneity as a cluster pair with 10 shared variable patterns.

Given the feature of cluster 4, with its strength of similarity being mostly based on below-average patterns, the researchers decided to converge only clusters 2, 6, and 7 into one cluster. Cluster 4 remains as a separate pairing. The stage two cluster model therefore reduces the number of clusters as shown in Table 3 (final column).

The data for 2019, compared with the baseline (2016), reveals persistent fiscal challenges for certain clusters of eurozone countries. Greece and Portugal continue to face high government debt levels, likely stemming from historical fiscal imbalances and exacerbated by sluggish economic growth. Germany, Luxembourg, and the Netherlands continue to show relative economic stability. These disparities illustrate the complex challenges to economic convergence, even amidst collective monetary policy efforts such as a general decrease in long-term interest rates to spur economic activity.

4.3. 2022 Data

Table 5 examines the case and variable patterns for the 2022 data using the same approach as with the previous periodic data sets.

Table 5. Countries and macroeconomic variable patterns 2022.

Country	Code	HICP2022	LTIR2022	GovCA2022	GDPCap2022	GrossDebt2022	Workingpop2022	IEratio2021	PopC2021	GDPper2022	Prod2022	Confid2022	Invest2021	Cluster Stage 1	Custer Stage 2
Italy	ITA	**114.2**	3.16	**−1.3**	**33,700**	144.4	**77.0**	1.09	**1.6**	3.7	105.0	−17.2	**20.4**	1	1
Slovenia	SVN	**116.9**	1.89	**−0.4**	**32,500**	69.9	**76.7**	1.07	**1.2**	5.4	86.0	−31.6	**20.3**	1	1
Spain	ESP	**116.0**	2.18	**0.6**	**30,000**	113.2	**78.4**	1.04	**3.1**	5.5	94.1	−26.0	**19.8**	1	1
Estonia	EST	**137.0**	**2.29**	**−2.2**	**30,600**	**18.4**	**78.2**	**1.00**	5.3		**82.5**	**−36.3**	28.9	2	2
Latvia	LVA	**131.5**	**2.27**	**−6.4**	**26,100**	**40.8**	**79.0**	**0.97**	−0.2	**2.8**	**75.8**	**−32.9**	22.3	2	2
Slovakia	SVK	**125.1**	**2.07**	**−8.3**	**23,600**	**57.8**	**77.9**	**0.99**	−1.5	**1.7**	**73.4**	**−32.4**	19.2	2	2
Finland	FIN	**113.7**	**1.69**	**−3.9**	**38,400**	73.0	**66.3**	**1.01**	4.1	**2.1**	**104.4**	**−18.5**	**23.6**	3	3
France	FRA	**114.0**	**1.70**	**−2.1**	**35,700**	111.6	**69.5**	**0.94**	2.0	**2.6**	**111.4**	**−22.5**	**24.2**	3	3
Germany	DEU	118.7	**1.14**	4.2	41,100	**66.3**	74.0	**1.13**	**3.7**	1.8	102.3	−22.1	21.8	4	4
Ireland	IRL	112.0	**1.75**	8.8	82,400	**44.7**	77.9	**1.43**	**5.4**	12.0	223.6	−21.9	23.3	4	4
Lithuania	LTU	137.6	**0.61**	−5.1	31,700	**38.4**	74.8	**1.05**	**12.4**	1.9	83.3	−8.1	21.4	4	3
Luxembourg	LUX	118.6	**1.73**	5.0	92,000	**24.6**	81.1	**1.20**	**13.2**	1.5	162.2	−20.9	16.6	4	4
Netherlands	NLD	122.8	**1.38**	4.4	45,600	**51.0**	77.3	**1.15**	**6.1**	4.5	107.4	−26.1	21.6	4	4
Austria	AUT	**121.1**	**1.71**	0.7	**44,100**	**78.4**	71.9	**1.02**	**5.8**	5.0	**115.7**	−29.6	**26.5**	5	5
Belgium	BEL	**123.3**	**1.73**	−3.5	**42,500**	**105.1**	80.7	**1.02**	**4.9**	3.2	**131.2**	−20.2	**24.2**	5	5
Cyprus	CYP	**110.2**	**2.96**	**−9.1**	**32,400**	86.5	**81.9**	1.01	**6.2**	**5.6**	**87.2**	−28.2	19.5	6	6
Malta	MLT	**113.7**	**2.41**	**−5.8**	**36,000**	53.4	**82.9**	1.10	**8.9**	**6.9**	**91.3**	−12.1	22.1	6	6
Portugal	PRT	**113.0**	**2.17**	−1.3	**27,200**	**113.9**	77.5	**0.93**	**2.5**	**6.7**	**74.6**	**−37.1**	**20.3**	7	6
Greece	GRC	**111.2**	**3.49**	−9.7	**23,900**	**171.3**	64.8	**0.84**	**−15.2**	**5.9**	**68.6**	**−47.9**	**13.3**	7	6
Mean		**119.5**	**2.02**	**−1.9**	**39,447**	**77.0**	**76.2**	**1.05**	**3.7**	**4.4**	**104.2**	**−25.9**	**21.5**		
Median		116.9	1.89	−2.1	33,700	69.9	77.5	1.02	4.1	4.1	94.1	−26.0	21.6		
St. Dev.		8.1	0.67	4.9	17,599	39.7	4.8	0.12	5.8	2.6	35.7	9.2	3.3		

Cluster 1 comprises Italy, Slovenia, and Spain. They share similarities with six variable scores. There are above-average scores for: government current accounts and working population, and below-average scores for: consumer prices, GDP per capita, population change, and investment.

Estonia, Latvia, and Slovakia share 10 similar variable scores in cluster 2. There are above-average scores for consumer prices, long-term interest rates, and working population. There are below-average scores for government current accounts, GDP per capita, gross government debt, import–export ratios, GDP change, productivity, and consumer confidence.

Cluster 3 is a pair comprising Finland, and France. They share similar scores for the majority of variables. There are above-average scores for productivity, consumer confidence,

and investment. They share below-average scores for consumer prices, long-term interest rates, government current accounts, GDP per capita, working population, import–export ratios, and GDP change.

The largest cluster with five members is cluster 4. The countries are: Germany, Ireland, Lithuania, Luxembourg, and the Netherlands. They share four similar scores, being average or above-average for import–export ratios, and above-average for population change, and below average for long-term interest rates and gross national debt.

The remaining clusters are pairs. Cluster 5 is Austria and Belgium. It has above-average scores for consumer prices, GDP per capita, gross national debt, population change, productivity, and investment. Below-average scores are evident for the variables, long-term interest rates and import–export ratios.

Cluster 6 is Cyprus and Malta with above-average scores for long-term interest rates, working population change and GDP change. There are below-average scores for consumer prices, government current accounts, GDP per capita, and productivity.

Finally, cluster 7 comprises of Portugal and Greece. It has above-average scores for long-term interest rates, gross national debt, and GDP change. There are below-average scores for consumer prices, GDP per capita, import–export ratios, population change, productivity, consumer confidence, and investment.

Table 6 shows the similarity matrix for the seven clusters. There are two clusters that share five variable patterns: clusters 6 and 7. For this reason, the two sets of pairs are combined to give a single cluster of four countries. This is the only change to the stage two model, as indicated in the final column of Table 5.

Table 6. Cluster similarity matrix, stage 1, 2022.

Cluster	1	2	3	4	5	6	7
1	x	1	2	0	0	2	2
2	1	x	3	1	2	3	3
3	2	3	x	1	4	2	2
4	0	1	1	x	2	0	0
5	0	2	4	2	x	0	0
6	2	3	2	0	0	x	5
7	2	3	2	0	0	5	x

Number of shared variable patterns per cluster pair. Row and column headers in bold text identify the clusters from Table 5.

The macroeconomic situation in 2022 shows continued fiscal challenges and economic shifts, potentially exacerbated by the lingering effects of the pandemic. For instance, Italy, Slovenia, and Spain reflect a surge in long-term interest rates from 2019, with each increasing by an average of 1.12 percentage points. Italy's increases from 1.95% to 3.16%, Slovenia's from 0.28% to 1.89%, and Spain's from 0.66% to 2.18%. This rise in LTIR reflects tightened financial conditions induced by pandemic-related economic pressures that created rising prices and supply shortages. The GDP per capita in these countries has also seen an increase, indicating a trajectory towards economic recovery. However, Italy's gross debt surges from 134.1% to 144.4%, echoing persistent fiscal challenges. On the other hand, for Estonia, Latvia, and Slovakia there is a noticeable increase in consumer prices, reflecting the inflation surge prevalent across the eurozone in early 2022. Germany, Ireland, Luxembourg, and the Netherlands continue to maintain relatively lower LTIR, indicating favourable monetary conditions. These countries also witness an increase in GDP per capita, suggesting economic resilience amidst global adversities. For instance, Ireland exhibits a substantial rise in GDP, supported by its robust export sector and favourable investment climate. The economic shocks produced by the pandemic magnified fiscal challenges in countries with already high government debt levels— i.e., Greece and Portugal. The high LTIR in Greece underscores financial market concerns, while the negative government current account in Cyprus (Cluster 6) and Slovakia (Cluster 2) mirrors fiscal stress.

4.4. Longitudinal Trends

The key variable changes most likely to influence euro member countries overall during the time periods studied relate to mean differences, which are: rising consumer prices, declining government current accounts, increasing GDP per capita, increases in the working population, declines in the import–export ratios, and increases in GDP growth (Table 7).

Table 7. Longitudinal variable trends, 2016, 2019, 2022.

Means	**HICP2016**	**LTIR2016**	**GovCA2016**	**GDPCap2016**	**GrossDebt2016**	**Workingpop2016**	**IEratio2016**	**PopC2016**	**GDPper2016**	**Prod2016**	**Confid2016**	**Invest2016**
2016	100.2	1.40	1.1	30,774	79.3	70.5	1.07	2.9	2.5	103.1	−8.0	20.5
2019	105.4	0.56	0.9	34,105	72.3	74.3	1.06	6.8	2.8	102.1	−6.2	22.5
2022	119.5	2.02	−1.9	39,447	77.0	76.2	1.05	3.7	4.4	104.2	−25.9	21.5
	↑		↓	↑		↑	↓		↑			
St Dev	**HICP2016**	**LTIR2016**	**GovCA2016**	**GDPCap2016**	**GrossDebt2016**	**Workingpop2016**	**IEratio2016**	**PopC2016**	**GDPper2016**	**Prod2016**	**Confid2016**	**Invest2016**
2016	0.6	1.94	3.5	13,556.97	40.7	5.4	0.07	6.4	1.5	31.0	13.4	4.8
2019	2.5	0.70	6.1	13,611.31	40.8	5.2	0.07	8.9	1.7	30.0	5.5	8.2
2022	8.1	0.67	4.9	17,599.05	39.7	4.8	0.12	5.8	2.6	35.7	9.2	3.3
	↑	↓		↑		↓			↑			

Any reducing change in the standard deviation of variables between 2016, 2019, 2022 provides limited evidence of convergence. This is a feature of long-term interest rates, and the size of the working-age population. The standard deviation of the percentage of total GDP that is invested declines over 5% between 2019 and 2022.

Figure 1 shows the longitudinal trends of the cluster formations.

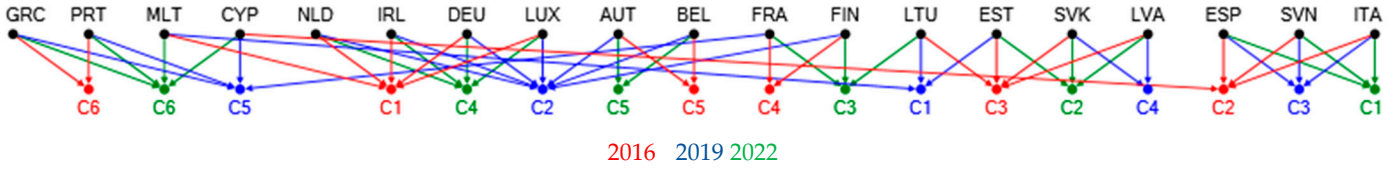

Figure 1. Cluster similarity over time.

There are four stable cluster groupings where countries remain in the same cluster over the three periods compared. Firstly, Germany, The Netherlands, Ireland, and Luxembourg. Secondly, Italy, Spain, and Slovenia. Thirdly, Slovakia and Latvia, and finally, Portugal and Greece. Other countries change the countries and clusters that they are most similar with over time.

There are important variable patterns that are associated with the enduring cluster memberships.

Table 8 explores longitudinal groupings by examining their relationship with stable variable patterns. The table shows countries that consistently share the same above or below mean variable scores for all three time periods, 2016, 2019, and 2022. Where variable

scores are inconsistent across the three time periods, no result is returned in the table and indicated by a blank cell. These patterns reveal more information about the characteristics of the core clusters in Figure 1. In Table 8, groups of countries that consistently share variable patterns across all three time periods have the pattern indicated in bold text.

Table 8. Longitudinal cluster patterns showing the consistency of shared variable patterns, 2016, 2019, 2022.

Country	Code	HICP	LTIR	GovCA	GDPCap	GrossDebt	Workingpop	IEratio	PopC	GDPper	Prod	Confid	Invest
Germany	DEU		**BELOW**	ABOVE	**ABOVE**	**BELOW**		**ABOVE**		BELOW		ABOVE	
Luxembourg	LUX		**BELOW**	ABOVE	**ABOVE**	**BELOW**	ABOVE	**ABOVE**	ABOVE		ABOVE	ABOVE	BELOW
Netherlands	NLD		**BELOW**	ABOVE	**ABOVE**	**BELOW**	ABOVE	**ABOVE**			ABOVE		
Ireland	IRL	BELOW	**BELOW**		**ABOVE**	**BELOW**		**ABOVE**			ABOVE	ABOVE	ABOVE
Austria	AUT	ABOVE	BELOW	ABOVE	ABOVE		BELOW				**ABOVE**		ABOVE
Belgium	BEL	ABOVE	BELOW	BELOW	ABOVE	ABOVE	ABOVE	BELOW		BELOW	**ABOVE**		ABOVE
Finland	FIN		BELOW	BELOW		BELOW	BELOW	BELOW			**ABOVE**	ABOVE	ABOVE
France	FRA			BELOW	BELOW	ABOVE	BELOW	BELOW	BELOW	BELOW	**ABOVE**		ABOVE
Italy	ITA	**BELOW**	ABOVE	**ABOVE**	**BELOW**	ABOVE	**ABOVE**	ABOVE	BELOW	BELOW	ABOVE		**BELOW**
Slovenia	SVN	**BELOW**	BELOW	**ABOVE**	**BELOW**	BELOW	**ABOVE**	ABOVE		ABOVE	BELOW	BELOW	**BELOW**
Spain	ESP	**BELOW**		**ABOVE**	**BELOW**	ABOVE	**ABOVE**				BELOW		**BELOW**
Cyprus	CYP	BELOW	ABOVE	BELOW	**BELOW**	ABOVE	**ABOVE**	BELOW	ABOVE	ABOVE	BELOW		BELOW
Malta	MLT				**BELOW**	BELOW	**ABOVE**	ABOVE	ABOVE	ABOVE	BELOW	ABOVE	
Latvia	LVA				**BELOW**	**BELOW**	ABOVE	BELOW	BELOW	BELOW	**BELOW**		
Slovakia	SVK			BELOW	**BELOW**	**BELOW**		BELOW	BELOW	BELOW	**BELOW**		
Estonia	EST	ABOVE			**BELOW**	**BELOW**	ABOVE	BELOW		ABOVE	**BELOW**		ABOVE
Lithuania	LTU	ABOVE	BELOW		BELOW	BELOW					BELOW	ABOVE	BELOW
Greece	GRC	BELOW	**ABOVE**	BELOW	**BELOW**	**ABOVE**	BELOW	**BELOW**	**BELOW**		**BELOW**		**BELOW**
Portugal	PRT		**ABOVE**		**BELOW**	**ABOVE**		**BELOW**	**BELOW**		**BELOW**		**BELOW**

The core clusters that are resilient to any change over the time periods researched are matched with their nearest neighbours, these being the countries that share limited patterns of resemblance with the core cluster groups in 2016, 2019, and 2022.

The first longitudinal cluster has Germany, Luxembourg, the Netherlands, and Ireland, as its core and they share consistently below-average long-term interest rates and gross national debt. They share above-average GDP per capita and import–export ratios.

In Table 8, the second longitudinal cluster does not comprise any countries that have been consistently in the same cluster for the 2016, 2019, and 2022 analysis. These other central and northern European countries in the second longitudinal cluster (Austria, Belgium, Finland, and France) share stable below-average long-term interest rates with the exception of France that had above-average interest rates in 2019 (but below in 2016 and 2022). Other patterns are contradictory, with the first longitudinal cluster, for example, with regard to data patterns for government current accounts and gross national debt. For the northern and central European countries, as a whole, above-average productivity is stable over time, apart from Germany where productivity was marginally below the mean average in 2022, (but above the median).

The third longitudinal cluster has the southern European countries of Italy, Slovenia, and Spain as its stable core. This core shares some characteristics with the Mediterranean islands, Cyprus, and Malta. The core group has stable below-average consumer price rises, GDP per capita, and investment (the latter is shared with Cyprus and Malta). These features are shared by Cyprus. The core has above-average government current account balances, but this feature is not shared with Cyprus and Malta (Cyprus is consistently below-average). All five countries share consistently above-average working populations. Italy is unusual in that it has consistently above-average productivity (like the northern and central European cluster) while all the others in this cluster have consistently below-average productivity.

The fourth longitudinal cluster is comprised of the Eastern European countries of Estonia, Latvia, and Slovakia at its core. They share consistently below-average scores for

GDP per capita, gross national debt, import–export ratios, and productivity. The additional country, Lithuania, shares the patterns for lower GDP per capita, gross national debt, and productivity.

Finally, Greece and Portugal are a consistent and stable cluster pair, remaining together for 2016, 2019, 2022, in Figure 1. They have some contrasting pattern characteristics to the rest of the euro group, with above-average interest rates and gross national debt. It is important to note the shared characteristic between the third, fourth, and fifth longitudinal clusters is consistently below-average GDP per capita and productivity (with the exception of France, for the latter). These features are shared by the majority of Southern and Eastern European countries. The central and northern countries tend towards the converse on these variable patterns, but not with complete longitudinal consistency.

DPS clusters the macroeconomic variables across eurozone countries for 2016, 2019, and 2022, offering a framework to understand their economic interrelations amidst recent financial crises and the COVID-19 pandemic, showing how similar economies group together and evolve over time. It distinguishes stable economies like Germany, Luxembourg, and the Netherlands from more challenged ones like Greece and Portugal, emphasising the need for tailored policies to address varying economic conditions and challenges within these clusters. By examining variable and case trends, the results underscore the enduring nature of some economic issues, advocating for tailored policies to cater to the diverse economic conditions and challenges within these clusters. This comprehensive insight not only enriches academic discourse on the effectiveness of economic policies and the pace of economic convergence but also serves as a valuable resource for a more informed policy discussion and the need for some policy diversity that is specific to country needs.

5. Discussion

The European currency is founded on core nominal convergence criteria that formed the basis of future macroeconomic stability for member countries and that were assumed to bring long-term economic and social benefits to their populations. Prior to the currency being launched, the nominal policy priority was currency exchange rate stability. Continuing nominal targets, once the single currency was implemented in 2002, were price stability evidenced by low consumer price inflation, and sustainable public finances, demonstrated by evidence from the government current account and level of gross government debt over the medium and longer term (Directorate General for Economic and Financial Affairs 2020). These convergence targets were believed to be critical to maintaining the harmonisation of low central bank interest rates across the euro currency member countries.

Previous 2016 research for *Economies* (Haynes and Haynes 2016) showed how difficult the convergence of sustainable public finances linked to government related expenditure targets had become during and after the financial crisis of 2008. The research update in this paper provides no evidence of a return to convergent patterns of government current account balances and gross debts, although it is argued some limited degree of stability has resulted compared to previous 2013 data and its analysis. For example, there are some reductions in the very divergent patterns of central bank interest rates that immediately followed the 2008 crisis. There are still, however, important 'club' differences to these patterns. Northern euro countries are consistently experiencing relatively lower interest rates over time (with the exception of France) in a way that is not evidenced in Southern and Eastern euro countries. As regards, gross government debt, the major relative difference over time is between the lower debt of Eastern European countries, when compared to the Southern European countries that experience higher debt (with the exception of Malta).

In the short term, DG ECFIN (2023) has suggested that high consumer prices may help contribute to a decline in the size of government current account deficits and gross debts. The new period of post-pandemic consumer inflation is, however, partly a break with past club pattern allegiances and shows a divergence towards instability where the future pattern and trajectory is far from clear (Fedajev et al. 2022). This disrupts the core focus of the nominal goal of price stability, on which the euro was founded, although the

European Commission currently sees this as a temporary and short-term policy challenge (DG ECFIN 2023). The disruption to stable consumer price inflation caused by Brexit, the COVID-19 pandemic, and war in Ukraine provides important evidence about how easily economic convergence can be undermined by external and unplanned events. Sudden and short-term anomalies may result. For example, the convergence of country investment patterns in 2019 is most likely a feature of the drop in investment created by COVID-19 and not necessarily a long-term trend.

The social policy aspiration for real convergence is that wealth and income will be better shared between the populations of euro member countries with reductions in the distribution of euro-defined GDP per capita. Here, there remains a major club divide between Northern euro currency members (with the exception of France) when compared with Eastern and Southern euro members. There is no substantive evidence of a trajectory towards greater equality of GDP per capita shared throughout all Euro member countries (see also, Ferreiro et al. 2017; Borsi and Metiu 2013). Large-scale fiscal intervention across the euro countries will be necessary to achieve convergence of GDP per capita, such as equalization of income tax policies and redistributions of income and this requires a much more substantial level of fiscal policy cooperation. There is little historical evidence that an open market, shared nominal macroeconomic monetary targets, and similarities in regional market regulations will reduce income and wealth inequalities (Rockoff 2000).

An important issue with regard to achieving structural convergence in the euro area in recent years has become the free flow of labour supply across member countries, designed to meet changing labour demands and growth in the European marketplace. Alongside this, there has been a sustained period of inward migration in many of the euro countries, with different approaches in countries as to how such immigration can access the labour market. It is therefore not surprising that the dynamics of the size of the working populations in euro member countries rather negate the club groupings evidenced for nominal and real convergence, with the exception of Southern European countries that together maintain relatively larger working populations compared to other euro members.

Delving into the divergent patterns of central bank interest rates among member states reveals nuanced monetary policy effectiveness and economic health across the region. For instance, the higher debt levels in Southern European nations compared to their Eastern counterparts underscore fiscal disparities and hint at varying levels of fiscal discipline. A granular examination of these economic variables reveals the attempted sustainability of public finances and the efficacy of the European Central Bank's monetary policy in anchoring inflation expectations, thereby seeking to foster price stability, a fundamental goal of the eurozone's nominal macroeconomic framework.

Other priority policy areas for structural macroeconomic improvements include better productivity and levels of investment. Productivity data shows that the relative advantages are being consistently located in Northern euro countries, as compared with the less productive Eastern and Southern euro members. Investment closely resembles the same club pattern as productivity, but with some notable country exceptions, such as Estonia, doing consistently well on the percentage of GDP invested, while Luxembourg is the converse.

Multivariate approaches to convergence, such as the method used in this paper, show some important evidence of both club and variable pattern consistencies over time, but with very limited evidence of any common convergence patterns for all countries. This is similar to the findings of Monfort et al. (2013). In an earlier study of EU-14 and euro members they found evidence of a North–South 'club' divide and little evidence that post-2000 euro currency memberships change this.

What is the relevance of a complex systems theoretical perspective in macroeconomics when seeking to understand the difficulties of a continental single currency policy that seeks to deliver macroeconomic convergence? The data analysis shows evidence of some complex patterns of stability and shared features of stability in so called 'clubs'; this in an otherwise often unstable and dynamic complex social and economic operating environment. This mirrors the meta theoretical framework of complex systems theory (Haynes and Alemna

2022). Institutional policy approaches seek to set a longevity of 'path dependency' where policy institutions such as the European Central Bank inform nominal performance like low inflation and government borrowing and debt. Such institutionalisation of economic policy is designed to produce more holistic economic convergence over the longer term. Unstable external factors, nevertheless, such as pandemics and trade disputes with non-euro members, and conflicts with neighbouring countries, make the expected outcomes of institutionalised path dependent policy trajectories more difficult to achieve in all countries. Club convergence, where small groups of countries retain similar features, or evolve in similar ways to cope with a changing external environment, is more likely to happen than a uniformity of convergence across a larger group of countries.

Complexity theory highlights the importance of considering different paths to causality. For example, equifinality, where different factors result in the same outcome and, multifinality, where the same factors lead to different outcomes. The research in this paper was not primarily concerned with the causality of a single dependent variable, although some variables began to be considered like that (for example, exploring the causes of GDP per capita and consumer price inflation). Overall, the methodology in our paper was to explore the general pattern of variables and evidence for them sharing specific dynamic pattern characteristics within-cluster 'club' groupings. In terms of potential causality and considering how different policies and dynamics might result in divergencies in outcomes, it is interesting to note the importance of 'outliers' in this respect. For example, France and Italy are unusual in sharing consistently above-average productivity and below-average GDP per capita and are not typical of either Northern or Southern club membership when comparing those two variables. While complexity is characterised by some case and variable patterns being more likely than others, these patterns and influences on outcomes do not necessarily remain in the same consistent and precise shape over time, and some cases are unique and more changeable that others, and therefore need careful qualitative consideration.

Furthermore, the multifaceted nature of economic convergence necessitates a robust analytical framework that transcends traditional econometric models. Employing a complex systems approach unravels the intricate network of variables that underpin the economic fabric of the eurozone. For instance, exploring the symbiotic relationships between labour mobility, productivity, and investment across member states yields a richer understanding of the convergence/divergence dynamics. Moreover, a comparative analysis of the 'club' groupings, through the lens of complex systems theory, elucidates the inherent and differing strengths and vulnerabilities within these different economic clusters. This in-depth analytical lens fosters a more enlightened discourse on the pragmatic and adaptive policy pathways that can foster a more harmonized economic landscape across the eurozone.

6. Conclusions

The use of the new case-based method, DPS, provides important evidence for the impact of system instability on policy goals to achieve economic and social convergence in different countries. This illustrates the fragility of system relationships, as explained by complexity theory when it is applied to economics and the social sciences (Rosser 1999; Arthur 2013, 2021). While country-based and variable-based patterns can be evidenced, country similarity appears to be historical and institutional and in part determined by path dependencies when state institutions and political policy processes are first established (Greener 2005). These historical convergences are in part resilience to the impact of current and future multivariate dynamics and instabilities. An example of this is how small groups of countries seem likely to remain similar for long periods of time, even though the variable patterns influencing that similarity at any one moment may evolve rapidly. Achieving the wider convergence of a larger and historically diverse group of countries looks to be difficult in policy terms (Rockoff 2000; Strielkowski and Höschle 2015). External and unplanned events are likely to push countries towards divergence rather than assisting with the policy aims of convergence. While single currency areas may impact monetary conditions and

enable some time limited aspects of stability for monetary markets, the vulnerability of single currency objectives to external and unforeseen political events is an important lesson for those other areas of the globe seeking such cooperations. Policy responses have to be well coordinated and agile in the face of external and unanticipated events.

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