Structures and Transformations: Heuristics of Economic Change[1]

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Abstract

The article identifies foundational principles of the structural analysis of economic, political and social systems, exploring their bearing on the study of structural transformations. In doing so, it delves especially into the conceptual resources provided by strands of economic theory. Particular importance is given to the relative positions of socio-economic groups, productive sectors, and institutions; the relative invariance of certain patterns of interdependence vis-à-vis others; and the view of economic dynamics as structural transformation subject to the condition of relative invariance. The article goes on to introduce and discuss a collection of papers that explore the relationship between structures and transformation with a view to understanding structural transformations in economic, political and social systems. A fundamental theme is the relationship between the range of transformations made possible by structures and the individual or collective actions taking place within those structures, which lead to some structural transformations instead of others.

Keywords

Structural economic analysis; Structural change; Structural dynamics; Economic change; Actions, structures and transformations

JEL codes: D57, L16, P00

[1] The set of contributions discussed in this paper includes papers originally presented at the conference 'Structures and Transformations: An Interdisciplinary Matrix for Political Economy', which was held on 26-27 October 2017 at the Accademia Nazionale dei Lincei, Rome and was jointly sponsored by the Interdisciplinary Research Centre 'Beniamino Segre', Accademia Nazionale dei Lincei, and by the Department of Economics of Alma Mater Studiorum University of Bologna. The organizing committee of the conference included Giorgio Lunghini, Maria Cristina Marcuzzo, Alberto Quadrio Curzio and Roberto Scazzieri. The collection also includes papers not presented at the conference but part of the same research programme. The comments and suggestions of conference participants are gratefully acknowledged. The usual caveat applies.

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1 Structures and transformations

Structural analysis is a powerful tool for the investigation of economic, political, and social systems. Its core principles are: (i) the attention for the relative positions of socio-economic groups, productive sectors, and institutions; (ii) the relative invariance of certain patterns of interdependence vis-à-vis others; (iii) the view of economic dynamics as structural transformation, that is, as change in the relative positions of socio-economic groups, productive sectors, and institutions subject to the condition of relative invariance. Structural analysis considers a plurality of levels of aggregation for the economic, political, and social systems under study. In other words, the analytically relevant components of each system may be not only the system's elementary units (such as individual actors or productive tasks), or the system itself as a unit (the macro-system) but also the manifold intermediate levels at which active causal relations can be found. Structural analysis has thus an intermediate position between macro- and micro-analysis. This makes it a privileged tool for investigating the internal configuration of economic systems, the constraints and opportunities specific to any given configuration, and the transformations possible or impossible under such configuration.

A distinctive feature of structural analysis is the emphasis on relationships and interdependencies rather than on the identity of the individual elements of the system under consideration. This approach leads it to emphasize 'a system of few *qualities* and *relationships* of a general character', which would be 'the solid and flexible basis on which to insert the qualities and relationships that are more specific to the different sciences' (de Giorgi, 1998, p. 72). As a result, structural analysis can provide heuristics that are to some extent independent of the specific identity of the system under consideration, which brings to light the generalizing potential of this type of investigation. For example, structural analysis presupposes the identification of the fundamental architecture of the socioeconomic system under consideration (Simon, 1962; Rescher and Simon, 1966; Cardinale, 2019; Scazzieri, 2021). In particular, the system's fundamental architecture allows identification of the relative positions of the system's elements (such as industries and other sets of productive activities, or socioeconomic classes and other social groups). The separation between fundamental architecture and the *range* of feasible relative positions compatible with it allows distinguishing between transformations of a contingent character and transformations in the fundamental architecture itself. In particular, that distinction brings to light the criterion of *relative structural invariance* (Landesmann and Scazzieri, 1990; Scazzieri, 2021). Relative invariance entails that each socioeconomic system can be seen as a set of relationships arranged in terms of a *hierarchy*.

The existence of fundamental invariant relationships allows identification of the range within which more contingent relationships may vary, and of some of the latter's modes of variation. For example, the utilization of a given fundamental technology for the provision of raw commodities allows identification of the range of structural changes that are feasible as long as that fundamental technology remains in place. This conceptual framework provides a heuristic into the processes by which a given hierarchy may explain: (i) the range of variation of contingent relationships for any given constellation of structural conditions; (ii) the expansion (or the contraction) in the range of feasible transformations as a result of changes in the system's fundamental architecture.

The special issue will contribute to the ongoing discussion on interdependencies between productive sectors or socio-economic groups, the relative invariance conditions characterizing those interdependencies, and the guided or spontaneous transformation processes feasible under those conditions. It will include papers investigating the interdependencies between resources and technology in a structural dynamics perspective, the relationship between specification of economic structure and heuristics of dynamic trajectories, and the relationship between specification of economic structure and configuration of policy domains.

2 Integrated vs. composite structures

The identification of fields of structural variation reflects the analytical representation of the socioeconomic structure under consideration. For each analytical representation calls attention to specific features of fundamental architecture to the exclusion of others. An especially relevant instance is, in the structural analysis of production systems, the distinction between *horizontal structures* and *vertical structures* (Baranzini and Scazzieri, 1990; Landesmann and Scazzieri, 1990).

The above distinction may be traced back to a pioneering contribution by Wassily Leontief (1991 [1928]). According to Leontief, any given socioeconomic system of sufficient complexity highlights a network of interdependencies, which may be 'structured either *in an integrated fashion* so that in the final analysis the reproduction of each individual element is directly or indirectly dependent on the simultaneous independent existence of all the other elements, or it may be seen as a *composite structure*, in which the whole consists of several independently reproduceable groups, of which each (directly or indirectly) satisfies the conditions for its own reproduction. In this latter case we are really talking about several wholly identical reproduction systems, which exist alongside each other but are separated by a phase difference' (Leontief, 1991 [1928], pp. 185-186, added emphasis). Leontief's distinction is of great importance since it allows separating two questions central to

structural analysis: 'on the one hand, the delineating of various stages of production from each other -one might speak in terms of zonal research- on the other, the establishing of the interrelationships between the elements within one and the same production stage' (Leontief, 1991 [1928], p. 200). According to Leontief, the possibility of arranging empirical information in terms of one or the other criterion (that is, in terms of an integrated or a composite structure) shows the close relationship between the 'nomological' view interested in finding laws and general causal patterns, and the 'idiographic' view interested in the historical reconstruction of particular effects starting with the corresponding causes (Leontief, 1991 [1928], p. 200). Integrated structures lend themselves to reciprocal (horizontal) dependencies between elements of a given socioeconomic setup (see also Quesnay, 1972 [1759]); Pasinetti, 1977, 2021a; Coffman, 2021; on the other hand, composite structures call attention to asymmetrical (vertical) dependencies between elements of that setup (see also Pasinetti, 1973; Quadrio Curzio, 1986). The consideration of horizontal or vertical relationships within a given socioeconomic context emphasizes different features of that context while also highlighting the complementarities between horizontal and vertical features along dynamic trajectories.

For example, the interdependencies characterizing horizontal structures bring to light the mutual conditioning between production activities in production systems producing goods by means of inputs that are themselves produced, but they also highlight compatibility bottlenecks that may appear when the limited availability of certain resources does not meet the proportionality requirements between productive activities associated with the technology in use. Under these circumstances the horizontal structure shows 'critical points' induced by scarcity phenomena external to the system of horizontal dependencies. This conceptual framework allows analysis of central features of the historical dynamics of socioeconomic systems, such as the antagonism-coexistence between processes delivering consumer goods and produced inputs without visible scarcity constraints and process working under the limited availability of certain essential resources (Quadrio Curzio and Scazzieri, 1986). These features highlight the relationship between structural interdependencies (with the corresponding *proportionality conditions* between activities) and exogeneous *availability conditions* due to the need of using essential resources whose availability can only be increased to a limited degree or cannot be increased at all (Quadrio Curzio, 1975, 1986; Quadrio Curzio and Pellizzari, 1999, 2018).

In the case of vertical structures, other features and critical points acquire prominence. The asymmetrical dependencies characterizing a vertical structure bring to light relationships of sequential causality between processes that are separated from one another by conditions of 'phase difference'

(Leontief) but they also emphasize that differences in the reproduction cycles of certain products can slow down or prevent certain structural change trajectories (Hicks, 1973; Lowe, 1976). As a result, temporal asymmetries between the dynamic paths followed by specific sectors, such as differences in the speed of response of specific sectors, or groups of sectors, to the same macroeconomic impulses, can be explained by structural features internal to the reproduction conditions of different sectors. For example, the different speeds of response may be explained by differences in the construction times of capital equipment, which may in turn generate fluctuations in levels of activity associated with the so-called reinvestment cycles (Aftalion, 1913; Robertson, 1915; Einarsen, 1938; Fanno, 1931; del Vecchio, 1956; Scazzieri, 1992; Cardinale and Scazzieri, 2017).

The distinction between horizontal and vertical structures is a characterizing feature of structural economic analysis and provides a conceptual framework whose central elements are: (i) the identification of the *analytical complementarity conditions* allowing the switch from a horizontal to a vertical representation of structure, and vice versa; (ii) the analysis of the *dynamic linkages* between horizontal and vertical interdependencies in the concrete situations in which the horizontal interdependencies between activities within an 'integrated structure' lead to the sequential dependence between different time phases within a 'composite structure' à la Leontief (see above); (iii) the determination of the *historical and institutional conditions* that bring to light critical thresholds in horizontal or vertical structures and allow identification of the conditions necessary and/or sufficient in order to overcome those thresholds. In this respect, we may note that those conditions are not necessarily limited to the structure in which the thresholds are most visible. For example, it may happen that certain horizontal bottlenecks can only be overcome if there is a corresponding transformation of the vertical structure, or vice versa.

Conditions for the analytical complementarity of horizontal and vertical representations of structure are discussed in Leontief, 1991 [1928], Sraffa, 1960, Pasinetti, 1973, Quadrio Curzio, 1986, 1996. Characterizing features of those contributions are the utilization of *aggregation and disaggregation procedures* allowing the transformation of a horizontal structure into a vertical structure, and vice versa. In this regard, the analytical conditions allowing the aforementioned switch in representation, whereby a given structure is represented horizontally or vertically, should be distinguished from the consideration of a materially different structure that displays more horizontal or vertical features. This can happen because of a process of structural change or because of consideration of a different level of aggregation. An example of the latter would be the shift of attention from a national economy to a transnational system of integrated supply chains, or,

conversely, from a transnational system of supply chains to a collection of distinct, and loosely connected, horizontal structures.

3 Time horizons

The distinction between analytical and 'material' interdependence considered above concerns the internal structure of economic systems rather than their scale of operation. When the latter is brought to attention, the differences between the time profiles of production activities emphasize the need to satisfy *availability conditions* for productive inputs, which may be significantly different depending on the time horizon under consideration. For example, intermediate products needed as inputs in a sector different from the one in which they are produced may require a production time longer than the production process of the sector in which they will be used (Hicks, 1973, Chapter XII; Scazzieri, 2010). Or new production techniques may allow the utilization as intermediate products of commodity stocks that a previous technical transformation had rendered obsolete (Quadrio Curzio, 1986; Quadrio Curzio and Pellizzari, 1999).

Leontief's distinction between *integrated structures* and *composite structures* brings light to a central feature of the relationship between analytical and 'material' conditions of interdependence. Integrated structures can be identified from interdependent product flows by adopting as observation period the time interval corresponding to the longest production process in the system under consideration. This allows the system of interdependent product flows to reproduce itself for any given technology in use. In contrast, composite structures reflect the asymmetries between processes within a given economic system and call attention to the fact that it may be possible to identify product groups that are reproducible separately from one another (Leontief). In the latter case, it is possible to single out subsystems whose reciprocal dependence is not immediate since, within a given time horizon, there may be groups of activities only using resources, equipment, and semi-finished products available within each group independently of any other subsystem. The shift to a longer time horizon may bring to light connections and dependencies that are invisible when a more circumscribed time horizon is considered. A particular and important case is that of resources whose availability cannot be increased independently of the length of the time horizon under consideration. Here, the resource endowments available to each group of activities cannot be augmented (or, respectively, reduced) by extending (reducing) the length of the time horizon, even if they can be varied by shifting from a given level of aggregation to another (Sraffa, 1998 [1925]; Scazzieri, 1993). This argument entails that the interdependencies generating integrated (horizontal) or composite

(vertical) structures may be different depending on the time horizon under consideration. As we move from short- to medium- and long-time horizons, initially independent subsystems may show increasingly dense patterns of connectivity, while initially integrated structures may generate semi-independent subsystems, and transform into composite structures under the influence of separate dynamic impulses such as differentiated patterns of resource utilization or technical change.

4 This collection of articles

A central feature of structural economic analysis is the consideration of economic structure as a constellation of elements (such as productive processes and individual or collective actors) distinguished by the *relative positions* of elements relative to one another. A given pattern of relative positions characterizes economic structure as the architecture of the system under consideration (Simon, 1962), specifying which connections between elements are possible and which ones are not. It also reflects the distribution of strong and weak linkages within the structure and ultimately the structure's responsiveness to factors of change. This issue is examined in the paper by Ragupathy Venkatachalam and Sunil Mitra Kumar on 'Economic Structures and Dynamics: A Morphogenetic View'. In this paper, Venkatachalam and Kumar argue that in structural analysis 'the idea of equivalence is central. One needs to map properties between various structures and should be able to conclude whether they are equivalent, alike or different', and that '[t]he exact notion of formal equivalence will obviously vary based on the field of study, the nature of structure and space' (Venkatachalam and Kumar, 2021, Section 2). The paper builds on Jean Piaget's idea of structure as 'a system of transformations' (Piaget, 1971, p. 71) and develops an analytical framework in which dynamics is considered as the transformation of a structure over time. This point of view grafts structural analysis in the analysis of complexity and calls attention to questions such as 'the extent of invariance of a structure under various transformations, properties that can or cannot be deduced from a given structural specification, stability, symmetry' (Venkatachalam and Kumar, 2021, Section 2). Conditions for structural equivalence are central to the strategy of this paper, seeing that 'one needs to map properties between various structures and should be able to conclude whether they are equivalent, alike or different. The exact notion of formal equivalence will obviously vary based on the field of study, the nature of structure and space. In general, the idea of *morphism* (a generalisation of homomorphism) plays a central role for understanding equivalence in category theory' (Venkatachalam and Kumar, 2021, Section 2). This approach leads to defining 'dynamic structures' as 'the collection of possible time paths or trajectories associated with a given system' (Venkatachalam and Kumar, 2021, Section 3.1). In Venkatachalam and Kumar's view, the core of

structural dynamics is the Janus-faced character of the relationships between structures and dynamics: '[t]he paths of evolution of the economic system are determined by the existing structure at any given point in time and the dynamic processes, in turn, alter that very structure' (Venkatachalam and Kumar, 2021, Section 5). In particular, Venkatachalam and Kumar call attention to studies of morphogenesis in developmental biology literature arguing that 'morphogenesis […] seeks not only to characterise but also identify the *mechanisms* underpinning the generation of shapes and form' (Venkatachalam and Kumar, 2021, Section 4). Turing's mathematical analysis of morphogenesis through loss of stability and symmetry-breaking; Fermi, Pasta, Ulam, and Tsingou's explanation of structural emergence from erratic behaviour; and von Neumann's and Ulam's analyses of connectivity (coupling) as a source of dynamic patterns within networks provide the building blocks of Venkatachalam and Kumar's framework. They view structural economic dynamics in terms of a unifying approach encompassing the role of coupling (connectivity) within networks of interdependencies, diffusion processes originating from dynamic triggers, and symmetry-breaking leading to the formation of new patterns of interdependence (morphogenesis). The mutual influence of connectivity, diffusion, and symmetry-breaking suggests a central role for *medium-term dynamics* as the framework in which intermediate stable forms are generated and structural evolution takes shape.

The relationship between patterns of connectivity and the evolution of complex structures is most visible when considering internal cycles involving transformations of energy and matter. In his paper on 'Role of Energy in Technological Dynamics' Sergio Carrà examines the cycles of energy and matter transformation from small-scale to large-scale complex systems. This approach is of special relevance when examining technological transformations addressing the issue of climate change. In this case, the transition from small- to large-scale complex systems involves the consideration of the internal hierarchy of those systems, in which relatively persistent patterns of connectivity (infrastructures) are required in order to support the transition to reduced accumulation of carbon dioxide in the atmosphere. Carrà's analysis starts with the consideration that 'the hydrocarbon-based energy occupies a relevant role in almost all areas of the human activities, by involving the economic, social and environmental aspects' (Carrà, 2020, Section 2). Technological developments greatly improved extraction and refining techniques, while important reserves were found in the Western Hemisphere. This contributed to the persistent role of hydrocarbons, whose contribution to total energy production is higher than 80%, to be compared with the contribution from nuclear fission which is slightly below 5%. Carrà argues that a discussion of the conditions for switching from one source of energy to another must be carried out by focussing on energy transformation and on the complex structures emerging from the *hierarchic interaction* between

subsystems. In fact, the effective transformation of energy is associated with the formation of complex and hierarchically arranged structures aimed at generating 'as much exergy as possible' (Carrà, 2020, Section 3). A central point is the relationship between the incoming flux of energy into a system and the energy 'downloaded' by that system. From this point of view, the widespread utilization of fossil fuels is problematic due to 'their transformation in carbon dioxide and water, dispersed in the atmosphere' (Carrà, 2020, Section 5). However, an economic system of increasing complexity presents an advantage, seeing that 'an organized economy not only uses resources in a more effective way, but it can have access to a wider range of resources thanks to its higher organized state' (Carrà, 2020, Section 5). At the same time, 'more stored energy is required to sustain a complex economy' so that 'more waste [is] ejected' (Carrà, 2020, Section 5). The paper emphasizes that the increase in organized complexity associated with greater interdependencies may help addressing the transformations required to reduce fossil fuel utilization provided a concerted and targeted effort is made to increase the effectiveness of energy transformation processes, to increase the utilization of renewable sources of energy, and to look for radical innovations in the energy field particularly 'relying on the ability of microorganisms to use renewable resources for biofuel synthesis' (Carrà, 2020, Section 8). A necessary condition of this transition is to make full use of the hierarchical arrangement of organized complexity, which involves building the large infrastructural platforms required for the transformation of the energy basis.

The following paper by Ariel Luis Wirkierman ('Productivity Homogenisation Trends of Six Advanced Industrial Economies: A Vertically Hyper-Integrated Approach') examines the implications of alternative patterns of connectivity for the analysis of productivity trends in several industrial economies (US, Germany, Japan, UK, France, and Italy). The analytical foundation of Wirkierman's analysis is the distinction between the representation of the economic system as a set of industries and its representation as a set of vertically integrated sectors. This distinction is shown to be of central relevance for what concerns productivity measurement. In fact, 'industry-specific direct labour productivities, while based on gross output in volume terms, reflect only partial views of the technique in use. For example, the productivity gap for a given industry across countries may have its origin on the productivity of the inputs supporting it, rather than on the activity itself' (Wirkierman, 2021, Section 1). The industry-based representation of the economy is contrasted with a representation by vertically hyper-integrated subsystems, such that gross outputs, inputs, and labour quantities are partitioned into relatively autonomous groups including both the quantities needed for the self-replacement of the economy and for the investment in the productive capacity needed for its expansion. The implications of switching from one type of representation to another are far-reaching. This is shown by productivity comparisons between countries, which may give different results

depending on the representation of interdependence that is adopted. In fact, as Wirkierman points out, the industry-based representation may conceal that productive differential for a given industry across countries could result from the productivity of inputs provided by other industries rather than from the industry itself. In this case, the representation in terms of vertically hyper-integrated subsystems allows measuring productivity differentials by taking full account of direct and indirect contributions from each industry to any other industry of the system. As a result, vertical hyper-integration 'may cast light on the "convergence hypothesis" from an alternative standpoint: system productivity measures summarise overall circularity in *each* single coefficient, so convergence in hyper-integrated productivity levels may provide a more accurate picture of sectoral gaps across countries' (Wirkierman, 2021, Section 1). The vertical hyper-integrated framework is used to assess the dynamics of productivity differentials for US, Germany, Japan, UK, France, and Italy by comparing the periods 1995-2007 and 2007-2015. The tendency to decreasing dispersion of cross-country hyper-integrated productivity levels in the period 1995-2007 is contrasted with the tendency to increasing dispersion observed for the period 2007-2015. This dynamic of aggregate productivity is shown to reflect the structural changes taking place in the economies under consideration, both from the point of view of their composition by industry and from that of the 'proportions with which different industries participate in every hyper-integrated sector' (Wirkierman, 2021, Section 4.4). The paper concludes by emphasizing that switching from the 'industry' to the 'growing subsystem' perspective provides a new industrial policy heuristic that complements the targeting of strategic industries with a systemic approach emphasizing that most industries presuppose a complex connectivity structure extending over the whole economy.

The connection between structure and dynamics brings to light the role of actions that take place within structures. As a result, the transformation of structures is to some extent open-ended. Existing structures may reveal or close off opportunities; they may even orient actors along certain dynamic paths, but they do not determine the specific actions taken in particular contexts. This means that structural change trajectories cannot be fully explained unless we consider the individual or collective actions that trigger the transforming potential within existing structures. The paper by Ivano Cardinale and Roberto Scazzieri ('Explaining Structural Change: Actions and Transformations') examines the relationship between structures and dynamics by emphasizing the role of relative invariances within structures. Any given structure consists of elements that can only be changed by following a limited range of sequences of transformation stages. The same is true for the relative positions of elements within structures and for the corresponding patterns of interdependence. Existing structures give shape to the range of trajectories that a given economic system can follow under the influence of dynamic impulses by making certain trajectories feasible and others unfeasible.

They are also likely to orient actors' responses along certain trajectories rather then others. However, human actions may or may not take up the opportunities associated with certain dynamic trajectories depending on actors' visualization of possibilities and on their objectives. In this connection, the paper argues that 'explaining structural change must follow a dual route depending on whether we consider the structural constraints determining which dynamic trajectories are feasible or the dynamic triggers driving the economy along a specific sequence of transformation stages' (Cardinale and Scazzieri, 2019, p. 399). Both points of view are needed for explaining structural change, which requires 'the identification of the causal mechanism associated with the existing set of interdependencies' as well as 'the reconstruction of the specific causal path followed by the economy' (Cardinale and Scazzieri, 2019, p. 399). This paper argues that the two above points of view may be associated with two different representations of interdependence within the economy. Horizontal interdependencies bring light to a causal mechanism in which processes are mutually related in terms of a proportionality condition that allows the 'viability' of any given set of interdependent activities, that is, its reproduction over time. On the other hand, any trajectory of structural transformation calls attention to a 'vertical' causal mechanism, in which old and new processes (or *combinations* of processes) are mutually related in terms of a dynamic proportionality condition governing the rate at which the flow of goods-in-process can move from one stage of production to another. This means that any actual transformation of structure is subject to two distinct constraints: the horizontal proportionality condition on processes delivering mutually necessary intermediate inputs, and the vertical proportionality condition on the sequencing of temporally related stages of production. The two conditions must be jointly met along a feasible transformation trajectory. However, 'combined horizontal and vertical constraints are not enough to determine the structural change trajectory' (Cardinale and Scazzieri, 2019, p. 400). This is because, in general, viability and sequencing conditions are compatible with a plurality of transformation trajectories, so that '[a]ctions are necessary to move from open-ended dynamics to specific paths of structural change' (Cardinale and Scazzieri, p. 400). The role of actions in determining structural transformation brings to light actors' *visualization of structure* as a critical factor in orienting their actions along a transformation trajectory. Horizontal and vertical representations call attention to different socio-economic aggregates, which may in turn lead to different individual and collective actions along a transformation path. For example, a horizontal representation highlights the reciprocal (circular) dependence between industries whereas a vertical representation highlights one-way dependencies between sequentially related stages of production. As a result, different transformation trajectories may be followed depending on which representations of connectivity are dominant in private actors' and policy makers' visualizations of economic structures. This suggests that explaining the

transformation of structures requires looking 'at the interface between theory, which addresses the configuration and dynamics of structural constraints and opportunities, and history, which may "close" open-endedness in different ways depending on context' (Cardinale and Scazzieri, 2019, p. 403).

The transformation of structures involves the interplay between existing structures and actions, which in turn reflect actors' visualization of the architecture of the economic system. The paper by Maria Cristina Marcuzzo and Eleonora Sanfilippo ('Keynes's personal investments in the London Stock Exchange and his views on the transformation of the British economy') examines the relationship between visualization and action by considering John Maynard Keynes's personal investments as a reflection of his view of the British economy and of the transformation processes occurring in it. The paper follows an approach different from works concentrating on performance metrics, in the belief that Keynes's personal investment behaviour 'also represents a good proxy for his view of the economic transformation his own country was undergoing in his times' (Marcuzzo and Sanfilippo, 2020, Section 1). This research question suggests a classification of assets by broad investment sectors (mining; industrials; transport; finance; soft raw materials; utilities; government and local authorities' bonds and stocks) to allow identification of a relationship between Keynes's perception of structural change and his choices as personal investor. The archival reconstruction of Keynes's personal investments carried out in this paper reveals a preference for gold and mining investment (with tin investment in a dominant position), for infrastructure (railways), and for industrial assets such as motor and airplane, relative to investment in government bonds, banks, and insurance. In reviewing Keynes's own description of his 'Pets philosophy' as rule for investment, the paper emphasizes that Keynes 'acted as an unconventional investor, insofar as the composition of his own portfolio did not reflect the composition by sector of the [London Stock Exchange] at the time: for example, he was definitely underweighted in Banking (where his investments were negligible) and over weighted in Mining. Moreover, our investigation shows that in his investment choices he attributed great importance to collection and careful analysis of the data relating to the fundamentals, at both the disaggregated and aggregate levels, while he tended to downplay all the contingent and short-lived factors that could affect prices' (Marcuzzo and Sanfilippo, 2020, Section 6). This approach to personal investment is consistent with the non-frequentist view of probability Keynes presents in the *Treatise on Probability* (Keynes, 1921) since it involves a shift away from the mere repetition of occurrences and an emphasis on the quality and reliability of the information possessed, consistently with Keynes's 'logical' view of probability and his emphasis on the 'weight of arguments'. This is shown by Keynes's attitude to gold mines, which was prominent in Keynes's investments due to gold's combination of 'solid certainty with alluring possibilities' (Keynes, *Daily*

Mail, 7 February 1933, CWK XXI: 229, quoted in Marcuzzo and Sanfilippo, 2020, Section 3.1.2). Apart from gold, which was mainly sought for its role as a bridge between short-term price variations and long-term value assessment, Keynes's personal investments reveal interest in commodities, and particularly metals such as tins, copper, lead and zinc, or raw materials such as cotton, jute, rubber, sugar, and tea. As to industrial products, the paper emphasizes Keynes's decreasing attention for traditional British products (such as steel, cotton and textile, cement, explosive, foodstuffs, and fertilizers) and his increasing attention for products he considered at the forefront of technological development, such as the products within the subsector 'Motor and Airplane'. Keynes's choices as personal investor and their evolution between the 1920s and the 1940s bring to light his perception of the problems facing the British economy, in which declining demand for activities such as coal mining, iron and steel, textile, and shipbuilding was combined with their relative lack of responsiveness in introducing new products and processes. In short, Keynes's perception of the relative decline of the manufacturing activities that had characterized the industrial development of Britain since the First Industrial Revolution, together with his awareness of institutional and organizational factors of retardation, are shown to be at the root of his actions as personal investor.

The following paper by Thomas Ferguson, Paul Jorgensen, and Jie Chen on 'How Money Drives US Congressional Elections: Linear Models of Money and Outcomes' shifts attention to the way in which agents' positions within structures exerts an influence on collective agency, and to the role of collective agency within evolving structures. The paper examines US Congressional elections adopting an "investment" approach to political competition and brings to light the role of financial flows from private actors in influencing election outcomes. This is done by bringing together 'contributions from executives, corporate treasuries […], political action committee contributions, and [recognizing] that they are all coming from the same companies' (Ferguson et al., 2019, Section 2). The paper's investigative technique also allows 'to pin down fairly precise measures of candidates' dependence on large donations' (Ferguson et al., 2019, Section 6). This approach leads to the discovery of a 'strongly linear' relation between the shares of the two-party vote going to the major party candidates' and the corresponding share of total campaign expenditures. In addition, the paper brings to light the role of income distribution in determining the pattern of political investment across income shares, as 'the top 1% of U.S. income earners' is shown to dominate 'both major parties' (Ferguson et al., 2019, Section 1). But income distribution is not independent of the distribution of 'political investors' across economic sectors in determining differential support for Democrats or Republicans. The interplay between personal income distribution and the sectoral distribution of political investors was in play in several recent US federal elections. This is shown by substantial differences between patterns of political investment depending on sectors and lines of activity. For

example, the authors emphasize 'the heavy concentration of polluting industries behind the 2012 Romney campaign' and 'the weight of leading private equity firms in the later stages of the Trump campaign in 2016' (Ferguson et al., 2019, Section 6). Also organized labour was politically active and sometimes made substantial contributions to influence the political process. However, the authors emphasize a declining trend in the share of organized labour' political investment: 'US labour has clearly been declining for more than a generation. In 2016, labor commanded only about 7% of the $8 billion plus entering into the 2016 election' (Ferguson et al., 2019, Section 6). The combined influence of macroeconomic and sectoral factors may lead to different patterns of political investment depending on which type of affiliations and cleavages are dominant under specific circumstances. In particular, inter-industry complementarities and cleavages may or may not significantly affect the pattern of political investment depending on 'the mobilization rate of the social classes and other groups making up the electorate and how active they are' (Ferguson et al., 2019, Section 6). The paper shows that political investment can be highly effective in influencing election outcomes. In this connection, the paper calls attention to the 'Golden Horde' of donors that made possible the Republican control of the House of Representatives in 1994 and the Senate election of 2016. The empirical analysis of the relationship between political investment and Congressional outcomes supports 'a broad investment approach to party competition' (Ferguson et al., 2019, Section 1). In fact, the paper shows that 'waves of money launched in defiance of impossibly long odds produced dramatic political upsets that can be shown to have been anticipated by scarcely anyone' (Ferguson et al., 2019, Section 1). This evidence leads the authors to conclude that, in spite of Sanders' 2016 bid for presidency being mainly supported by small donors, the candidates' dependence on large donations remains to this day the dominant factor in explaining the influence of money on US political competition.

How patterns of interdependence between socioeconomic actors relate to those actors' visualization of interdependence, and how the ensuing actions might affect interdependence in turn, is at the centre of the paper by Ivano Cardinale and Michael Landesmann on 'Generalising the political economy of structural change: A Structural Political Economy approach'. This paper extends the Structural Political Economy approach, whose emphasis is on intermediate levels of aggregation and on interdependencies between socio-economic aggregates that may or may not coincide with productive sectors and/or social classes. The paper considers a variety of definitions of 'sectors', which for example may be identified in terms of the final output they produce or in terms of a specific input, such as a particular energy source, public good, or infrastructure. It also introduces a distinction between 'sectors' seen as aggregations of productive units and 'social groups' seen as 'aggregations of workers, voters, households, or territorial entities' (Cardinale and Landesmann, 2020, Section 1).

The distinction is associated with the assumption that sectors have a forward-looking attitude in pursuing their specific interests (which includes 'political investment') whereas social groups have a 'reactive' attitude, in that they 'respond mostly to actual outcomes (such as income or employment), hence to the *observed* effects of investment activities, of interdependencies, and of induced system dynamics' (Cardinale and Landesmann, 2020, Section 2). The key idea is that the outcome of sectoral-interest politics is not immediately visible at the systemic level, as certain thresholds need to be crossed for the impact of sectoral interests to become relevant at the electoral level. This *lack of synchronisation* is at the route of the *leads and lags* approach to structural change of the paper. While making clear that the interest of a sector or group 'cannot be taken as given' since 'it depends on the representation of the system [that sector or group] adopts' (Cardinale and Landesmann, 2020, Section 1), the paper reconstructs how different representations are associated with different partial interests of specific actors and different understandings of 'systemic interest', i.e. understandings of how to preserve the viability of the system as a whole, in the absence of which the pursuit of partial interests could be jeopardised. Moreover, relevant sectors and groups may have different representations of interdependencies and different visualizations of particular and systemic interests. In conclusion, the paper explains political-economic change as resulting from the interplay between structural transformations and the actions resulting from how actors visualize the structures within which they act.

The concluding paper by Luigi Pasinetti, 'Structural Dynamics versus a Macroeconomic Approach - A Final Statement?' emphasizes that although structural dynamics is a distinctive feature of the evolution of modern industrial economies, the structural dynamics line of investigation is relatively novel. Pasinetti argues that the relationship between structural dynamics and macroeconomic modelling is instance of the need to overcome the aggregative approach when analysing the evolution of industrial economies. The viewpoints of aggregate and disaggregate dynamic analysis have been the focus of a discussion between Pasinetti himself and Robert Solow, whose main points are taken up in this paper. At the core of Solow's approach is the view that '[t]he role of certain fundamental principles […] is easier to understand in a fully aggregative context. But the way these principles work themselves out in practice may need to be studied in an explicitly multi-sectoral model' (Solow, 2012, p. 274). Pasinetti maintains that the two approaches to economic dynamics are not complementary as they express two fundamentally different visions of a dynamic trajectory: '[t]he *vision* behind structural dynamics originates from the consideration of a permanently *evolving* economic system. The *vision* behind the aggregate model of traditional growth theory embodies, on the other hand, a static approach, or at most a stationary view of the economic system, and the reason is that it is inherently incapable of absorbing any change of the economic structure in

time' (Pasinetti, 2021b). In Pasinetti's view a multi-sector model is not simply a more detailed version of the one-sector model. This is because a distinctive feature of a multi-sectoral model economy is its structure, which is associated with a particular set of sectoral proportions at any given time. The aggregate and disaggregate approaches would be complementary if sectoral proportions could remain unchanged along the path followed by a growing economic system. In this case, growth would be 'an expansion at constant proportions […] of the initial [..] position assumed to have been achieved, by the economic system, at the starting point of time' (Pasinetti, 2021b). In historical reality, however, changes of technology and of per capita consumption of different goods and services render the assumption of constant sectoral proportions untenable. This requires approaching the evolution of a multisectoral economy by explicitly focussing on changes of sectoral proportions (transformation of structure). This point of view makes it necessary to overcome the fully aggregative approach (one-sector modelling) and to examine the macroeconomy by adopting an alternative perspective. In this connection, Pasinetti emphasizes the possibility of identifying the *range of proportions* between sectors of the macroeconomy that would achieve a systemic objective, such as full employment, by taking into account the dynamic processes transforming the production and consumption coefficients over time. However, 'it will be the task of the institutions of the economic system to govern the interaction between individual efforts and consumption choices, so as to drive the economic system to the fulfilment of such a macroeconomic condition' (Pasinetti, 2021b). In this way, collective actions, and in particular the policies designed and implemented by coordinating agencies, acquire a central role in guiding the transformation of structures along specific dynamic trajectories.

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