

# The incorporation of structural change into growth theory: A historical appraisal

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## Abstract

Despite being an empirical fact that structural change is an inseparable companion of the growth process, it appears as if growth theorists have relegated it to a secondary role. One of the reasons for this apparent neglect with the subject of structural change is the analytical difficulties of dealing with the issue of sectoral dynamics. Another reason is the fact that for a long time the analysis of growth, from a theoretical perspective, has focused predominantly on aspects of supply and technical progress. This paper provides an overview of some of the main works of modern growth theory and appraises the introduction of the subject of structural change into growth models emphasizing the more recent literature on the issue. The exposition elucidates the sources of structural change and surveys some of the recent works that integrate structural change into the growth framework, commenting on their main features and contributions.

## Resumo

Apesar de ser um fato empírico que o processo de mudança estrutural é parte inseparável do processo de crescimento econômico, os teóricos do crescimento parecem relegá-lo a um papel secundário. Uma das razões para esta aparente negligência com relação ao tema da mudança estrutural é a dificuldade analítica de trabalhar com a questão da dinâmica setorial. Outra razão está ligada ao fato de que por muito tempo a análise do processo de crescimento, do ponto de vista teórico, esteve focada predominantemente em aspectos de oferta e do progresso técnico. Este artigo fornece uma visão geral de alguns dos principais trabalhos da moderna teoria do crescimento e aprecia a introdução da questão da mudança estrutural nos modelos de crescimento econômico com ênfase na literatura mais recente. A exposição elucidada as origens da mudança estrutural e revisa alguns dos principais trabalhos que integram mudança estrutural e crescimento, comentando suas principais características e contribuições.

*Keywords:* Growth theory, Structural change, Kaldor facts, Kuznets facts, Dual economy

*JEL:* O100, O400

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## 1. Introduction

Although the process of long-run economic growth might seem stable in the aggregate, in historical perspective, the decline of the agricultural sector and the expansion of the industrial and the service sectors have led to a massive transformation of the economic landscape. One possible way to define structural change is: the process of reallocation of resources across these three broad sectors (agriculture, manufacturing, and services) that accompanies modern economic growth. Many authors including [Fischer \(1939\)](#), [Clark \(1940\)](#), [Kuznets \(1957\)](#) and [Chenery \(1960\)](#) have documented this process. Despite most of these works being predominantly empirical, some authors started to lay down the basic theoretical relations that later would become the base of the theory of structural change. One example is Colin Clark. He related the observed shifts to differential productivity growth and Engel effects, the two principal elements in subsequent attempts to account for the transformation in the structure of production ([Syrquin, 1988](#), 213).

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Some authors, such as Simon Kuznets and Luigi Pasinetti, despite following very different approaches<sup>1</sup>, are praised for having emphasized the important aspects of structural change. Kuznets<sup>2</sup> in particular documented and analysed the process of structural transformation and showed it to be an integral part of modern economic growth. His analysis gave rise to a broader search for uniform features or “stylized facts” of development and growth.

In his Nobel lecture, Simon Kuznets summarized six characteristics of modern economic growth that emerged in his analysis based on conventional measures of national product and its components: population, labour force, and the like. The third of his six characteristics states that “the rate of structural transformation of the economy is high. Major aspects of structural change include the shift away from agriculture to nonagricultural pursuits and, recently, away from industry to services.” (Kuznets, 1973, 248). Kongsamut et al. (2001) termed these empirical regularities the ‘Kuznets facts’ in analogy to the stylized facts established by Kaldor (1961).

In a more recent contribution, Maddison (1987) documented the same sort of regularity on the reallocation of labour in six major industrialized countries (France, Germany, Japan, Netherlands, U.K. and U.S.). His data shows that the average employment share in agriculture was 46.0% in 1870 and fell to 5.5% by 1984. During the same period, the average employment share in the service sector increased from 26.4% to 62.2%. The most commonly observed pattern of structural change is characterized by a systematic fall in the share of labour allocated to agriculture over time, by a steady increase in the share of labour in services, and by a hump-shaped pattern for the share of labour in manufacturing. Herrendorf et al. (2014) reported evidence of this pattern for currently rich countries<sup>3</sup>.

Despite appearing to be one of the obvious features of empirical growth, structural change has not been fully integrated into growth theory yet. One of the reasons for this is the fact that many of the early models of growth were based on aggregate variables. While this approach highlights important aspects of the growth process, it is unable to analyse the driving forces of structural change. In order to incorporate structural dynamics into growth models, multi-sector<sup>4</sup> models had to be developed. Luigi Pasinetti recurrently pointed out the limitations of aggregate models. He has argued that,

Technical progress, productivity, consumption, investment, are no longer sufficient to define the economic system in a dynamic research. We must go beyond this, and find out what lies behind the façade of these aggregate expressions. In short, the research must be formulated in disaggregate terms. (Pasinetti and Spaventa, 1960, 1770).

A second reason is the fact that for a long time the analysis of growth has focused predominantly on aspects of supply and technical progress. This particular focus has led to the development of models ill-equipped to replicate the empirical features of structural change. Let us briefly elaborate on that. Structural change is thought to originate from two sources. It is the result of sectoral differences in income elasticities of demand (demand side explanation), or of sectoral differences in productivity growth (supply side explanation). On the demand side, standard growth models normally assume homothetic preferences, which imply that all the goods have the same unitary income elasticities and that rich and poor individuals consume all the goods in the same proportion. On the supply side, they usually assume identical productivity growth across all sectors. Although not very realistic, these assumptions simplify the analysis and make models more tractable and suitable for analysing other aspects of growth than structural change. According to Moshe Syrquin:

For Kuznets, and more generally in economic history and development, growth and structural change are strongly interrelated. Once we abandon the fictional world of homothetic preferences, neutral productivity growth with no systematic sectoral effects, perfect mobility, and markets that adjust instantaneously, structural change emerges as a central feature of the process of development and an essential element in accounting for the rate and pattern of growth. It can retard growth if its pace is too slow or its direction inefficient, but it can contribute to growth if

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<sup>1</sup>For more on the distinction of the two approaches refer to Syrquin (2012)

<sup>2</sup>Kuznets (1966) documented structural change for 13 OECD countries and the USSR between 1800 and 1960.

<sup>3</sup>Belgium, Finland, France, Japan, Korea, Netherlands, Spain, Sweden, United Kingdom and United States.

<sup>4</sup>The term ‘multi-sector’ refers here primarily to the assumption of multiple consumption sectors/goods.

it improves the allocation of resources by, for example, reducing the disparity in factor returns across sectors or facilitating the exploitation of economies of scale (Syrquin, 2012, 72).

Until the beginning of the 1990's most works on structural change were empirically-oriented contributions. Only recently that there has been a consistent effort to make structural change an integral part of modern growth theory. This paper provides an overview of some of the main works of modern growth theory and assess the introduction of the subject of structural change into growth models with emphasizing the more recent literature. A similar review in spirit was done by Krüger (2008), however, his focus was on the relation of structural change to productivity and technical progress. The next section briefly presents some of the most influential models of growth without structural change in growth theory since the end of World War II. Section 3 presents some early works on dual economy models, here considered the precursors of structural change growth models. Section 4 discusses the sources of structural change and presents some of the recent articles that have reconciled structural change and economic growth. Section 5 summarizes the Pasinetic model of structural change. Section 6 reviews some of the recent articles in the evolutionary school that analyses structural change and growth using agent-based models. Section 7 presents the New Latin American Structuralist (NLAS) growth theory, an approach that integrates increasing per capita income, sectoral dynamics, productive diversification and international specialization across countries. Finally, section 8 presents our final remarks.

## 2. An economic growth theory without structural change

The exogenous and its successor the endogenous theory of economic growth can be understood as a long and arduous effort, which last for almost half a century, dedicated to identify and isolate the determinants of sustained growth. Throughout this endeavour the theory and its models focused on some specific determinants of economic growth such as saving and investment decision, human capital, learning by doing and R&D in an increasing returns to scale environment in order to explain sustained long-run economic growth. In some models, sustainable growth is the result of a continuous innovation process generated by increases in labour productivity, capital productivity or both, in others it is generated by product diversification and creative destruction or by radical innovation. Sustainable growth implies structural change and vice versa. However, structural change has been absent in modern growth theory, as described in more details in this section. It is interesting to note that structural change has been present in the business cycle theory but not in growth theory. Despite the absence of the expression “structural change”, there were some early attempts to explain macroeconomic fluctuations on the basis of industrial structural change made by Robertson (1915), Aftalion (1927), Frisch (1933)<sup>5</sup> and Schumpeter (1939). Even Schumpeter referred to “industrial structure” rather than “structural change” and used the term in the same meaning as Alfred Marshall, namely industrial diversification, despite of the known criticism from the first to the second. Modern growth theory chose to follow the aggregated approach, inspired by the nascent macroeconomic theory, either Keynesian or the microfounded neoclassical.

### 2.1. One-sector exogenous growth models

After World War II, with a number of newly independent nations, the problem of promoting economic growth became a priority and growth theory came to occupy a central position in modern economics. The first models that tried to tackle the issue of economic growth were highly aggregated, and thus not intended for analysing the complexities of structural change. Among the most important articles published at that time were the works of Roy Harrod (1939; 1948) and Evsey Domar (1946; 1947)<sup>6</sup>. Harrod's model extended the short run Keynesian static analysis into a long run dynamic one, and sought the answer to the question of what must be the rate of growth of income in a growing economy that equals investment and saving and guarantees a moving equilibrium through time. His analysis aimed at determining the necessary conditions to realize full-capacity utilization and full employment.

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<sup>5</sup>A curiosity, Ragnar Frisch was who invented the term “econometrics” and was the first to use the words “microeconomics” to refer to the study of single firms and industries, and “macroeconomics” to refer to the study of the aggregate economy.

<sup>6</sup>An important earlier contribution to growth theory is Young (1928).

Harrod's article inspired a wave of contributions, including one of the most influential works in growth theory, Robert Solow's 1956 article *A Contribution to the Theory of Economic Growth*. Solow's model was comprised of three equations: an aggregate production function that exhibits constant-returns-to-scale with smooth substitution and diminishing returns to capital and labour; an equation describing capital accumulation on the assumption of a constant rate of savings as a fraction of output; and a labour-supply function in which the labour force grows at an exogenous rate. Solow argued that an economy would automatically gravitate towards equilibrium if the relative price of labour and capital are flexible enough, and a spectrum of techniques exist so that the economy can move along a continuous production function combining different amounts of capital and labour.

In the Solovian model, the long-run equilibrium growth rate became independent of savings and investment decisions. Any increase in the economy saving or investment ratio would be offset by an increase in the capital-output ratio, leaving the long-run growth rate unchanged, as long as diminishing returns to capital exist. With the introduction of technical progress, diminishing returns to capital are offset, but then output and capital per worker grow at the same rate as technical progress, which grows at an exogenously given rate. Therefore, without technical progress the effects of diminishing returns would eventually cause economic growth to cease.

Throughout the 1960s, the first Solow model was extended into several directions. Solow himself modified his model introducing the notion of vintage capital with embodied technological progress and derived a new version without direct substitution between factors of production (Solow, 1959).

One particularly important extension was done by Cass (1965) and Koopmans (1965). They modified and microfounded the choice of consumption in the Solovian model using the intertemporal maximisation developed by Ramsey (1928). The final model came to be known as the Cass-Koopmans-Ramsey model. The authors departed from the assumption of fixed saving rate and incorporated the permanent income and life-cycle savings hypotheses into the Solovian model. By incorporating these hypotheses, the saving behaviour becomes the result of explicit intertemporal utility maximization, i.e. the saving rate becomes endogenously determined. Therefore, unlike in the Solow model, where the saving rate is constant, in the Cass-Koopmans-Ramsey model it may fluctuate along the transition to the long run steady state. The model also showed that when exogenous technical progress is introduced, capital, consumption and output all grow at the same rate as the exogenous technical progress in the steady state. analyzing Over the next three decades, growth theory tended to focus predominantly on how to endogenize technical progress. Economists believe that technical progress is not exogenous, but actually depends on factors such as economic decisions made by profit seeking firms, funding of science and accumulation of human capital. If technical progress is an endogenous variable then it has to be determined within the economic system. The problem with incorporating endogenous technical progress into growth theory is how to deal with the issue of increasing returns to scale.

## 2.2. One-sector endogenous growth models

One example of early attempt to endogenize technical progress is Arrow (1962). Arrow used a mechanism called "learning by doing". The idea is that the growth of technical progress, commonly represented by the letter  $A$  is an unintended result of the experience of producing new capital goods. By assuming a process of learning by doing, Arrow was able to establish a link between investment in capital and technical progress.

Learning by doing was assumed to be external to both firms, the ones producing the new capital goods and the ones acquiring them, so they take the rate of technological progress as being given independently of their own production of capital goods. Thus, since in a competitive equilibrium no additional compensation would be paid to  $A$ , each firm maximizes profit by paying capital and labour their marginal products. Nevertheless, the growth of  $A$  becomes endogenous, in the sense that an increase in the saving propensity would affect its time path (Aghion and Howitt, 1998, 23). However, the model was fully worked out only in the case of a fixed capital-labour ratio and fixed (but vintage-specific) labour requirements. This implied that in the long run the growth of output was limited by growth in labour, thus in the absence of exogenous population growth, economic growth is no longer endogenous and becomes zero. In that sense, Arrow's model was not fully endogenous.

An important empirical regularity about the mechanism of learning by doing is that its external effect is bounded. So if the number of industries is fixed and their learning effects are bounded, growth cannot be sustained in the long run. A solution to this problem is to consider the possibility of new products being

constantly introduced by way of learning externalities across industries and/or R&D, such mechanism was introduced in later models based on innovations. Despite its shortcomings, Arrow's idea of learning by doing formed the basis of the first type of endogenous growth models, which is known as the AK model.

The idea behind AK models is that growth is directly linked to two processes: learning by doing and capital accumulation. When firms accumulate capital, learning by doing generates technological progress, which is itself a kind of capital good (disembodied capital good), that tends to raise the marginal product of capital, thus offsetting the tendency for the marginal product to diminish when technology is unchanged. Hence, the source of increasing returns in AK models at the aggregate level is not capital accumulation itself, but the learning processes. According to this type of model, high growth rates are sustained by saving a large fraction of output, needed to finance a higher rate of technological progress.

The first AK model that accounted for sustained growth in per-capita output was that of [Frankel \(1962\)](#). Frankel wanted to reconcile the positive long-run growth result of Harrod-Domar with the factor-substitutability and market-clearing features of the Solovian model. In order to do that he used Arrow's learning by doing mechanism. He recognized that because individual firms contribute to the accumulation of technological knowledge when they accumulate capital, Harrod-Domar model did not require fixed coefficients and that aggregate productivity would depend upon the total amount of capital that has been accumulated by all firms. Therefore, as in Solow, Frankel's model displayed factor-substitutability (with Cobb-Douglas production technologies) and market-clearing, and as in Harrod, the model generated a long-run growth rate that depended on the saving rate, which was assumed to be constant.

Despite Frankel's earlier contribution, [Romer \(1986\)](#) and [Lucas \(1988\)](#) are considered the pioneering works of the neoclassical endogenous growth theory. [Romer \(1986\)](#) built an AK model, where productivity increased as a result of learning-by-doing externalities of the same sort as in [Frankel \(1962\)](#), but in which the constant saving rate was replaced by representative individual intertemporal utility maximization à la Ramsey<sup>7</sup>.

[Lucas \(1988\)](#), inspired by [Becker \(1964\)](#) theory of human capital, developed an AK model where the creation and transmission of knowledge occurs through human capital accumulation. He distinguishes two sources of human capital accumulation (or skill acquisition), namely education and learning by doing. By assuming that human capital accumulation involves constant returns to the existing stock of human capital, the model produces a positive growth rate in the steady state.

### *2.3. Multi-product endogenous growth models*

A second wave of endogenous growth models came with the development of the so-called product-variety or expanding variety models. These are based on horizontal innovation, a type of innovation that causes productivity growth by creating new, but not necessarily improved, varieties of intermediate products. Horizontal innovation can be interpreted as a process innovation. Product-variety models do not deal directly with structural change, because they still have only one consumption or final goods sector. However, since they focus on innovation and diversification, they contributed to the insertion of the issue on growth theory's agenda.

One of the advantages of product-variety endogenous growth models is the fact that they allow for a more explicit treatment of innovation and a better analysis of its structural effects. Most models based on horizontal innovation follow a similar structure consisting of three sequentially connected sectors: one sector that produces various 'designs' ('ideas', 'knowledge', etc.); a second sector that uses these 'designs' to produce various intermediate goods; and a third sector that uses the intermediate goods to produce the final good (and in most models, the final good is used-foregone-as an input in producing 'designs' and/or intermediate goods) ([Park, 2010](#), 755). This differentiation between research, intermediate and final goods sectors, add to some extent some notion of structural change into these models, but not the structural change in the sense of Kuznets.

[Romer \(1987\)](#) using the framework of monopolistic competition extended by [Ethier \(1982\)](#)<sup>8</sup>, developed an early version of a product-variety growth model. He assumes that productivity growth comes, not from

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<sup>7</sup>[Ramsey \(1928\)](#)

<sup>8</sup>The basic approach to the benefits from variety comes from [Spence \(1976\)](#). [Dixit and Stiglitz \(1977\)](#) refined Spence's analysis and used to express consumer preferences over a variety of goods. [Ethier \(1982\)](#) applied this representation to inputs of production.

learning externalities among individual firms, but from the continuous increase in the variety of specialized intermediate products, which prevents aggregate capital from running into decreasing returns. In this second model, Romer formalized an idea present in [Young \(1928\)](#), which is that growth can be sustained by the increased specialization of labour across an increasing variety of activities. As the economy grows, the larger market makes it worth paying the fixed costs of producing a large number of intermediate inputs, increasing the division of labour (specialization) and raising the productivity of labour and capital, which maintains growth ([Aghion and Howitt, 1998](#), 36).

A more elaborated product-variety growth model was developed in [Romer \(1990\)](#), which is one of the most important contributions to the NEG theory. Romer extended his previous model and introduced a competitive research sector, which uses human capital and the existing stock of knowledge to generate new knowledge (blueprints or new designs) for new inputs (intermediate goods or machines) as a result of voluntary profit-motivated horizontal innovations. A monopolistically competitive intermediate-goods sector uses the new designs together with forgone output to produce a new variety of an intermediate good (new machines). The consumer goods sector produces final output using labour and intermediate goods, with a production function with a functional form borrowed from [Ethier \(1982\)](#). Final goods can be used for consumption and investment (in producing new blueprints).

In [Romer \(1990\)](#), there are two sources of increasing returns, namely specialization (increased labour division) and research spillovers. When a new design enables the production of a new intermediate good (new machine) there is an increase in the division (specialization) of labour, so an increase in the variety of machines, raises the productivity of labour. Additionally, a new design also increases the total stock of knowledge and thereby increases the productivity of human capital in the research sector, generating research spillovers. All researchers benefit from the accumulated knowledge  $A$  embodied in the existing designs. In other words, technological knowledge is a non-rival good. But at the same time knowledge is also excludable in the sense that intermediate firms must pay for the exclusive use of new designs which are monopolized by the firms which created them. In this model the aggregate production function exhibits constant returns to scale from the viewpoint of final good firms, which take the variety of machines as given, and increasing returns to scale for the economy as a whole.

The product-variety framework has been extended in several directions<sup>9</sup>. [Grossman and Helpman \(1991](#), chapter 4) model utility as a function of an expanding variety of consumer goods due to a sort of product innovation but where innovative products are in no way superior to older varieties, what eliminates the possibility of product obsolescence. In their framework real income increase because consumers show love-for-variety, meaning that the greater is the number of differentiated varieties that the individual consumes, the higher is his utility.

Models based on horizontal innovation have contributed to the dissemination of an idea of structural change, since they acknowledge the existence of many heterogeneous capital goods in the real economy, which are produced by different sectors/technologies. Nevertheless, structural change in these models is limited to changes across capital-goods sectors, not the kind of broad sectoral dynamics described by the Kuznets facts.

The next stage in the evolution of growth models without structural change came with the emergence of vertical innovation models of quality improvement. This approach has come to be known as the Schumpeterian approach to endogenous growth and grew out of modern industrial organization theory. These type of models embody the force that [Schumpeter \(1942\)](#) called “creative destruction”, and draw on the idea that growth is generated by a random sequence of quality-improving or also called vertical innovations that make existing products obsolete. In Schumpeterian models of endogenous growth a new variety of intermediate good replaces the old one, and its use raises the technology parameter  $A$  by the constant factor.

Despite some earlier works<sup>10</sup>, the benchmark model of Schumpeterian endogenous growth was developed by [Aghion and Howitt \(1992\)](#), where there is a research sector which is portrayed as in the patent-race literature surveyed in [Tirole \(1988\)](#) and [Reinganum \(1989\)](#). In their model, growth results exclusively from technological progress generated by competition among research firms that create innovations. Each

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<sup>9</sup>We refer the reader to [Gancia and Zilibotti \(2005\)](#) for a more thorough review.

<sup>10</sup>One of the earliest versions of a Schumpeterian endogenous growth model is [Segerstrom et al. \(1990\)](#). In their model, sustained growth arises from a succession of product improvements in a fixed number of sectors.

innovation consists of a new intermediate good, whose use as input allows more efficient methods to be used in producing the consumption good. Research firms are motivated by the prospect of monopoly rents that can be captured when a successful innovation is patented. The monopoly rents, however, will only last until the next innovation, which will render obsolete the existing intermediate good (Aghion and Howitt, 1992). While vertical and horizontal innovation based models complement each other, in both type of models, the old products disappear only through the introduction of new products, which means that the number of final products remains constant.

Much of the work developed by the exogenous and the early endogenous growth theory adopted an aggregated strategy. Despite being insightful on the conditions required for a steady state growth path, the structure and diversification of economic system was neglected in favour of deepening the understanding of the determinants of growth and its effects. The later endogenous growth models, such as the product-variety and the Schumpeterian models have showed that an important mechanism of sustained growth is the rise of variety based on new and improved capital. The evolution of economic system through diversification implies a change in productive structure. However, these models have difficulties in explaining major processes of structural changes, sector interdependence and transfer of resources across different industries. Aghion and Howitt (1998, 65) recognise that these models

[...] miss the stages of development in which resources are gradually reallocated from agriculture to manufacturing and then to services, all with different factor requirements and different technological dynamics. The economy is always a scaled up version of what it was years ago, and no matter how far it has developed already prospects for future development are always a scaled up version of what they were years ago.

In order to explain the major processes of structural changes, sector interdependence and transfer of resources across different industries models with more than one final good sector were necessary.

### 3. Dual economy: the precursor of growth and structural change theory

One-sector growth models have been extensively used by economists of all schools of thought. The main advantage of this type of model is their minimalist structure, what makes them highly tractable. One-sector models focus essentially on the growth process within a modern sector. However, they abstract from several features of the process of economic growth, making it not suitable for analysing the first stages of economic development and inter-sectoral phenomena such as industrialization or structural change.

By the beginning of the 1950s, some economists dissatisfied with the approach followed by aggregate growth theory, started to developed alternative frameworks better suited to describe the process of structural change that occurs in the first stages of economic development. One of these alternative approaches came to be known as dual economy model, and include the works of Lewis (1954), Ranis and Fei (1961) and Jorgenson (1961) among others.

Dual economy models are commonly used to represent the first stages of an economy's development. A period in which, emphasis is laid on the balance between capital accumulation and the growth of population, each adjusting to the other. These models are based on the concept of structural heterogeneity, in which the economy is composed of two asymmetric sectors, a relatively advanced and a relatively backward sector. These asymmetries are not merely technological but also include institutional, behavioural, and informational aspects. These two sectors follow completely different economic logics, so they cannot be lumped together as the neoclassical theory does with the capital and the final goods sectors. The two sectors differ in terms of the goods produced, the nature of the growth process, wages and employment mechanisms. The traditional sector is characterized by subsistence wages, abundance of labour, low productivity, labour-intensive production process, no capital accumulation and no technical progress. In contrast, the modern sector is defined by higher wages as compared to the traditional sector, higher marginal productivity, capital-intensive production process, technical progress. Dual economy models focus on inter-sectoral relationships and flows. Growth in these models depend in large part on the rate at which resources, especially labour, can be transferred from the traditional to the modern sector. The sectors have received other denominations in the literature such as capitalist and subsistence, modern and traditional, industry and agriculture, urban and rural and primary and secondary.

The first dual economy model was formalized by [Lewis \(1954\)](#). The Lewis model, as it came to be known, is a classical model consisted of an underdeveloped economy with two sectors: a traditional, overpopulated subsistence sector characterized by zero marginal labour productivity and a high-productivity modern sector. There is an unlimited supply of labour available at subsistence wage, so labour is able to move to the modern sector without lowering output. Moreover, capitalists save everything, but workers (and landlords) save nothing. The unlimited supply of labour from the traditional sector keeps wages from increasing in the modern sector and ensures that capital accumulation in that sector is sustained over time. Both labour transfer and the modern sector employment growth are brought about by output expansion in the modern sector. The speed with which this expansion occurs is determined by the rate of investment and capital accumulation in the modern sector. Thus, the source of structural transformation can be found in the unlimited supply of labour from the traditional sector. The Lewis model underlines the importance of transfers of resources from low-productivity to high-productivity activities in the process of economic development.

[Jorgenson \(1961\)](#) is another seminal example of a dual economy model. He develops a neoclassical version of Lewis dual economy model. Jorgenson's model assumes two sectors: agriculture and industry. Agricultural output depends on labour and on a fixed amount of land. Industrial output depends on labour and on capital. The production functions have the Cobb-Douglas form, with constant returns to scale and neutral technological change. Only labourers in the advanced sector can be assumed to respond to wage differentials between employment opportunities in agriculture and industry. Industrial wage-rate is equal to the marginal product of labour. In Jorgenson's model the division of labour between the two sectors is straightforward: if there is no agricultural surplus, all labour remains in the agricultural sector; if an agricultural surplus can be generated, labour is released from the land and transferred to the manufacturing sector at a rate that is equal to the rate of growth of the agricultural surplus. Manufacturing production is only possible if some initial capital stock exist, however small it may be, the model shows that there is no critical level of initial capital endowment below which no sustained growth is possible. Even the smallest initial stock can give rise to sustained growth. Once the initial injection of capital is made, capital accumulation in the manufacturing sector continues at a pace determined by the growth of the labour force in that sector and by the terms of trade between the two sectors. The modern sector is also subject to technical progress, so the more rapid the rate of technical change, the higher the saving ratio, and the more rapid the rate of growth of population, the more rapid is the pace of growth in the advanced sector. Eventually, the economy is dominated by the development of the advanced sector and becomes more and more like the advanced economic systems described neoclassical model and less like a dual economy.

In dual economy models, the assumption of unlimited supply of labour is crucial, because it allows the possibility of having increasing saving and in turn capital accumulation and faster growth without increasing wages. However, this process does not continue forever. Eventually, the withdrawal of labour from the traditional sector reaches the point at which the marginal product of the remaining labour rises to equality with the subsistence wage. From this point on wages rise in both sectors as growth continues and workers can choose and offer their labour to the highest bidder (the traditional or the modern sector). A labour market, in a neoclassical way, is formed. The dualistic structure is over and the economy enters a new stage of development characterized by scarcity of labour.

There is another class of models with two-sectors that divide the economy in capital and consumption goods sector. These models are very different from the dual economy, and despite having two sectors were not intended at analysing structural transformation. In this class of model all the final good sectors (agriculture, manufacturing, service) have the same structure, thus they can be aggregated into one unified "consumption" goods sector. Examples of this type of models are [Meade \(1961\)](#), [Uzawa \(1961\)](#), [Kurz \(1963\)](#), [Takayama \(1963, 1965\)](#).

Dual economy models can be seen as one of the first attempts to model economic growth with structural change. They provided important insights on the determinants and on the outcomes of sectoral structural dynamics. However, these models were limited in scope and not fully equipped to incorporate all the driving mechanisms of structural change. More comprehensive models were required in order to fully analyse the complexities involved in the process of structural transformation. Some of these models are discussed in the next section.

## 4. Structural change and growth

Recently, a new wave of growth models have developed better ways of analysing the process of structural change and some have been able to reconcile structural change with the broad patterns of aggregate balanced growth. The literature has identified several channels to explain the process of structural change, ranging from demand-driven factors to purely technological determinants. The mechanism used to integrate structural change into growth models depends in part on the assumptions made about the origin of the structural change and in part on the characteristics of the model, if it is balanced or non-balanced.

One explanation about the sources of structural change relies on differences in income elasticities of demand across sectors. This explanation has been dubbed ‘utility-based’ and suggests that if one assumes non-unitary expenditure elasticities of demand, then increases in real per-capita expenditure levels affect the sectoral expenditure shares leading to the reallocation of labour across sectors. In order to capture these differences in income elasticity of demand across sectors, non-homothetic preferences have to be assumed. Authors that locate the origin of structural change in long-run changes in consumer tastes have incorporated structural dynamics into their models through the assumption of non-homothetic utility functions. These are multi-sector models consistent with Engel’s law and in which structural change is driven by differences in the income elasticity of demand across goods. Engel’s law states that as a household’s income increases, the fraction that it spends on food (agricultural products) declines. Several authors have found that Engel’s law holds not only for food, but it is a more general law of consumption<sup>11</sup>. According to Houthakker (1987) Engel’s law is one of the most robust empirical findings in economics.

A different explanation regarding the sources of the process of structural change is based on changes in relative prices. These changes affect the expenditure structure whenever the elasticity of substitution across sectors is different from one. This view of structural change is known in the literature as the ‘technological’ explanation. Authors that adopt this view incorporate structural change into their models through two mechanisms: (1) by assuming differential productivity growth across sectors or; (2) by assuming changes in the relative prices of inputs if sectors vary in the intensity with which they use inputs and there are changes in the relative supply of factors (Herrendorf et al., 2014). Despite their differences, these two mechanisms can account for structural change from a supply side perspective. Some authors see the utility-based and the technological explanations as competing theories. However, there is not enough evidence in the literature that proves that they cannot coexist. Some authors were able to derive structural change from both sources simultaneously, (Boppart, 2014) is one example.

### 4.1. Structural change and non-balanced aggregate growth

Another characteristic of models that integrate structural change and growth is related to the issue of reconciling structural change with the Kaldor facts. The Kaldor stylized facts propose that the growth rate, the interest rate, the capital output ratio, and the labour share are roughly constant over time while capital per worker and real wage grows over time (Kaldor, 1961). These regularities provide a good characterization of the long run behaviour of the U.S. economy and are believed by many to be a reasonable approximation of the long-run growth experience of a modern economy. Consistency with the Kaldor facts is not a feature present in all the models that combine growth with structural change. The reason for this might be found in the interpretation of the Kaldor facts. According to Pasinetti, Kaldor never interpreted his ‘facts’ as an empirical justification for the construction of a theory of balanced growth. Nicholas Kaldor himself did not claim that any of the regularities he had uncovered would be constant at all times. Independently of the reason, some authors decided to focus on structural change and abstract from the empirical regularities of the Kaldor facts. Some of these works are summarized in this section.

Baumol (1967) is one of the first articles to model structural change based on the technological explanation in which unbalanced growth is a general feature of the growth process because different sectors grow at different rates owing to different rates of technological progress. He built a model consisted of two sectors, a ‘progressive’ and a ‘non-progressive’ one and of a single factor, labour. In the progressive sector, as a result of continuing technological progress, labour productivity grows cumulatively at a constant compounded rate  $r$ , and in the non-progressive sector labour productivity is constant. Baumol’s models makes four propositions:

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<sup>11</sup>Deaton and Muellbauer (1980) concluded that the vast majority of studies obtains the result that the expenditure share of a product changes systematically with income.

(1) through time the non-progressive sector unitary cost of output, relative to that of the progressive sector, will rise without limit; (2) unless demand for it is highly inelastic, output in the non-progressive sector will decline and perhaps approach zero; (3) in order to maintain balanced growth, represented by a constant ratio between the outputs of the two sectors, the share of the labour force allocated to the non-progressive sector must approach unity; (4) an attempt to maintain balanced growth, in a world of unbalanced productivity, will lead to a zero rate of growth of real output-per-capita.

Matsuyama (1992) assessed the role of agriculture productivity in the process of industrialization. He builds a two-sector model of endogenous growth, where he is able to combine Engel's Law with learning-by-doing externalities in the industrial sector. The labour market is competitive and the wage rate is equalized across the two sectors. He makes two key assumptions in his article: (a) preferences are non-homothetic and the income elasticity of demand for the agricultural good is less than unitary, and (b) manufacturing productivity rises over time because of learning-by-doing. Agricultural productivity is determined purely exogenously. The model also analyses the relationship between industrialization and the assumptions concerning the openness of the economy. For the closed economy case, the model finds that an exogenous increase in agricultural productivity shifts labour from agriculture to manufacturing and thereby accelerates economic growth. However, for the open economy case, there exists a negative link between agricultural productivity and economic growth. An economy with less productive agricultural sector allocates more labour to manufacturing and will grow faster, in contrast, an economy with a more productive agricultural sector squeezes out the manufacturing sector de-industrializing over time and growing slower. Some limitations of the model are the fact that agricultural productivity is determined purely exogenously, there is no learning-by-doing in agriculture and technological advances in manufacturing do not improve agricultural productivity.

More recently, Echevarria (1997) introduced structural change on a dynamic general equilibrium model. Her paper explains the relation between income levels and rates of growth as an effect of changes in sectoral composition driven by different income elasticities for primaries, manufacturing and services. She assumed three different consumption goods (primary, manufacturing and services) demanded by agents displaying non-homothetic preferences. There are two factors of production: labour and capital, and each consumption good is produced using different factor intensities. Capital is produced in the second sector (manufacturing) and distributed among all the sectors. Since the productivity rate in each sectors is different and exogenously determined, the growth rate of the economy is affected by changes in sectoral composition, which is in turn driven by non-homothetic preferences (Echevarria, 1997, 431). The assumption of nonhomotheticity of preferences is crucial and drives the results in the model. Echevarria explains that a poor country, which consumes mainly necessities (primary), cannot save (invest) much. As it gets richer, it will invest or save more, thereby encouraging growth. At the same time production will shift to the second sector (manufacturing), which has a higher rate of technical change; thus, the first effect is reinforced. Both effects, increase in investment and increase in average total factor productivity, imply an acceleration in the growth rate. Yet, the savings rate (net savings or investment as percentage of GDP) does not increase monotonically over time, eventually the savings rate falls, thus driving the growth rate down. If, at the same time, production shifts to the third sector (service) with its lower rate of technical change, that will reinforce the reduction in the growth rate Echevarria (1997, 445). The model predicts the following regularities: (1) a hump-shaped correlation between growth rates and income levels, with poor countries having the lowest rate of growth and middle-income countries having the highest growth rate; (2) the higher proportion of agriculture on GDP in poor countries, and the higher proportion of services on GDP in rich countries; (3) the comparatively more expensive services in rich countries; (4) the larger share of the labour force employed in agriculture in less-developed countries, and the larger share employed in services in developed countries; and (5) the higher share of output paid to labour in rich countries. Echevarria concludes that sectoral composition explains an important part of the variation in growth rates observed across countries.

Following a different approach, Park (1998) analyses structural change focusing on structural transformation from an agriculture-based to a manufacturing-based economy. He developed a three-factor, three-goods endogenous growth model with a non-homothetic Stone-Geary type utility function to analyse transitional dynamics of structural change. The three factors are land, unskilled labour and the capital stock, which includes physical and human capital. The three goods are agricultural goods, manufacturing goods and new capital goods. In Park's model the long-run growth rate of the economy is determined by the size of the

capital-producing sector, but the growth rate of each good is different on the balanced growth path as well as during the transitional period and although the capital-producing sector is assumed to be the engine of economic growth, the sectoral growth rate of this sector is not necessarily highest. Stone-Geary utility is useful and convenient, since it allows the presence of subsistence level and the possibility of income elasticity of demand for goods be less than unitary. This kind of utility function implies that there is a minimum, or subsistence level of food consumption that the household must consume. After this level has been achieved, the household starts to demand other items, in this case manufactured goods. Therefore, Stone-Geary utility has the ability to yield different growth rates during the transitional period. Park shows that sectoral contributions of respective industries to economic growth are variable and different and that structural change in production and factor use favours the manufacturing industry as opposed to the agricultural industry during the transitional period.

Laitner (2000) shows that structural change can affect the economy's saving rate through the operation of Engel's law taking account the composition of assets in household portfolios. Assuming the existence of non-homothetic preferences, Laitner builds a model with two sectors: agriculture and manufacturing. The model is based on the following structure: household saving follows the stages of life-cycle behaviour with overlapping generations, where each household lives for two periods, and is identical to all others born at the same time. There are no inheritances or bequests and the household takes prices as given. Young households will save all labour earnings and retired households will spend all their wealth. This pattern do not change over time even if incomes change, but the composition of consumption depends on changes in income. On the production side, aggregate effective labour supply depends on the number of young households and current technology. Exogenous technological progress raises per-capita income over time. In Laitner's model, a household whose standard of living is low cares only about agricultural consumption, but a household with a high standard of living, on the other hand, becomes satiated with agricultural products and devotes its remaining expenditures exclusively to manufactured goods. Hence, Engel's law implies a demand shift from agriculture to manufacturing goods as income rises. Consequently, the economy goes from an initial position where it specializes in agriculture to devoting more and more labour to manufacturing production. In the limit, the share of agriculture in total GDP tends to zero and the share of manufacturing converges to unity.

Another work where structural change is explained through differences in income elasticities of demand across sectors applying non-homothetic preferences of Stone-Geary type is Caselli and Coleman (2001). They made a joint study of the U.S. structural change (the decline of agriculture as the dominating sector) and regional average wage convergence. The authors attempted to explain the decline of agriculture as the dominating sector in the United States and the convergence of income per-capita across the U.S. States. They used human capital accumulation to explain discrepancies in labour and output trends in the decline of agriculture. The model features a closed economy with two locations, North and South; two goods, farm and manufacturing; and three factors of production, land, labour, and capital. They assumed that North and South are equally good at producing manufactures but the South enjoys a comparative advantage in the production of farm goods. The non-homotheticity is represented by a less than unit income elasticity of demand for farm good.

Gollin et al. (2002) built a model of structural change to explain why the process of industrialization occurs at different dates and why it proceeds slowly. The authors, like others, also make use of a non-homothetic utility function of the Stone-Geary variety in order to generate structural transformation. The model uses a basic neoclassical framework modified to include both an agricultural and a non-agricultural sector. Countries begin the process of industrialization only after they satisfy their basic agricultural needs. Hence, low agricultural productivity can substantially delay industrialization. Asymptotically, agriculture's employment share shrinks to zero, and the model becomes identical to the standard one-sector neoclassical growth model. One important conclusion is that improvements in agricultural productivity can accelerate the start of industrialization and so, have large effects on a country's relative income.

#### 4.2. Structural change and balanced aggregate growth

Although balanced aggregate growth is not an inevitable property of growth models, most of them strive to be consistent with the Kaldor facts. One of the properties of balanced aggregate growth models is that the fraction of capital and labour allocated to different industries remain constant over time. Hence, *prima facie*, combining structural change at the sectoral level with the Kaldor facts at the aggregate level seems to be non-trivial. However, some authors were able to explain a transition along which, aggregate

variables exhibit an almost balanced growth path, while there is sectoral change. Some of the works that have reconciled structural change and the Kaldor facts are summarized in this section.

[Kongsamut et al. \(2001\)](#) is one of the first articles that have reconciled structural change and the Kaldor facts. In their article, the authors build a three-sector model displaying what they defined as a generalized balanced growth path, which is a trajectory consistent with the dynamics of structural change and along which the real interest rate is constant. Their approach is also based on the Engel's Law, with structural change being driven by income effects. The authors used a Stone-Geary utility function, which [Acemoglu](#) describes as being "[...] a highly tractable way of introducing income elasticities that are different from one for different subcomponents of consumption and Engel's Law" ([Acemoglu, 2009](#), 699). They directly manipulated the utility function in order to generate different income elasticities of the goods and sectors. Income elasticity of demand was assumed less than one for agricultural goods, equal to one for manufacturing goods, and greater than one for services. Although being perhaps the most popular in the literature, especially in models with two goods<sup>12</sup>, this Stone-Geary-type specification has some disadvantages. It is only applicable when working with a small number of goods. Moreover, in order to be consistent with the generalized balanced growth path, [Kongsamut et al. \(2001\)](#) had to rely on a widely criticized knife-edge condition, which ties together preference and technology parameters and implies constant relative prices.

In another article, [Ngai and Pissarides \(2007\)](#) formalized the first mechanism that derives structural change purely from different sectoral total factor productivity (TFP) growth rates. They show that, given a low (below one) elasticity of substitution between the final goods produced by each sector, and assuming that all goods have unit income elasticity, different TFP growth rates predict sectoral employment changes. [Ngai and Pissarides'](#) model contains many consumption goods and a single capital good, supplied by a manufacturing sector. They assume identical Cobb-Douglas production functions in all sectors except for their rates of total factor productivity growth. Each sector produces a differentiated good that enters a constant elasticity of substitution (CES) utility function. The model is able to predict a shift of employment away from sectors with high rate of technological progress toward sectors with low growth, and eventually, in the limit, all employment converges to only two sectors, the sector producing capital goods and the sector with the lowest rate of productivity growth ([Ngai and Pissarides, 2007](#), 438). In order to satisfy Kaldor's stylized facts of aggregate growth a logarithmic intertemporal utility function is required. [Ngai and Pissarides \(2007\)](#)'s results are consistent with the evidence concerning the decline of agriculture's employment share, the rise and then fall of the manufacturing share, and the rise in the service share. The key requirement for their results is a low substitutability between final goods. [Ngai and Pissarides'](#) model confirms [Baumol \(1967\)](#)'s claim that the production costs and prices of the stagnant sector should rise indefinitely and labour should move in the direction of the stagnant sector. However, it contradicts Baumol's conclusion that as more weight is shifted to the stagnant sector, the economy's growth rate will be on a declining trend and eventually converge to zero. The reason for the contrasting result is that [Ngai and Pissarides](#) included capital in their analysis, which was left out in [Baumol \(1967\)](#).

[Foellmi and Zweimüeller \(2008\)](#) developed a growth model consistent with both the Kaldor and Kuznets facts, based on the assumption of hierarchical preferences. Their model shows that reallocation of labour is driven by differences in income elasticities across sectors. The basic idea of their analysis is that households expand consumption along a hierarchy of needs, in which goods are weighted according to their essentiality. In order to depict the equilibrium process of growth and structural change consistent with the Kaldor facts, the 'hierarchy function', which characterizes the willingness of consumers to move from high priority to low priority goods, must take a particular form with some specific characteristics. In their model, the authors adopt a particular form of power function. [Foellmi and Zweimüeller'](#) model is capable of generating movements not only of labour out of agriculture and into services, but also a hump shape in the evolution of the manufacturing share, with a period of increasing manufacturing employment followed by a period of de-industrialization, replicating empirically observed patterns. Differently from other models that also adopt the utility-based explanation for structural change with non-homothetic preferences, [Foellmi and Zweimüeller'](#) model introduces a situation where new goods are continuously introduced. Each new good starts out as a luxury with a high income elasticity and ends up as a necessity with a low income elasticity. According to the authors, these non-linearities in Engel curves generate consumption cycles that account

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<sup>12</sup>See e.g. [Matsuyama \(1992\)](#)

for structural change. For the sake of simplicity and to highlight the demand channel, the authors assume exogenous and identical sectoral productivity growth across all sector, the relative price structure remains constant over time. Despite addressing the issue of structural change along a growth path consistent with the Kaldor facts [Foellmi and Zweimüeller](#)'s model relies on income effects alone in order to explain structural change.

[Acemoglu and Guerrieri \(2008\)](#) following a different approach construct a model that allows for differences in capital intensities across sectors. In their model capital deepening and sectoral factor intensity differences are the determinants of the relative price dynamic. The authors build a two-sector general equilibrium model with constant elasticity of substitution preferences and Cobb-Douglas production technologies, where they show that, capital deepening increases the relative output of the more capital-intensive sector while simultaneously induces a reallocation of capital and labour away from that sector ([Acemoglu and Guerrieri, 2008](#)). The authors also show that provided the elasticity of substitution is less than one, one of the sectors (typically the more capital-intensive one) grows faster than the rest of the economy, but because the relative prices move against this sector, its (price-weighted) value grows at a slower rate than the rest of the economy. Moreover, they show that capital and labour are continuously reallocated away from the more rapidly growing sector, thus generating sectoral structural change. Their model shows that convergence to equilibrium is slow with the capital share in national income and the interest rate varying only by relatively small amounts. Despite reconciling structural change with balanced growth, in [Acemoglu and Guerrieri](#)'s model the Kaldor facts hold only asymptotically. Moreover, regarding the demand side the authors do recognize the importance of income effects but abstract from non-homotheticity of preferences, placing the source of structural change on the supply side of the economy.

It is possible to believe that the two explanations for structural change described above, the utility-based and the technological explanation are not mutually excludable, but actually complementary. [Boppart \(2014\)](#) provides empirical evidence that both drivers of structural change are relevant. Moreover, he builds a model integrating both explanations. He combines non-homothetic preferences and differential TFP growth while reconciling the Kaldor facts with structural change. Boppart relies on non-Gorman preferences where the marginal propensity to consume a “good” and a “service” differs between rich and poor households and inequality affects the aggregate demand structure. The author conducts a structural estimation that allows for the decomposition of the structural change into an income and a substitution effect showing that both channels of structural change are of roughly equal importance. The empirical analysis shows that the model's functional form fits the data and the framework can replicate the observed structural change quantitatively ([Boppart, 2014](#)). While advancing in the understanding of the interplay between the two drivers of structural change, Boppart's model do not contemplate the possibility of creation of new sectors.

The role of the Kaldor facts in describing the path of growth of modern capitalist economies of the XXI century is, at least, debatable. For instance, [Jones and Romer \(2010\)](#) points out that the Kaldor facts might be outdated since they revolved around a single state variable, namely physical capital. They argue that the facts should be updated and include variables such as ideas, institutions, population, and human capital. Another article that questions the validity of the Kaldor facts is [Jorgenson and Timmer \(2011\)](#). The authors examine whether Kaldor's stylized facts provide an accurate description of more recent structural changes. The authors especially question Kaldor's stability of the share of labour in GDP over time, they find that the labour share in value-added is declining and that the decline is pervasive in all sectors and regions, except in US finance and business services. How well the Kaldor facts really represent long-run economic growth is an open question. Especially regarding developing and less developed countries.

Some authors believe that general equilibrium and aggregate balanced models may not be the best way to represent long-run economic growth. In the next sections we summarize two schools of thought that follow a different methodology to analyse the issue of structural change, the Passinettian model of structural change and the agent-based evolutionary growth theory. These schools do not see the economy as a balanced system or as an unbalanced one heading towards equilibrium; they see the economic system as being in constant change, in constant evolution.

## 5. Pasinetti's structural change

An important contribution to the development of the theoretical foundations of structural change was given by Luigi Pasinetti. One of the merits of his contribution was to make the issue of structural change the

centre of his analysis of growth. Pasinetti shifted the focus of the analysis from the determinants of growth to the structural dynamics of the economic system. His theory of structural dynamics was laid out in two books published in 1981 and 1993. The name of his books are illustrative of his interest in explaining the origin and effects of structural change on growth, and especially, on the development of societies: *Structural Change and Economic Growth* (1981) and *Structural Economic Dynamics* (1993).

Pasinetti follows a completely different approach from the authors surveyed in the previous sections. His theory is based on post-Keynesian and classical elements and stresses the inevitability of structural change. While for some authors structural change is a transitional step towards balanced growth, in Pasinetti's approach disequilibrium and instability are the normal state of affairs. Economic growth is seen as a process of continuous change. Pasinetti's view of structural change is based on what he calls a pure production model. This model abstracts from institutions of the economic system and the behavioural modes of economic agents and concentrates on the natural or primary characteristics that enable a system to grow.

The prime mover of structural change in Pasinetti's analysis is technical progress as a result of exogenous learning activity. Technical progress in a sector has two effects. The first effect is the reduction of the labour coefficient in that sector and consequently an increase in productivity. Increases in productivity lead to increases in per-capita income. These two things are inseparable as Pasinetti puts it: "Increases in productivity and increases in income are two facets of the same phenomenon. Since the first implies the second, and the composition of the second determines the relevance of the first, the one cannot be considered if the other is ignored." (Pasinetti, 1981, 69). Increases in per-capita income "endows single individuals with the possibility of obtaining larger amounts, or a larger number, of goods and services, or entirely new goods and services altogether." (Pasinetti, 1993, 37). However, consumers do not expand their demand for all goods proportionally, consumption expansion follows Engel's law, when consumption of a good has become satiated, only then attention turns to the next higher good in the hierarchical ordering. The second effect of technical progress is the emergence of new products. Thus, over time, the sector's labour and demand coefficients are modified by technical progress and by changes in consumer's tastes. If the rate of variation of these two coefficients are equal, the economy expands the various sectors proportionately, and its structure remains unchanged over time. This is what happens in the traditional models of exogenous growth. However, nothing guarantees that these rates will be the same. If the rates are different, as normally happens, the economy experiences structural dynamics of employment. Hence, in Pasinetti's analysis, structural dynamics of technology and demand generates structural dynamics of employment.

One of the weaknesses of Pasinetti's model was the assumption that the labour and demand coefficients were exogenously determined. Recently, Andersen (2001) overcame this weakness and developed an evolutionary micro founded model based on a set of rules that made endogenous the demand coefficients, the labour coefficients, and the number of available sectors.

## 6. Agent-based evolutionary growth theory

The last generations of endogenous growth introduced the mechanism of creation-destruction as an explanation for long-run growth. Following a similar vein, the evolutionary theory of growth introduced a mechanism of productive diversification that can be interpreted as a type of structural change. With its roots on the works of Nelson and Winter (1982) and Dosi (1982) among others, the evolutionary growth theory's early works focused on the issues of changes in technology and innovation, concentrating less on full analytic solutions and more on illustrative simulations including agent-based modelling. Models relating specifically to growth with structural change are fairly recent in this literature.

One example is Montobbio (2002), where he analyses the determinants of structural change and aggregate productivity growth based on the aggregation of the behaviours of heterogeneous firms in different economic sectors. Using an evolutionary approach, Montobbio sheds new light on the determinants of sectoral shifts and non-uniform growth. The main purpose of his analysis is to show that productivity growth, at sectoral and aggregate levels, is the result of a general evolutionary process. In order to do that the model explores the properties that connect the distribution of heterogeneous firms to the growth of industries, and the mechanisms that account for changes in the relative weight of different sectors (i.e. structural change) within an economy. Aggregate productivity growth is analysed as the result of the aggregation and interdependence of heterogeneous firms and sectors and is guided by the selection mechanisms within and between industries. Moreover, he analyses the impact of sector-specific income elasticities of demand. One of Montobbio's

findings is that the aggregate growth rate of labour productivity depends negatively upon the covariance between the sectoral elasticities of demand and the sectoral average unit costs, positively on the exogenous rate of demand growth and is proportional to the variance between sectoral unit costs and to the average of firms' unit cost variances within sectors.

Following a different approach from Montobbio, [Saviotti and Pyka \(2004\)](#) construct an evolutionary model where growth and structural change are driven by the creation of new sectors. The authors develop a dynamic model of growth involving qualitative change where economic development is driven by the creation of new industrial sectors. In their model, they put forward two hypotheses that link variety to economic development: (1) the growth in variety is a necessary requirement for long-term economic development, and (2) variety growth, leading to the development of new sectors, and productivity growth in pre-existing sectors, are complementary and not independent aspects of economic development. The authors justify these two hypotheses based on the imbalance between productivity growth and demand growth raised in [Pasinetti \(1981, 1993\)](#). According to [Saviotti and Pyka](#), if the economy were constituted by a constant set of activities, in presence of growing productivity it would become possible to produce all demanded goods and services with a decreasing proportion of the resources used as inputs, including labour. This imbalance would then constitute a bottleneck for economic development and could lead to technological unemployment. The introduction of new goods and services can be a way of compensating for the potential displacement of labour and of other resources.

Another article that tackles the issue of structural change from an evolutionary perspective is [Ciarli et al. \(2010\)](#). The authors offer a theoretical analysis of long-run economic growth as an outcome of structural changes. In an agent-based micro-founded framework they investigate the properties of a growth model that embeds the relation between technological and organizational change, income distribution and the dynamics of consumption affecting macroeconomic growth. Microeconomic behaviours are modelled in line with the large and consolidated evolutionary theory of technical change and economic growth, while the macro-framework borrows from the structuralist literature including the presence of a capital sector and endogenous consumption classes. They observe and explain the interactions between technological change, firm organization, income distribution, consumption behaviour and growth. [Ciarli et al.](#) confirm the relevance and interdependence of these structural changes and underline their microeconomic sources.

Agent-based evolutionary models are very powerful and complex. These type of models can only be solved through computational simulations. The main purpose of these models is to bring together and to integrate elements that were disconnected and isolated in the literature within a coherent theoretical framework.

## 7. Structural change and international trade

In recent years, there has been an effort to develop an integrated theory that includes increasing per capita income, sectoral dynamics, productive diversification and international specialization across countries. Structural change theory has focused in explaining the growth process of a country as a closed economic system. It has been paying scarce attention to the effects of structural change on world inequality, which trap some nations under poverty and ties them in a perpetual lagged position. A more complete explanation of this process has been made available by what can be called the New Latin American Structuralist (NLAS) growth theory. This approach combines three important branches: the contribution of Latin American Structuralism (LAS), originally due to [Prebisch \(1950\)](#), [ECLAC \(1954\)](#), [Cimoli \(1988\)](#) and more recently to [Cimoli and Porcile \(2010, 2014\)](#); the growth theory led by demand under balance of payment restriction [Thirlwall \(1979\)](#) and technological change and its effects on international trade [Dosi et al. \(1990\)](#). An empirical study in which the NLAS approach is grounded is [Hausmann et al. \(2006\)](#), where the authors show that countries that export goods associated with higher productivity levels grow more rapidly, even after controlling for initial income per head, human capital levels, and time-invariant country characteristics.

According to the NLAS approach, the level of diversification and technological development of a country's productive structure conditions its insertion in the international trade which, in turn, determine its balance of payment (BoP) equilibrium and in the end, its national gross product consistent with these BoP equilibrium. A country with low productive diversification, due to low technological capabilities, tend to specialize in the production of few commodities in order to explore the relative, but restrict advantages. Since this economy do not produce many of the final and intermediate goods that it requires, its dependency on

imports is high. The income elasticity of these imports tend to be high, while the income elasticity of its exports tend to be low. This combination produces a permanent restriction on growth. If the rate of growth remains high for consecutive periods, an external crisis emerges to correct the BoP deficit, reducing the growth rate. The external crisis can be postponed by attracting capital inflow through high interest rates. However, high interest rates discourage investment leading to a situation of insufficient demand. Growth in this economy cannot be sustained, after some periods accumulating external deficits the system exhibit its internal contradiction and growth without fail stops. The NLAS approach falls in line with the Schumpeterian and endogenous theory of growth when it locates the source of long-run sustained growth in the innovation and diversification processes. Yet, the NLAS approach differs from the tradition, in two important aspects. The first is the recognition of the important role played by aggregated demand, which became the main channel through which the restrictions operate. The second is the integration of structural change and growth into the international trade literature.

One recent example of this literature is [Cimoli et al. \(2010\)](#). The authors depart from the Schumpeterian assumption that countries that increase the share of technology-intensive sectors in their economic structures benefit more from technological learning and innovation. These countries are more able to respond to changes in the international markets and to compete in sectors whose demand grows at higher rates. The authors find evidence that certain kinds of structural change (namely those in which technologically intensive sectors increase their participation in the economy) favour growth. The process of structural change was measured by the Krugman Index and by the participation of high-tech and medium-tech exports in total exports. Both variables show a positive association with relative rates of growth in the international economy.

In the NLAS approach, structural change is embedded in the idea of productive diversification, which is captured by an aggregate index that represents the number of different goods the economy is able to produce and export. Structural change is analysed from a macroeconomic standpoint and, therefore, different from the evolutionary micro-approach where structural change emerges from the decision of individual firms. Despite being a macroeconomic approach, the NLAS has the advantage of allowing for the analysis of the insertion of a country or region into the international economy.

## 8. Final remarks

Modern growth theory has gone through a series of transformations since its birth. The focus of its analysis has expanded and the features of the models have become more complex. What we have seen in recent years is a new wave of models that are incorporating structural change into growth theory in ways never attempted before. These models have contributed to the understanding of the mechanisms behind the relationship between growth and structural change and have pushed further the frontier of the field of growth theory. However, as Acemoglu points out “[...] we are still far from a satisfactory framework for understanding the process of sectoral reallocation of factors [...]” ([Acemoglu, 2009](#), 720). Moreover, the majority of the models that analyse structural change focus on the reallocation of productive factors from some sectors of the economy to others, normally from agriculture to manufacturing and then to services. However, [Jorgenson and Timmer \(2011\)](#) argues that the classical trichotomy among agriculture, manufacturing, and services may have lost most of its relevance. They have discovered enormous heterogeneity among different services subsectors, largely ignored in the previous literature, something that calls for greater attention to individual service sectors to understand the process of economic growth and structural change. The next step in the evolution of modelling structural change has to include finding better ways to account for sector heterogeneity. In addition, the majority of growth models that deal with structural change assume the number of sectors and/or products in the economy to be constant. From the analytical standpoint, this simplification makes models more tractable. However, if one wants to understand the interactions between sectoral dynamics and growth, models should account for the increase/decrease in the number of sector/products in the economy. Lastly, the analysis of the impacts of structural change on international trade and its feedback effects on growth must also be considered if a comprehensive theory of growth and structural change is to be developed.

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