Surveying structural change: seminal contributions and a bibliometric account

Ester Gomes da Silva

(esilva@letras.up.pt)

Faculdade de Letras/ISFLUP

Universidade do Porto

Aurora A.C. Teixeira

(ateixeira@fep.up.pt)

Faculdade de Economia/CEMPRE and

INESC Porto

Universidade do Porto

Abstract

Structural change analysis has an important tradition in economic theory. However, up to the present date, no attempt had been made to provide an overall survey on the matter. In the present paper we try to fill this gap by providing a comprehensive survey of the economic literature on structural change, covering the early foundations until the more recent years. We focus on 'seminal' contributions, and from them we establish the links with the more recent works. This is done with resource to bibliometric methods which combined 9703 citations from the area's 'seed journal' and a review of the 910 abstracts of all theoretical and empirical articles on structural change analysis that were published over the past forty years in the economic journals indexed in the Econlit database. Based on this analysis we testify the recent uprise of interest on structural change analysis where technological issues gained increasing relevance. The 1990s have witnessed an increasing relevance of formal work, but more recently such trend was not confirm, being observed a strong impetus towards empirically-led work prompted by the emergence of the New Economy and its impact on the overall workings of the economic system. Our analysis further reveals that most contributions put great emphasis on technology driven growth lacking an appropriate treatment of the demand side.

Keywords: Structural Change; Bibliometrics; Econlit

JEL-Codes: O10; O30; C89

Under revisions in Structural Change and Economic Dynamics

1. Introduction

Structural change analysis is differentiated from standard economic research in that it assumes that the infinite multiplicity of reality can be studied by focussing on a relatively small number of groups or activities that comprise the economic system, and thus form the economic structure.[1] In this sense, a structural representation provides a selective description of the economic system, which is obtained by substituting the observed heterogeneity with sets of classes of relatively homogeneous groups of agents or sectors of activity. In this framework, the definition of structure and of the unit of analysis is made to depend on the problem under investigation. This allows for a considerable degree of flexibility that is absent from standard micro and macroeconomic analyses, thus making it an appealing tool for the study of economic dynamics. The complexity of economic change is probably better understood within a framework which permits changing from one classification scheme to another, so as to obtain the structural representation that is most suited to analyzing the impact of a particular force of change, or to describing the economic system at a particular moment in time. Moreover, the division of the economic system into different subsystems means that differentiated patterns of change in those subsystems can be taken into account (the different elements of a productive structure are transformed at different speeds), which is entirely at odds with stationary state dynamics.[2]

Despite the fact that structural change analysis has an important tradition in economic theory, to the best of our knowledge, there has been no attempt to provide an overall survey on the matter. Several factors may account for this. Firstly, even though the phenomenon of structural change is as old as the very problems of economic development, the term 'economics of structural change' was until recently practically unknown. The enormous heterogeneity of studies in this area, inherently related with the complexity of the matter, does not lend itself easily to a unified approach and only recently there have been some attempts (Baranzini and Scazzieri, 1990; Landesmann and Scazzieri, 1996) to organize the theoretical approach in a systematic manner. Secondly, the terms 'structure' and 'structural change' are widely used in economic research under very different meanings and, in many cases, those meanings have no connection with 'structural change analysis' (see our discussion in Section

---

[1] See also Hagemann *et al.* (2003) for a discussion of the purpose and scope of the economics of structural change.

[2] See the discussion in Landesmann and Scazzieri (1990) on this feature of structural change and on the notion of 'relative structural invariance'.

2 below). This presents several difficulties when trying to identify and organize the existing theoretical and empirical work in the field.

This paper attempts to fill this gap, providing a comprehensive survey of the economic literature on structural change, covering the early foundations until the more recent years. Over this period, an enormous amount of potentially relevant literature has been published, and as such, there is no reasonable way in which one can do justice to all of it. In these circumstances, we emphasize 'seminal' contributions, and from them we attempt to establish the links with the more recent works. This is partially done with resource to bibliometric methods, which are used in two different fronts. First of all, we analyse citations and co-authoring, taking *Structural Change and Economic Dynamics* as the 'seed journal'.[3] This exercise helps us to identify the most influential contributions, particularly in the more recent period, in which the characterization of a particular piece of work as 'seminal' is more controversial. At the same time, it provides some clues on the clustering of contributions and on the identification of the main streams of the literature.[4] Secondly, we undertake a review of the abstracts of all theoretical and empirical articles on structural change analysis that were published in the economic journals found in the Econlit database over the past forty years. The classification of these articles according to the main theme of research and the methodologies used helps us to interpret the recent trends on the literature, in a period marked by a significant revival of interest on structural change analysis.

From a chronological perspective, one can distinguish between different periods, according to the relative importance addressed to structural change analysis. While in the classical period a great deal of attention was given to long-term dynamics and to their association with structural change, those issues became to be seen as marginal with the emergence of the marginalist revolution by the end of the 19th century, and its emphasis on the problems of optimal resource allocation. As a matter of fact, the inter-war period was characterized by an almost total neglect of structural change analysis, with only a few notable exceptions - Schumpeter, Leontief and a few other authors- addressing this topic. In the 1950s and 1960s there was a revival of interest in structural change analysis that was intimately related with the appearance and consolidation of development economics as an autonomous field of research. This uprise of interest, however, did not disseminate to the mainstream, with formal theories of economic growth typically being developed with little reference to the changing structure

---

[3] In this regard we agree with Leydesdorff (2007) who point that citation environments only make sense locally.
[4] We acknowledge and deeply thank the contribution of one anonymous referee for highlighting this issue.

of the economy. Furthermore, in the 1970s, a deep transformation taking place in development economics, with a shift towards a micro approach that made intensive use of the neoclassical framework, induced a strong decline in structural change analysis within this particular branch of economic research. During the last decades, more precisely from the late 1980s onwards, there has been a growing interest in structural change analysis that is apparent from the emergence of a journal - Structural Change and Economic Dynamics – devoted particularly to this topic. In this context, it seems particularly pertinent to make an assessment of the more recent contributions in this area, and to address the links with previous research.

The paper is structured as follows. In Section 2 we present a brief discussion on the analytical difficulties associated with the organization of the relevant literature on structural change analysis and describe the bibliometric exercises undertaken. In Section 3 we discuss the early foundations of structural change analysis, considering the writtings from the classical authors and Schumpeter's work. Section 4 is devoted to the formal analysis of structural change, including the contributions on the analytical representation of economic structure and formal theories of economic growth and structural change. In Section 5 we present some of the applied work that emerged from the 1950s onwards, with particular emphasis on the contributions focusing on empirical and historical processes of structural change. In Section 6 we analyse the recent trends on structural change analysis, presenting an overview and interpretation of these developments. Section 7 concludes.

2. Methodological considerations on the analysis of structural change research

An important aspect to be taken into account when analyzing the literature on the economics of structural change is that the terms 'structure' and 'structural change' are used in economic research under very different meanings, and some of those meanings have no direct bearing on 'structural change analysis'. Moreover, in many cases, there is considerable vagueness in the ways in which the terms are used, which hampers a precise interpretation of what is meant.[5]

In his semantic study of 'structure' and 'structural change', Machlup (1991) provides an extensive list of the various (economic) uses of the terms, distinguishing them according to their relative degree of clearness. Taking into account only the clearer definitions, there are at least nine different meanings with which structure and structural change can be related. Along

---

[5] According to Machlup, structure (and thus structural change) 'is often a weaselword used to avoid commitment to a definite and clear thought' (Machlup, 1991: 75).

with the notion of economic structure as 'different arrangements of productive activity in the economy especially to different *distributions* of productive factors among various sectors of the economy, various occupations, geographic regions, types of product, etc.' (Machlup, 1991: 76, original emphasis), which seems to be the most common use of the term in development economics and in economic history, there are several other meanings, expressing the appeal of this term in an extensive array of theoretical and applied research. For example, structure is also used to denote the fundamental conditions that are assumed as invariant for purposes of analysis and modelling, regardless of the nature of the model and, simultaneously, it is taken as synonymous of a 'composition that does not change easily' (Machlup, 1991: 78), referring mostly to the composition of basic macro-economic magnitudes, such as national product, investment, employment, exports or imports. This latter feature of structure as composition is also apparent in Ishikawa's (1987: 523) definition of structural change, in which it is seen as 'a change in the relative weight of significant components of the aggregative indicators of the economy, such as national product and expenditure, exports and imports, and the population and labour force'.

For the purposes of this study, only theoretical and empirical studies developed according to the framework of structural change analysis described above were considered, disregarding all other possible uses of the terms. More precisely, the studies selected were those that divide the economic system into a limited number of subsystems, in order to analyze the dynamic properties of the economy as a whole. Studies focussing on the econometrical meaning of structural change were also disregarded, especially those that are mostly concerned with the development of testing procedures to cope with the phenomenon of time series structural change.

As stated before, in order to enrich the literature survey and provide additional insight on the main trends of research, we develop two major bibliometric exercises. The first one consists in performing citation analysis, taking *Structural Change and Economic Dynamics* (SCED) as the 'seed journal'.[6] More precisely, we undertake a comprehensive analysis of the references cited in all articles published in this journal, from its first issue to the most recent one (January 2007), vol. 18, issue 1.[7] The total number of analysed papers was 419, and from the list of references obtained (which totalled 9703) we calculated 'impact' measures, both for

[6] *Structural Change and Economic Dynamics* is a journal devoted particularly to this topic, and although it has only commenced publication in the early 1990s, it is by far the journal with the higher number of publications on the field, according to our research on the Econlit database (21% of total papers from 1969 up to 2005).
[7] A minimal amount o papers (15), mostly concentrated upon the 1991-1995 period, had to be disregarded due to inappropriate digitalization.

authors (Table A1 in Appendix) and articles (Table A2 in Appendix). It is important to note that this reference data gathering was quite troublesome and time consuming task. The majority of the almost 10 thousands references were collected by a 'copy-paste' procedure from original articles. Only a few more recent articles had its references indexed in *Scopus*,[8] permitting in this way to export references directly to an excel file. Given that the references were not uniformly cited in each of the SCED's articles, we had then to harmonize the references and only afterwards to perform the citation analysis.[9] Such quantitative analysis helped us to identify the most influential works in this area of research, providing, at the same time, important clues on the clustering of contributions and on the identification of the main streams of the literature, which were incorporated in the survey analysis developed along the following sections.[10]

The second bibliometric exercise is based on the analysis of the abstracts from all articles published on structural change analysis found in the Econlit database from January 1969 up to August 2005. The database was constructed by using the term 'structural change' as the search keyword. The total number of analyzed records was 2329, where texts corresponding to comments, rejoinders, *corrigendas* or addressing different meanings of structural change were eliminated from the categorization. Also, some records did not have an abstract and were also excluded (but included in the temporal analysis). In the end, 910 records remained (from a total of 1247 with and without abstracts). Publications on the economics of structural change were analyzed in terms of eleven main themes, which were selected on the basis of the literature review undertaken. Those themes are: 1) Development; 2) Technical change and innovation; 3) Convergence and growth; 4) Economic fluctuations; 5) International trade; 6) Employment and migrations; 7) Industrial dynamics; 8) Institutions and policies; 9) Regional and urban economics; 10) Measurement and methods; 11) Environment and sustainability. Based on this classification, we assess the relative weight of each theme of research and, most importantly, infer the trends in structural change analysis in the most recent period, which, as referred earlier, has been characterized by a significant reawakening of interest in the field.

---

[8] *Scopus* is the largest abstract and citation database of research literature and quality web sources (http://www.info.scopus.com/overview/).
[9] Most of existing works involving citation analysis do not required such enormous effort as the journals involved are indexed in ISI Web of Knowledge (produced by Thomson Scientific), which automatically provides the references and corresponding citations.
[10] In Table A3 in Appendix we present the matrix of co-authorship among the most influential authors on structural change theme. This permitted us to identify both the clustering of contributions and the main streams of the literature - we acknowledge one of the referees for such useful suggestion. This was then depicted in Figure A1, which schematically overviews the conceptual analysis performed in Section 3.

Apart from the main theme of research, the articles were also classified according to the main method of research used, by considering six major classes: 1) formal; 2) appreciative; 3) formal and empirical; 4) appreciative and empirical; 5) empirical; and 6) surveys.[11] This categorization enables us not only to perform a full characterization of the literature on structural change analysis, but more importantly, it provides important clues on the relationship between the increasing relevance of structural change analysis and the (eventually) growing formalism in the research methods used. The mathematization of economics is probably the most important feature in the history of twentieth-century economics (Morgan, 1999; Mirowski, 2000; Weintraub, 2002). The use of models has become the dominant practice – in the view of many, the way of doing 'good economics'. It is therefore expectable that the current up rise of interest in this field is correlated with a change in the main methodologies undertaken.

3. Foundations of structural change analysis

Classical economists (1700s-1870)

The idea that the dynamics of economic systems is inherently associated with changes in their structure had already been explored by classical economists. Although they did not actually use the term 'structure' in any significant way, many authors (e.g. Steuart, 1767; Turgot, 1766; Smith, 1776) contended that the progress of wealth was intimately related to changes in the pattern of interaction among a few critical variables, which can be seen as distinct representations of the economic structure. For example, in Smith's *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), there is an explicit reference to the relationship between the sectoral composition of the economy and the stage of development reached. In fact, each stage is characterized by a particular composition of product, and a change in this composition is seen as a major requirement to reach higher stages of development.

Furthermore, in classical essays, there is an explicit attempt to identify the major forces that allow the economy to switch from one structure to another. In Smith's (1763; 1776) work, the main dynamic impulse to change comes from the division of labour. The productivity gains associated with labour specialization, related to the greater dexterity of the workforce, to the rationalization of resources and to higher incentives to innovate, induced changes in the identity and composition of economic activities, thus giving rise to a new structure of the

---

[11] The distinction between formal and appreciative theorizing follows Nelson and Winter's (1982) original proposal and intends to separate the theoretical explanations that are expressed in mathematical terms (through modellization), from the theoretical work in which this kind of construction is absent.

economy. Another contribution in this period, from Rae (1834), points to invention, rather than the division of labour, as the major force driving structural change. From his perspective, the invention of new tools and machines brings on the division of labour (and not the other way around), which is then reflected in the changing structure of the economy. Ricardo (1817), in his turn, emphasized the role of non-producible resources in the progress of wealth. Output growth requires growth of factor inputs but land is 'not unlimited in quantity and uniform in quality' (Ricardo, 1817: 70). This means that as growth proceeds, more land must be taken into cultivation, but land cannot be created. The growth of overall production requires then a continuous substitution of produced for non-produced inputs, which implies the changing composition of the productive system, together with significant changes in income distribution.

For the most part, classical economics was carried out in a rather descriptive fashion, without an explicit analytical account of the economic structure. Some exceptions to this general pattern can nevertheless be found in the works of Quesnay (1758) and Marx (1885). The first author, in his *Tableau Économique* (1758), provided a simple description of the analytical structure of the economy, exploring the general interdependence between economic sectors. Crucial to Quesnay's analysis was the notion that 'natural proportions' between sectors could be identified and that it would be possible to examine whether or not a given pattern of social expenditure was a sustainable one. The same idea was also present in Marx's schemes of accumulation and reproduction of capital (Marx, 1885), perhaps the most rigorous formulation to date of a growth model. Distinguishing between 'constant' and 'variable' capital, the former representing circulating capital such as raw materials and the latter meaning advances to labour (i.e., wage payments), Marx (1885) argued that the tendency for increases over time in the ratio of constant to variable capital (the 'organic composition of capital') implied a re-proportioning of the various commodities produced. He also stressed that this transformation had to follow a particular pattern, so as to achieve a viable expansion of the economic system. In both cases, the analytical representation of the economic structure is based on a circular view of the productive process. Goods are produced not only from natural factors of production, but also from each other, and a particular good x entering the production of a good y can also use the latter in its production.[12] It should be noted, however,

---

[12] In contrast with this view, the Austrian theory of the formation of capital (Böhm-Bawerk, 1891) analyses the productive process from a linear perspective. Defining capital (whether fixed or circulating) as an aggregate of intermediate products, Böhm-Bawerk formulates the concept of 'period of production', which corresponds to the time lag between the investment of 'original factors' (land and labour) and the acquisition of consumable

that while Quesnay's scheme is inherently static, without any indication about the way in which the economic system is supposed to evolve over time, Marx does also consider structural dynamics, through its schemes of extended reproduction.[13]

The Schumpeterian legacy

After Marx, the interest on the study of the causes of 'progress of wealth' strongly decayed. The emergence of the marginalist revolution by the end of the 19th century, with its emphasis on the problems of optimal resource allocation, shifted the focus away from long-term dynamics and their association with structural change. A long hiatus thus existed until the appearance of Schumpeter's work, which took up again the analysis of long-term economic movements of the economy at a time of almost complete neglect on the matter.

Like Marx and other classical authors, Schumpeter was aware that structure had to change if there were to be long-term shifts in economic well-being. In his view, innovation[14] - arising from technological competition among firms -, was the major driving force behind such changes: once an (important) innovation was introduced, the prospect of extra profits would lead to a complex process of dissemination by imitation and further improvement by other firms in the market, along with the appearance of other innovations in related fields of activity. There was thus a tendency for innovations to cluster, not only in certain activities, but also in particular time periods. For a while, the 'cluster' of activities in which innovation appeared would grow at a higher rate than the overall growth rate of the economy, but sooner or later, the potential for further growth would become exhausted, and growth would slow down. According to Schumpeter (1939), this cyclical development of clusters could be transmitted to the overall economy, contributing in this way to the observed discontinuity of the growth process and to the formation of business cycles of several lengths.[15]

---

commodities. From this analysis, all goods are grouped according to their distance in time from the consumer, which provides an overall linear picture of the productive process.

[13] The introduction of dynamics within a 'pure circular-flow model' is accomplished by Marx through the consideration of a 'dynamic behavioural principle', associated with the utilization of the surplus of a particular accounting period in the subsequent period. See, in this respect, Landesmann and Scazzieri (1990).

[14] Schumpeter defines innovation in a broad sense as 'new combinations of existing factors of production' (Schumpeter, 1928: 377), exemplifying with the emergence of new products and new methods of production, the creation or exploitation of new markets and new ways to organize business.

[15] Schumpeter's ideas on the relationship between innovation and business cycles were not well received by the economic community at the time of their publication, and were severely criticized by Kuznets (1940), who questioned their logical coherence and adherence to reality. In the 1970s, however, those ideas were once again brought to the fore, and became the centre of an intense debate among the supporters of Schumpeter's thesis on 'long waves' and its detractors, a debate that still remains today. See Fagerberg (2003) for a discussion on the matter.

In Schumpeter's analysis a major thrust is thus entitled to structural change, which is taken not as an additional feature of the growth path, but rather as representing the very essence of economic development. Nevertheless, apart from a general description of the 'swarming' and 'bandwagon' effects associated with the cyclical pattern of the economy, Schumpeter leaves largely unexplored the structural adjustment process of the economy following innovation. In particular, as pointed out by Gualerzi (2001), the impact of the demand side in shaping the overall transformation of the economy is left totally aside.[16]

These limitations do not obscure, however, the notable contribution of Schumpeter in providing an endogenous explanation of economic change in the economy, which laid the foundations for much of the recent literature on structural change analysis (see Figure A1 in Appendix).[17] The acknowledgement and wide recognition of Schumpeter's seminal contribution came, nevertheless, many years after the publication of his work,[18] which although reflecting the singularity of Schumpeter's concerns in his lifetime period, may also reflect the non-formalized character of his approach, in a period in which neoclassical economics and mathematical theorizing were becoming increasingly dominant. As a matter of fact, the relative lack of interest on structural change analysis for a long period of time may indeed be related to the strong unbalance towards empirical, historically related studies in detriment of more formally oriented research. There were, however, a number of important studies in the field adopting formal methods of analysis, which will be described in some detail in the following section.

4. Formal approaches to structural change and economic growth

Formal theories of economic growth typically have been developed with little reference to the changing structure of the economy. Yet it is well-known that growth fundamentally changes the structure of the economy and the composition of its main aggregates.

Formal structural theories of economic growth take as the point of departure an analytical representation of the economic structure, which provides a selective description of the economic system. This analytical step permits to move from 'infinite variety' to a relatively small number of classes in which agents or activities are clustered, thus allowing to explore in an easier way uneven economic dynamics (Hagemann et al., 2003). The adoption of a

---

[16] Schumpeter even argues that 'it is the producer who as a rule initiates economic change, and consumers are educated by him if necessary' (Schumpeter, 1934, cited in Gualerzi, 2001), which makes clear the general irrelevance addressed to consumers and demand in his analysis of economic growth.
[17] This point is further developed in Section 6.
[18] Fagerberg (2003) locates the revival of interest in Schumpeter's work in the period following the economic slowdown of the 1970s.

particular structural specification is, of course, dependent upon the focus of the investigation. At this level, a traditional distinction stresses the differences between 'horizontal' and 'vertical' representations of the economic structure. Horizontal representations describe the economic system as a circular structure, with economic activities being clustered into mutually dependent classes. As mentioned before, this type of representation of the economic system was a hallmark of classical economists's works, in which production was seen as an essentially circular process. In the modern period, a circular representation of this type, in which no information is given about the time structure of the horizontal interdependencies among sectors (that is, in which a point-input point-output representation of processes is assumed) can be found in von Neumann (1937) and Sraffa (1960) models. Though developing their works with different backgrounds and different intentions, both authors perspectived production as a circular process where commodities are produced by means of commodities and production takes place trough processes of unit time duration.[19] Leontief (1928, 1941) also explores the idea of general interdependence and circularity of production in his detailed quantitative description of the economic system. In his model, the production process is illustrated by means of multiple causal relationships, where certain commodities are generated by other commodities that are themselves used and consumed in further production. In the dynamic formulations of the Leontief system (e.g. Leontief, 1953, 1970), the horizontal-flow description is supplemented by the specification of construction and delivery lags that incorporate the time structure of inter-sectoral flows. These formulations permit the simulation of structural changes (such as changes in the composition of final demand and changes in technology), assessing their implications in terms of the overall workings of the economic system. Lowe (1955, 1976) also makes a combined use of the horizontal approach and the specification of the time structure of inter-sectoral flows in his studies on 'traverse analysis'.

Differently from these contributions, vertical representations exclude the consideration of horizontal interdependences, stressing uni-directional relationships and asymmetric dependence in the clustering process. An early contribution to the analysis of the economic system in 'vertically-integrated' terms can be found in Sraffa's *Production of Commodities by Means of Commodities* (Sraffa, 1960, Appendix A). Sraffa demonstrates that in the general case of production of commodities by means of commodities it is possible to move from a

---

[19] In particular, Sraffa's (1960) major concern was the revival of the classical approach to the theory of production, value and distribution, while von Neumann (1937) basically attempted to find an equilibrium solution of a multi-sectoral economic system.

'circular' to a 'vertical' representation of the economy. This is accomplished by splitting up the circular flow into a number of distinct 'net product' subsystems, in which each subsystem represents a one-way relationship from dated inputs of original factors (labour and means of production) to the corresponding final commodity. Sraffa's brief account on the vertical representation of economic system would be further developed by Pasinetti (1973). In this work, Pasinetti elegantly displays the analytical operation involved in the transformation of the usual input-output scheme (e.g. Leontief, 1941) into a set of vertically integrated sectors, providing at the same time a rigorous examination of the logical properties of the process of vertical integration. Under this framework, the economic system is partitioned in a number of vertically integrated sectors equivalent to the number of final commodities produced, with each vertically integrated sector expressing in a consolidated way the quantities of labour and intermediate inputs that are directly or indirectly required to obtain a particular final commodity.[20] The logical operation of forming vertically integrated sectors then permits to analyse general theoretical problems associated with the (uneven) dynamics of growth and its association with technical change without any reference to intermediate uses of the commodities.[21]

An alternative approach to remove horizontal interdependencies in the Sraffa-Leontief system has been proposed by Richard Goodwin (Goodwin, 1976, 1983, Goodwin and Punzo, 1987). This is accomplished by transforming the original space into an imaginary space, in which the eigenvectors of the square input matrix are used as 'general coordinates'.[22] This transformation defines *n* distinct composite commodities, with each commodity being produced entirely out of inputs of its own product. Therefore, the method allows for a separate investigation of a single sector in the economy, as if each sector were a Ricardian 'Corn Economy'.

A totally vertically integrated representation of production is also proposed by Hicks (1973). Hicks overcomes the difficulty of the Austrian's representation of production activities in introducing durable means of production, by defining each productive process as a stream of labour inputs delivering a stream of final product outputs,[23] with all intermediate products used in the production of final goods being ultimately reduced to the amount of labour that

---

[20] The sum of these inputs and labour requirements must, of course, express the total inputs used in the system as a whole.

[21] In particular, it prevents the system of equations from breaking down, due to a change in the technical coefficients, as was the case with inter-industry systems of equations.

[22] In this method, however, a complete removal of sectoral interdependencies is undertaken, while in Pasinetti's work an attempt is made to retain the maximum structure possible. For a comparison of the two methods see Pasinetti (1990) and Cozzi (1990).

[23] A flow-input flow-output profile, instead of the Austrian flow-input point-output framework.

was used in their production. In this 'neo-Austrian' framework, each process of production is seen as comprising two sequentially related phases: a 'construction' phase, in which labour is used to produce machinery and no final product is obtained, and the 'utilization' phase, in which the machinery obtained in the former phase is combined with labour in the production of final goods. The economic system is thus composed of two large interconnected 'sections', the first including the activities that belong to the construction phase, and the second including the activities of the utilization phase. This vision of production allows the study of problems of transition between production techniques and, more generally, non-proportional growth, within the context of historical time.

In an intermediate approach between the two extremes of purely horizontal and vertical representations of the economic structure we have Georgescu-Roegen's (1971) fund-flow model. In this model, the time dimension is explicit taken into account through the consideration of different time profiles of the inputs, which are classified as being of the 'fund' or the 'flow' type.[24] By adding information on the temporal pattern of use and combination of the resources in the production process, the model allows the specification of temporal complementarities that provide additional 'vertical' information along with conventional information regarding technical coefficients provided by the input-output framework. This brings new perspectives for the analysis of the dynamics of economic systems.

Horizontal and vertical representations of economic structure have been used in a number of seminal contributions analysing the uneven dynamics of economic growth within a structural change focus. As mentioned before, the use of one particular descriptive-analytical tool, rather than the other, or even the combined use of both methods, is dependent upon the specific focus of the investigation, with the different approaches offering complementary views of the growth process.[25]

Among the studies that explicitly take into account the restructuring of the economy accompanying growth there is one strand of research - the so-called 'traverse analysis' (see

---

[24] Under this classification, 'funds' represent the agents of the transformation process, entering and coming out of the production process with their efficiency intact, while 'flows' are the objects and the products of the process. Examples of funds or agents are land, capital and human capital, which transform input flows (raw materials, intermediate inputs and inputs needed for maintenance of capital) into output flows (products and waste) (see Georgescu-Roegen, 1971, pp. 230-233). For a presentation of the 'fund-flow' model see also Tani (1988) and Piacentini (1995).

[25] Though some authors claim the relative superiority of vertical approaches for studying non-proportional growth (e.g. Belloc, 1980; Amendola, 1984), there are also arguments in favour of the opposite view (e.g. Lowe, 1976; Hagemann, 1990), with several authors stressing the complementary nature of both approaches (Hicks, 1973; Zamagni, 1984; Hagemann, 1990). For a comparative account of the relative merits of horizontal and vertical approaches see Hagemann (1990).

Figure A1) - that focuses on transition paths, analysing the changes occurring in an economy that was originally in steady-state and that has been disturbed by changes in exogenous determinants of growth, such as changes in technology and factor supplies. A common feature of the contributions within this type of investigation is the emphasis given to structural rigidities (horizontal, as well as vertical rigidities) as major factors determining the dynamics of an economic system subject to a source of change. It is the consideration of such rigidities that places the analysis in the context of historical time, rather than logical time, with economic dynamics being seen as the result of (irreversible) changes taking place in a sequential manner.

Ricardo's analysis of technological unemployment in his brief chapter 'On Machinery' in the *Principles* is generally regarded as laying the grounds for this type of research. Following Ricardo, both Lowe and Hicks, the pioneering authors of 'traverse analysis', put great emphasis on the possibility of technical change having the consequence of creating unemployment, analysing the conditions under which displaced labour originated during the transition can be reabsorbed in the end of the process. This problem is, however, approached by the authors in different ways, which rely on distinct descriptive-analytical representations of economic structure. As mentioned before, Lowe (1955, 1976) adopts a horizontal approach, elaborating on a modified version of the Marxian schema of reproduction. The main modification introduced by Lowe – the division of the Marxian capital goods-producing sector into one sector that produces the equipment for the consumer goods sector, and the 'machine-tools' sector that produces the equipment for both subgroups of the capital goods sector - allows him to establish a hierarchical organization of the economy, in which the 'machine-tools' sector assumes the key role. Indeed, under the assumption of full utilization of the economy's capital stock, any process of expansion implies a prior increase in fixed capital in this sector (and subsequently in the other capital-goods producing sector), so as to obtain an increase in the production of consumption goods. The adjustment path of the economy is thus characterized by a *sequential* process of production and re-proportioning of the economy, in which the capital stock is rebuilt.[26]

Hicks made use of the horizontal scheme in his first analysis of the traverse in *Capital and Growth* (1965), in which he develops a two-sector model of an economy which employs labour and tractors to produce corn and tractors, with technical coefficients of production that

---

[26] A thorough discussion of Lowe's work can be seen in Hagemann (1990) and Gehrke and Hagemann (1996).

are fixed for each sector.[27] However, he soon became disappointed with the inter-industry approach, switching to a vertically integrated approach in his *Capital and Time* (1973).[28] In this 'neo-Austrian' framework,[29] an once-over change in technology leads to a transition period, until the full utilization of the new technology is reached.[30] In particular, there will be a period of time (the 'early phase of the traverse') during which processes using old and new techniques will coexist. Hicks uses this framework to re-examine Ricardo's analysis of technological unemployment, considering alternative dynamic paths – 'full-employment' and 'fixwage' traverses. It is shown that technological unemployment may arise on the transition period, but that the long – term effects are likely to go the other way, with displaced labour being fully absorbed in the end of the process.

Both Lowe and Hicks' works on 'traverse analysis' have inspired subsequent developments in the literature. For example, Lowe's concerns on the strategic role of the machines-tool sector were integrated in studies focusing on economic planning in developing economies in the 1950s and 1960s (e.g. Mahalanobis, 1955; Dobb, 1960; Sen, 1960; Navqi, 1963). More recently, a few attempts have been made to analyse some features of transitional paths not explored in the seminal works of Lowe and Hicks, combining both vertical and horizontal representations of the economic structure (e.g. Quadrio-Curzio and Pellizzari, 1999; Baldone, 1996; Quadrio-Curzio, 1986; Belloc, 1980). Baldone (1996), for example, integrates the neo-Austrian method in his inter-industrial representation of the economic system, by defining the production process of the machine sector as a sequence of construction and utilization phases. In this framework, the transition process between two techniques is represented by the emergence of a sequence of mixed techniques, that is, the simultaneous use of several technologies at each moment in time, which lasts until all the 'old' processes cease functioning. An important result of the model is that residuals may arise in the transition process, due to disproportions between the availability and the effective use of commodities, which complexifies the determination of transition paths. Multiple trajectories also feature transition when the impact of technical change is analysed in terms of the introduction of new

---

[27] It is in this work that the first formal definition of traverse is put forward (see Hicks, 1965, p. 184).

[28] At the origin of this change was the need to focus on innovations that took the form of new methods for making the same final product, something that could not be accomplished in a multi-sectoral model with a horizontal structure, since 'there is no way of establishing a physical relation between the capital goods that are required in the one technique and those that are required in the other' (Hicks, 1977: 193). Hicks, however, did not exclude entirely the horizontal approach, which is explored, in parallel with the vertical integration approach, in a later work (Hicks, 1985).

[29] The configuration of the productive process under this framework has been described above.

[30] Like in Lowe's model, but under a different framework, a major result is thus that the inherited stock of fixed capital represents a major bottleneck that the economy has to overcome in order to reach the new steady growth equilibrium path.

products. A rather complex picture of structural dynamics is also present in Quadrio-Curzio's contributions. Inspired by the work of Ricardo and taking Sraffa's *Production of Commodities by Means of Commodities* (1960) as the point of departure for the analysis, Quadrio-Curzio – on his own and in collaboration with Pellizari -, emphasizes the limiting role of scarce, non-produced means of production in the growth process. In particular, it is demonstrated by means of a multi-sectoral model that increasing scarcity leads to the activation of successive technologies in order to produce the raw material, leading to the adoption of mixed technologies at each moment in time. In this context, by introducing a vertical decomposition within the framework of an inter-industrial approach, the mixed technology that is in use in a particular moment of time can be seen as the combination of a number of subsystems equivalent to the number of technologies activated. At the same time, because the structures of the technologies that are successively emerging may differ from 'older' technologies, a residual will be created, with potential negative effects on the overall growth rate of the economy. A major result within this frame of analysis is then that the maximum sustainable growth rate of the economy is not uniform, but rather depends on the number and type of subsystems that are operated and on their relative compatibility at any point of time.

These recent trends on traverse analysis seem to suggest that important insights on transitional dynamics may be uncovered if horizontal and vertical descriptions of the economic system are taken into account under complementary terms. But despite their inherent potential for the study of economic dynamics, traverse theory seems to remain a relatively unexplored method of enquiry, with only a few authors introducing relevant contributions in the field.

A different approach to the relationship between structural change and economic growth, developed independently of the analytical construction of the steady-state, can be found in the work of Pasinetti (1981, 1993). In contrast with the studies outlined above, in which structural change is an out-of-equilibrium feature, in Pasinetti's work it represents a permanent feature accompanying growth. Moreover, while in those studies the fundamental forces of change are seen as originating mainly in the supply side of the economy (through changes in technology and factor supplies), Pasinetti attributes a fundamental role to changes in demand, which are incorporated in the analysis by means of a generalization of Engel's law.[31]

---

[31] Leon (1967) also integrates Engel's law in his theoretical analysis of growth and structural change. According to his main argument, the non-uniformity of the increase in demand, as predicted by Engel's law, implies that the rate of profits is permanently differentiated across industries, with the industries that benefit most from consumption increases achieving both higher rates of growth and profit. The existence in simultaneous of different profit rates in the economy is, at the same time, explained by the monopolistic structure of the market,

Pasinetti attempts to provide a general conception of the dynamics of growth and structural change that takes explicitly into account the uneven impact of technological and demand changes among sectors, an issue tipically neglected in contemporary theories of economic growth.[32] In a return to the classical tradition, Pasinetti sets out his analysis in terms of the 'natural system', in which all relations are investigated in a pre-institutional context. The basic theoretical scheme, developed in terms of vertically integrated sectors, was presented in great detail in his 1981 book – *Structural Change and Economic Growth*. The 1993 publication - *Structural Economic Dynamics* - represents a continuity in this line of research, but within the more essential framework of a 'pure labour production model', a minimal model 'that contains the very essential features of the 'production' paradigm, to which classical and Keynesian economics belongs' (Pasinetti, 1993: xiv). The primary concern of the model is the definition of the conditions that must be fulfilled for an economy to achieve and maintain a 'satisfactory state of economic growth', described as a state in which there is approximately full employment of the labour force and full utilization of productive resources (Pasinetti and Scazzieri, 1987: 527). In this framework, individual and social learning is seen as the major engine of economic change. It influences the dynamics of the economic system through two major channels: a 'strictly technological' one (Pasinetti, 1993: 36) which refers to productivity increases and to the emergence of new techniques and new products in the economy, and a demand-related one, associated with the rise in per capita income and its influence on consumer demand, as described by Engel's law. Technology and demand are thus seen as the main determinants of long-term economic dynamics, though their influences are separated. Technology determines the evolution of prices, in line with the classical labour theory of value, whilst effective demand determines the dynamics of production, as within the Keynesian approach.[33] From the structural dynamics of technology and of demand arises, as a consequence, the structural dynamics of employment. In this respect, Pasinetti (1981, 1993) demonstrates that the full employment condition raises a *permanent* problem of complex

---

which is seen as a 'permanent feature of capitalism' (Leon, 1967: 54). But unlike Pasinetti's comprehensive analysis on growth and structural change, Leon does not express his views in mathematical terms.

[32] According to the author, those theories, though very elegant from a mathematical point of view, are entirely dissociated with the historical records of growth and structural change in industrial economies, as documented in the works of authors such as Kuznets and Chenery (Pasinetti, 1993, ch.1). A notorious example is found in von Neumann's multi-sectoral growth model (von Neumann, 1937), in which it is assumed that the relative weights of the different productive sectors are constant over time, thus leading to an equi-proportional dynamics of the entire economic system.

[33] The theoretical framework expresses this separation, by considering two systems of equations, in physical quantities and in prices, which remain separated over time. At the same time, changes in demand and in labour productivity, which determine changes in quantity movements and in prices, respectively, are different in each sector.

macroeconomic coordination.[34] The emergence of technical progress, though extremely beneficial in terms of the new goods and services that it introduces, and the rise in productivity that it brings about, also bears complex problems of adjustment in the economy. In fact, an immediate consequence of technical progress is a decrease in technical coefficients, and thus a tendency to generate unemployment as time goes on. Although there are a number of ways to counter this tendency (see Pasinetti, 1993: 54), full employment can only be reached if there is an adequate level of labour mobility between productive activities and/or a reduction in the available labour (through a decrease in the activity rate and/or an increase in leisure time).[35] In any case, the necessary adjustment that is needed in each single period of time requires the coordination of individual and collective choices that is far from being automatic. This raises a number of institutional and policy questions so as to adequately respond to the challenging task of pursuing full employment.[36]

A common strand of criticism of Pasinetti's theoretical schemes concerns the exogenous treatment of the main engines of structural dynamics, that is, changes in technology and consumers' preferences [see, for example, Gualerzi (2001) and Harris (1982)].[37] Although Pasinetti relates both factors with the *learning principle*, learning itself is essentially unexplained and therefore the question of what moves the driving forces of the economy remains unanswered. At this level, an extension of Pasinetti's 1981 model that relates productivity growth with the emergence of technological revolutions has been proposed by Reati (1998a, 1998b). In line with the long-wave theory, originated in Schumpeter and recently elaborated in neo-Schumpeterian strands (e.g. Freeman et al, 1982; Kleinknecht, 1987; Freeman and Perez, 1988), in Reati's model (Reati, 1998a) radical process innovations entail a substantial rise in productivity for the innovator that is progressively diffused throughout the sector in a non-linear fashion. The pattern of diffusion influences the productivity curve of the sector, which, in turn, determines the dynamics of the price system.

---

[34] Unlike steady-state growth models, in Pasinetti's framework there is never a possibility of maintaining equilibrium conditions through time. Technical change and the evolution of consumption patterns operate continuously, thus leading to new conditions of economic equilibrium, one period after another.

[35] In this respect, increases of per capita demand would not be sufficient, given the inherent tendency of saturation of consumption described by Engel's law.

[36] At this point, it is worth recalling that although this work may be seen as presenting a theory of technological unemployment, following previous insights developed by Keynes, it goes well beyond Keynes' short-term analysis. In fact, it shows the existence of a permanent problem of unemployment that arises from the very nature of long-run growth, which is a distance removed from the usual Keynesian argument.

[37] Gualerzi, in particular, has argued that Pasinetti's reliance on Engel's law and on the inherent simplified notion of needs and needs hierarchy is not capable of capturing the technological and social dimensions that influence consumption, meaning that the articulation with economic development cannot be appropriately explored.

In the more elaborated version of the model (Reati, 1998b) the influence of long-wave patterns on demand and on the dynamics of the quantity system is also explored. In particular, it is shown that demand, as well as physical output in the final sectors, also exhibit a S-shaped profile. The impact of innovation in employment is relatively uncertain, depending on the nature of the particular innovation at issue (that is, if it is a product or a process innovation), and in the case of process innovations, depending on the values assumed by price and income elasticities of demand. Andersen (2001) also attempts to endogenize demand and technology factors in Pasinetti's 1993 model, by transforming this framework into an evolutionary model with explicit microfoundations. The microfoundations rest upon the definition of a number of 'rules of thumb' concerning the endogenous evolution of demand coefficients, labour coefficients and the number of available sectors, which is initially explored in a 'Robinson Crusoe economy', and in the last part of the paper is extended to the the more general case of an economy formed by several exchanging consumer-producer firms. As aknowledged by the author, the present version of the model demonstrates that Pasinetti's theoretical scheme can be approached by a 'bottom-up' perspective, but there is still a long way to go before its 'structural economic dynamics' can be derived from a micro-founded evolutionary frame of analysis.

Another attempt to to endogenize demand on a dynamic theory of growth and structural change, this time through the consideration of an endogenous process of market creation, has been developed by Gualerzi (2001). In *Consumption and Growth*, Gualerzi integrates several elements of Schumpeter, Pasinetti and Levine's contributions (among others) into a demand-led growth theory elaborated within a Keynesian framework, in which market expansion, associated with the evolution of consumption patterns, leads to and is fuelled by investment. More precisely, market expansion depends on the strategies of market development pursued by firms in order to identify and benefit from potential demand, which determine changes in consumption that in turn create conditions for further investment. Those strategies vary according to the 'stage' of market development - the innovation, intensive growth and extensive growth phases – which in broad terms follow product cycle stages. Like in Schumpeter's work, innovation is followed by growth and structural change, but in this case the structural dynamics of market creation is associated with the evolution of consumption patterns. In this context, a great emphasis is put on the adequacy of new products to the individuals' needs (which are socially determined and as such do not arise 'naturally') and an important role is addressed to uncommitted income and to its distribution. As the author

clearly recognizes, the theoretical effort carried out is still very general and schematic, and it is not expressed in a formally rigorous manner.[38] But even in these terms, it sheds considerable light on relatively unexplored aspects of the growth process, providing fruitful questions for further theoretical work.

Differently from these contributions, Baumol's (1967)[39] seminal work on the relationship between structural change and economic growth does not explicitly take into account the demand side. A major emphasis is given to the uneven impact of technology among sectors (like in Pasinetti's work), which ultimately explains the 'unbalanced' nature of economic growth. According to Baumol, the economy can indeed be seen as comprising two major groups of activities: those that are technologically progressive, in which innovations, capital deepening and economies of scale boost a continuous rise in productivity; and those that can only enjoy sporadic increases in productivity.[40] This distinction between sectors is put forward in a model, in which labour productivity rises cumulatively in one sector, while in the other it is held constant over time. Since wages increase in the same way in all sectors, this leads to the cumulative rise of relative costs in the non-progressive sector of the economy, which cannot compensate for the rise in wage levels. Consequently, the activities in this latter sector will tend to be driven off the market, unless their demand is relatively price inelastic.[41] In this case, their relative share in output can be maintained, and as a result, an increasing number of the total labour force must be transferred to this sector, with the consequent slowdown in the rate of growth of the economy (the well-known 'cost-disease' effect). Considering that there is a low substitutability in demand structures, this result can explain the increase in the 'service share' in total employment in the economy, an argument that has had considerable echo in the services literature.[42]

Recently, an attempt was made to include the demand side in Baumol's model and examine the consequences of 'cost-disease' on aggregate employment. Extending Baumol's model through the introduction of Pasinetti's sectoral demand functions, Notarangelo (1999) shows

[38] Gualerzi himself sees his contribution more as a 'framework capable of guiding more focused empirical studies' (Gualerzi, 2001: xiii) than a means to provide determinate predictions.

[39] A more recent application of the original model can be found in Baumol (2001).

[40] This basic distinction stems from the intrinsic nature of the activities, and particularly from the role played by labour in the corresponding production processes. While in some activities, such as manufacturing, labour is only a means to attain the product, in others, like most of the service activities, it constitutes an end in itself. This particular feature makes technological substitution of the workforce difficult to achieve, and thus productivity increases are slower than in the rest of the economy.

[41] At this point, Baumol (1967) argues that some activities that face relatively inelastic demands may continue in the market, either by receiving public support (like theatres, for example), or by becoming market niches, directed towards luxury trade (such as high quality food or clothing services).

[42] For a recent survey, see Shettkat and Yocarini (2006).

that the former can be interpreted as a particular case of Pasinetti's model, with labour mobility between productive activities being a necessary condition for macroeconomic stability and sectoral growth rates depending on both productivity and demand factors. It is shown furthermore that the change in the relative shares of employment predicted by Baumol may lead in some cases to the rise of involuntary Keynesian unemployment.

As will be further explored in the subsequent section, the above mentioned seminal formal contributions remained quite distant from a contemporaneous far more prolific strand of research within a structural change focus developed along appreciative and historical lines. Furthermore, with the notable exceptions of Leontief's input-output model and Baumol's unbalanced growth model, which have prompted a vast number of empirical applications,[43] most theoretical developments remained confined into the strict field of economic theory, or gave rise only to a few incursions into the empirical level of analysis. A notable example is Pasinetti's model of economic growth and structural change. Despite being the most prominent theory of structural change (see Table A2), it has given rise (to our knowledge) only to a very recent empirical application developed by Hölzl and Reinstaller (2007).[44] The concept of vertically-integrated production has also been used in a relativelly small number of empirical studies describing the connections between sectors and the processes of productive integration (see, for example, Peterson, 1979; Wolff, 1985; Sánchez Chóliz and Duarte, 2006). There seems thus to remain a wide gap between economic theory and empirical research, despite the growing availability of data and the increasing sophistication of statistical and econometric methods.

5. Empirical and historical processes of structural change

Contrasting with its general neglect in formal theories of economic growth, structural change has traditionally played a fundamental role within empirical and theoretical studies of developing and transition economies. In fact, the early stages of development economics as an autonomous field of research were characterized by a 'systemic' view of economic reality, with most studies attempting to explore theoretical arguments by which the observed

---

[43] Leontief's input-output approach, in particular, was mainly conceived as a tool applicable to empirical analysis (cf. Leontief, 1987), which explains the wide dissemination of the method in empirical work. For an overview of the numerous areas of application of input-output models see Rose and Miernyk (1989).

[44] Hölzl and Reinstaller (2007) use Pasinetti's (1981, 1993) model of structural dynamics in the specification of a structural vector autorregressive model which allows them to study the relative importance of productivity and demand shocks in generating sectoral growth and their relation to industrial change in Austrian manufacturing during the 1971-1995 period. The results show some correspondence with Pasinetti's main predictions; in particular, it is found that sectoral patterns in employment and output growth depend negatively upon productivity growth and positively upon sectoral growth rates of demand, though there is some heterogeneity of responses among sectors.

processes of structural transformation could best be explained. Those theoretical explanations were mainly developed along appreciative strands, with little resource to formal reasoning, and a policy-oriented approach was generally undertaken, with a number of policy recommendations aimed at improving countries' economic performance being formulated. A few examples of this approach can be mentioned. Rostow's 'stage approach' to development (Rostow, 1960) reported the existence of structural discontinuities in the process of development, which were related to the concept of necessary pre-requisites for the transition to higher stages of development. One of the pre-requisites of the centre stage – the take-off – was the emergence of a leading sector that would induce the transformation of the productive structure in order to achieve higher rates of growth. Although this theory was later heavily criticized, in particular by Gershenkron (1962), who argued against the notion of a unique path of development, it had considerable impact on the contemporary views of development. At about this time, the dual-economy models (Lewis, 1954) and 'big-push' theories were also very popular. They all stressed out the importance of taking into account sectoral differences in order to explain the overall progress of the economy. In Lewis's model those differences were addressed through the distinction between the traditional and the modern sectors of the economy. In the face of a stagnant traditional sector with a high elastic supply of labour, the shift of labour towards modern industry would be beneficial at the aggregate level, as workers with low productivity would be put to more productive uses, and growth would continue until the modern sector had exhausted all reserves of labour in the subsistence sector. The works of Rosenstein-Rodan (1943, 1961) and Nurkse (1953), in their turn, emphasized sectoral differences as a requirement for balanced growth. In the former, the complementarities among different industries, such as those between production and consumption structures, were the main argument in favour of large-scale planned industrialization (the 'big-push'). Only through a planned industrialization effort would it be possible to distribute investment in the 'right' proportions, matching the structure of output to the structure of domestic demand. Nurkse, for his part, argued in favour of the promotion of a diversified increase in output that took into account domestic elasticities of demand in order to create mutually supporting demand (Nurkse, 1953). The necessity of directing investment resources towards expanding the capacity of the basic sectors of the economy through planning was also stressed by Dobb (1960), Sen (1960) and Navqi (1963), who shared Lowe's concern on the strategic role of the machines-tool sector.

Changes in the composition of production, employment and trade were also crucial within the 'structuralist' school of thought originated at ECLA (e.g. Prebisch, 1950; Furtado, 1967). The unifying and determinant idea behind this school of thought derived precisely from the notion that developed and developing countries had fundamental differences in the structure of their economies, and that those differences led to a continuous and reinforcing movement towards the progressive dependency of the periphery relatively to the centre. According to the expressed views, unless state intervention aimed at promoting the structural transformation of the economy was implemented, developing economies would face unemployment, external disequilibrium and deterioration of the terms of trade which would materialize into a vicious circle of underdevelopment.

In a different approach, a vast amount of studies attempted to identify generalizations about long term economic development and structural change based on comparative study of historical experience. In many cases the analysis started from the aprioristic decomposition of the economic system into a relatively small number of sectors, and structural dynamics were mainly identified with the process of sectoral re-proportioning of the economy. Hoffman (1931, 1958), for example, investigated the pattern of industrial growth in a group of economies distinguishing between consumer and capital goods industries. According to his view all industrialization processes could be described by the evolution of the relative weights of the two groups of industries, with the capital goods industry raising its relative importance in the course of the development process. Fisher (1939), in his turn, adopted a tri-partite decomposition of the economy, distinguishing between primary, secondary and tertiary production. Despite using Clark's original nomenclature,[45] Fisher proposed a different interpretation that was based on the structure of consumer demand.[46] Under this formulation, Clark's scheme acquired a more precise connection with the relationship between growth and changes in output and demand composition, which according to the author permitted to focus attention on the 'growing points' of the economy. A tri-partite decomposition of the economic system, which in broad terms reflects the 'agriculture, industry and services' classification, was also used by Kuznets (1961, 1971) in his notable empirical contribution on the economic

---

[45] Clark (1938) identified in broad terms primary production with agriculture and related industries (like fishery, forestry, and hunting), secondary production with manufacturing, and tertiary production with all economic activities not included under the first two categories.

[46] Under the proposed framework, primary production would be related to the economic activities that satisfy basic primary needs, secondary production would include 'all manufacturing activities designed to produce things for which there is a more or less standardized or conventional demand, but which could not be described as essentials' (Fisher, 1939: 31), and finally, tertiary production would include 'every new or relatively new type of consumers' demand, the production and distribution of which is made possible by improvements in technical efficiency, which release resources hitherto required for primary or secondary production' (Fisher, 1939: 32).

growth of nations.[47] Building upon historical series of national income and product for a vast number of countries, Kuznets found a historical association between high rates of growth of per capita product and productivity and the high rate of shifts in production structure. The strong association between growth and structural change was then explained as the result of the combined action of three main factors - changes in the structure of consumer demand, changes in comparative advantage and changes in technology – from which technological change assumed clear prominence. According to the expressed argument, the uneven distribution of technological innovation among the existing branches of production led to the concentration of its influence on a particular group of 'growth' industries, which induced the overall transformation of the productive structure. This transformation was then followed by changes in other aspects of the social sphere, including demographic, legal and institutional changes, and changes in 'social ideology', which in turn could be translated into further changes in technology and in the structure of production.[48]

Other studies adopted a similar approach, but derived the decomposition of the economic system from the analysis undertaken, rather than relying on an aprioristic classification of economic activities. A few examples can be found in the works of Svennilson (1954), Rosenberg (1963) and Chenery and his co-authors (e.g. Chenery, 1960; Chenery and Taylor, 1968; Chenery and Syrquin, 1975). Svennilson examined in great detail the process of economic transformation in a number of European countries in the first half of the 20th century, building on long series of national aggregates and markets and industries's data. From this analysis, he pointed out a number of interdependencies between long-term economic growth and structural transformation. Changes in consumers' demand accompanying rising income, for example, were seen as giving rise to changes in the industrial and occupational distribution of the labour force, and to changes in the form of population settlement, which in turn could influence growth, by revealing new needs that induced further innovation. The role of investment in promoting technological transformation and economic growth was also emphasized by Svennilson, who considered the inertia in the renewal of capital equipment as one of the main factors explaining the observed low rate of

---

[47] Though reflecting to some extent the basic criterion of Fisher (1939), expressing the position occupied by the products on the scale of the immediacy and priority of demand, this decomposition of the economic system was not used by Kuznets, as it was by Fisher, as a means to infer the growth potential of the economy. In fact, Kuznets points out several flaws in the sectoral structure considered, which arise mainly from its incapacity to reveal the impact of technological progress on growth, the basic source of 'modern economic growth' (Kuznets, 1971).

[48] The sequences of change in the economic and social structure as described by Kuznets (1971) can follow a number of different paths. The path described in these lines is only one of the possibilities.

economic growth in Europe in the interwar period.[49] The link between investment and economic growth was also stressed by Rosenberg (1963), though different reasons were called upon. Analyzing the history of today's developed countries, Rosenberg highlighted the crucial role that the capital goods sector has had in stimulating technological innovation. Not only was it in this sector that most of the major innovations arose, but most importantly, it was the emergence of a progressively more highly specialized capital goods sector that opened the way to the formation of a technological background that has provided the necessary skills and attitudes conducive to technical progress. According to Rosenberg, the size of the capital goods sector takes on critical importance: in line with Smith (1776), it is argued that the efficiency of capital-goods industries, more than consumer-goods industries, depends to a considerable degree on the extent of the division of labour, which in turn depends on the size of the market. Because capital-goods industries usually enjoy economies of specialization, benefiting from increasing efficiency levels when they concentrate on a relatively narrow range of products, a large demand for their products is necessarily required.[50]

The search for uniform patterns on the relationship between long term economic development and changes in the economic structure using both cross-section and time series data was also actively pursued by Hollis Chenery, on his own and in collaboration with other authors (e.g. Chenery, 1960; Chenery and Taylor, 1968; Chenery and Syrquin, 1975). A common feature of these studies is the use of a rigorous statistical framework in the search of regularities from which an endogenous determination of structural classification schemes and an identification of general patterns of economic development is derived. Chenery and Taylor (1968), for example, compare post-war changes in the composition of the national product of several countries using a panoply of econometrical tests and from this exercise they derive the clustering of the economies into three distinct groups – large, small primary-oriented and small industry-oriented - which show different growth patterns, and reveal distinct interactions of scale and resource endowments. Chenery and Syrquin (1975) extend the search for uniformities, enlarging the number of structural variables considered and applying

---

[49] In this context, we may see a convergence between Svennilson's empirical findings and Lowe and Hicks's models of 'traverse analysis', which emphasized precisely the limitations imposed by the inherited stock of fixed capital in the process of economic growth.
[50] Applying this argument to underdeveloped economies, Rosenberg (1963) argues that their incapacity in developing capital-saving techniques in a symmetrical way to that which occurred in developed economies (where the relative scarcity of labour gave rise to the development of labour-saving technology) is explained by the absence of an organized domestic capital goods sector. Indeed, the capacity to develop capital-saving technologies would necessarily imply the development of a capital goods sector in the first place.

regression analysis to a very large sample of countries.[51] From the regression results they derive 'stylized facts' of development, and establish a typology of developing countries that takes into account resource endowments and differences in development strategies along with other structural variables.

It is worthwhile pointing out that this line of research associated with the study of developing and transition economies has been developed quite independently from formal theories of growth and structural change, analysed in the previous section. In fact, there are only a few convergence points between both streams of the literature, most notably related to the Marxian-based contributions to development and economic planning (e.g. Feldman, 1928; Mahalanobis, 1955; Dobb, 1960; Sen, 1960) which, as already noted, adopted theoretical shemes similar to Lowe's model, and to the application of Leontief's input-output model to the analysis of developing economies.[52] Many early applications of the input-output method were precisely carried out within the broad area of economic development, with the method being used in the analysis of a full range of problems facing developing economies, such as the allocation of investment, barriers to trade, inflation or income distribution.[53] For the rest, it seems fair to say that both approaches enjoyed quite separate existences.[54]

The literature on structural change associated with the study of developing and transition economies suffered, however, a considerable decay in the 1970s, when development economics experienced a profound transformation in its core methodologies and major themes of debate (Backhouse, 1990). The interest in the formulation of (ambitious) macro theories of development strongly declined with the shift of development economics towards a micro approach that made intensive use of the neoclassical toolbox. In contrast with earlier models that stressed 'structural rigidities', this new (neoclassical) approach assumed the existence of a reasonable degree of flexibility in the economy (e.g. Little, 1982). The answers to be given to the problems of underdeveloped economies, according to this new approach, ought to be based on the definition of the right incentives to get markets working (Easterley, 2002), rather than on substituting the market through (structuralist) planned intervention. The

---

[51] Only socialist countries and countries with very low levels of population were excluded.

[52] Interestingly, a recent contribution from Araújo and Teixeira (2002) formally demonstrates that the Feldman-Mahalanobis growth model can be seen as a particular case of Pasinetti's (1981, 1993) model of structural change, a relation that had already established in descriptive terms by Halevi (1996).

[53] For a comprehensive overview of the application of input-output analysis in development planning and policy see Rose and Miernick (1989).

[54] It is worth noting, at this point, that while Chenery did not made use of any particular theory in the study of the relationship between structural change and long-term development, he did consider the Walrasian general equilibrium theory in what concerned the overall functioning of markets and prices [see, in this respect, Chenery (1988) and Ascher (1996)].

resurgence of neoclassical development economics and its reliance on the price mechanism led inevitably to decreasing interest in structural change analysis, though the latter on its own does not necessarily translate into state intervention. As Chenery (1988) puts it, 'recognizing the interrelations among the principal elements of the structural transformation does not in itself constitute an argument for more government intervention or overall planning' (Chenery, 1988: 201). But even in a considerable lesser extent than before, some studies still follow the traditional approach, attempting to formalize earlier theoretical contributions (e.g. Murphy et al., 1989; Ros, 2000) and to extend and refine the search for regularities regarding structural transformation and economic growth from intercountry and intertemporal comparisons (e.g. Wang et al., 1992; Raiser et al., 2004). Ros (2000), for example, combines Lewis, Rosenstein-Rodan and Nurkse's contributions into a formally rigorous development model, which generates multiple equilibria, so that depending on initial conditions, vicious or virtuous circles of development can arise, explaining both observed patterns of divergence and convergence among countries. Raiser et al. (2004), for their part, develop an analytical framework that permits to overcome some of the drawbacks associated with the methodology used by Chenery and his co-authors in cross-country comparison of economic structures. In particular, a model is developed in which the notion of 'stylyzed facts' of development is made compatible with the existence of structural differences in countries with similar levels of income.

Some of the earlier structuralist analysis has also reemerged within the SCEPA research group of the New School for Social Research, though in a way more in line with conventional economic analysis. An important part of the research undertaken in this centre which has a broad policy-oriented approach focuses on growth and development experiences of developing and transition economies from a structural change perspective (e.g. Pieper, 2000; You and Lee, 2000; Milberg, 2004; Rada and Taylor, 2006). These studies examine the ways by which transition and developing economies have responded to liberalization and market-oriented policies, emphasizing the role of structural and institutional changes in the process. In studies in which a comparison between countries is undertaken, the general conclusion is that sustained growth experiences in successful regions are intimately connected with strong structural transformation, comprising changes in output, employment and international trade sectoral shares, while slow-growing regions experience much more modest changes (e.g. Pieper, 2000; Rada and Taylor, 2006). At the same time, there is a widely expressed view according to which broad-based industrial upgrading and higher labour standards in developing economies can only be attained if industrial policies, combined with focused

competition policies aimed at promoting R&D and developing technological capabilities are put into practice (Pieper, 2000; Milberg, 2004).

6. Recent trends in structural change analysis

A brief overlook of Figure 1 below, which presents the evolution of the relative weight of articles on structural change analysis in the total articles published in the Econlit database during the 1969-2005 period, reveals a striking rise in the interest on the matter in the more recent period, more precisely from the 1990s onwards, when compared with the previous decades. The rising importance of this approach in this period is also apparent from the establishment in 1990 of a new journal devoted particularly to this topic - *Structural Change and Economic Dynamics*.


Figure 1: Evolution of the relative weight of articles on Structural Change in the total articles published in Econlit, 1969-2005

Note: The line results from dividing the number of papers on structural change by the total number of papers published in each year in journals indexed in Econlit. Just as a reference, the number of papers published under the heading of 'structural change' totalled 1247 between 1969-2005, whereas the corresponding number for all areas is 453457.

The marked uprise of papers published on structural change analysis in the more recent period is accompanied by a change in the main themes of analysis explored. Along with 'convergence and growth' that remains the most relevant category throughout the period under study, but which has recently lost ground, there is a notable increase in 'international trade' and in 'technical change and innovation' themes of analysis which importance has been continuously rising, and is particularly relevant in more recent years.[55]

---

[55] The classification of papers according to the main theme of analysis was only performed from the 1980s onwards, because in the earlier period the selected papers did not have an abstract.
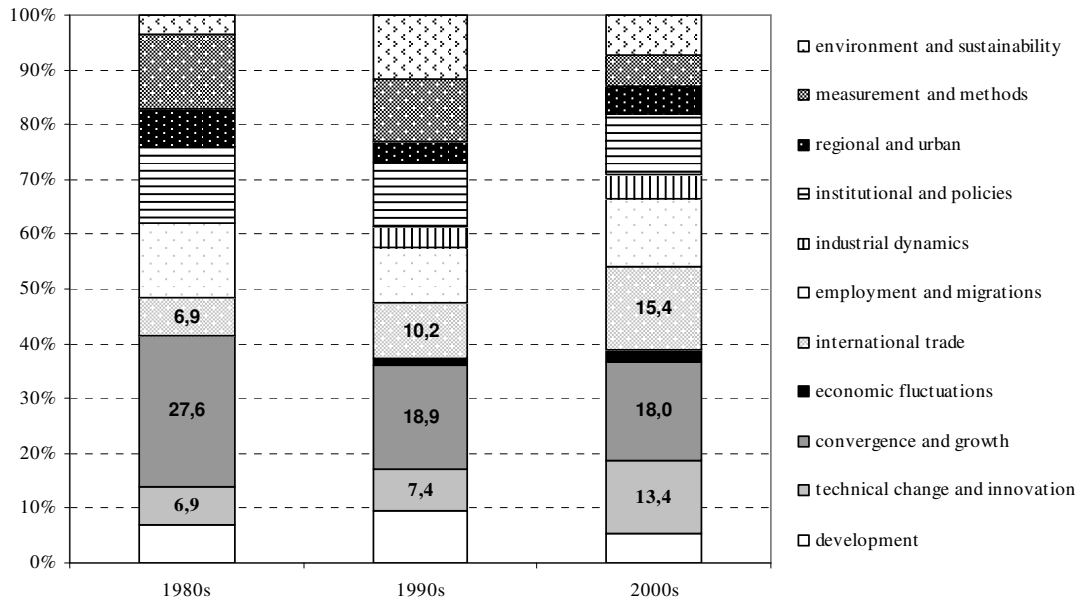
Figure 2: The distribution (%) of papers on Structural Change by main theme of analysis

Source: Authors' own computations based on articles in journals collected from the Econlit database, 1969-2005 (n=910).

The same tendency can be seen from the classification of articles by JEL codes, in which the temporal period under study is extended by an additional decade – the 1970s. In this case, the increasing relevance of technological issues is even more evident: the share of papers concerned with Technological Change (which is usually included under the heading JEL code O – Development, Technological, Change and Growth) almost trebled from 5.4% in the 1980s to 13.8% in the 1990s. This trend remained in the 2000s reaching the status of dominant category in this last period.
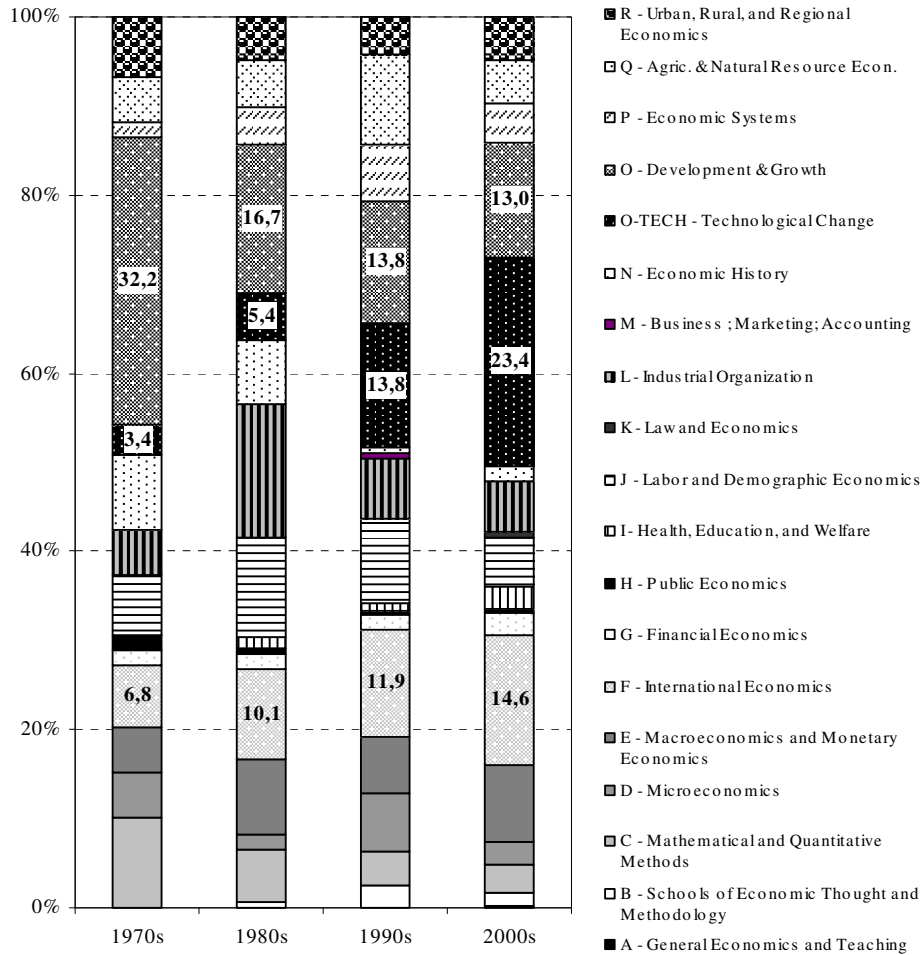
Figure 3: The distribution (%) of papers on Structural Change by JEL Codes

Source: Authors' own computations based on articles in journals collected from the Econlit database, 1969-2005 (n=910).

In light of these results, the rising importance of structural change analysis seems to be primarily related with increasing interest in the explanation of the phenomena of technical change. As it has been repeatedly pointed out in the literature (see, for example, Freeman, 1994) the 1980s and 1990s witnessed 'a far greater readiness to look inside the 'black box' (Rosenberg, 1982) and study the actual processes of invention, innovation and diffusion within and between firms, industries and countries' (Freeman, 1994: 464). The emergence of the *New Economy* and the controversy generated around the impact of information and communication technologies (ICTs) on aggregate productivity growth (the so-called 'productivity paradox') further stimulated the debate on technical change and its impact on

growth.[56] Together with important developments occurring in mainstream economics (e.g. Lucas, 1988, 1993; Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992), a growing body of the literature has been developed in the last 20 years under an alternative approach, known as 'neo-Schumpeterian' or 'evolutionary' economics (see Figure A1 in Appendix). Proponents of this latter approach strongly criticize mainstream economics, arguing that a theory which is firmly grounded on purely rational behaviour and equilibrium assumptions cannot deal appropriately with the complex and uncertain nature of technology (see, for example, Nelson and Winter, 1982; Dosi, 1988; Dosi et al., 1988). In contrast, they stress the idea of disharmony and competition in the growth process, and place themselves at quite distant from aggregate production function models, by explicitly addressing the connection between processes of change at micro and industrial levels and overall macroeconomic dynamics.[57] From this perspective, processes of microevolutions of technique, organization and institution are significantly affected by higher-level changes and vice-versa, which means that causal connections between macroeconomic variables cannot be fully understood without considering the interdependence among the different levels of analysis (Nelson and Winter, 1982). It is precisely in the connection with this attempt to develop an alternative to mainstream economics for the analysis of the relationship between technical change and economic growth that, according to our view, a substantial part of the recent uprise of interest in structural change analysis can be explained. Indeed, structural change analysis comes forward as a powerful analytical tool that is capable of establishing the links between changes at the level of microstructures and higher-level changes, while providing, at the same time, a more realistic account of the process of technology adoption and its effects on the economy, by emphasizing the sequential and path-dependent nature of economic change. In particular, it provides a useful foundation for the study of the adjustment and intertemporal coordination problems brought on by technical progress, an issue that is totally neglected by the mainstream equilibrium approach, which takes intertemporal coordination for granted.[58] As Amendola and Gaffard (1998: 107) clearly state 'it is only through the consideration of relations which bring about different aggregations that we

---

[56] See, for example, Baily and Gordon (1988), David (1990) and more recently Freeman (2001) and Amendola *et al.* (2005).

[57] One of the main challenges posed by Nelson and Winter in their landmark book *An Evolutionary Theory of Economic Change* (Nelson and Winter, 1982) concerns precisely the need to establish the links between diversity and uncertainty at the micro level and relatively ordered growth and technological patterns at the macroeconomic level.

[58] See in this respect Amendola and Gaffard (1998), and more recently Amendola *et al.* (2005).

introduce real time, irreversibilities, and qualitative change', and are thus able to address the complexity and uncertainty of technical progress.

It is no surprise, in this context, to find amongst the most influential works in structural change analysis in the more recent period, along with the seminal works from Pasinetti, Goodwin, Leontief and Baumol, several contributions associated with neo-Schumpeterian and evolutionary strands of thought.[59] Indeed, according to our citation analysis (which can be consulted in Appendix), a significant part of the most cited works (Table A2) is developed by authors who elaborate Schumpeter's theoretical scheme relating innovation, economic growth and structural change into a systemic theory of innovation and diffusion (such as Cristopher Freeman, Giovanni Dosi, Richard Nelson and Sidney Winter, among others).[60] Within such a perspective, the strong connection between major technological breakthroughs, structural change and economic growth is analysed in terms of technological systems, trajectories of technology and technological paradigms. Freeman et al. (1982), in one of the seminal contributions in the field, suggest the notion of 'new technological system' to account for the 'constellations of innovation which are technically and economically interrelated' (Freeman, 1991: 223). A historical overview of the succession of 'technological systems' since the First Industrial Revolution is provided by Freeman and Soete (1997), who characterize the current epoch, strongly based on the application of information and communication technologies, as the 'information age'. Dosi (1982), in his turn, uses the Kuhnian concept of 'scientific paradigm' to derive the analogous concept of 'technological paradigm', which in his model ultimately determines the cluster of possible technological directions to pursue ('technological trajectories').[61] This framework allows him to distinguish between continuous changes and discontinuities in technological innovation by considering, respectively, changes along a technological paradigm and changes in the paradigm itself. At the same time, it sheds some light on the procedures by which new technological paradigms emerge and are selected among a set of possible options, permitting to identify regularities in the pattern of technical

---

[59] Goodwin's later work can also be characterized as 'evolutionary'. During the last 10 to 15 years of his life, Goodwin attempted to integrate in a unified framework of analysis Schumpeter's insights on technology and innovation with Marxian ideas of functional distribution of income and Keynes's concern on lack of effective demand. See, for example, Goodwin (1987, 1991, 1993) and Landesmann and Goodwin (1994).

[60] Along with this very large 'cluster' comprising neo-Schumpeterian insights, there is a smaller cluster of authors that focus on economy-environment relationships and on the long-term viability of economic processes. This cluster is composed by the contributions of Nicholas Georgescu-Roegen, Faye Duchin, Robert Ayres and Robert Costanza.

[61] Nelson and Winter (1982) use the concept of 'natural trajectories' to refer to the same technological paths within a technological paradigm.

change that may partially account for the relatively ordered patterns of growth.[62] Perez (1983, 1985) further explores the relationship between technological trajectories and structural change introducing the concept of 'techno-economic paradigm'. According to Perez, it is possible to identify the Kondratiev waves with the rise and fall of successive technological revolutions, which introduce new ways of managing and organizing the economy that are so pervasive that they affect almost all industries and economic activities. In this case, the change from one paradigm to another not only lies in the opportunity to economically explore a cluster of radical innovations, as in Dosi's work, but it is crucially dependent on the emergence of a 'key factor' whose abundant supply, rapidly falling costs and multiple applications facilitate the spread of innovation throughout the economy.[63]

All these contributions stress the profound impact of *diffusion* of major technological breakthroughs in the structure of the economy and in economic growth. As the diffusion of the pervasive new technologies unfolds, the dynamic set of industries that is more closely related with its exploitation assumes progressivelly higher importance, stimulating growth, while sectors associated with older technologies see their relative influence diminish. Not only there is considerable change in the growth rates and in the productive structure of the economy, but also important institutional and social changes arise. As argued by neo-Schumpeterian theory, diffusion is never immediate or automatic, but is strongly dependent upon a number of characteristics of the 'receiving' economy, and in particular in its ability to adequate its institutions to the new forms of organization and management of the economic activity required by the new technological paradigm [see especially Perez (1985) and Freeman and Perez (1988)]. At the same time, because the assimilation and development of technology by the country (firms) is strongly influenced by the specific historical, cultural and institutional environment where firms are located, geographical factors gain theoretical relevance, as explored by Nelson and Wright (1992) in their concept of 'national technology' and by Freeman (1987, 1992), Nelson (1992, 1993) and Lundvall (1992), among others, in the literature on national and regional systems of innovation.

Research developed in neo-Schumpeterian and evolutionary strands focusing on the diffusion process in an international perspective is also heavily cited in our database (e.g. Fagerberg, 1987, 1988a, 1994; Abramovitz, 1986, 1994; Dosi et al., 1990; Verspagen, 1993). In this

---

[62] In this respect, Dosi (1982) explicitly considers the interplay between scientific advances, economic factors and institutional variables, providing a more comprehensive account of the factors behind technological change than do the pure 'demand-pull' (Schmookler, 1966) or 'technology-push' theories.

[63] At the turn of the 20th century, for example, the role of key-factor was played by low-cost steel, whereas in our days, according to Perez, it falls upon cheap microelectronics.

'technology-gap' literature the non-automatic character of diffusion is once again strongly emphasized. Successful catch-up, it is argued, can only be achieved by countries that possess adequate 'social capabilities', that is, those with sufficient educational attainements and adequately qualified and organized institutions that enable them to exploit the available technological opportunities.[64] The pace at which the potential for catch-up is realized depends furthermore on a number of factors, related with the ways in which the diffusion of knowledge is made, the domestic capability to innovate, the pace of structural change, the rates of investment and expansion of demand, and the degree of 'technological congruence' (Abramovitz, 1986, 1994) of the backward country relatively to the technological leader. Recent work in this area (Fagerberg and Verspagen, 2002) suggests that catching up on the basis of diffusion has become more difficult in the more recent period, while innovation has increased its relative importance. This finding is interpreted as reflecting the new (and higher) requirements imposed by the new technological paradigm (the ICT revolution), in terms of skills and infrastructure, in the process of technological imitation.

As we have indicated, the neo-Schumpeterian approach to the analysis of the relationship between technical change and economic growth is build upon a much broader (and realistic) account of technical change than conventional mainstream analysis. Technical change is conceived as a cumulative and path-dependent 'learning' process that is strongly embedded in organizational and institutional structures.[65] In this process, there is an ever-presence of elements of uncertainty and diversity, and the technology that ultimately is 'selected' by market forces is not necessarily the most efficient one (which once more contrasts sharply with mainstream assumptions of optimizing rationality). This issue is explored in great depth in the works of Paul David and W.B. Arthur (e.g. David, 1975, 1985; Arthur, 1988, 1989, 1994), which lie amongst the most cited works in our database (Table A2; Figure A1). In general terms, David and Arthur show that the occurrence of random events or 'historical accidents', particularly in the early phases of the introduction of a technology, may have a decisive influence on the long-run outcomes of the economy. In some cases, the presence of scale economies and increasing returns, whether derived from network externalities, learning effects or investment indivisibilities, may even 'lock-in' the economy to an inferior

---

[64] See Fagerberg (1994) for an overview on the field.
[65] It is worth recalling at this point that the idea of technical change as a learning process, strongly opposed to the neoclassical construction of production functions, is also present in Pasinetti's seminal contributions on structural change and economic growth (Pasinetti, 1981, 1993).

technology, as the example of the QWERTY typewriter keyboard so clearly illustrates (David, 1985).

The above mentioned neo-Schumpeterian contributions focusing on the long-term dynamics behaviour of the economic system and on its association with technical and institutional change, have been mostly developed under appreciative and empirical strands, with few recourse to formalization.[66] Nevertheless, in the recent past a growing body of research has attempted to formalize the main insights from this literature, following Nelson and Winter's (1982) urge to combine 'appreciative theorizing' with formal modelling. In the long-waves literature, for example, Goodwin (1987) presents a model in which the impact of technology on the economy is transformed by the internal dynamics of the economic system, which reshapes the non-cyclical rate of emergence of a major innovational cluster into both business cycles and long waves. Silverberg and Lehnert (1993), in their turn, develop a Schumpeterian dynamic model based on the Goodwin growth cycle, in which a capital stock 'vintage' structure is assumed. Their main finding is that 'clustering' of innovations is not necessary for generating long-waves; it is only required that the process of arrivals of new technologies is stochastic. More recently, Silverberg (2002) presents a 'mosaic-avalanche' model based on percolation theory that illustrates the emergence of macroinnovations from a stream of incremental innovations, which are then transmitted to changes in sectoral structures and macro-economic performance.[67] The conceptual framework of 'technology gaps' has also been formalized by Verspagen (1991), Amable (1993), and more recently, Los and Verspagen (2006). Verspagen (1991) develops a non-linear model of convergence that accounts for both situations of 'catching-up' and 'falling-behind'. It is shown that countries with relatively low 'social capability' levels and with a high technological distance are in great risk of widening their distance relatively to the more developed countries, while countries with high relative levels of 'social capability' and a small initial technological gap are more likely to catch up. Amable (1993) presents a linear catch-up model in which some of the determinants of 'social capability' - investment, innovation and education - are endogenized, and that also allows for both converging and diverging tendencies. More recently, Los and Verspagen (2006) develop a dynamic model in which the impact of innovation, learning and technology spillovers on

---

[66] Notable exceptions are Arthur's (1988, 1989, 1994) and Nelson and Winter's (1982) contributions. These seminal works are, however, mostly focused on the industry-level dynamics of technological evolution, rather than on the analysis of long-term dynamics of the economic system and its association with structural change.

[67] Andergassen and Nardini (2005) have recently developed a model in which innovation waves emerge endogenously from the interaction of single sectors. Their model is, however, explicitly grounded on maximizing behaviour and representative agent assumptions, which are very much at odds with the perspective inherent in the evolutionary framework.

output growth, convergence and structural change is analysed. In line with the technology-gap literature, it is found that convergence between countries is far from being automatic, depending on social capability and on the degree of technological congruence of countries. The simulation results demonstrate, however, that in order to get a deeper understanding of the dynamics of productivity gaps, the influences of learning-by-doing and of the interaction between economic structure and technology have also to be taken into account.

Other attempts to formalize neo-Schumpeterian and evolutionary insights explicitly address the links between changes at the level of microstructures and higher-level changes, drawing attention to the disequilibrium processes by which new technologies are generated and spread out on the economy. These theories are in close connection with structural change analysis, since the dynamics of the economic system is seen as strongly dependent on the structural configuration of the economy and on its pattern of change. One of the earliest contributions in the field can be found in Silverberg et al.'s (1988) evolutionary model of the diffusion of innovations. This model attempts to integrate some crucial features of technology and technical change - namely its inherent diversity and uncertainty, cumulativeness and path-dependency - in the process of diffusion, considering an evolutionary environment characterized by micro-diversity and selective pressures at the firm level. Simulation results show that relatively ordered diffusion paths (the conventional S-shaped form of the diffusion curve) can be derived from turbulent dynamics at the micro-economic level. The emergence of relatively ordered patterns in macroeconomic variables from the interaction among heterogeneous agents in a context of technological diversity is also found in Chiaromonte and Dosi's (1993) evolutionary model of endogenous economic growth. A relatively stable macroeconomic growth pattern is compatible and indeed requires, high heterogeneity at the micro level. The interaction between the micro and macro levels in the economy has been also heavily studied by Eliasson in several studies using the Swedish micro-to-macro model MOSES (e.g. Eliasson, 1984, 1991; Eliasson et al., 2004). In Eliasson et al. (2004) this model is used to perform simulations on the impact and sustainability of the New Economy, under the hypothesis that the full potential of the new technologies can only be accomplished when it is diffused in the 'older industries' through the Schumpeterian process of creative destruction. The simulation experiments show that the time lenght required by new technological paradigms to realize their potential productivity gains is extremely long, which may provide an explanation for the observed productivity paradox. It is also demonstrated that successful adoption of radical technologies is dependent upon the local 'receiver competence'

of the society, which is in line with previously mentioned studies focusing on institutional and 'social capability' factors.

These modelling exercises (and, in general terms, most of the neo-Schumpeterian and evolutionary literature) put great emphasis on technology driven growth (though combined with factors such as institutional change and industry dynamics), lacking a systematic treatment of the demand side. In the recent past there have been, however, some attempts to combine both supply-side and demand-side factors within the micro-to-macro approach to the process of economic development. Saviotti and Pyka (2004a, 2004b), for example, present a model in which changes in the composition of the economic system accompanying the emergence of pervasive innovations are seen in articulation with changes occurring at the demand side of the economy.[68] Indeed, in this model, it is the saturation of given sectors due to Engel's law that induces changes in the composition of the economic system that in turn provides the stimulus for economic growth. Montobbio (2002) also takes into account the role of demand in his evolutionary model of structural change. In this work the intermediate 'meso' level of analysis is brought into the fore, through the extension of Metcalfe's (1998) model on evolutionary dynamics within a single-industry to a multi-sectoral framework.[69] Along with supply and demand factors, it is shown that specific characteristics of firms and sectors, and the specific combination of the characteristics of the interdependent sectors account for patterns of productivity growth at macroeconomic level. In particular, changing sectoral composition due to selection and sorting mechanisms within and between industries plays a significant role, which means that positive rates of aggregate productivity growth can occur, even in the absence of technical progress at the firm level. The relationship between meso and macro levels of inquiry is also approached in a recent paper from Metcalfe et al. (2006). The authors develop an evolutionary model in which growth is perspectived as an essentially adaptive process in response to innovation and changes in demand. Productivity growth differences at the industry level and macroeconomic productivity growth emerge from market coordination processes and are explained on the basis of the combined influence of Fabricant's Law and differential income elasticities of demand at the industry level. In a similar way to the seminal work from Pasinetti (1981, 1993), the explicit consideration of

---

[68] The composition of the economic system is defined in the model under very broad terms, comprising all levels of aggregation, with sectors being defined as 'collections of firms that produce a differentiated product' (Saviotti and Pyka, 2004b: 272).
[69] In so doing, the model goes a step further relatively to the abundant evolutionary literature on the partial frameworks of firm and industry, approaching the relationship between industrial and macro levels of inquiry while taking explicitly into account the role of microfoundations.

demand issues in these models has been done with recourse to a generalization of Engel's law. As stated before, the reliance on Engel's law only permits to take into account a broad hierarchization of needs, and for this reason, it is not capable of addressing the complex interactions between technological change and changes in patterns of consumer behaviour. In this context, the development of a dynamic theory of demand and its articulation with the formal treatment of technological change seems to be an imperative issue for future research in the field.

The attempt to provide a consistent theoretical framework for an alternative approach to the study of economic change, to which the development of a rigorous frame of analysis was seen as a fundamental step (Silverberg, 1988), seem to explain the trend towards increasing formalism observed in the 1990s. Indeed, in this decade, there was a significant increase in the relative weight of articles adopting a purely formal or a combined formal/empirical approach, as can be seen in Figure 4.
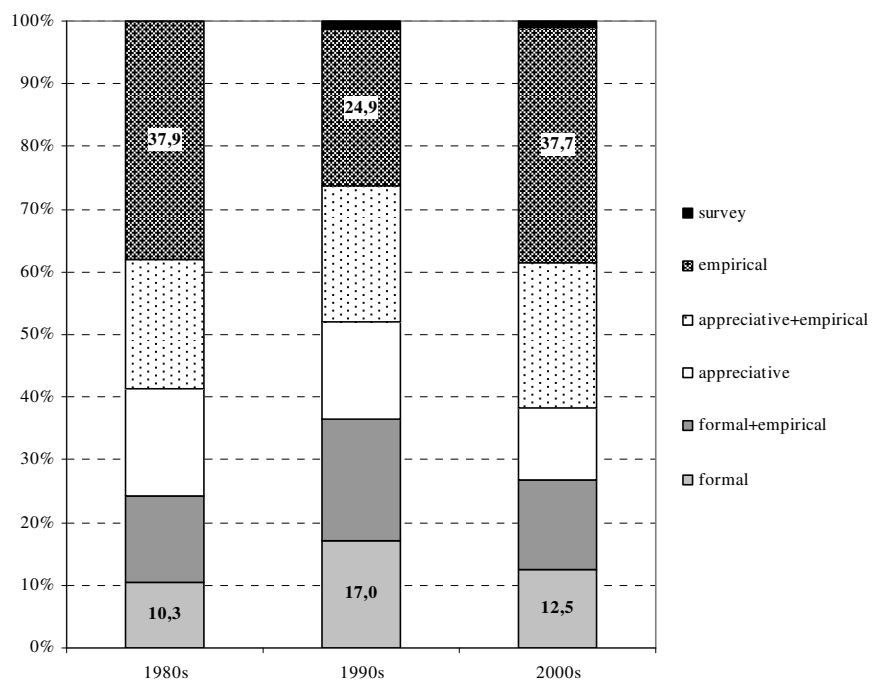
Figure 4: The distribution (%) of papers on Structural Change by Type

Source: Authors' own computations based on articles in journals collected from the Econlit database, 1969-2005 (n=910)

The tendency towards increasing formalism does not seem to have endured, however, in more recent years (the 2000s), with a new decay of the relative importance of formal studies being

observed.[70] It seems that along with the emergence of several modelling exercises (from which we have mentioned only a few), the revival of Schumpeterian themes in articulation with structural change analysis has materialized in a much more intense way in empirically-led studies, which remained dominant over the entire period. Indeed, the emphasis put by neo-Schumpeterian theory on the relationship between economic growth and the group of dynamic industries associated with the new technological paradigm has led to a vast amount of empirical research looking at the impact of leading technological sectors, and in particular of ICT-related industries, in the processes of economic growth and structural change.[71] The contribution from technologically leading industries to aggregate productivity growth has been assessed using both purely descriptive techniques, such as shift-share analysis (e.g. Quah, 1997; Fagerberg, 2000; Timmer and Szirmai, 2000; Peneder, 2003), and econometric estimation methods (e.g. Amable, 2000; Fagerberg, 2000; Carree, 2003; Peneder, 2003). Typically, purely accounting procedures find that the structural change effect has only a minor role in explaining productivity growth, while the use of econometric approaches leads in most cases to the finding of a significant positive relationship between structural variables and economic growth, suggesting the existence of substantial positive spillovers arising from leading technological industries to the rest of the economy (see, for example, Amable, 2000; Fagerberg, 2000; Peneder, 2003).[72] At the same time, the role of technology as a source of productivity growth and structural transformation has been examined in a vast number of contributions using input-output analysis (e.g. Oosterhaven and Hoen, 1998; Peneder et al., 2003; Franke and Kalmbach, 2005; Sánchez Chóliz and Duarte, 2006). The evidence found in these studies points to an important role played by technology in the overall processes of growth and structural change. The results reveal, furthermore, a diferentiated impact of technological change among sectors, with the 'modern sectors' that have the larger growth rates (generally ICT-related sectors and business-related services) being simultaneously the sectors that experience the most positive impact of technological change (e.g. Oosterhaven and Hoen, 1998; Peneder et al., 2003; Franke and Kalmbach 2005).

---

[70] It is important to bear in mind that for this last period, the available data, though analysed in relative terms, relates to only half of the decade.

[71] The growing concern with the effects of the ICT revolution is reflected in the rising share of papers addressing the issue in the more recent period, according to our bibliometric analysis. Their relative importance within structural change research seems however to remain relatively small (only 11% of papers published in the 2000s), though the classification procedure used may have underestimated their relative share (we only counted as 'ICT related papers' the papers whose abstract made an explicit reference to these industries).

[72] A significant spillover effect of ICT related industries is also found in Ten Raa and Wolff (2000), who find that'computers and office machinery' were the main 'engine of growth' of the US economy during the 1970s and 1980s. These findings are based on a new method for the decomposition of total TFP growth that takes into account the spillovers of technical change among sectors within a general equilibrium input–output framework.

The empirical literature on the role of technologically-leading industries on economic growth has led furthermore to a changing image of the services sector, with several studies pointing out the impact of the new technological paradigm in the creation of new and improved services, and in the development of knowledge-intensive service branches (e.g. Petit and Soete, 2000; Petit, 2002; Peneder et al., 2003). The high productivity growth rates found in these sectors, together with evidence showing the decreasing role of manufacturing for economic growth in the more recent period (e.g. Fagerberg and Verspagen, 1999, 2002) has led to the abandonment of the traditional view regarding manufacturing as the major producer and user of technology and as the sector providing the major stimulus to growth (e.g. Kaldor, 1966, 1970; Cornwall, 1976, 1977).[73] The new evidence on the performance of service sectors has inclusivelly led to a change of focus in the services literature, with the debate on the consequences of de-industrialisation and on the impact of rising services in the productivity slowdown being to some extent replaced by a far more optimistic view. In this context, though much of the literature explaining tertiarization still focuses on demand determinants of sectoral growth and on 'cost-disease' arguments (Baumol, 1967, 2002; Baumol et al., 1989), an increasing amount of research has recently been emphasizing the role of technological factors (e.g. Andersen et al., 2000; Miles and Tomlinson, 2000 Peneder et al., 2003).

Following theoretical insights, much of the empirical literature can be criticized for not addressing such fundamental issues as the change in patterns of demand associated with the spread of new technologies, suffering, to some extent, from 'technological determinism'. In a rather singular approach, Gualerzi (2001) has recently provided an empirical account of the structural dynamics of the the U.S. economy in the post-war period in which the ICT revolution is seen in articulation with changes in demand and modes of life. His findings suggest that transformations occurring within the consumption sphere were the key factors in explaining the structural dynamics of the 1980s. Though leading to important advances in technology and innovation, within a process of industrial dynamics that favoured the selective expansion of technologically advanced industries (such as computers, electronics and advanced chemicals), the process of market creation was not capable to sustain generalized expansion and rapid growth. According to the expressed argument, in the 1990s the pace of aggregate growth accelerated because the new technologies were successful in transforming

---

[73] There are, however, other studies that find that the rapid growth of high-qualification services and other services is not reflected in a parallel improvement in their productive efficiency (Sánchez Chóliz and Duarte, 2006; Ten Raa and Wolff, 2000) or see their good performance mostly as a consequence of the structural changes occurring in the manufacturing sector (Franke and Kalmbach, 2005).

the modes of life, overcoming some of the limits that constrained market expansion in the 1980s. But even in this more optimistic scenario, there remains a 'pattern of selective and highly concentrated expansion' that makes unclear the extent to which the new technologies can effectively sustain a new long wave of development.

A last point on the characterization of the recent developments on structural change analysis is worth mentioning. When only the papers published in *Structural Change and Economic Dynamics* (SCED) are considered, the relative importance of formal vs. empirical studies is reverted, though the marked uprise of empirical work in the 2000s is maintained (Figure 5). Indeed, formal studies become the dominant category, with formal and formal+empirical studies representing 59.3% and 44.6% of total papers published in the 1990s and 2000s, respectively.
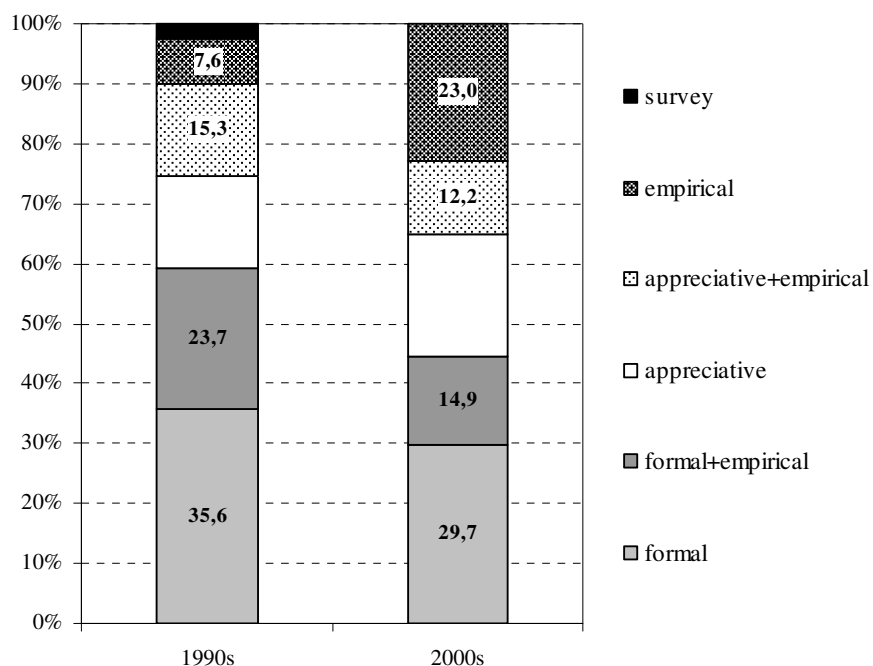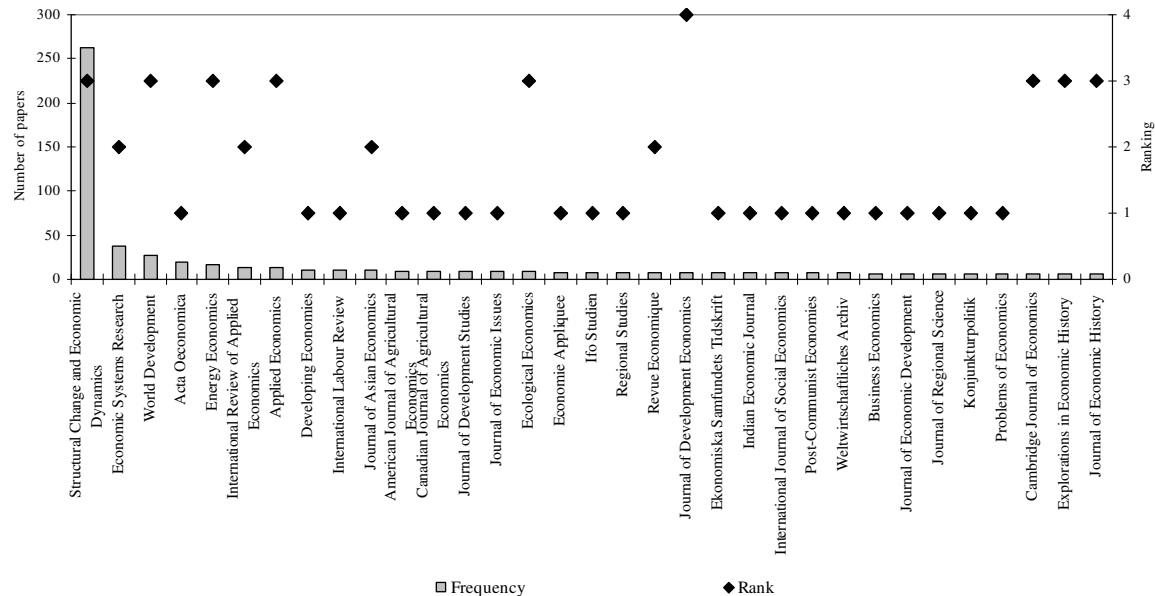

Figure 5: The distribution (%) of papers published in SCED on Structural Change by Type

Source: Authors' own computations based on articles in SCED collected from the Econlit database, 1969-2005 (n=192)

According to our bibliometric analysis SCED concentrates a substantial percentage (21%) of the total papers analyzed, with all other papers being scattered throughout a vast number of journals (Figure 6). While SCED is classified as a B journal according to our purposed

ranking of journals (i.e., 'good journals for all research fields' cf. the Tinberg Institute grid),[74] most of the other publishing sources are relatively low ranked.[75] The results seem to confirm, in this way, the widely held vision according to which formalism is increasingly seen as a synonymous of doing 'good economics'. Furthermore, the absence of top-ranked generalist journals in the top-30 journals in which papers focusing on structural change analysis are published is elucidative of the rather 'specialized' character of this literature, which seems to remain kept apart from hardcore mainstream economics.

Figure 6: Structural change papers by Top-30 Journals
Source: Authors' own computations based on articles in journals collected from the Econlit database, 1969-2005 (n=1247).
Note: Top-30 Journals comprise 47.2% of total papers.

---

[74] Based on the March 2006 RePEc journals list by impact factor and (partially) applying the Tinbergen Institute classification system, we computed a ranking of the academic journals indexed in Econlit. The Tinbergen Institute has drawn up a classification of journals in the field of economics. In this ranking, journals have been classified as: AA: generally accepted top-level journals; A: very good journals covering economics in general and the top journals in each field; B: good journals for all research fields. This classification is roughly based on the following cut offs (according to the impact factor), AA: > 3; A: > 1.5; B > 0.3. We added three other categories, C: >0.1, D: impact factor lower than 0.1, and NC: journals that are not ranked (in RePEc, the Tinbergen Institute ranking, or Kalaitzidakis *et al*., 2003).

[75] Although there is a reasonable number of B journals in the top-10 ranking, NC (Non-classified) is the predominant classification for the entire top-30 group. This is representative of the overall sample (1247 papers) in which 48% of papers are NC while the highest ranking journals (AA; A, and B) represent approximately 41% of papers.

7. Conclusions

In this paper an attempt was made to organize the literature on structural change analysis, from its early foundations until the present days. Despite its important tradition within economic research and the significant revival of interest on the field in the more recent period, to the best of our knowledge, such an effort had not yet been undertaken.

Along with a survey of the economic literature on structural change analysis which emphasizes 'seminal' contributions and their links with more recent works, we also provide an interpretation for the more recent trends in the literature. This was partially done with resource to bibliometric methods, which were used in two different but complementary ways: firstly by analysing citation and co-authoring of papers published on the journal *Structural Change and Economic Dynamics*; and secondly by reviewing the abstracts of all theoretical and empirical articles on structural change analysis that were published over the past forty years in the economic journals indexed in the Econlit database.

Both methodologies are congruent in relating the recent uprise of interest on structural change analysis with an attempt to develop an alternative approach to mainstream economic theory for the analysis of the relationship between technical change and economic growth. Not only technological issues gain increasing relevance along the period under study, but also the most influential authors/writtings according to our bibliometric results can be seen as strong representatives of a new perspective for the study of technological change. Our analysis shows, furthermore, that the 1990s have witnessed an increasing relevance of formal work, which is in close agreement with the attempt to consolidate this new approach as an alternative against the rigorous modelling framework of neoclassical economics. Evidence concerning the more recent years does not confirm this tendency, though it refers only to half of the decade, which might reflect the strong impetus towards empirically-led work prompted by the emergence of the New Economy and its impact on the overall workings of the economic system.

Along with a relative deficit of formal work, our analysis also reveals that most contributions put great emphasis on technology driven growth (though combined with factors such as institutional change and industry dynamics), lacking an appropriate (micro-founded) treatment of the demand side. The development of a dynamic theory of demand and its articulation with the formal treatment of structural and technological change seems, therefore, to constitute a very promising avenue for future research.