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# ON THE DYNAMICS OF ECONOMIC GROWTH\*

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\* DOI: <https://doi.org/10.18601/01245996.v23n44.13>. Reception: 28-09-2020, revision: 14-10-2020, acceptance: 27-11-2020. Citation suggestion: Lorente, L. (2021). On the dynamics of economic growth. *Revista de Economía Institucional*, 23(44), 1-15.

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### **Sobre la dinámica del crecimiento económico**

*Resumen* Este artículo defiende la necesidad de sustituir las teorías de crecimiento más difundidas hoy por un análisis dinámico de la economía, libre de equilibrios y de trayectorias óptimas. Sintetiza las principales características de una posible teoría alternativa, en la que la innovación es la causa primaria del crecimiento observado durante los últimos dos siglos. Esboza también un nuevo método de análisis dinámico y expone alguno de sus principales resultados. Finaliza con algunas conclusiones y recomendaciones de política económica.

Palabras clave: crecimiento económico, equilibrio, desequilibrio, innovación, tecnología, análisis dinámico, circuito, productividad, inflación, distribución del ingreso, sector financiero, política fiscal, intervención del Estado; JEL: O40, O33, E27, G01, B41

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### **On the dynamics of economic growth**

*Abstract* The growth theories most widely used today ought to be replaced with a dynamic analysis of the economy, free of equilibrium and optimal trajectories. This article synthesizes the main characteristics of a possible alternative theory, in which innovations are the primary cause of the growth observed during the last two centuries. It also outlines a new method of dynamic analysis and presents some of its main results. It ends with some recommendations for economic policy.

Keywords: economic growth, equilibrium, disequilibrium, innovation, technology, dynamic analysis, circuit, productivity, inflation, income distribution, financial sector, fiscal policies, State intervention; JEL: O40, O33, E27, G01, B41

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### **Sobre a dinâmica do crescimento econômico**

*Resumo* Este artigo defende a necessidade de substituir as teorias de crescimento mais amplamente usadas hoje com uma análise dinâmica da economia, livre de equilíbrio e ótimas trajetórias. Ele sintetiza as principais características de uma possível teoria alternativa, na qual a inovação é a principal causa do crescimento visto durante os últimos dois séculos. Ele também descreve um novo método de análise dinâmica e apresenta alguns de seus principais resultados. Termina com algumas conclusões e recomendações de política econômica.

Palavras-chave: crescimento econômico, equilíbrio, desequilíbrio, inovação, tecnologia, análise dinâmica, circuito, produtividade, inflação, distribuição de renda, setor financeiro, política fiscal, intervenção do Estado; JEL: O40, O33, E27, G01, B41

This essay defends a paradigm shift in the theory of economic growth and proposes an alternative vision.

Despite the many studies inspired by neoclassical, Keynesian, evolutionary and institutional theories, as well as development theories, the determinants of economic growth remain controversial and there is no consensus about what policies would conduce to it. Every model inspired by those theories fails in empirical validation and, furthermore, they all ignore one or more essential characteristic features of modern economies (Lorente, 2019a).

The search for answers to the central problem of economic growth must start a couple of centuries ago, when a social transformation that began in Northern Europe broke a long history of stagnant societies, trapped in a vicious circle between a slow increase in population and a lack of food that put an end to it.

The so called Industrial Revolution started a process of exponential increase in production, followed by a gradual reduction in prices and an improvement in the standard of living for an increasingly numerous subset of the population. Some countries developed rapidly while many others stayed poor. But, from time to time, a few of the undeveloped seemed to jump into a process of very fast growth. Many years later, in the middle of the last century, the confluence of economic intervention policies and of a more equitable distribution of income triggered what came to be known as a mass consumption society, that rapidly spread throughout the world and in which many countries still thrive, despite a recent deterioration in their distributions of wealth and income.

Despite their many differences, all these episodes of growth share one essential feature: they were processes of cumulative change driven by technical innovations. Knowing so brings forward a fundamental question: When and how can innovations induce a process of economic growth?

## A GAP BETWEEN THEORY AND EVIDENCE

There are four normative principles common to many growth theories, halfway between inescapable requirement and tacit assumption. They are normative because their origin is not empirical, but philosophical or, better, ideological.

Almost all theories of development include the first two; most growth theories presuppose the first three, but neoclassical growth models usually postulate all four.

The first principle is that growth is due to the prior accumulation of capital, either physical or human. So, all models start by finding out how much capital is available and assume that output can only increase if more capital is accessed first. This idea is present in almost all economic theories, at least from David Ricardo onward.

The second principle refers to technology and states that the product is determined by a known production function, or that it has a fixed and also known relationship with the accumulated capital. Besides, knowing available capital is often enough to calculate the possible product, given that there usually are some unemployed laborers and some slack of natural resources.

The third principle is methodological and states that every solution involves some form of equilibrium. With very few exceptions, it is implicitly assumed that such equilibrium is achievable and, in general, it remains also tacit that it agrees with the Walras ideal, so that it is a stable equilibrium and survives to shocks.

The fourth principle, which is also methodological, requires that every growth model must be the result of a dynamic optimization, which implies that the represented system must be a Hamiltonian one.

To begin with, there is a conflict between the fourth principle and the ideal of equilibrium to which the third aspires because Hamiltonian systems do not admit attractors. Once perfect cycles are excluded – because they do not exist in economics – the only admissible solutions are saddle points whose environment is unstable. In these systems there may be equilibrium points, but these are almost impossible to reach because moving along the very special trajectories that lead to them is like walking on a razor's edge. In other words, those trajectories form a set of zero measure in the phase space, so that an economic system chosen at random has zero probability of being over one of those trajectories. Furthermore, given the inherent instability of the saddle point solutions, even if the system were in one equilibrium point or over one of those trajectories, any small disturbance would continue to get worse until the self-destruction of the represented economy.

In order to guarantee that the system remains on one of those very special trajectories that could take it towards some stationary point, neoclassical theory introduces an ad hoc and impossible assumption of “rational expectations” that no real agent or system could ever satisfy, mainly because they would require infinite knowledge and instantaneous calculation powers.

These four normative principles are in conflict with available historical evidence, qualitative observation of economic behavior, and statistical analysis of economic systems. They must be discarded and replaced with the following four *empirical observations* that fully agree with modern economic growth.

The first observation is that the main engine of modern growth is innovation. This is the essential difference that stands in contrast to pre-capitalist societies which grew by accumulation of capital and labor, but essentially without change in technology, and soon encountered increasing land rents and other similar barriers, as Roberto Malthus described centuries ago.

Modern economic theory begins with Adam Smith and it is really odd that almost all who continued his work in economics disregarded the extraordinary importance that he gave to innovation. Just in the first chapter of his book on the *Wealth of Nations*, he explains and illustrates with a few examples that while accumulating capital can increase the product by a certain percentage, innovating can multiply it by two, ten or more in a very short time.

But economic theory very early diverted its attention to capital, making it the essential factor of production and, with David Ricardo, using it to justify the distribution of the product and the control over all the productive activities.

Innovation has several consequences: one is that innovating destroys any previous relationship between the amount of capital and the product obtained. The concept of production function becomes then useless because the successive innovations will introduce unpredictable changes in the inputs used, jumps in the efficiency of processes and qualitative adjustments in the type of worker.

Another consequence of innovations is the obsolescence of capital, which does not slowly wear out, like gradual depreciation concept suggests, but rather needs to be abruptly replaced before the end of its useful life.

The second observation is that the net amount of capital existing at a given moment only matters for the distribution of the product.

Of course, investment that accumulates capital is still necessary, but since this occurs in parallel with innovation, it also destroys old capital. The net result can be a final amount of capital similar, or even less than the previous one, but with a higher product.

It is essential to note that companies do not invest because they consider that they have too much or not enough capital. They do so because their sales are increasing and they must expand their installed

capacity, or because they are going to introduce a new product with a promising market, or because they find a technological improvement, or because they know that some competitor have innovated and could put at risk their market share.

Once it has been defined that the prospected sales justify investing and how much new finance they would need, then the only measure of capital that matters for the managers of the company is the book value of its assets and the amount of its debts, because that is the information about capital that banks and potential investors want to see.

In short: capital is a direct determinant of the distribution of a product that has already been obtained and sold, while it only has an indirect and fluctuating relationship with the attainable level of production.

The third observation is that there cannot be equilibria, tendencies to equilibrium, or warranted paths to some privileged state. This is simply a methodological consequence of innovations, that continuously change the conditions of production and the state of markets, and also because future innovations cannot be predicted or prepared for.

In order to find today a stable equilibrium, we would need to freeze the technology now in use, or else to know which goods and services will be available in the future and make in the present all the relevant decisions of production and consumption.

But to anticipate the future is to contradict the very concept of innovation. We must recognize that history is a succession of imbalances, where each change is the determinant of other changes, in an ever new sequence. As the poet Antonio Machado said, “there are no pathways, the path is traced by walking.”

The fourth and last observation is that it is impossible to find optimal trajectories, because at no time is there enough information about the future. Really, we cannot even propose a probabilistic future, because successive innovations will also modify any probability distribution.

But, even though the future is radically uncertain, it does not lead to a complete chaos because the economy is a network with many feedbacks, some positive that reinforce changes, but other negative that eventually compensate them. The result of this complexity is a kind of dynamic stability, with fluctuations that are strictly unpredictable, but usually bounded. In this environment, the “rational expectations” of neoclassical theory are an absolute impossibility,

but adaptive expectations, adaptive learning and adaptive control are usually viable strategies.

### INNOVATION AS A DRIVER OF ECONOMIC GROWTH

Innovation does not immediately modify the cash flows that the company has been receiving, but reduces its unit costs and thus generates a rent, i. e., a surplus of purchasing capacity that turns into disposable income for the innovator and immediately translates into additional demand, possibly for investment goods. The dynamic competition between leaders and imitators will later lower prices and shift those rents in favor of the final consumer, but the stream of successive innovations maintains a permanent level of rents in the economy as a whole, so the average rate of profit never falls to the minimum regulated by the interest rate.

This process of innovating and generating rents – which increases the purchasing power even with the same previous level of monetary income – is enough for an increase to appear in the real gross product of all the economy, which will soon be accompanied by an adjustment in relative prices. The increased physical volume of sales becomes a sufficient reason to invest and, at the same time, the increased anticipated volume of operations justifies introducing new technology that reduces unit costs once again. Thus, it is possible to grow at an exponential rate even if there is no prior expansion of means of payment: it only takes a sustained pace of innovations.

Furthermore, if innovations appear in products consumed by a large fraction of the population, the impact of income will be enough to justify more investment, employment will grow and the process will be repeated over and over again, moving from one production sector to another and, eventually, creating an economy of mass consumption.

However, if sales grow only in elite consumer products, the additional number of units may not justify investment in research and development of new technology. In such case, the virtuous circle of innovation, income generation and market expansion will not close and, although some growth could still be possible, it will be much less than the technological potential of that economy.

Several empirical studies also show that the aggregate of all companies generates just the resources they need for their investments, without requiring additional assistance other than financial intermediation among companies. This result supports Lauchlin Currie's observation that the sum of the depreciation allowances plus retained

earnings by the United States nonfinancial corporate sector matched almost exactly the total amount of investments in that same sector, year after year and over the course of many years.

And it is natural for this to happen if we take into account that companies resort to credit to complete the financing of their large investment projects, and must pay those credits before requesting new ones: this is enough reason to expect that, in the long term, each company must cover the total cost of its investments with her self-generated surpluses (retained benefits and depreciation reserves), or go bankrupt if it does not succeed. Furthermore, if this financial circuit must close sometime for each individual company, it must also close in any given year for the aggregate of all the companies, with the only condition that their investments be more or less uniformly distributed among the different phases ranging from new investment until full amortization of those investments.

The virtual existence of this internal financing circuit between companies of the real sector leads to conclude that household savings are not essential to sustain investment, but only complementary. Normally, the bulk of household savings will be available to sustain a parallel consumption circuit, through bank and financial placements of some households against the expenses in durable goods and housing of others. While it is possible to channel part of these savings from the household sector to companies, that will subtract an equal amount from the sales of durable goods or new houses. Thus, contrary to the usual belief, to divert an increasing fraction of those savings to finance corporate investments could be self-conflicting, because it will jeopardize the main motive for investing that other companies previously had. In the aggregate, there would not be more investment, or faster growth.

Conversely, an additional injection of monetary resources such as, for example, a deficit spending by the State, could accelerate the growth process because it would increase the total amount of final sales. But if to that injection of resources we add some form of protectionism, or any subsidy to producers that isolates them from the competition, then we will have inflation instead of innovation and the growth process will be put in danger.

## **THE ECONOMY WORKS AS A COMPLEX NETWORK**

The technology in use creates a network of mutual relationships that links a multitude of companies and coordinates their decisions. In

such an environment, sales are essentially a collective phenomenon and their common level becomes the determinant of investment decisions, to which innovation and subsequent growth are linked.

In mass consumption societies, sales are also a collective phenomenon governed by imitation and emulation between income strata. When the prices of a durable product fall, the freed purchasing capacity will likely be used to buy a different product, not multiple units of the same product. The same is true when income increases compared to the immediate upper income stratum, allowing emulating some of their distinctive consumption. Thus, consumer choice is never independent, but is guided by the behavior of others and the pressure of propaganda.

Recognizing that a technological network exists that connects companies, and that another social network links consumers, leads us to stop the analysis at an intermediate level, much closer to macro aggregates than to the individuals of the neoclassical micro theory. In a way, the macro situation is what determines the micro decisions and not the other way around.

Since it is impossible to forecast the future in an environment of permanent innovation, all decisions are subject to error. There cannot be “rational expectations”, but only an adaptive behavior that corrects, on the fly, any discrepancies between what was planned and what is currently measured.

If companies are guided by a common situation and, additionally, each one can implement some error correcting mechanism, then there is no need for central planners, comprehensive information, “Walrasian auctioneers” or any other such fiction that sets equilibrium prices.

Companies can choose their prices to cover whatever costs they are actually paying, decide a production volume and adjust it at a later time, if they observe any discrepancy between actual and planned sales. Their internal accounting provides enough information to detect undesired inventories of inputs and outputs, and to design a corrective strategy. And if those quantitative adjustments are insufficient to eliminate the unwanted inventories, then they will have to resort to a change in technology, or to revise their prices, and undergo the market test once again.

The decision to invest is always conditional on available liquidity, so currency and financial assets are an inseparable part of investment and production decisions. Under normal conditions, banks and the capital market serve as intermediaries for companies and households in the real sector, so there is a close correlation between the physical opera-

tions of goods and services markets, and their monetary counterparts. But the financial sector has the possibility of creating assets without a real counterpart by resorting to bank credit. In this way, it is possible to superimpose successive layers of financial intermediaries without any direct effect on the real investments decided by the productive sector, except for the multiplication of costs and commissions that the companies must pay for the financial services that they actually need.

In general, this will happen whenever there is a concentration of income that diverts resources from investment in activities related to mass consumption, toward goods and services of an elitist nature. Companies will then distract their investment surpluses toward the payment of dividends, or toward the purchase of other companies, or to buy their own shares. Thus, the generation of employment will fall below its potential, the participation of labor in the product will decrease and the concentration of income will soar.

High income from dividends or capital gains eventually ends up in the capital market where it induces a rapid appreciation of *pre-existing assets*, independently of any real current investments. The increased value of those assets induces and supports more credits and sets in motion a speculative spiral, effectively creating a boom period where the real sector also enjoys some increase in its sales. However, as already mentioned, this increase is not focused on mass consumption goods and cannot give rise to the chain of innovations, associated rents and growth.

It is always possible to inflate the speculative bubble because any bank credit operation implies the creation of means of payment. In this case, the new money will not have inflationary effects even though there is no parallel increase in the activities of the real sector, because the new monetary resources remain rotating in the capital market, absorbed by the new flows of purchase and sale operations and their increased values. But when the bubble bursts, banks close their credit window and the sole income of the real circuit must pay all debts, both those of the companies and those of the asset owners who were speculating in the capital market. Then investments, sales of all kinds, and employment collapse simultaneously, more loans default and the system starts a recession, or even falls into a deep depression.

## MODELING CIRCUIT DYNAMICS

The economy is populated with companies that pay dividends and salaries to households that, in a circular loop, use their income to

buy the products and services that those companies provide. Some companies produce capital goods that sell to other firms and there is a State that perceives taxes and contract companies, hires personnel and pays subsidies. Broadly speaking, the economy works like a closed circuit engaged in self-reproducing over and over again, but there is no place in it for static equilibria nor for privileged trajectories, because a permanent current of innovations changes the technology in use and the range of available products. However, the economy is far from an absolute chaos.

The flow of innovations blocks the traditional methods of analysis that always look for stable solutions and optima, but there are alternatives better suited for studying a dynamic system (Lorente, 2019b).

As mentioned above, the individual components of the economy, mainly companies and households, behave with some degree of synchrony, usually enough to determine groups, strata or other aggregates of macro or meso economic nature. Most of those aggregates mimic the same micro behaviors that the global situation tends to synchronize. However, their interaction with other aggregates can bring forth new, systemic, properties, so that the emergent macro behavior can be very different from the micro or “representative agent” one.

Sometimes the interactions describe a closed loop and bring forth a dampening of initial changes, in a process known as negative feedback. Other times, the sequence of interactions elicits an amplification of the initial change, called a positive feedback.

There is a certain degree of homeostatic self-regulation in every economic system. Many economic variables oscillate along the so called “business cycles”, with trajectories that return once and again towards a previous value without ever repeating it exactly. It is possible to mimic this behavior superposing two loops, one with positive feedback and fast response, and the other with negative feedback and slower reaction time. A third loop with positive feedback can provide a growth trend.

The economy is a very complex network of loops, but it is always possible to identify some dominant loops that govern most of the dynamics to be explained. The numerical simulation allows to build models of the economic circuit, starting from very simple cases and adding more complexity step by step. In the end, the simulation model should reflect an economy with a real sector, banking and capital markets, in situations of stable and unstable growth, and also during speculative effervescence and subsequent crisis.

The parameters of these models must be calibrated with data from a specific country. The United States is an appropriate case study because it has very detailed statistics and, as a country, it has seen little change in overall growth trends. Stability in average growth rates began around the 1870s and has continued since then with very few temporary interruptions, due to the world wars and the Great Depression of the 1930s. However, the ideal period to make a calibration is 1960-2000, because it has statistical series of uniform coverage and quality; it embraces several economic cycles and includes significant macro policy adjustments, but without major breaks in the growth trend, and without the distortion of deep financial crises.

All these conditions make it possible to start with a very simple model and then enrich it, gradually adding variables and operational details (Lorente, 2019a).

Another country with less uniformity in growth and, perhaps, with abrupt changes in trend, would force to start the simulation with a much more complex model instead of building it gradually.

## REVISITING THE STATE'S ROLE

If it were not for the excesses of neoliberal policies and the obsession for privatizations, it would not be necessary to mention some functions traditionally entrusted to the State, like: a) safeguarding the proper functioning of markets; b) guaranteeing justice and public security; c) providing basic infrastructure services (energy, water, and sewerage among others); d) ensuring means of transportation and communication, e) supporting a system of public and universal education, f) providing public health services, and g) ensuring universal access to personal health services.

However, in the context of this article, the central point to examine is the role of the State in two specific areas: promoting innovations and achieving continuous exponential growth.

A first requirement is to attain and protect an income distribution that encourages some form of mass consumption, which can be both of goods and services. Today, given that the modern economy is at the beginning of an accelerated process of automation, the emphasis would likely be in increasing services. The industry will instead follow the same path that agriculture followed a century ago, that is, a rapid increase in productivity per worker and a parallel fall in employment, a fast rise in its physical product but a faster drop of relative prices, so that the entire sector will lose its current share in the Global Product.

The second crucial objective for the State is to find a new support scheme for the social transition that has already begun and that will accelerate in the coming years. The rapid spread of automation and the obsolescence of many technologies will destroy a large fraction of current employment. Of course, innovations will create new job positions, many stable and well paid, but will also require retraining of less educated workers faster than seems possible and many will suffer a reduction in their income.

History provides some examples of similar transformations. By the end of the XIX century, the Prussian State discovered that in order to create a modern economy, transforming very rapidly a rural society into an urban and industrial one, it had to intervene in the market and ensure a minimum of social support services. In association with the large industries, the State promoted basic education, technical training and financing of university activities. Almost at the same time, introduced legislation for a “new deal” with workers, creating public health insurance and pension guarantees, replacing the traditional protections previously provided by the village economy and the extended family for the care of infants, in the event of illness and during old age. The new Germany achieved very rapid growth and, at the same time, was able to alleviate the trauma of extreme poverty, re-train the workforce, and create the most advanced scientific community of its time. Some decades later, all these innovations gave birth to the social welfare system in many other countries.

The automation process gives rise now an issue no less challenging. If we want to continue with innovation and growth, we must avoid the impoverishment of displaced workers and support the training of new specialties. It is necessary to compensate for the destruction of the social fabric that the changes will bring about and, at the same time, support greater social mobility.

None of this seems possible within the micro-enterprise mentality that neoliberalism has projected onto the macroeconomic policy, with the doctrine of austerity and the systematic trimming of the workers incomes, as if an entire country was equivalent to a small neighborhood store whose only hope of profit lies in reducing the costs that it pays.

On the contrary, it is necessary to sustain growth by generating the necessary purchasing capacity, beginning from the lower income segments and then upward. The proposals for a minimum income per person that recently began to circulate in the public discourse could

become a direct means of creating mass consumer demand. And the prospect of increased sales will certainly be much more effective for eliciting innovations, than the current policies of credit and tax benefits without clear market outlook.

Sustaining purchasing power begins with salary improvement and includes a pension policy that replaces at least a substantial part of the income that retirees stop getting.

This effect cannot be achieved with private pension funds, which only manage to divert household savings from their natural purposes. Those savings are not necessary to sustain the current investments of the real economy, so that they will replace an equal amount of financial resources in the businesses that receive them, and will return to the capital market without any addition to real investment.

The proliferation of all kind of financial funds in the recent decades, not only private pension funds, has multiplied the volume of financial operations, added successive layers of intermediation – with a corresponding explosion of commissions and financial profits – and induced an over-valuation of assets. In most countries, the hypertrophy of the financial sector supported a parallel process of concentration in incomes and wealth; in many of those countries, it also ignited episodes of speculation that ended in serious crises.

All these undesirable consequences could have being avoided with better financial regulation and by turning back to fiscal policies.

Public spending can be used to directly promote real investment; pensions must be paid with fiscal sources; subsidies can be focused into particular segments of the population, and a minimum universal income is perfectly feasible.

In all these cases, it is always possible to design fiscal strategies that avoid inflationary consequences. The dynamic analysis of the circuit easily shows that a progressive tax scheme, appropriately focused, can offset the effects of public investment and of distributed spending such as wages, subsidies, and pensions. The free operation of the markets will channel any excess of income to benefits and then to financial investments, mostly in the capital markets. After that, taxes can remove from circulation the excess of buying capacity that might otherwise become a motive for financial speculation or for price inflation.

Clearly, taxes cannot fall mainly on income from work or on final consumption, as is the case today, because the final goal of the fiscal policy is to keep in motion a continuously growing circuit of incomes and expenses. What should be taxed are the surpluses of that circuit

that end up accumulated in financial assets, unproductive properties and other luxuries not needed to support the production circuit.

As Thomas Piketty's analyses show, the accumulation of wealth and capital gains in the capital markets have led, along the last half century, to a concentration of capital whose share of income grows much faster than the economies that are supposed to generate such earnings. Only taxes on capital could stop this process, and there is no reason to believe that such taxes would hinder real investments. We have already seen that sales expectations are the determinants of real investments and that the real sector can, even must, finance them with their own resources, possibly with the aid of bridging loans provided by banks (Lorente, 2019b).

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