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Endogenous growth and structural economic dynamics: A comparative analysis

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Abstract

This study provides a deeper investigation into growth theories by comparing Paul Romer's endogenous growth theory with Luigi Pasinetti's structural economic dynamics framework. The analysis is primarily theoretical. The methodology is analytical and conceptual, grounded in a comparative theoretical framework. This paper employs a deductive approach to explore the internal consistency and evolutionary trajectories of these two distinct growth paradigms. Using the Solow growth model as a baseline, the paper examines the innovative contributions of Romer and Pasinetti to the field. Although these theories differ methodologically and epistemologically, they share a fundamental emphasis on technical progress, defined as technological knowledge, as the primary driver of economic growth. This study highlights their commonalities, specifically their focus on knowledge, learning, and skills as the core engines of progress, while noting that Pasinetti adopts a more evolutionary perspective. Finally, the paper contrasts their specific analytical toolkits: Romer's reliance on the aggregate production function and the rational expectations hypothesis versus Pasinetti's utilization of input-output analysis, vertically integrated sectors, and the "natural system" of production. The paper aims to provide new insights for future research, contributing to the debate regarding alternative approaches to growth theory.

Keywords: Knowledge, Learning, Pasinetti's structural economic dynamics, Romer's endogenous growth, Solow exogenous growth mode, Technological change.

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Contents

Contribution of this paper to the literature
This study's originality lies in its comparative synthesis of two traditionally siloed paradigms: neoclassical endogenous growth and structural economic dynamics. By deconstructing their disparate analytical toolkits, aggregate production functions versus vertically integrated sectors, the paper reveals significant methodological differences alongside surprising convergences in knowledge-led progress. This offers a novel, bridge-building perspective that transcends standard ideological divides.

1. Introduction

This paper aims to provide a comparative analysis of the endogenous growth theory developed by Paul Romer and the structural economic dynamics proposed by Luigi Pasinetti. Despite the methodological and epistemological differences between the two theories, the rationale for their comparison lies in the fact that both were innovative in emphasizing the key role of technical progress, interpreted as technological knowledge, in the growth process (Schilirò, 1994).

Economic growth was considered a central topic of economic theory by classical economists, notably Adam Smith, David Ricardo, Thomas Malthus, and Karl Marx. Technological progress, in turn, was regarded as one of the main drivers of a country's economic growth. Subsequently, the issue of growth was largely neglected by neoclassical (marginalist) economists, who focused instead on equilibrium analysis within a static framework.

Schumpeter (1911) rekindled economic theory's interest in the growth process after several decades of relative neglect. Like the classical economists, he regarded technological progress as the cornerstone of a country's economic growth. According to Schumpeter, the entrepreneur is the central figure in his growth theory: through innovative activity, the entrepreneur seeks to outperform competitors and thereby fuels economic growth. His theory emphasizes the importance of science and technology, the continuity of technological change, the diffusion of innovation, and a particular focus on the role of the entrepreneur.

Other significant contributions to growth theory following Schumpeter include Ramsey (1928) who proposed an exogenous growth model in which the saving rate is determined through a process of rational choice; Neumann (1945) a mathematically sophisticated framework that posits constant and infinite growth in which all sectors of the economy expand at the same rate; and Harrod (1939) model, of Keynesian origin, which explains the growth rate of an economy in terms of the level of saving and capital productivity. Harrod's analysis starts from short-run premises and highlights the conditions necessary to establish equilibrium between aggregate saving and investment in a dynamic economy. He essentially argues that there is no natural tendency for an economy to experience balanced growth.

Domar (1946) proposed a model similar to Harrod's; together, the two are known as the Harrod–Domar model. Domar emphasized that income growth must be proportional to investment and saving in order for the economic system to remain on an equilibrium growth path, even in the long run. However, if the key parameters, the saving rate, the capital–output ratio, or the growth rate of the labor force, deviate even slightly from their equilibrium values, the economy may experience rising unemployment or sustained inflation.

In his seminal contribution, Solow (1956) criticizes Harrod (1939) and, more generally, the Harrod–Domar model for assuming that production factors are combined in fixed proportions, particularly that the substitution between labor and capital occurs only in fixed ratios. This assumption explains the inherent instability of the model. Moreover, these models assume that the saving rate, the growth rate of the labor force, and the capital–output ratio are equal to one another and are exogenously given constants. In practice, however, this rarely occurs, as these variables are of a different nature and therefore tend to vary independently. Their equality would thus be purely accidental.

Solow's (1956) and Solow's (1957) theoretical contributions to growth, as well as those of other neoclassical economists associated with this approach, focus primarily on capital accumulation while neglecting the crucial role of technical progress, which is treated as a residual. For this reason, these models are classified as exogenous growth models, in which technological change is represented by an exogenous parameter.

Subsequently, Arrow (1962), through his dynamic model centered on learning by doing, sought to explain technical progress rather than treating it as an exogenous given, as in Solow's framework. According to Arrow, technical change arises from the accumulation of experience derived from investment in physical capital, which in turn leads to increases in factor productivity. Arrow's contribution represents an early attempt to endogenize economic growth. However, this theoretical framework assumes that productivity improvements occur in an essentially incidental manner, as a by-product of capital accumulation, rather than as an autonomous and independent process. After examining Solow's exogenous growth model, this paper analyzes Romer's contributions to endogenous growth, a theory suggesting that economic growth and prosperity stem from internal factors such as human capital development, technological innovation, and strategic investments. The paper compares Romer's theory with Pasinetti's alternative theoretical strand of structural economic dynamics. Comparing these two models illustrates how economic theory does not evolve along a single paradigm, but rather through diverse methodological approaches, each of which illuminates different aspects of a complex economic reality. The final section offers critical reflections on these approaches, highlighting their most innovative contributions to growth theory.

2. Solow Exogenous Growth Model

Growth theory in the 1950s is characterized by the contributions of Solow (1956) and Solow (1957), whose models, alongside those of Swan (1956), focus on capital accumulation. These works build upon foundations laid by Ramsey (1928) regarding the role of saving, though Ramsey's focus was specifically on achieving maximum intertemporal utility.[1] Furthermore, in the Ramsey model, as well as in subsequent neoclassical growth models

[1] Solow and Swan inspired by Ramsey simplified the saving behavior into a constant rate (s), whereas Ramsey (1928) (and later (Cass, 1965; Koopmans, 1965)) treated saving as a choice to maximize utility.

(Cass, 1965; Koopmans, 1965), the growth rate of per-capita output is a decreasing function of the level of per-capita capital stock, a direct consequence of diminishing marginal returns to capital.

The Solow (1956) is an equilibrium growth model characterized by exogenous variables such as the saving rate and the population growth rate. Because growth is eventually constrained by diminishing returns to capital,[2] Solow introduces neutral technological progress in the second part of his 1956 contribution. Although treated as an exogenous variable, this inclusion is necessary to justify the continuous growth of real wages and per-capita income in the long run.

Solow (1956) employs an aggregate production function to characterize technological possibilities. This function involves two factors of production, capital (K) and labor (L), measured in physical units, while output (Y) represents net production after accounting for capital depreciation:[3]

$$Y = F(K, L) \qquad (1)$$

Equation 1 is assumed to be strictly increasing in both inputs, exhibiting diminishing marginal returns to each factor and constant returns to scale (i.e., it is homogeneous of degree 1 in K and L). Thus, it satisfies the standard neoclassical conditions. A common functional form satisfying these properties is the Cobb-Douglas production function.

The capital stock K(t) takes the form of an accumulation of a composite commodity. Net investment I(t) is the rate of increase of this capital stock, dK/dt. Therefore, at any instant of time, we have the following identity:

$$dK/dt \equiv \dot{K} = I(t) \qquad (2)$$

The third fundamental equation of the Solow model is the saving-investment function. Assuming a closed economy with no government sector, saving and investment are represented as a constant fraction of total income Y(t):

$$S(t) = I(t) = s\,Y(t) \qquad (3)$$

By substituting the production function (Equation 1) into Equation 3, we obtain the fundamental law of motion for capital.

$$\dot{K} = s\,F(K, L) \qquad (4)$$

Equation 4 then is the engine of the model. It represents how the economy evolves over time.

In this context, as long as s F (K, L) > 0, the total capital stock increases. However, the growth of the capital-labor ratio will continue only as long as the savings generated are sufficient to exceed the requirements of labor force growth. Once savings are exactly offset by the need to equip new workers, the economy reaches its steady state.

Solow develops his model by building upon the framework established by Harrod (1939). Due to exogenous population growth, the labor force increases at a constant relative rate *n*. Since Solow assumes no technological change, *n* corresponds directly to Harrod's "natural rate of growth".

$$L(t) = L_o e^{nt} \qquad (5)$$

In addition to the previous equations, the marginal productivity equation determines the real wage (w): $\partial F(K, L)/\partial L = w$.

In Equation 4, L represents total employment (labor demand), while in Equation 5, L represents the available labor supply. Solow assumes that full employment is maintained perpetually by identifying these two variables as one and the same.

Solow (1956) analytically determines the time path of capital accumulation, assuming the full employment of the available capital stock, and derives the corresponding time path of real output.

Furthermore, Solow demonstrates the existence of various equilibrium growth paths. He specifically investigates whether a steady-state path of capital accumulation exists that is consistently compatible with any given exogenous growth rate of the labor force.[4] To this end, he introduces a new variable into the model, $r = K/L$, which expresses the ratio of capital L to labor (or capital intensity). Using the rate of change of this ratio $\dot{r}$, Solow explains that when $\dot{r} = 0$, the capital-labor ratio is constant. This condition leads to the fundamental equation of growth. In this state, the capital stock expands at the exact same rate as the labor force (*n*). Under this condition, the warranted growth rate, determined by the savings rate and the real rate of return on capital, aligns with the natural growth rate.

$$s\,F(r,1) = n\,r \text{ and } \dot{r} = 0$$

Where $s\,F(r,1)$ is the actual investment and $n\,r$ is the investment required to keep r constant (break-even investment).[5]

Solow's breakthrough is showing that the warranted rate is not fixed (as Harrod thought) but adjusts to the natural rate because $\dot{r}$ can vary. In fact, according to his analytical framework, in a production model with variable proportions and constant returns to scale, there is a tendency for the natural and warranted growth rates to coincide. This long-run equilibrium result mirrors the condition in Harrod (1939) where the natural rate equals the warranted rate. However, in Solow's framework, this outcome is not a "fortuitous event" (the Harrodian "knife-edge"), but rather a consequence of endogenous adjustments in the capital-labor ratio. Consequently, the economic system can adapt to any given labor force growth rate and eventually approach a steady state of constant proportional expansion.

Thus, in the Solow (1956) model, even if an economic system initially moves away from the steady state, it will gradually converge toward it; that is, it will tend toward steady-state growth in the long run. A steady-state growth path is achieved when production, capital, and labor all grow at the same rate, while output per worker and capital per worker remain constant.

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[2] This means that as capital per worker increases, the marginal product of capital falls. Thus, the growth rate of per capita output is a decreasing function of the capital stock. This is due to the law of diminishing marginal productivity.

[3] While Solow (1956) used net output, most modern textbooks (e. g., Acemoglu (2009)) use gross output and explicitly subtract depreciation in the capital motion equation.

[4] For a comprehensive treatment of this part of the Solow model.

[5] In a figure, the function *nr* is represented by a ray through the origin with slope *n*. Instead, the function s F (*r*, l) passes through the origin and convex upward. There is no output unless both inputs are positive, and diminishing marginal productivity of capital, as would be the case, for example, with the Cobb-Douglas function (Solow, 1956).

Also, the Solow model demonstrates that a sustained increase in capital investment, driven by a higher savings rate, only increases the growth rate temporarily. As the capital-to-labor ratio rises (increasing capital intensity), the marginal product of additional capital units decreases due to diminishing returns. Consequently, the economy returns to a long-run steady state where total output grows at the same rate as the labor force, assuming no technological progress. In this state, per capita output and real wages cease to increase.

For these reasons, Solow recognized that capital accumulation alone cannot sustain long-term growth due to diminishing returns. Consequently, technological progress emerges as the primary driver of a country's wealth (Solow, 1988). The central criticism of the Solow (1956) model, however, is that it treats technological progress as an exogenous factor, leaving the fundamental cause of growth unexplained within the model itself.

In the second part of his seminal work, Solow (1956) extends the basic model by introducing technological progress, specifically focusing on the case of Hicks-neutral technical change.[6] Crucially, this remains an exogenous variable within the framework. Technical change is defined as 'neutral' if it shifts the production function without altering the marginal rate of substitution between capital and labor for a given capital-to-labor ratio. Consequently, the production function is rewritten as:

$$Y = A\,(t)\,F(K, L) \qquad (1a)$$

Where A(t) represents the efficiency of the economy, capturing the cumulative effect of technological advancements over time.

In this extended model, which incorporates neutral and exogenous technological progress, the capital stock grows in the long run at a relative rate of $n + g/b$, surpassing the simple population growth rate (n) that would prevail without technological change. Simultaneously, the steady-state growth rate of real output is $n + ag/b$. This rate is not only higher than n, but it can also exceed $n + g$ (provided $a > 1/2$). The logic behind this acceleration is that increased real output leads to higher levels of absolute savings and investment, which further stimulate the growth rate. Consequently, in this scenario, the capital-labor ratio never converges to a fixed equilibrium value; instead, it grows indefinitely (Solow, 1956).[7]

Solow's (1956) model represents a landmark contribution to growth theory. While it does not capture every driver of economic expansion, it crucially demonstrates that capital accumulation alone cannot sustain long-term growth. Beyond its reliance on exogenous variables, such as technological progress and human capital, the model is also frequently criticized for its lack of microeconomic foundations, as it does not explicitly model the decision-making processes of individual households and firms.

Subsequently, Solow (1957) provides a seminal empirical analysis of the long-term growth of the U.S. economy. He demonstrates that between 1909 and 1949, the primary driver of economic growth was technological progress, rather than the mere accumulation of labor and capital.

Utilizing a Cobb-Douglas production function, this framework assumes Hicks-neutral and exogenous technical progress. Solow introduced a methodology for decomposing growth into shifts *of* the aggregate production function versus movements *along* it. This method relies on the assumption of competitive factor markets, where factors of production are remunerated according to their marginal productivities. As a landmark in growth accounting, this study has influenced a vast body of empirical literature, with subsequent research applying the model to various international contexts to debate the precise measurement of factor contributions to total output.

In conclusion, Solow's theoretical contribution remains a milestone in growth theory, establishing exogenous technological progress as the fundamental force driving long-term expansion. While Solow identifies technology as the key driver, his original works leave the nature of this progress largely unexplained. Solow (1957) captures the rate of technical change by accounting for the portion of output growth that exceeds the contributions of labor and capital; yet, Solow measures this growth without endogenizing it. Despite this 'black box' approach, Solow's legacy has ensured that both economists and policymakers prioritize technological advancement as the primary lens through which economic growth is understood.

3. Paul Romer and the Theory of Endogenous Growth

As discussed in the previous section, Solow (1956) assumes diminishing marginal returns to capital and exogenous technological progress. While long-run growth is influenced by savings behavior and population growth, the model predicts convergence among economies with identical structural parameters. Furthermore, in the absence of technological change, the long-run growth rate of output per worker is zero. Within this framework, differences in saving rates explain variations in income levels across countries, whereas policy interventions have only a limited impact on permanent growth rates.

Consequently, in Solow (1956), and more generally in neoclassical growth models (Cass, 1965; Koopmans, 1965), per capita output tends to converge toward a steady-state value in the absence of technological change, resulting in zero long-run per capita growth. This outcome follows directly from the assumption of diminishing marginal returns to capital in the production function.

Romer (1986) endogenous growth theory overcomes the limitations of diminishing returns to capital by positioning knowledge at the center of the theoretical framework. His empirical analysis highlights a lack of convergence between developing and advanced economies, suggesting that aggregate production functions may exhibit increasing returns. However, Romer acknowledges that long-term trends and aggregate data remain difficult to interpret. This empirical component of Romer's (1986) contribution represents one of the first attempts to explain divergent growth patterns through knowledge accumulation and its associated spillover effects.

By endogenizing technical progress, Romer analytically integrated increasing returns into dynamic general equilibrium models. While Young (1928) had previously emphasized the role of increasing returns in economic progress, his arguments remained primarily qualitative; the mathematical tools required to formulate explicit

[6] Hicks-neutral is the specific name for the type of technical change Solow describes, where the ratio of marginal products remains unchanged.

[7] Further extensions of the model address the labor supply, which was previously assumed to be completely inelastic with respect to real wages. Additional modifications allow for a variable savings rate, the introduction of fiscal policy, specifically taxation, and fluctuating population growth rates.

dynamic models with increasing returns were not yet fully developed. In contrast to Young, Arrow (1962) proposed a dynamic analytical growth model based on learning-by-doing. In Arrow's framework, increasing returns are present and arise from the discovery of new knowledge as a byproduct of investment and production. Crucially, these increasing returns are external to individual firms, as the resulting knowledge becomes a public good.[8] In his model, the productivity of a given firm is an increasing function of the cumulative aggregate investment of the industry.

While acknowledging Arrow's focus on learning, Romer (1986) notes that increasing returns can lead to divergent integrals in the objective function, potentially threatening the existence of an optimal equilibrium. He critiques the Arrow (1962) model for its reliance on exogenous population growth to offset diminishing returns to capital. In response, Romer introduces non-decreasing marginal productivity of knowledge, which facilitates sustained per capita growth even within a stable population.

Endogenizing technical progress allows for a reevaluation of labor specialization as a driver of long-term growth, reviving (Schumpeter, 1942) concept of 'creative destruction' as a fundamental catalyst for economic expansion. Romer (1986) and Lucas Jr (1988) demonstrate that long-term growth rates can be explained by the intentional decisions of economic agents, rather than by relying on exogenous technological shocks. In this view, new knowledge is generated within the economic system, creating positive externalities for productivity and per capita output. A central tenet of this theory is that knowledge, viewed as an intangible capital asset, serves as a primary production input characterized by increasing marginal productivity.

The 1986 model assumes increasing, rather than decreasing, marginal productivity of knowledge, viewed here as an intangible capital asset. This assumption is fundamental to reversing the standard findings of neoclassical growth theory. Consequently, long-run growth is driven by the accumulation of knowledge by far-sighted, profit-maximizing agents" (Romer, 1986).

Furthermore, while the production of consumption goods exhibits increasing returns to the knowledge stock, which itself possesses an increasing marginal product, the creation of new knowledge is governed by a research technology characterized by diminishing returns. Unlike neoclassical models where capital is subject to diminishing marginal productivity, Romer (1986) approach allows knowledge to grow without limit; however, the diminishing returns within the research technology serve to bound the growth rate of the state variable. Analytically, the model assumes a production function for consumer goods that is globally convex rather than concave. This function implies a maximum possible growth rate for per capita production, a direct constraint imposed by the research technology's limitations. In this framework, the growth rate of the state variable represents its percentage change over a specific period.

Furthermore, the model ensures a finite social optimum through diminishing returns to research, which imposes a maximum technologically feasible growth rate for knowledge. While production can accelerate, it remains logically bounded by this limit, preventing unsustainable growth in consumption and utility.

Simultaneously, the model allows the investment rate and the rate of return on capital to increase rather than decrease as the capital stock grows. This leads to the possible divergence of per capita output, where less developed countries may experience persistent stagnation. Notably, these results arise without assuming exogenous shocks or cross-country differences; even with identical, stationary preferences and technology, abandoning the global assumption of diminishing returns permits these heterogeneous outcomes.

A hallmark of Romer (1986) model is that investment in knowledge entails a natural externality.[9] Romer assumes that learning by doing creates a knowledge externality, arguing that when a single firm creates new knowledge, it exerts a positive external effect on the production capabilities of others because knowledge cannot be perfectly patented or kept secret. These externalities are integral to sustaining long-run growth; by incorporating them, Romer demonstrates that while individual firms face diminishing returns, the economy as a whole achieves constant or increasing returns. This occurs because knowledge, at the aggregate level, functions as a non-rival good.

Ultimately, the presence of knowledge externalities implies that private markets will under-invest in innovation, providing a normative justification for policy interventions to address these market failures. In Romer's model, firms maximize private profit but fail to capture the total social value of the knowledge they create due to spillovers. Consequently, the private sector tends to produce a sub-optimal level of knowledge. This creates a distinct wedge between private and social returns, resulting in an equilibrium where the market-driven growth rate falls below the social optimum.

Increasing returns in the production of goods, decreasing returns in the production of new knowledge, and externalities are the three defining elements of Romer (1986) model. Together, they facilitate a well-specified competitive equilibrium. In fact, Romer demonstrates that despite these increasing returns, a competitive equilibrium with externalities exists; while this equilibrium is not Pareto optimal, it provides a robust framework for explaining historical growth in the absence of public intervention.

Unlike growth models that employ increasing returns within a continuous-time optimization framework (Romer, 1986; Weitzman, 1970), the approach hinges on specific assumptions regarding search technology. Specifically, diminishing returns to research constrain the growth rate of the state variable (knowledge). Romer provides a general demonstration that such restrictions on the growth rate of the state variable are sufficient to ensure the existence of an optimum within a continuous-time model.

Essentially, the proposed framework is a competitive equilibrium model with externalities. Rather than solving a social planner's problem directly, this equilibrium is derived by maximizing a representative agent's utility while treating the path of an endogenously determined aggregate variable as given. In conventional externality analysis, focus typically rests on the social optimum and the corrective taxes required to sustain it. While Romer addresses these normative issues, he emphasizes the positive characterization of the no-intervention competitive equilibrium, arguing it is a more realistic representation of historically observed growth. A primary contribution of the paper is demonstrating that such a suboptimal equilibrium can be analyzed using elementary tools, specifically the

[8] A public good is non-rivalrous. It possesses the property that its use by one firm or individual in no way limits its use by another. In this sense, rivalry is a purely technological attribute of the good itself.
[9] Grossman and Helpman (1991) provide another example of endogenous growth driven by externalities.

qualitative analysis of differential equations, such as phase plane analysis, to show how the stock of knowledge and consumption evolve over time, even when the equilibrium equations cannot be derived from a stationary maximization problem.

In his Romer (1986) presents two models. The first is a simplified two-period, discrete-time framework of competitive equilibrium. He demonstrates that while this equilibrium satisfies a constrained optimality criterion, the outcome is nonetheless sub-optimal in the absence of government intervention.[10] Within this structure, Romer shows how increasing returns to scale at the aggregate level can coexist with competitive behavior at the firm level. The first fundamental hypothesis of this two-period model assumes that the production function F (k_i, K, x_i) is concave in the firm-specific inputs k_i and vector $\mathbf{x}_i$ for any fixed value of the aggregate knowledge stock, K. This hypothesis ensures the existence of a competitive equilibrium by maintaining diminishing returns at the firm level, even as increasing returns characterize the economy as a whole.

The second major assumption requires that F exhibit global increasing marginal productivity of knowledge from a social perspective. This stronger condition on increasing returns distinguishes Romer (1986) production function from the earlier models of Arrow (1962), Levhari (1966), and Sheshinski (1967). These models were limited by a vague treatment of specialization as a form of increasing returns, a reliance on exogenous population growth, and the problematic implication that per capita output growth is a monotonically increasing function of population growth. By contrast, Romer (1986) argues that incomplete models, which treat technological change as exogenous or endogenize it only descriptively, fail to adequately address welfare implications or empirical phenomena, such as declining growth rates and the persistent lack of convergence in per capita output.

The two-period model demonstrates a competitive equilibrium with externalities, where equilibrium quantities solve a concave maximization problem. Consequently, prices can be derived from the shadow prices (or Lagrange multipliers) associated with the constraints of this problem.

The second model presented in Romer (1986) is an infinite-horizon growth model in continuous time. The majority of the assumptions in this second model are identical to those of the two-period version. For instance, it is assumed that the production function is homogeneous of degree one, all agents are price-takers, and firms take the aggregate path of knowledge as given.

However, in this version, additional knowledge is produced by foregoing current consumption, with a trade-off that is no longer assumed to be one-for-one. The rate of growth of knowledge is represented by:

$$\dot{k} = G\,(I, k).$$

This implies that by investing an amount I of foregone consumption into research, a firm with a current stock of private knowledge k induces a growth rate $\dot{k}$. The function G is assumed to be concave and homogeneous of degree one.

The accumulation equation, expressed in terms of proportional growth rates, is:

$$\dot{k}/k = g\,(I/k), \text{ with } g(y) = G\,(y, 1)$$

A crucial assumption of this model is that g is bounded from above by a constant α, which imposes a strong form of diminishing returns in research. Specifically, for a given private stock of knowledge, the marginal product of investment in research, Dg, declines rapidly enough to bound g between 0 and α. Additionally, knowledge is non-depreciable, and investment is irreversible, meaning knowledge cannot be converted back into consumption goods. [11]

For simplicity, population growth is left out since it is not necessary for unbounded growth in per capita income. If knowledge and physical capital are assumed to be used in a fixed proportion in production, the variable k (t) can be interpreted as a composite capital good.[12] Given the increasing marginal productivity of knowledge, increasing marginal productivity of a composite k would still be possible if the increasing marginal productivity of knowledge were sufficient to outweigh the decreasing marginal productivity associated with the physical capital.

By assuming that increasing returns arise from the increasing marginal productivity of the stock of knowledge, Romer (1986) maintains the plausible conjecture that, even with a fixed population and physical capital, knowledge will never reach a level where its marginal product is so low that research is no longer worthwhile. However, Romer constrains the production of new knowledge (the research process itself) to exhibit diminishing marginal productivity at any given point in time. This ensures that while long-run growth is possible, the rate of investment in any single period remains bounded.

Moreover, Romer (1986) characterizes the social optimum, demonstrating that it cannot be supported as a competitive equilibrium without government intervention. He then establishes the existence and characterization of the competitive equilibrium, subsequently providing a welfare analysis that compares the two outcomes.

This second model proposed by Romer (1986) stands in direct contrast to the neoclassical standard, which features endogenous physical capital accumulation but lacks a mechanism for knowledge accumulation. However, his framework can be interpreted as a special case of a two-state variable model in which knowledge and physical capital are utilized in fixed proportions. Incorporating such an extension serves to broaden the range of possible equilibrium outcomes.

Romer (1986) concludes that once the operation of the basic model is established, incorporating additional state variables is straightforward. While the implications of a model featuring both the increasing marginal productivity of knowledge and the decreasing marginal productivity of physical capital can be derived from this framework, the geometric analysis using the phase plane becomes impossible with more than one state variable. Consequently, researchers must rely on numerical methods or the direct solution of dynamic systems of equations.

3.1. Romer (1987) Model: Increasing Returns to Specialization

[10] This model is globally sub-optimal because the private return on investment is lower than the social return; firms cannot internalize the spillover benefits that their knowledge production provides to others.

[11] In the model, units are normalized such that Dg (0) = 1, where one unit of knowledge equals the output of one unit of consumption invested at an arbitrarily slow rate.

[12] It is the approach used by Arrow (1962) in the learning-by-doing model.

In his Romer (1987) shifts his focus from the "learning-by-doing" spillovers of his 1986 work to a model where growth is driven by the expansion of the variety of intermediate goods. The article serves as a pivotal bridge between his earlier research and his 1990 model of endogenous technological change. By reviving Adam Smith's classical idea that the division of labor is limited by the extent of the market, Romer (1987) highlights that growth does not simply result from accumulating more of the same machines; rather, it stems from a greater variety of specialized intermediate inputs. The model demonstrates that variety, not just volume, is what drives long-run productivity. Moreover, in contrast to standard models characterized by diminishing returns to capital, Romer argues that if capital is distributed across an increasing number of different specialized goods, these diminishing returns can be offset, thereby enabling permanent growth.

The defining features of the 1987 model include an increasing variety of intermediate goods, structural specialization that facilitates increasing returns, and a move toward a monopolistic competition framework.[13] A crucial result of Romer (1987) model is that it generates endogenous growth even under the assumption that the stock of primary resources (such as labor) is fixed. Through the fixed nature of these resources, Romer demonstrates that population growth is not a prerequisite for sustained economic growth, provided there is increasing specialization.

In conclusion, this 1987 framework is essential to the development of Romer's endogenous growth theory, as it introduces a range of specialized intermediate inputs that allow the economy to expand. By endogenously determining the degree of specialization, the model demonstrates how an increasing variety of inputs can mitigate diminishing returns to capital, providing a structural mechanism for sustained long-run growth.

3.2. Romer (1990)Model on Endogenous Growth

Romer (1990) introduced a sophisticated endogenous growth framework in which long-run growth persists without exogenous shocks. He models technological progress as an expansion in product variety. This framework rests upon several core assumptions regarding the nature of innovation and its macroeconomic role. Central to his thesis is the assertion that technological progress, rather than mere resource accumulation, underpins economic expansion by incentivizing capital investment.

Unlike exogenous models, Romer posits that innovation is endogenously determined by profit-seeking agents responding to market signals. Crucially, the model distinguishes technical knowledge from traditional commodities based on its non-rivalrous nature: while developing new instructions involves a high upfront fixed cost, these instructions can be reused indefinitely at zero additional marginal cost. This creates an inherent scalability, as technology functions as a fixed-cost input with near-zero replication costs. Consequently, in contrast to the earlier framework of Romer (1986), which conceptualizes knowledge as a non-excludable public good arising from capital externalities, the 1990 model defines ideas as non-rival but partially excludable via mechanisms such as patents (Jones, 2019). Under this framework, excludability is determined by both the inherent nature of the technology and the prevailing legal infrastructure (Romer, 1990).[14] Institutions thus play a critical role in economic dynamics; by granting temporary property rights, the patent system enables the partial excludability of innovations, allowing firms to recoup their R&D investments (Jones, 2019). Ultimately, this non-rivalry is the foundational element of the model: because ideas can be utilized simultaneously by multiple agents, their integration with rival inputs generates increasing returns to scale, thereby facilitating sustained economic growth.

The shift in market structure between these two models is equally fundamental. While Romer (1986) assumes perfect competition with externalities, Romer (1990), following the groundwork laid in 1987, necessitates a monopolistic competition framework. This structure is essential because R&D entails high upfront fixed costs, such as the initial creation of a blueprint. Under perfect competition, price is driven down to marginal cost; however, because the marginal cost of replicating an idea is near zero, firms must be able to charge a markup to recoup their investment. Such pricing power is only attainable if firms maintain a degree of market power over their specific inventions, typically secured through intellectual property rights.[15] Furthermore, whereas knowledge in the 1986 model is treated as a byproduct of passive spillovers from physical capital, the 1990 model conceptualizes knowledge as the result of intentional R&D conducted by profit-maximizing firms.[16] In this framework, researchers leverage human capital to expand product variety by inventing novel types of intermediate inputs. [17] This "standing on the shoulders of giants" mechanism ensures that each new design augments the aggregate stock of knowledge, rendering future innovation progressively more efficient and cost-effective.

One could argue that the transition from Romer (1986) to Romer (1990) mirrors the shift between the Schumpeter Mark I and Schumpeter Mark II innovation regimes. While the 1986 model reflects a Mark I environment of competitive externalities and learning-by-doing, the 1990 model captures the Mark II regime, where innovation is institutionalized within profit-maximizing firms possessing market power.

Romer (1990) presents a model consisting of three distinct sectors: a final goods sector, an intermediate goods sector, and a research (R&D) sector. Specifically, the R&D sector employs human capital and the existing stock of knowledge to produce new designs or blueprints.[18] The intermediate goods sector, in turn, acts as the engine of growth by converting these abstract ideas into physical capital goods. This process characterizes "variety-based" growth, a concept introduced in Romer (1987), where economic expansion is driven not by the qualitative

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[13] In this paper, Romer moves toward a monopolistic competition framework, utilizing it to justify the equilibrium variety of intermediate goods. However, it is in his 1990 paper that this market structure becomes the fully realized engine of growth, providing the necessary incentives for R&D through the expectation of monopoly profits.
[14] A good is excludable if the owner can prevent others from using it.
[15] Monopolistic competition is, therefore, the source of the remuneration of technological progress.
[16] Innovation is cumulative: every new design adds to the total stock of knowledge. By allowing new inventors to 'stand on the shoulders of giants,' this spillover mechanism makes future research progressively more efficient and less costly.
[17] Romer takes inspiration from the variety models by Dixit and Stiglitz (1977) and Ethier (1982).
[18] This represents the non-rival component of the model. While an individual's new blueprint is protected by a patent (making it excludable), the cumulative stock of existing blueprints enhances the general productivity of all researchers. In this way, knowledge functions as a capital input with external benefits.

improvement of existing machines, but by the continuous expansion of the total number of distinct capital varieties[19].

The model incorporates several simplifying assumptions to maintain analytical tractability. First, both the total population and the aggregate labor supply are assumed to be constant. Second, the total stock of human capital (H) is fixed, as is the fraction of that stock supplied to the market. Consequently, the aggregate supplies of labor (L) and human capital (H) are treated as exogenous constants. To streamline the dynamic analysis, the model focuses exclusively on equilibria characterized by constant growth rates. Third, the assumption that capital accumulation occurs via foregone output implies that capital goods are produced within a sector utilizing the same technology as the final-output sector. Fourth, the research process is conceptualized as being uniquely human-capital intensive. Romer (1990) formalizes this by adopting an "extreme specification" in which new designs and knowledge are produced using only the existing stock of knowledge and human capital as inputs.

Romer's framework emphasizes the necessity of robust public and private support for R&D, intellectual property, and human capital to catalyze innovation. While this perspective offers fresh insights into long-term economic expansion, it faces criticism for its reliance on theoretical assumptions, such as increasing returns to scale and the non-rivalry of ideas, which remain difficult to validate through empirical evidence.

The Romer (1990) model is the cornerstone of Romer's endogenous growth theory. It provides the economic justification for private-sector R&D: firms invest in research to produce a "blueprint," which, protected by intellectual property rights, grants them a legal monopoly over a specific variety of intermediate goods.

In conclusion, Romer's theory posits that knowledge and innovation function as the primary engines of increasing returns to scale; unlike physical capital, investment in knowledge generates compounding benefits over time. Consequently, an unregulated market is no longer considered the "best of all possible worlds," as the presence of market failures necessitates a strategic role for institutions. Romer (1990) also argues that unbounded growth and incomplete appropriability are fundamental characteristics of economic expansion, both of which are inextricably linked to non-convexities in production.[20] When private firms and the public sector invest in research and development, they produce ideas with broad externalities across diverse industries. These innovations facilitate more sophisticated production methodologies, the emergence of entirely new industrial sectors, and a sustained rise in living standards. Crucially, due to the non-rivalrous nature of ideas, these benefits do not succumb to diminishing marginal returns; rather, they generate increasing returns to scale as they are leveraged across the macroeconomy. Furthermore, human capital serves as a vital catalyst for this trajectory. An educated workforce does not merely enhance routine task efficiency but actively generates the technological breakthroughs necessary to sustain a virtuous cycle of endogenous economic expansion.

4. Pasinetti's Structural Dynamics and Economic Growth

The themes of structural change and structural dynamics are central to Pasinetti's analysis of economic growth. In his Pasinetti (1981) argues that economic structure evolves over time, driven by shifts in both the conditions of production and the composition of demand, with technological progress acting as the *primum movens* of change. Pasinetti invokes Smith (1776), noting that growth and qualitative changes in production depend on human intelligence, dexterity, and skill. These factors, highlighted by Smith and revisited by Pasinetti, remain highly relevant in the current economic debate on growth. Indeed, intelligence and skill are the primary factors influencing productivity and, consequently, growth. Because growth is rooted in human know-how, it is inherently endogenous. Artificial Intelligence, itself a product of human intelligence, is now emerging as a primary engine for productivity growth. Through the creation of a recursive tool like AI, human intelligence can now accelerate the productivity that Smith first observed in the pin factory.

While Romer provides the micro-foundations for how non-rivalrous knowledge generates growth within a market structure, Pasinetti offers a macro-dynamic framework that emphasizes how growth reshapes the economy's sectoral composition.

By constructing a multisectoral model, Pasinetti demonstrates that growth is inherently uneven, driven by divergent productivity trends across various sectors. This analysis of structural change of an economic system that grows unevenly mirrors the earlier work of Schumpeter (1934) and Schumpeter (1942), who identified innovation as the distinctive feature of capitalist society. For Schumpeter, as for Pasinetti, innovation dictates shifts in both the quality and quantity of goods, acting as the primary catalyst for economic development (Pasinetti, 1981). Furthermore, this position stands in stark contrast to steady-state models[21]. Pasinetti posits that growth is inherently disproportionate, as productivity potential varies across commodities, directly affecting the amount of labor required per unit of output.

By denoting the rate of change of productivity in sector i as ρ_i and in sector j as ρ_j, he assumes.

$$\rho_i \neq \rho_j$$

Furthermore, Pasinetti rejects the assumption that demand for all goods grows at a uniform rate, grounding his model in Engel's Law and the concept of a hierarchy of needs (Garbellini & Wirkierman, 2014). Consequently, structural change is a systemic necessity rather than an anomaly; it arises because it is technologically and statistically improbable for every sector to maintain a constant relative share, as this would require identical rates of technological progress and income elasticity across all industries simultaneously. Within this framework, effective demand plays a critical role: as sectoral productivity ρ_i increases over time, technical coefficients of production a_{ij} decrease, necessitating a corresponding rise in the demand coefficients r_i to maintain full employment. Because the model does not guarantee that full employment will be achieved automatically, rather, it must be pursued through deliberate policies that ensure a continuous adjustment of demand.

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[19] While the expanding variety in Romer (1990) consists of intermediate capital goods, Grossman and Helpman (1991) focus on an expansion of consumer product variety. In contrast, Aghion and Howitt (1992) model growth through "quality ladders," where technological progress occurs via the creative destruction of existing goods rather than a mere increase in variety.

[20] Non-convexities refer to the departure from standard competitive assumptions (where production sets are convex) caused by high fixed costs and increasing returns, which prevent price-taking behavior from being efficient.

[21] Pasinetti's departure from the "steady state" is crucial; he argues that since productivity and demand rarely grow at identical rates across all sectors, the economic system is in a state of permanent flux.

Pasinetti starts from Leontief's framework for inter-industrial analysis (Leontief, 1951, 1953), confirming a continuity and compatibility between Leontief's approach to structural analysis and his own. Moreover, Pasinetti draws the concept of the *sub-system* from Sraffa (1960), who introduced the term within a theoretical model where production is depicted as a circular process[22]. In a later article, Pasinetti (1986) explains that he seeks to synthesize Sraffa's circular production theory with Keynesian macroeconomic analysis. By representing the economic system through vertically integrated sectors, he bridges Sraffa's focus on price consistency and inter-industry relations with the Keynesian emphasis on effective demand and the long-run evolution of output.

By partitioning the economic system into *sub-systems*, Pasinetti establishes a direct relationship between a specific quantity of labor and each unit of final consumption (Schilirò, 2006). Utilizing *sub-systems* is crucial for analyzing non-uniform growth, as it facilitates the study of differentiated structural change across the economy. This approach avoids the "analytical unification" that often obscures sector-specific dynamics.

Starting from the analytical expressions that determine the *sub-systems*, Pasinetti introduces vertically integrated sectors (Pasinetti, 1973), which he deems essential for dynamic analysis. He first defines the *vertically integrated labor coefficient*. This scalar represents the total amount of direct and indirect labor required by the economic system to produce one physical unit of the i^{th} commodity as a final good. Similarly, he defines a column vector representing the heterogeneous physical quantities of commodities required, both directly and indirectly, to produce that same unit of the i^{th} commodity as a final good. This specific composite of commodities is termed *a unit of vertically integrated production capacity*. Together, the labor coefficient and this vector constitute the *vertically integrated sector* for the production of the i^{th} commodity as a final good for both consumption and investment, compactly representing a *sub-system*.[23]

In Pasinetti's framework, the process of vertical integration is a device for performing structural analysis by reclassifying the economic system into *logical units*, a necessary step for dynamic analysis. A significant feature of the *vertically integrated sector* is its invariance to technical progress. Relationships expressed in these units maintain their validity over time, possessing an autonomy independent of shifts in their physical composition. This stands in stark contrast to capital goods expressed in ordinary physical units, which are subject to constant substitution processes. The breakdown of the economic system into *vertically integrated sectors* yields synthetic notions that simplify dynamic analysis, enabling a direct grasp of how economic structures evolve over time (Schilirò, 2006).

Pasinetti highlights two distinct approaches to analyzing an economic system's structure. The first is the circular approach, which represents and decomposes the production system into *sub-systems*. This allows for the analysis of complex interconnections between production processes, both in physical terms (addressing fixed capital, joint production, and natural resources) and in value terms (examining income distribution and relative price variations). The second is the vertical integration approach, which focuses on sectors where intermediate process complications are internalized. This analysis centers on the relationship between final goods at one end of the production chain and their ultimate labor requirements at the other (Schilirò, 2006).

Pasinetti asserts that these two approaches are complementary: a one-to-one correspondence exists between an economic system expressed as a set of "industries" and one represented by *vertically integrated sectors*, holding for both physical quantities and prices. However, this correspondence is valid only for a fixed technique at a specific point in time. Once the system undergoes structural change, or more precisely, structural dynamics, this static mapping is disrupted. Consequently, it is essential to retain both perspectives: the circular approach to capture the instantaneous interdependencies of production, and the vertical approach to trace the system's evolution and the long-term patterns of economic growth.

A defining feature of Pasinetti's approach is his search for fundamental pre-institutional properties that correspond to what the Classical economists termed "natural." He states (Pasinetti, 1981):

"To develop, first of all, a theory which remains neutral with respect to the institutional organization of society."

He distinguishes between two levels of analysis, the natural and the institutional, contending that the underlying technical and functional requirements of the economy must be understood before being layered with specific social or legal frameworks (Pasinetti, 1981).

In this study, the natural relations associated with structural dynamics are analyzed in two stages. First, they are examined within the context of a pure labor production economy, and subsequently, within a more complex framework that incorporates capital goods.

Pasinetti (1981) model, which defines "natural features" as the necessary requirements for equilibrium growth, reveals the conditions for maintaining full employment over time (flow equilibrium) and the conditions for maintaining full utilization of productive capacity over time (stock equilibrium).

An issue that this model has raised is the distinction between the general dynamic analysis of the price and quantity systems, governed by macroeconomic conditions, and the dynamic equilibrium paths, which vary according to each possible exogenous combination of distributive variables. Furthermore, there is the specific case of the "natural" economic system, resulting from a particular closure of the price system, where Pasinetti has chosen to use an arbitrary scale factor.

Another point of contention is the pre-institutional nature of the model, which some critics have occasionally mistaken for "pre-industrial." In reality, Pasinetti's aim was to identify the primary and "natural" characteristics of a pure production system, echoing David Ricardo's original concept. Ultimately, his work is a matter of the level of abstraction rather than an attempt to provide a direct description of empirical reality.

In conclusion, Pasinetti sought to integrate structural change into the analysis of economic growth, aiming to push growth theory beyond the steady state by abandoning the unrealistic hypothesis of balanced growth. His model is built upon a series of key assumptions regarding the evolution of technical change and demand patterns, and it is characterized by a high level of abstraction.

[22] The concept of production as a circular flow, and the corresponding 'horizontal' integration, is also present in Neumann (1945), Leontief (1951), Hicks (1965), and Quadrio Curzio (1986). In the horizontally integrated models, each commodity appears as both an input and an output; consequently, neither primary resource, nor any final consumption commodity is assigned a logically pre-eminent role.

[23] An application of Pasinetti (1981) analytical framework using vertical integration in the Italian economy can be found in Schilirò (1986).

4.1. Pasinetti's Structural Economic Dynamics

In integrates dynamic analysis with structural change, defining structural dynamics as the evolution over time of the composition, and consequently the structure, of macroeconomic magnitudes. Empirical evidence demonstrates that the long-term development of industrialized economies occurs through a continuous modification of the production structure; this structure is subject to systematic changes rather than remaining constant, a fact that decisively rejects models of proportional dynamics.

A central tenet of his theory is that the origins of structural dynamics must be found within the evolution of demand. This perspective offers a highly relevant theoretical vision of the evolution of modern market economies.

The 1993 book represents a significant refinement of Pasinetti (1981), which established the foundational groundwork for these constructs. Central to his framework is the analytical concept of vertically integrated sectors, a notion he further revised and extended. Pasinetti presents his argument in its most essential form, acknowledging that this minimal model represents an early stage in a broader research program. In a departure from his 1981 work, natural relations are analyzed within a pure labor economy, where labor is the sole input and consumption is the only end-use of output.[24] Consequently, the primary results of the theoretical model emerge independently of capital goods. These results derive from a renewed emphasis on the learning principle, which is explicitly identified as the fundamental force behind structural dynamics. This focus clarifies the nature of his theoretical approach, positioning the model at a high level of abstraction that allows critical points to emerge more distinctly. Through this model, Pasinetti emphasizes that technical progress, rather than capital accumulation, is the primary driver of long-term dynamics in industrial economies.

In contrast to Sraffa (1960), where production is defined by the use of commodities to produce other commodities, this framework assumes that goods are produced solely by means of labor.

Pasinetti's pure labor model treats production as a process defined by extensive specialization and the division of labor, features central to the functioning of a modern advanced economy. Under this model, each individual produces, or contributes to the production of, only a single type of good. This specialization facilitates significant labor productivity gains, necessitating that individuals obtain all other goods through exchange.

Pasinetti's model consists of a system of physical quantities and a system of prices that are entirely decoupled. Indeed, these systems can be solved independently of one another. Prices are proportional to labor coefficients, defined as the quantity of labor multiplied by the unit wage. In a system where labor is the sole factor of production, prices are necessarily proportional to the quantity of labor. This result echoes the theory of Classical economists, who termed these 'natural prices' because they reflect the permanent determinants of production costs as expressed by labor requirements. Regarding the system of physical quantities, output levels are proportional to consumption coefficients—defined as per capita demand for consumer goods multiplied by the total population. Under the simplifying assumption that the total population coincides with the working population, this solution to the system of quantities yields a theory of production dominated by effective demand. This result, clearly of Keynesian origin, implies that regardless of the specific decision-making processes of firms, the physical quantities produced are determined by the level of effective demand for various goods. Furthermore, within this system, there is a single constraint that is macroeconomic rather than sectoral. This constraint, which represents a necessary condition for equilibrium, is determined by the aggregate availability of labor, that is, the requirement of full employment. In this pure labor model, the structural dynamics of prices are analyzed almost exclusively through vertical integration. Regarding quantities, however, it emphasizes the necessity of using vertically integrated and inter-industry analyses in a complementary manner. To conclude, Pasinetti seeks logical coherence and epistemological validity within his structural dynamics framework, as its capacity to generate normative implications necessitates a rigorous analytical foundation. By isolating the "natural" requirements of an economy, independent of specific institutions, he establishes the impact of effective demand and the conditions for full employment, effectively bridging the gap between abstract theory and policy prescription.

5. Discussion and Conclusion

Romer's endogenous growth theory represents a landmark contribution to economic analysis. Its emphasis on increasing returns to knowledge, externalities, monopolistic competition, and product variety offers a level of originality that departs significantly from the traditional neoclassical school. Above all, Romer's work is noteworthy for providing the foundational perspectives that paved the way for the neo-Schumpeterian framework. A key evolution of this lineage is found in Aghion and Howitt (1992), who formalize the Schumpeterian idea that progress is inherently disruptive. Through their "Quality Ladder" concept, they focus on vertical growth, where each innovation improves the quality of an existing intermediate good, rendering the previous version obsolete. Furthermore, their model specifically addresses the complexities of uncertainty within the innovation process.

Pasinetti's structural dynamics is also noteworthy because it challenges the one-sector bias of mainstream growth models by proposing a multisectoral framework. Moreover, he argues that growth is a disequilibrium process that fundamentally alters both production and consumption patterns. It is not only technological progress but also the non-proportional evolution of demand that explains the dynamics of uneven growth across sectors. Furthermore, the endogeneity of his model relies on learning, viewed as the true engine of wealth, and shifts in demand that are considered internal to human progress. Specifically, sustained growth requires a balance between the learning of producers (technical progress) and the learning of consumers (demand evolution).

While Paul Romer's endogenous growth theory and Luigi Pasinetti's structural economic dynamics framework differ methodologically and epistemologically, they share a fundamental emphasis on technical progress, conceptualized as the accumulation of technological knowledge, as the primary driver of growth. Both frameworks are anchored in the Schumpeterian vision of innovation, which fosters a dynamic environment essential for sustained expansion. Furthermore, both models depart from the exogenous treatment of technology characteristic of the Solow model. However, in Romer's model, growth is endogenous because it stems from intentional, profit-motivated investment in innovation. Within this framework, firms invest in Research and Development (R&D) to

[24] Pasinetti, however, recognizes that his previous work (Pasinetti, 1981) provides a broader analytical framework—one that accounts for capital goods and, consequently, two distinct categories of demand: consumption and investment.

produce new "blueprints." Because knowledge is a non-rivalrous good, it generates increasing returns to scale, allowing the economy to sustain growth indefinitely.

Pasinetti's structural economic dynamics conceptualizes growth as a process of continuous internal transformation. Learning is the primary source of technical progress and structural change. Within this framework, growth is driven by the interplay between productivity-enhancing technical progress and the evolution of demand; as rising incomes shift consumer preferences (Engel's Law), the entire economic structure must adapt.

Ultimately, while both authors highlight learning processes and human capital to render technological change endogenous, they approach the concept from distinct analytical perspectives: Romer focuses on aggregate growth rates through a neoclassical lens of rational expectations, whereas Pasinetti emphasizes sectoral composition, vertically integrated sectors, and a departure from the rational expectations assumption.

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