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From Linearity to the Complexity of Production Systems, Towards A Sustainable Perspective

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Classical economic theory assumes the structure of linear production promotes the balance of markets, discarding the presence of externalities, given the rationality of the economic agent. The objective of this essay is to counter-argue the linear vision of production, which through the sciences of complexity and postulates of non-linear dynamics, as methods of contrasting, allow to assume the need for a more complex view of the to shift towards a transcomplex epistemological base, which alludes to the material closure cycle model, as an alternative to optimize and efficient both the functionality of production units and the productive factors. The arguments refer to the relevance of a complex perspective of the production system, given the series of interactions that are manifested between agents and factors, as well as the energies, materials and waste dissipated, many of them with adverse effects on the environment, translated into behavior market dynamics (in terms of costs and prices), and that the linear model omits them.

Keywords: Linear production; non-linear dynamics; Production System.

1. Introduction

Production systems not only imply the presence of a set of agents, economic factors and direct and indirect interactions, but, above all, it is intended to optimize the use of inputs and materials, to increase the functionality of markets such as the reduction of negative externalities to the environment, in search of building sustainable productive environments.

In this task, it is argued, the relevance of creating denser fabrics and production environments, capable of taking advantage of the waste generated in the production line, through the inclusion of other agents and productive components, seeking to reduce environmental externalities as much as possible.

The epistemological confrontation between classical economic theory and production systems made it possible to elucidate that the structure of linear production does not always favor the equilibrium of markets, much less do economic agents behave rationally in terms of seeking collective benefits. The counter-argument of the linear vision of production, through the sciences of complexity and the postulates of non-linear dynamics, as methods of contrast,

allows us to assume the need for a more complex vision of production in order to veer towards a transcomplex epistemological base, which alludes to the model of the cycle of closure of materials. as an alternative to optimize and make efficient both the functionality of the production units and the productive factors, where the inclusion of other scientific visions such as Physics and Biology (through the laws of thermodynamics), show not only the interpretative breadth of production systems, but also the relevance of building these environments as an alternative to turn to sustainability.

The functionality of linear production from the perspective of classical economic theory

Classical economic theory constitutes one of the main bastions of economic science, whose widely founded and proven approaches permeated the thought of the time, translated into a school of formation and into a doctrine of application. The theoretical, modelling and instrumental forcefulness soon paved the way, and an unprecedented sum of followers, who made such approaches their own, either to generate their own analytical perspectives, expand their postulates or generate greater evidence in order to scale their ideological influence in contexts of dominance such as capitalism, international politics and the control of markets (Hernández, 2007).

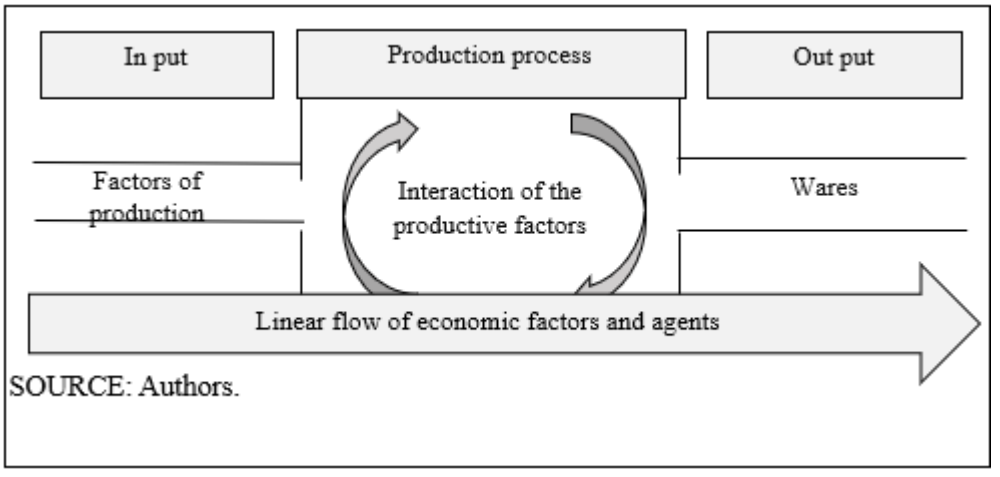
Thus, the vision of this theory is based on the rationality of economic agents, whose optimizing behavior gave functionality and efficiency to the production units, modeled through the black box shown in Figure 1, whose linear character is integrated by three major phases:

1. In-put . A set of inputs and materials that can be converted into factors of production.

2nd. Production process. Interaction and combination of the set of inputs, which with their transformation generates new products for direct and indirect consumption.

3rd. Out put . Range of finished products, available on the market for consumption.

Figure 1. Black box production model



Classical economic theory assumes that this productive linearity leads to an adequate functioning of the market, interpreted as a relative stability between producers-consumers through equilibrium, which in turn creates a productive environment of greater dynamism.

even assuming the absence of failures and externalities. When a possible imbalance occurred, it was the same forces of the imbalance and the rationality of the economic agents that pressured the adjustment of the price, considered as the main mechanism of regulation and market stability (Gómez, 2010).

This position was very well argued and evidenced through the approaches of classical economists such as Say, Walras, Pareto, Edgeworth and others, who through different instruments and models (black box, closed economic circuit, Cartesian plane, among others) generated evidence of great value that endorsed the apparent relevance of economic and productive linearity under the ceteris paribus criterion. discarding any disadvantageous and dysfunctional behavior of the markets, as well as scalar effects, such as socio-environmental externalities.

The ups and downs of productive linearity

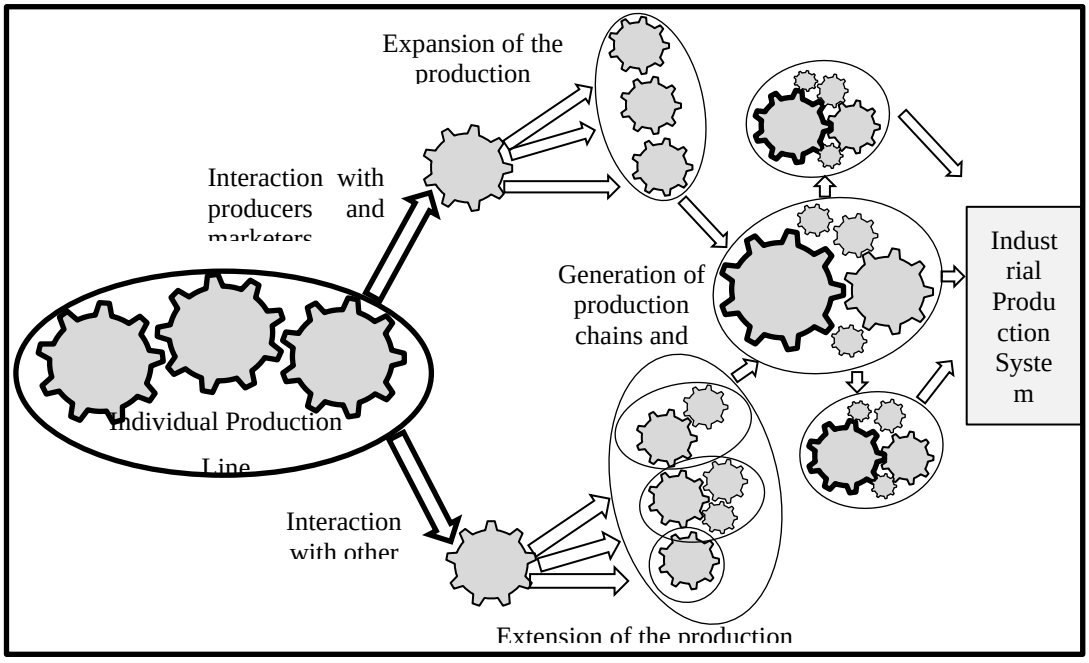
Despite the seasoned arguments issued by classical economists, when contrasted with some perspectives associated with Economics, such as Philosophy, Psychology, Sociology, even Physics, Chemistry, Biology, among others, we find that the human being, in that rational, ethical and non-selfish connotation, loses relevance.

The philosopher Thomas Hobbes, argued that man is evil by nature, is selfish and antisocial. Even the English classical economist Jeremy Bhentam, father of economic utilitarianism, argued that human beings behave selfishly according to their preferences for utility. This selfishness, which can be described as psychological, implies that the rationality and decision of the economic man is for his own benefit and not for that of his fellow men, so the more individual utility, the better well-being, which contradicts the approaches of the theory of abstinence. Even Kant assumes that autonomous rational capacity breaks with the principle of balance, equality, and equity.

To these ideas are added the contributions of J. Locke, F. Bacon, I. Newton, R. Descartes, K. Marx, and others, who define a broader and more extensive epistemological course, going beyond the postulates of linear rationality, market equilibrium, the functionality of the economic circuit and the uniformity of the production model, that is, the ceteris paribus criterion, begins to lose validity, to assume that any activity carried out by man (in his capacity as an economic agent) or of the production units, is necessary the intervention of other agents, companies, elements and components present in other contexts and latitudes, in whose interactions, links and associations, can generate market failures, environmental externalities and other types of economic dysfunctions, considered as natural behaviors or reactions of human anthropic behaviors.

The presence of this infinity of interactions extends the productive linearity, through the generation of chains and networks, whose scalarity interweaves denser environments to configure production systems (industrial, for example), as can be seen in Figure 2, to make the production process more efficient and attenuate externalities towards the territorial environment.

Figure 2. Extension and dynamism of productive linearity



SOURCE: Iglesias, 2021, p. 24.

"The social crisis of Fordism determined the exhaustion of the Taylorist modes of realisation of productive profits. More broadly, he radically questioned the dynamics of the cross-relations that have to do with the knowledge economy and the relations between capital and labour and finance/production. For this reason, this crisis can be interpreted as a true historical rupture within the dynamics of capitalism. This rupture is manifested especially through two of the main tendencies of contemporary capitalism. The first has to do with the imposing process of financialization, which must be reread in the light of the transformations of the division of labor and the genealogy of the process of regulating the wage relation. The second tendency is related to the generalization and centrality of knowledge within an organization of production that increasingly tends to go beyond the limits of companies and become social production" (Fumagalli, 2010, p. 85).

Thus, the classical reductionism of production was densified to consider that the linear model must have a more complex connotation, added to the natural non-rational behavior of the human being as an economic agent. In this way, the black box must be seen as a system, with continuous direct and indirect interaction with other elements, whose anthropic nature generates waste in the form of materials, energy and gases that alter both the state of the environment (externalities) and the functioning of the market, which must also be seen as a system (market system).

"In the course of the last two centuries of capitalist production, the modes of accumulation have been structurally transformed, but this has in no way reduced the character of hierarchy/subordination that distinguishes the capital-labor relation. The metamorphosis of the accumulation process over time has not only corroded the forms of organization of production,

the modes of supply of labor power or the structure of capital, but also the forms of ownership, direction and control" (Fumagalli, 2010, p. 84).

In this complex vision visualized in Figure 3, the productive linearity is extended from three to seven phases, namely:

1. Pre-in put. A set of agents and conditions that play the role of suppliers of inputs, materials and energy, with the required natural characteristics and attributes.

2nd. In-put . Range of inputs and materials that can become factors of production.

3rd. Production process. Interaction and combination of the set of inputs, whose transformation generates new products for direct and indirect consumption.

4. Out put . Range of finished products, available on the market for consumption.

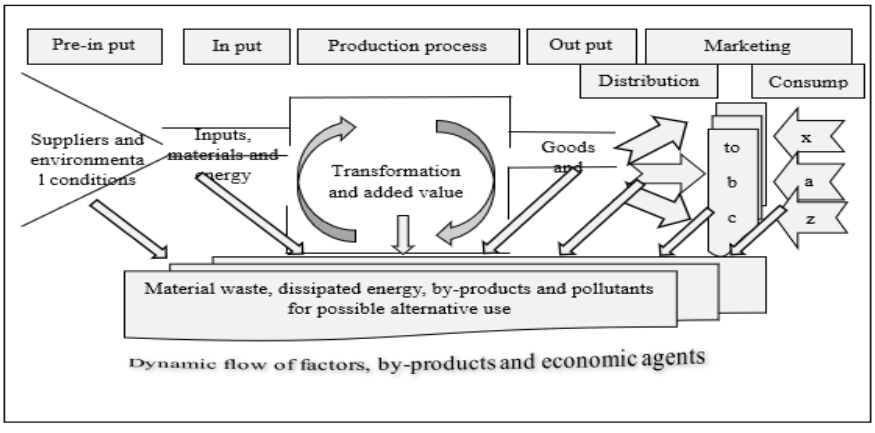
5. Distribution. Location and disposition of goods and services in the market.

6. Marketing. Accessibility of goods to different types of markets (market segmentation) according to consumer preferences.

7th. Consumption. Consumption preferences according to the user's needs.

The interesting thing about this extension and complexity is that at each stage of the production system, energy, gases, by-products and other types of material waste are dissipated, some usable and reusable, and others, whose characteristics cannot be given an alternative use, such as carbon dioxide (CO2), degraded heat, dust, among others. they are those that are still considered as externalities to the environment. This means that, despite the fact that the production system has been optimized, the repercussions increase, consequently altering the functioning of the market, so that by conceiving production and the market itself as complex systems, it is inappropriate to assume the existence of equilibria, rather what it should refer to is the tendency of stable behaviors. or as Prigogine calls it, non-linear dynamics (Gutiérrez & González, 2012).

Figure 3. Extended linear model: complex production system



a, b, c: Types of market where goods and services are traded.

x, y, z: Types of consumers according to the type of market where they turn.

Source: Authors' elaboration based on Iglesias, 2021.

Non-linearity applied to the production system

To understand the scalar effects of the complex production system, it is necessary to add other visions such as Biology and Physics, which, through the principles of thermodynamics, provide ample information on productive inputs. This thermodynamics of non-equilibrium (Prigogine) accounts for non-deterministic, emergent and self-organizing behaviors and processes, which promote other systems of increasing complexity such as market diversification, price competition, solid waste generation, consumer competition, induced consumption preferences, commodification of natural resources as the basis of production, among others (Delgado, 2011; Ortiz, Delgado, & Gómez, 2016).

"Everything that cannot be known can be analyzed as if it were composed of an assembly, articulation or simple interaction of heterogeneous elements, and that these tend to be organized into interdependent systems, and that the basic rules of this self-organization must be sought in the dynamics of the flows of matter, energy and information" (Tyrtania, 2009, p. 14).

This long and complex vision of the previous linear productive model, now with a systemic character, allows us to witness that the modification and alteration of the set of inputs and materials translates into added value, which means that the material essence of the productive factors is maintained (the thermodynamic law of material conservation), in whose transformation some characteristics are continuously and irreversibly degraded. original attributions and benefits, to obtain new products aimed at satisfying the needs of a growing number of demanders.

It is at this stage of the production process, where, in addition to finding application of the second law of thermodynamics, a greater amount of dissipated energy, residual materials and other by-products are also generated, which, not being able to be used, end up in controlled and uncontrolled spaces in the form of polluting or harmful materials to the environment, whose gradual or radical increase causes greater negative externalities and environmental pressure. But also the fact of diversifying the production system implies a greater extraction of resources from natural sources, which in the medium and long term causes depredation, erosion and extinction of some natural resources for production.

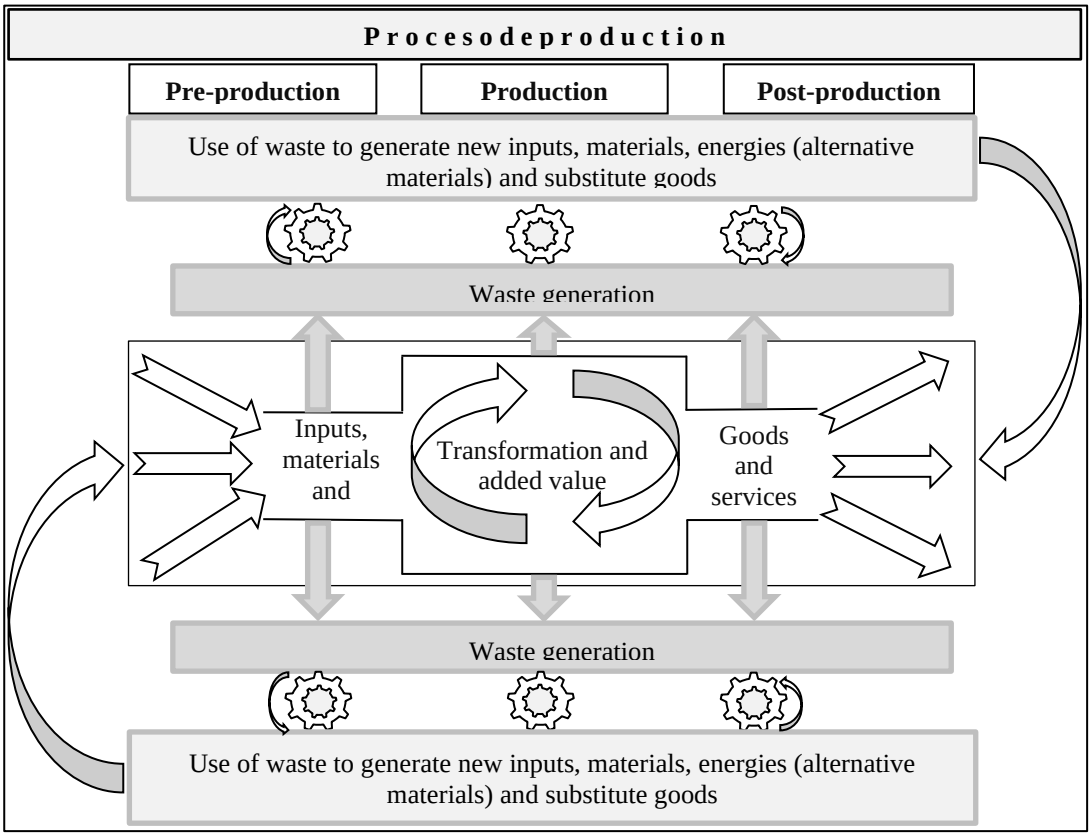
This phenomenon is what explains the third law of thermodynamics, that is, the impossibility of generating more polluting waste than the environment can tolerate and the inability to extract more resources than what is available or existing in the environment.

In this dynamic, a set of new agents and production units shown in Figure 4 are added, which through the synergies that are created, take advantage of the waste generated throughout the production chain, trying to reduce environmental pressure and promoting the cycle of closure of materials, thus extending the existence of the productive factors in different forms or presentations.

In this model of productive synergies and expanded flow of resources, there is a complex transfer of materials, energy and by-products that carry out the set of agents that make up the dynamic productive ecosystem, and that in the end configure a food web, whose main characteristic is the indefinite use of energy prior to its dissipation in the form of heat or gas

(pollutant). This means that, in the expanded model of production, material by-products and energies are susceptible to being used to the maximum in order to take advantage of their utility, giving rise to the closed cycle of materials, open only to the input and output of energy, where biological decompositions supply other materials for reuse for another trophic level (Carrillo, 2013).

Figure 4. Production synergies and material flow: closing cycle



Source: Iglesias, 2021, p. 28.

"Change in a complex system can only be achieved with an integrated system, moving from a society of apparent abundance and waste to an austere one, restricting as much as possible the uses of critical materials, the use of long-lived goods, the substitution of scarce materials for abundant ones and intensive recycling" (Bermejo, 2011, p. 338).

The complex vision of the production system is what demands, or rather, requires a rethinking of the disciplinary epistemological bases, to create transdisciplinary and transversal perspectives that provide more information in order to expand paradigms and provide greater elements of understanding of the environment, production, human rationality and its survival, seeking the creation of sustainable production systems. through the "material closure cycle" approach (González, 2012).

"The analysis of the materials cycle is focused on systematically describing the sequence of

stages that occur in the process, of different materials, for purposes of use in industrial activities, considered from extraction to disposal, identifying hypothetical or real ties that could allow the closure of the system cycle" (Carrillo, 2013, p. 33).

The demand of this "new" model of production is to move from linear relations between production units, to the construction of exchange networks and links between actors and institutions, which favors a high level of exchange and the consolidation of an industrial ecosystem.

2. Conclusions

Despite the seasoned arguments of classical economic theory regarding the functionality of linear production, considered one of the main bastions of economic science, its theoretical, modelal, and instrumental forcefulness found limitations in explaining the dynamic and non-rational behavior of both production units and economic agents. Therefore, the ceteris paribus criterion lost validity in the face of non-linear dynamics, a product of the multiple interactions and market failures that occur during the transformation of matter and energy.

In the face of this reductionism, the need to expand and complicate the linear productive model is assumed, where categories such as the laws of thermodynamics are included to extend the extra-economic implications of productive inputs. This approach, also known as non-equilibrium thermodynamics, extols that non-deterministic, emergent and self-organizing behaviors and processes give rise to other systems of increasing complexity, which defines an alternative path to optimize materials, in order to create a longer cycle that encourages the massive use of waste, and move towards the creation of sustainable production systems.

References

1. Bermejo, Roberto (2011). Manual for a sustainable economy. Cataract. Madrid.
2. Delgado, Carlos (2011). Towards a new knowledge. Bioethics in the contemporary revolution of knowledge. Aquarius Publications. Havana. Cuba.
3. Fumagalli, Andrea (2010). Bioeconomy and cognitive capitalism. Towards a new paradigm of accumulation. Dream trafficker. Navarre.
4. Gómez, Moisés (2010). A brief history of economic doctrines. Sphinx publishing group. Mexico
5. Gutiérrez, Esthela and Édgar González (2012). From theories of development to sustainable development. UANL. XXI century. Mexico.
6. Hernández, Rafael (2007). History of Economic Thought. Porrúa. Mexico.
7. Iglesias Piña, David (2021). Conditions of the infrastructure and equipment of the industrial parks of the State of Mexico. Possibilities of forming sustainable production systems. Scientific communication. Mexico.
8. Ortiz, Pedro Antonio; Alfredo Delgado and Francisco Gómez (2016). Systems Far from Equilibrium: A Language for Transdisciplinary Dialogue. AM Editores, Clave editorial. Mexico.
9. Tyrtania, Leonardo (2009). Evolution and society. Thermodynamics of survival for a human-scale society. Juan Pablos editor. Mexico.