ORIGINAL RESEARCH PAPER

Economics

FROM LINEARITY TO COMPLEXITY OF PRODUCTION. AN EPISTEMOLOGICAL CONTRAST

KEY WORDS: Linear production; non-linear dynamics; production system

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ABSTRACT

Classical economic theory assumes that linear production leads to market equilibrium, ruling out the presence of externalities, given the rationality of economic agents. The objective of this article is to counter-argue the linear vision of production, which the postulates of non-linear dynamics, as methods of contrastation, allow us to assume the need for a more complex vision of production to turn towards an epistemological base that alludes to the model of the material closure cycle, as an alternative to optimize and make the functionality of the production units and productive factors more efficient.

The arguments refer to the relevance of a complex perspective of the production system, given the series of interactions between agents and factors, as well as the energies, materials and wastes dissipated, many of which have adverse effects on the environment, translated into dynamic market behavior (in terms of costs and prices), and which the linear model omits.

Classical Economic Theory And Linear Production

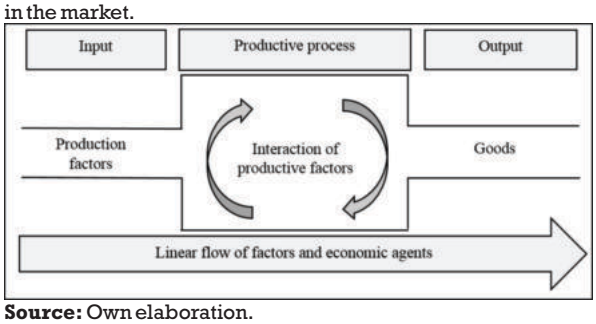
Classical economic theory constitutes one of the main bastions of economic science, whose theoretical forcefulness soon paved the way for escalating its ideological influence in contexts of domination such as capitalism, international politics and market control (Hernández, 2007).

The vision of this theory is based on the rationality of the 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 main phases:

1°. *Input*. Set of inputs and materials to be converted into factors of production.

2°. Productive process. Interaction and combination of the set of inputs to generate direct and indirect consumer products.

3°. *Output*. Range of finished products, ready for consumption in the market.



Source: Own elaboration.
Figure 1. Black box production model

Classical economic theory assumes that this productive linearity leads to an adequate functioning of the market, explained by the presence of equilibrium between producers and consumers, devoid of failures and externalities, which is the reason for the unnecessary intervention of other agents.

This position was very well argued and evidenced through the approaches of classical economists such as Say, Walras, Pareto and Edgeworth, who generated valuable evidence to support the apparent relevance of economic and productive linearity under the criterion céteris páribus.

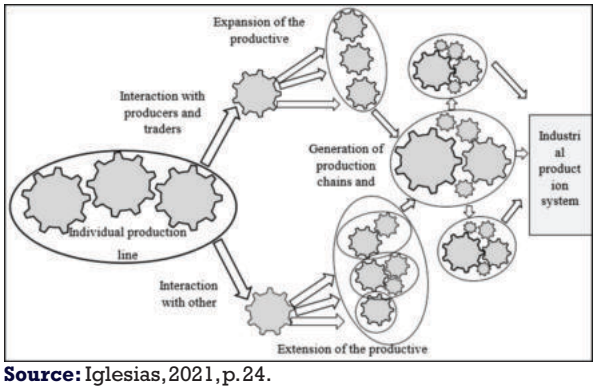
From Argumentation To The Limitations Of Productive Linearity

In spite of the seasoned arguments issued by classical economists, when contrasted with some perspectives such as Philosophy, Psychology, Sociology, even Physics, Chemistry and Biology, it is found that the human being, in that rational, ethical and not selfish connotation, loses relevance.

T. Hobbes argued that man is evil by nature, selfish and antisocial. Even J. Bhentam argued that human beings behave selfishly according to their utility preferences. This selfishness, which can be qualified as psychological, implies that the rationality and the decision of the economic man is for his own benefit and not for that of his fellow men, so that the more individual utility, the better welfare, which contradicts the approaches of the theory of abstinence. Even Kant assumes that autonomous rational capacity breaks with the principle of equilibrium, equality and equity.

To these ideas are added the contributions of J. Locke, F. Bacon, I. Newton, R. Descartes and K. Marx. Marx, who define a broader and more extensive epistemological path, surpassing the postulates of linear rationality, market equilibrium, the functionality of the economic circuit and the uniformity of the production model, i.e., the criterion céteris páribus, begins to lose validity, since any activity developed by the agents generates market failures and environmental externalities, derived from economic dysfunctionalities.

The presence of this infinitude of interactions extends the productive linearity, to the point of configuring production systems, as shown in Figure 2, to make the productive process more efficient and reduce the effects of externalities.

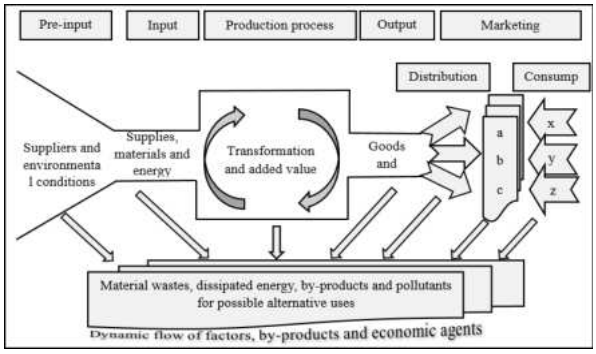


Source: Iglesias, 2021, p. 24.
Figure 2. Extension and dynamism of productive linearity

Thus, the classical reductionism of production was densified to consider that the linear model should have a more complex connotation, as a system of continuous direct and indirect interaction with other elements. In this complex vision visualized in Figure 3, the productive linearity is extended to

seven phases:
1°. Pre-*input*. Set of agents and conditions that play the role of suppliers of inputs, materials and energy.
2°. *Input*. Range of inputs and materials that can be converted into factors of production.
3°. Productive process. Interaction and combination of inputs to generate new products for direct and indirect consumption.
4°. *Output*. Range of finished products, available on the market for consumption.
5°. Distribution. Location and disposition of goods and services in the market.
6°. Commercialization. Accessibility of goods to different types of markets according to consumer preferences.
7°. Consumption. Purchasing preferences according to the user's needs.

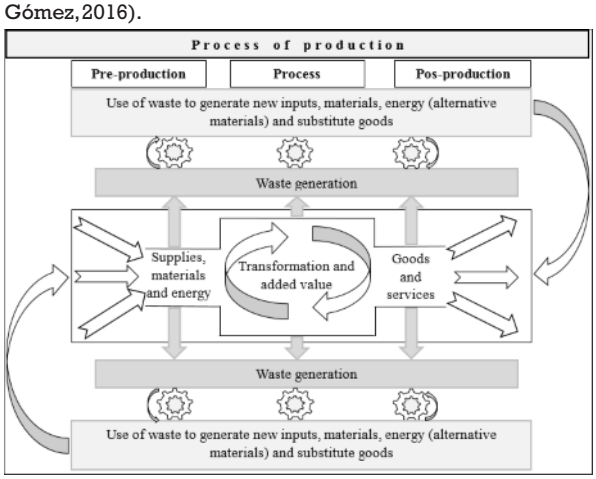
In view of this extension and complexity of the production system, it is inappropriate to assume the existence of equilibria, but rather to refer to what Prigogine calls non-linear dynamics (Gutiérrez y González, 2012).



Source: Own elaboration based on Iglesias, 2021.
Figure 3. Extended linear model: complex production system
a, b, c: Types of markets in which goods and services are traded.
x, y, z: Types of consumers according to the type of market they use.

Non-linearity Associated With The Production System

The non-linearity proposed by Prigogine, accounts for non-deterministic, emergent and self-organizing behaviors and processes, which lead to other systems of increasing complexity such as market diversification, price competition, solid waste generation, consumption competition, induced consumption preferences, commoditization of natural resources, among others (Delgado, 2011; Ortiz, Delgado and Gómez, 2016).



Source: Iglesias, 2021, p. 28.

Figure 4. Productive synergies and material flow: closing cycle

This long and complex vision of the linear model, now with a systemic character, is translated into added value, in whose transformation some characteristics and attributes are continuously and irreversibly degraded, in order to obtain new products oriented to satisfy the needs of a growing number of demanders (thermodynamic law of material conservation).

In this dynamic, a set of new agents and production units are added, as shown in Figure 4, which through the synergies that are created, take advantage of waste, trying to reduce environmental pressure and promote the closing cycle of materials, thus extending the existence of 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 make up the dynamic productive ecosystem, which in the end form a trophic network, seeking to make the most of the by-products, materials and energies, giving rise to the closed cycle of materials, where biological decompositions supply other materials for reuse at another trophic level (Carrillo, 2013).

The complex vision of the production system is what demands the rethinking of the disciplinary epistemological bases, to create transdisciplinary perspectives that provide greater interpretation that broaden the paradigms and provide additional elements for the understanding of production and human rationality, seeking to create sustainable production systems, through the approach of the "cycle of material closure" (Carrillo, 2013).

The requirement of this "new" production model is to move from linear relationships between production units to the construction of exchange networks and linkages between actors and institutions that favor a high level of flows and the consolidation of an industrial ecosystem.

CONCLUSIONS

In spite of the arguments of classical economic theory about the functionality of linear production, considered as one of the main bastions of economic science, its theoretical forcefulness found limitations to explain the dynamic and non-rational behavior of production units and economic agents, therefore, the criteria céteris páribus, lost validity in the face of non-linear dynamics, product of the multiple interactions and market failures that arise during the transformation of matter and energy.

In the face of this reductionism, it is assumed the need to broaden and complexify the linear productive model, including categories such as the laws of thermodynamics to extend the extra-economic implications of productive inputs. This approach, also known as non-equilibrium thermodynamics, emphasizes that non-deterministic, emergent and self-organizing behaviors and processes give rise to other systems of increasing complexity, which define an alternative path to optimize materials, in order to create a longer cycle that promotes the massive use of waste, thus closing the materials cycle.

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