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ECONOMIC GROWTH: THE STRUCTURE OF PRODUCTION AND MONETARY POLICIES

CRECIMIENTO ECONÓMICO: LA ESTRUCTURA DE LA PRODUCCIÓN Y LAS POLÍTICAS MONETARIAS

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ABSTRACT

There is much literature and discussion on the topic of economic growth and money supply given the numerous points of view that exist. In the thick of the COVID-19 pandemic, policymakers and prominent economists looked to revive employment, investment, and production and to tame rising inflation. Monetary and fiscal policies promoted prior to the outbreak of COVID-19 seem to be the core issue. This essay examines Hayek's critical assumptions on the effects of the money supply on both the volume and direction of output through production structure, prices, and interest rates. We provide a theoretical model to analyze essential macroeconomic variables and to discover new formulas to measure economic trends and forecast the interest rate at any given instant. Analyzing data from the United States of America according to the Bureau of Economic Analysis (BEA) and the Federal Reserve (Fed), the results suggest that one year ago the Fed should have aimed for an interest rate of approximately four percent (4.0%). In the Addendum to this paper, we include a table demonstrating the usefulness of the proposed model when dealing with steady economic growth.

KEYWORDS: HAYEK, MONEY-ELASTICITY, THRIFT, PROFIT, INTEREST, INFLATION.
JEL CLASSIFICATION: O40, O42.

RESUMEN

Sobre el crecimiento económico y la oferta de dinero hay abundante literatura y discusiones como diferentes visiones puedan existir. Actualmente, en el corazón de la pandemia por Covid-19, los responsables de las políticas públicas y prominentes economistas buscan revivir el empleo, la inversión, la producción y el control de la explosión de la inflación. La política monetaria y fiscal promovida antes de la propagación de Covid-19 parece ser el centro del problema. Esta investigación examina supuestos de Hayek acerca de los efectos de la oferta de dinero en el volumen y dirección de la producción mediante su impacto en la estructura de la producción, en la tasa de interés y en los precios. El modelo propuesto busca analizar variables económicas claves y alcanzar nuevas fórmulas para medir las tendencias económicas y predecir la tasa de interés a cada instante. Al analizar datos de los Estados Unidos de América brindados por la Bureau of Economic Analysis (BEA) y la Federal Reserve (Fed) los resultados sugieren que hace un año la Fed debió lograr una

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tasa de interés del cuatro por cien (4.0%) aproximadamente. Los principales resultados se registran en el apéndice a esta investigación con objeto de valorar la utilidad del modelo propuesto.

PALABRAS CLAVE: HAYEK, ELASTICIDAD DEL DINERO, AHORRO, GANANCIA, TASA DE INTERÉS, INFLACIÓN.
CLASIFICACIÓN JEL: O40, O42.

I. INTRODUCTION

The central aim of this paper is to provide possible answers to *what determines the path—the level and rate of growth—of full employment or potential output, which is a question of growth theory, and what determines the level of actual output relative to potential output at any given time, which is a question of income determination or stabilization theory* (Branson, 1988, p. 5). The main objective is to suggest an analytical method of approach that unravels the relationship between core variables of dynamic economic growth associated with changes in the structure of production and money supply. *If we know that the level of actual output depends on the level of money supply, we also know, at least in part, how to change the level of output if it is unsatisfactorily low* (Branson, 1988, p. 5). This will be our approach in proposing a fairly comprehensive model that we hope will help to illustrate monetary and dynamic economic growth phenomena.

In a dynamic economy the *level and rate of growth* of production income requires a certain *level and rate of growth* of money. These processes are influenced by production techniques, thrifting, interest rates, profits, wages, prices, investments, and institutional development. All these factors determine the level and rate of growth of resource composition, the *primus motor* in a dynamic economy. The output growth rate is elastic with respect to small changes in resource composition and this, in turn, to small changes in profit expectations. When resource composition is not *automatically* or *spontaneously* achieving a satisfactory level and rate of growth, within limits, institutional impulses may be required; this *explains the cycle, structure, regularity, and duration* of economic growth (Kaldor, 1943). Friedman (1982) emphasizes that the experience demonstrates that *monetary policy is not an effective instrument for achieving directly either full employment or economic growth* as it could be for price stability.

Hayek (1935, p. 131) cautioned that:

> It is quite conceivable that a distortion of relative prices and a misdirection of production by monetary influences could only be avoided if *firstly,* the total money stream remained constant, and *secondly,* all prices were completely flexible, *and, thirdly,* all long-term contracts were based on a correct anticipation of future price movements. This would mean that, if the second and third conditions are not given, the ideal could not be realized by any kind of monetary policy.

Hayek's assumptions on how the money supply impacts the structure of production seem reasonable. We will emphasize cost and production growth as a fundamental coordinate of the production structure, along with profit at market prices, which state the value of production, and considering that the rate of interest is a fraction of the rate of profit. As the money supply can be altered by governments and central banks beyond thrift levels, thereby influencing the interest rate, the direction and level of investment and production might change. In conclusion, we provide an analysis of data from the United States of America to show the usefulness of our suggested model.

II. THE STRUCTURE OF PRODUCTION

The cost of production C is related to the market price per unit of effective resources; ρ for capital K and w for labor L required at each instant to generate a unit of product q:

$$C = \mathrm{F}(\rho K, wL) \qquad (1)$$

Defining $C = cq$, where $c = \rho + w$ is the aggregated cost of production per unit of q, and inserting that into equation (1), we get:

$$cq = \mathrm{F}(\rho K, wL) \qquad (2)$$

Let us state the *actual* K as a fraction κ of the *disposable* capital $\underline{K}$ and for effective employment L as a fraction l of the labor force $\underline{L}$ in a dynamic economy,[2] such that $\kappa = K/\underline{K}; l = L/\underline{L}$ at each given instant and, therefore, per function (2) the dynamic cost of production is:

$$cq = \mathrm{F}(\rho\kappa\underline{K}, wl\underline{L}) \qquad (3)$$

Hence:

$$c = \mathrm{F}(\rho\kappa\ \underline{K}/q, wl\ \underline{L}/q) \qquad (4)$$

Resources here are treated as *flows* of quantities and *value* instead of *stocks*. For each monetary unit invested we get $[1 = \kappa\ \rho/c\ \underline{K}/q, l\ w/c\ \underline{L}/q]$. If $\alpha = \underline{K}/q$ is the capital *contribution* to production and $\beta = \rho/c$ the capital *contribution* to the cost of production, then for labor $1 - \alpha\beta\kappa = l\ w/c\ \underline{L}/q$.

Per equation (3), after differentiating and inserting the definitions above, we obtain the production growth function:

$$\lambda = f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] \qquad (5)$$

where k represents the *instantaneous* rate of capital accumulation at each $[(\tau, t); (\tau < t)]$ instant and $\tau + h = t$; $(h > 0)$ or $dK/d\tau = \acute{K}$ and $k = \acute{K}/K_\tau \therefore \acute{K} = kK_\tau$ and similar proceeding for labor and production growth. Assuming $\lambda = 0$ at any given instant of the production process, per equation (5): $-(1 - \alpha\beta\kappa)n = \alpha\beta k\kappa$ and $|-n/k| = \alpha\beta\kappa/(1 - \alpha\beta\kappa)$ and defining $\mu = |-n/k|$, then

$$\mu = \alpha\beta\kappa/(1 - \alpha\beta\kappa\,)\ ;\ \forall\colon \{\alpha\beta\kappa|(0 \leq \alpha\beta\kappa < 1)\} and \left[\lim_{\alpha\beta\kappa\to 0} \mathrm{F}(\mu) = 0;\ \lim_{\alpha\beta\kappa\to 1} \mathrm{F}(\mu) = \infty\right] (6)$$

where μ is the elasticity of labor at small changes on capital alone, it is defining the changes of resource composition in the structure of production, which might change at variations of the production cost and technological changes that improve capital and labor productivity at each given instant. If it is feasible to compute (μ, β), then:

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2 Let us see that $\underline{L} = L, \text{Ł}$ where Ł represents unemployed persons, such that $1 = L/\underline{L}, \text{Ł}/\underline{L}$ and $\text{ł} = \text{Ł}/\underline{L}$ such that $1 = (l, \text{ł})$ and if $l = 1$ then $\text{ł} = 0$ meaning full employment of the labor force. Let $Y = F(K, L)$ be a production function and defining $L = \underline{L} - \text{Ł}$ then $Y = F[K, (\underline{L} - \text{Ł})]$ and if $r = \frac{K}{\underline{L} - \text{Ł}}$ then $Y = F[r, 1]\ (\underline{L} - \text{Ł})$ which differentiated gives $(dY/dt)/Y = f[r, 1]\ \ [(d\underline{L}/dt)/\underline{L} - (d\text{Ł}/dt)/\text{Ł})] \therefore \lambda = f[r, 1](n - \tilde{n})$ where $\tilde{n}$ is the rate of growth of unemployment. This result expresses Okun's reflection on the fall of production level due to an increase of unemployment.

$$\alpha = \mu/(1+\mu)\beta\kappa \qquad (7)$$

If β, κ were unknown or difficult to measure, then:

$$\alpha\beta\kappa = \mu/(1+\mu) \qquad (8)$$

If $\alpha\beta\kappa = \kappa\,\rho/c\ \underline{K}/q$ then $\rho\kappa\underline{K} = C_K$ is the total cost of capital at each instant (net of depreciation) and $cq = C$, we can set $\alpha\beta\kappa = C_K/C$ the capital contribution to the cost of production.

To discover how these variables introduce instabilities into the production processes, let us define the value of resource composition as $\upsilon = \kappa/l\ \ \rho/w\ \ \underline{K}/\underline{L}$ and let $\varepsilon = \kappa/l$ be the composite coefficient of acceleration of the real resource composition $r = \underline{K}/\underline{L}$ and $\tau = \rho/w$ such that:

$$\upsilon = \varepsilon\tau r \qquad (9)$$

III. PROFIT AND PRODUCTION GROWTH

The entrepreneur does not produce with a view to satisfying a certain demand […] but on the basis of a calculation of profitability […] he only looks at the price which he can expect to get […]. The other factor […] is the price the producer has to pay for raw materials, labour-power, tools and borrowed capital — *i.e.*, his costs (Hayek, 1931, 1933, pp. 68, 70).

Markets reveal profit in the form of a rate of profit π, i.e., *the rate of return over the cost of production*,[3] so let g be profit such that:

$$g = \pi c \qquad (10)$$

and $\partial g = \pi\partial c$ assuming π is constant[4]. If we multiply both sides of function (3) by π, the level of profit becomes $\pi cq = \pi F(\rho\kappa\underline{K}, wl\underline{L})$ and per equation (10):

$$gq = \pi F(\rho\kappa\underline{K}\,, wl\underline{L}) \qquad (11)$$

Therefore, $g = \pi F[\alpha\rho\kappa\,, wl\ \underline{L}/q]$ and $1 = F[\alpha\pi\kappa\,\rho/g, \pi l\ w/g\ \underline{L}/q]$ and if $\delta = \rho/g$ then $1 = F[\alpha\pi\kappa\delta, \pi l\ w/g\ \underline{L}/q]$ such that $(1-\alpha\pi\kappa\delta) = \pi l\ w/g\ \underline{L}/q$. If we differentiate function (11) in terms of q and insert the definitions above, then:

$$\lambda = f[\alpha\pi\delta\kappa k, (1-\alpha\pi\delta\kappa)n] \quad (12)$$

at $\lambda = 0$, $|-n/k| = \alpha\pi\delta\kappa/(1-\alpha\pi\delta\kappa) \therefore$

$$\mu = \alpha\pi\delta\kappa/(1-\alpha\pi\delta\kappa) \qquad (13)$$

Paraphrasing Hayek (1933), an improvement in the expectations of π may drive μ above its previous level.

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3 The rate of profit on investments is the main source of both the demand and supply of loanable funds (Hayek, 1931/2009, p. 355).

4 Per the total differential of equation (10) $dg/d\pi = c + \pi\ dc/d\pi$ and if $dg/d\pi = 0$ then $c = -\pi\ dc/d\pi \therefore d\pi = -\pi\ dc/c$, which explains that given π, the greater the changes in the cost of production the lesser the *marginal* profit.

Then:

$$\alpha\pi\delta\text{ķ} = \mu/(1+\mu) \qquad (14)$$

and:

$$\alpha = \mu/(1+\mu)\pi\delta\text{ķ} \qquad (15)$$

Accurate information about δ is difficult to obtain, but we can estimate it by equalizing equations (14) and (8) to get $\alpha\beta = \alpha\pi\delta \therefore \beta = \pi\delta$ at $g = \pi c$. Let p be the market price of q and:

$$p = c + g = (1+\pi)c \qquad (16)$$

So π can be estimated as:

$$\pi = p/c - 1 \qquad (17)$$

And per equation (10):

$$g = (p/c - 1)c \qquad (18)$$

Then, per equation (16): $g = p - c$.[5]

IV. THE VALUE OF PRODUCTION

Let the function of the value of production be:

$$V = pq = F(\rho\text{ķ}\underline{\text{K}}, wl\underline{\text{L}})(1+\pi) \qquad (19)$$

If we define $\sigma = \rho/p$, then the production function is:

$$q = F(\sigma\text{ķ}\underline{\text{K}}, w/p\ l\underline{\text{L}})(1+\pi) \qquad (20)$$

and $1 = F(\alpha\sigma\text{ķ}, w/p\ \ \underline{\text{L}}/q\ l)(1+\pi)$ then $[1 - \alpha\sigma\text{ķ}(1+\pi)] = w/p\ \ \underline{\text{L}}/q\ l(1+\pi)$. If we differentiate function (20) and insert these definitions, then:

$$\lambda = f[\alpha\sigma\text{ķ}k(1+\pi), [1-\alpha\sigma\text{ķ}(1+\pi)]n] \qquad (21)$$

At $\lambda = 0$, $|-n/k| = \alpha\sigma\text{ķ}(1+\pi)/[1-\alpha\sigma\text{ķ}(1+\pi)]$ and:

$$\mu = \alpha\sigma\text{ķ}(1+\pi)/[1-\alpha\sigma\text{ķ}(1+\pi)] \qquad (22)$$

So:

$$\alpha = \mu/[(1+\mu)(1+\pi)\sigma\text{ķ}] \qquad (23)$$

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5 The effective income p at a given c per unit of q owing to π or to q demand intensity at each given instant. This differs from the simple difference between *current expenditure* c and *current receipts* p per unit of q (Hayek, 1932b).

This explains that the capital—and labor—contribution to production growth depends on resource composition and the rate of profit.

V. INTEREST RATE AND PRODUCTION GROWTH

The rate of interest is an active element of economic disturbances and hence the necessary margin of profit between the price of the products and that of the means of production (Hayek, 1931, 1933, p. 76). Moreover, the nominal rate of interest is a fraction {ɪ: (0,1)} of profit charged by the financial system, so:

$$i = ɪ\pi \qquad (24)$$

i would be directly determined by π (Hayek, 1931), thereby defining the *share* of financial capital (κ) in production, presuming *that an improvement in the expectations of π may drive i* above *its previous level* due to an increase in the demand for money. The *net* rate of profit is $л = \pi - ɪ\pi$ ∴

$$л = (1 - ɪ)\pi \qquad (25)$$

Multiplying both sides of this equation by c will result in the net profit: $\bar{g} = лc = (1 - ɪ)\pi c$ ∴

$$\bar{g} = (1 - ɪ)\pi c \qquad (26)$$

Given ɪ, $\bar{g}$ could fluctuate as π changes given that it causes i to vary.[6]

Hayek (1933, p. 199) asserts that "…credits are only given when and where their utilization is profitable, or at least appears to be so. Profitability is determined […] by the ratio of the interest paid on these credits to the profits earned by their use".[7] Per equation (24) $\hat{\imath} = ic = ɪ\pi c$ and per equation (10):

$$\hat{\imath} = ɪg \qquad (27)$$

$\hat{\imath}$ is the average interest, such that:

$$\hat{\imath} = [ɪ/(1 - ɪ)]\,\bar{g} \qquad (28)$$

And per equation (16) and (26):

$$p = [(1 + \pi)/(1 - ɪ)\pi]\,\bar{g} \qquad (29)$$

This explains that, *ceteris paribus,* ɪ changes might cause p fluctuations in the same direction.

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6 For a series of expected $\bar{g}$ at each given instant given $i = ɪ\pi$ using π as a *rate of discount* or Fisher's (1930) *rate of return over cost* or Keynes' (1936) *marginal efficiency of investment,* from equation (28): $c = \bar{g}_1/(1 - ɪ)\pi + \bar{g}_2/[(1 - ɪ)\pi]^2 \ldots \bar{g}_n/[(1 - ɪ)\pi]^n$; $(0 \leq ɪ < 1;\ \pi > 0)$, such that, within certain limits, the greater π, *ceteris paribus,* the lesser c and the incentive to invest will be strong at any given instant.

7 Marx (1986) analyzed in depth the origin of the general interest rate as a fraction of the rate of profit; see Villalobos Céspedes (2010).

Hayek's (1933, pp. 212–213) assertion is that: In a state of equilibrium, the difference necessarily existing between the prices of finished products and those of the means of production must correspond to î. It is: $p = c + (\pi c - \imath\pi c) \therefore p = c + (1 - \imath)\pi c \therefore p - c = (1 - \imath)\pi c$ and $g = \bar{g}$ such that $g - \bar{g} = \hat{\imath}$ just as much must be saved from current consumption and made available for investment as is necessary for the maintenance of the structure of production [...] the supply of producer's goods [...] exactly adequate to maintain production on the existing scale (Hayek, 1933, p. 213). Therefore, $i = \pi; \{\forall: (\imath = 1)\}$ (Fisher, 1930, p. 294) will not suffice for such critical assumption owing to $л = 0$ (Hayek, 1932c, 1975).

Per equation (29) $[(1 - \imath)\pi/\bar{g}]p = (1 + \pi)$ which inserted into function (21) gives the potential $\lambda = f[\alpha\pi\sigma p ϗ k(1 - \imath)/\bar{g}\,, (1 - \alpha\pi\sigma p ϗ\,(1 - \imath)/\bar{g})\,n]$ owing to $\sigma = \rho/p$:

$$\lambda = f[\alpha\pi\rho ϗ k\,(1 - \imath)/\bar{g}\,, (1 - \alpha\pi\rho ϗ\,(1 - \imath)/\bar{g})n] \qquad (30)$$

At $\lambda = 0$:

$$\alpha = [\mu/(1 + \mu)]\,[\bar{g}/(1 - \imath)\pi\rho ϗ\,] \qquad (31)$$

Now α computes capital *contribution* to production growth and financial capital *share*; hence, *ceteris paribus,* increases in $\imath$ will raise α and labor contribution will diminish. From function (30) let $\lambda_K = \alpha\pi\rho ϗ k\,(1 - \imath)/\bar{g}$ be the relative contribution of capital to production growth and defining $\lambda_K/k = \alpha\pi\rho ϗ\,(1 - \imath)/\bar{g}$ as its marginal contribution and if $\gamma_K = \lambda_K/k$ then:

$$\gamma_K = \alpha\pi\rho ϗ\,(1 - \imath)/\bar{g} \qquad (32)$$

This equation containing that fraction going toward financial capital as interest is: $\gamma_K = \alpha\pi ϗ\,\rho/\bar{g} - \alpha\imath\pi ϗ\,\rho/\bar{g}$ and the share of financial capital on production growth γ_κ at each given instant is:

$$\gamma_\kappa = \alpha\imath\pi ϗ\,\rho/\bar{g} = \alpha ϗ\,\imath/(1 - \imath)\,\rho/c \qquad (33)$$

Let $\lambda_L/n = 1 - \alpha\pi\rho ϗ\,(1 - \imath)/\bar{g}$ be the relative contribution of labor to production growth and if we define $\gamma_L = \lambda_L/n$, then:

$$\gamma_L = 1 - \alpha\pi\rho ϗ\,(1 - \imath)/\bar{g} \qquad (34)$$

Multiplying both sides of equations (32) and (34) by λ we find the *potential resources share* and *financial capital share* on production growth; for capital:

$$(\Upsilon_K = \alpha\pi\rho ϗ\lambda\,(1 - \imath)/\bar{g}\; = \alpha\beta ϗ\lambda \qquad (35)$$

And after multiplying by q we can gauge the average share of capital:

$$\acute{\Upsilon}_K = \alpha\pi\rho ϗ\,\lambda q(1 - \imath)/\bar{g}\; = \alpha\beta ϗ\lambda q \qquad (36)$$

And for labor:

$$\Upsilon_L = (1 - \alpha\pi\rho ϗ\,(1 - \imath)/\bar{g})\lambda = (1 - \alpha\beta ϗ)\lambda \qquad (37)$$

And also:

$$\acute{Y}_L = [1 - \alpha\pi\rho\text{ķ}\,(1 - \text{ı})/\bar{g}]\,\lambda q = (1 - \alpha\beta\text{ķ})\lambda q \qquad (38)$$

Let $\acute{Y} = \lambda q$ be the additional production at each instant to be distributed as $\acute{Y} = \acute{Y}_K + \acute{Y}_L$. If a fraction of q represents interest, then after multiplying equation (33) by λq:

$$\acute{Y}_\kappa = I = \alpha\text{ı}\pi\text{ķ}\lambda q\,\rho/\bar{g} = \alpha\text{ķ}\;\text{ı}/(1 - \text{ı})\,\rho/c\,\lambda q = \text{ı}/(1 - \text{ı})\,\alpha\beta\text{ķ}\lambda q;\;\; \{\forall\colon \text{ı}\,(0 \le \text{ı} < 1)\}. \quad (39)$$

VI. MONEY SUPPLY AND INFLATION

Monetary influences play a dominant role in determining both the volume and direction of production [...] owing to the dependence on money of every productive activity (Hayek, 1931). If the volume of money M equals the value of production $pq = V$ at each given instant, then:

$$M = pq \qquad (40)$$

This identity is unstable; when denoted as a coefficient of money acceleration or coefficient of money transactions e, then:

$$e = M/pq \qquad (41)$$

and:

$$M = epq \qquad (42)$$

If we differentiate this equation assuming e is constant, $mM = e(\lambda + \acute{p})pq$ and if we define $\dot{m} = mM$ as the *effective* volume at which M changes, we get:

$$\dot{m} = e(\lambda + \acute{p})pq \qquad (43)$$

where pq is the *nominal* Gross Domestic Product (GDP), λ is the *real* change on production growth q measured by the *real* GDP and $\acute{p}$ must be evaluated by the *Implicit Price Deflator for* GDP.[8] If $e = 1$, $\dot{m} = (\lambda + \acute{p})pq$ and thus $\dot{m}$ might be owed to $\acute{p}$, the *effected or expected inflation* due to changes in $(\rho, w, \pi, \text{ı})$, and to λ, *ceteris paribus,* at each given instant.[9]

At $\dot{m} = 0$ in the above equation, then $-\acute{p} = \lambda$, which explains that prices and productivity may take opposite directions; thus, the *purchasing power of money would have to change with every change in total product* (Hayek, 1931, 1932b), which is *the only means of avoiding the misdirection of production* (Hayek, 1931).[10] Avoiding $\acute{p}$ oscillations due to λ could redirect

8 Friedman (1960) proposed a *simpler rule* "The stock of money be increased at a fixed rate year-in and year-out without any variation in the rate of increase to meet cyclical needs". He suggested a rate of increase of 3 – 5 per cent per year.

9 The expression $(\lambda + \acute{p})$ is the *nominal growth rate* GDP, which could have *potential advantages* as monetary policy target (Bernanke, 2022).

10 Hayek (1935, p. 161) explained that: "the concept of neutral money was meant in the first place to be an instrument of theoretical analysis and not necessarily a tool of practical policy [...] this would also set up an ideal of policy". And: "For practical ideal of monetary policy [...] it is clearly not of much help, it still appears to me as a useful concept to describe a real theoretical problem: the conditions under which it would be conceivable that in a monetary economy prices behave as they are supposed to behave in equilibrium analysis". (Hayek,1931/ 2009, pp. 30–31, footnote 1.)

production and income distribution processes[11]. However, e could accelerate M-velocity because of the speed at which prices, the rate of profit, the rate of interest, and production growth evolve, i.e., the *effective circulation* or *quantity times velocity of circulation* (Hayek, 1933) or the proportion of the total *movements* of goods exchanged against money (Hayek, 1931, 1932b).[12] If we insert equation (29) into (43), this yields $\dot{m} = (\lambda + \acute{p})[(1 + \pi)/(1 - \iota)\pi]\, \bar{g}eq$ and if we replace λ from equation (5), $\dot{m}$ oscillations can be estimated at effective or anticipated changes in $(\kappa, \rho, w, \pi, \iota, k, n)$, *ceteris paribus*:

$$\dot{m} = e[f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] + \acute{p}][(1 + \pi)/(1 - \iota)\pi]\, \bar{g}q \qquad (44)$$

If we simplify this based on equation (16) and the definitions above, then:

$$\dot{m} = e[f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] + \acute{p}]\ \ (1 + \pi)cq \qquad (45)$$

or:

$$\dot{m} = e[f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] + \acute{p}]\ pq \qquad (46)$$

Hence potential fluctuations in $\dot{m}$ can be elicited by λ and/or price oscillation.

Let $m = \dot{m}/pq = \dot{m}/M = \dot{m}/V$ be *M-velocity* or its rate of variation, which transmutes equation (46) into:

$$m = e[f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] + \acute{p}] \qquad (47)$$

Let ε be the elasticity of the volume of money at small changes in production growth and/or inflation rate[13], and assuming $e = 1$:

$$\varepsilon = m/[f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] + \acute{p}] \qquad (48)$$

Paraphrasing Einstein (1920), let ε be a universal constant in a relatively stationary economy, where $m, \lambda, \acute{p}$ are not simultaneous or synchronous events with determined constancy of ε, independent of the state of monetary policies, financial credits and government expenditure—and epidemics, invasions (wars)—and natural adversities, e.g.

Let us assume that at the time t_A of a period t_i there exists a *structure of production*, the *reference body*, such that $\varepsilon = 1$ and thus $m = \lambda + \acute{p}$. At a state of relative stationary economy, suppose that λ increases (or decreases) from time t_A to time t_B, the magnitude of which is measured in the direction $\lambda_B - \lambda_A$ in red on line ε of Figure 1. This change in λ *is expected* to be reflected on $\acute{p}_A$ given at t_A to induce its variation, whose magnitude is measured in the direction $\acute{p}_A - \lambda_B$ along on the dotted red line. These events of *different magnitudes* are supposed to occur at the *same time period* $t_B - t_A$, but the magnitude of λ (and $m, \acute{p}$) is independent of t.[14] Therefore we suggest the following equation:

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11 "The losses and redistribution of income, caused by the misdirection of production will naturally have a permanent effect […] in a direction opposite to the impact of the monetary change" (Hayek, 1931/2009, p. 35, footnote 2.).

12 Sraffa (1932, p. 44, footnote) criticized Hayek for "overlook[ing] that the velocity is bound to change as the direct result of a change in prices".

13 Per equation (41): $(dM/M)/[d(pq)/(pq)] = \varepsilon \therefore dM/d(pq) * (pq)/M = \varepsilon \therefore dM/d(pq) = \varepsilon e$ and when $e = 1$ then $\varepsilon = m/(\lambda, \acute{p})$.

14 "If we wish to describe the motion of a material point, the values of its coordinates must be expressed as functions of time. It is always to be borne in mind that such a mathematical definition has a physical sense, only when we have a

$$2\lambda_B = \lambda_A + \acute{p}_A \qquad (49)$$

And the constant ε is measured as follows:

$$\varepsilon = 2\lambda_B/(\lambda_A + \acute{p}_A) \qquad (50)$$

For this we operate on equation (49) to get:

$$\lambda_B = 1/2\,(\lambda_A + \acute{p}_A) \qquad (51)$$

and when inserting this result into equation (50) we obtain $\varepsilon = 1$. In a stationary economy it is supposed that m will vary proportionally to $\lambda + \acute{p}$ at $\varepsilon = 1$ such that:

$$m_A \gtrless \lambda_B + \acute{p}_A \qquad (52)$$

Inserting equation (51) into (52) will result in $m_A = 1/2\,(\lambda_A + \acute{p}_A\,) + \acute{p}_A$ and rearranged, we get:

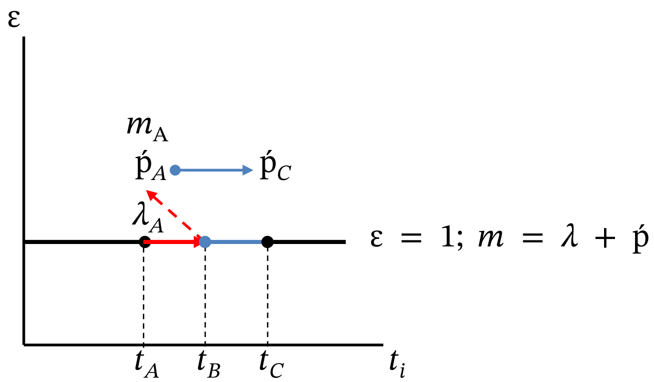
$$m_A = 1/2\,\lambda_A + 3/2\,\acute{p}_A \qquad (53)$$

These three variables will change at non-synchronized t_i as we already stated and Figure 2 illustrates. Assuming $m = 0$ to say that m remains constant from t to $(t + h)$ allows us to derive from equation (53) that:

$$\acute{p} = -\,1/3\,\lambda \qquad (54)$$

This suggests that in a stationary economy in which the level of money remains constant, at $(t + h)$, prices could drop (or rise) 1/3 of λ.

FIGURE 1
PRODUCTION GROWTH IN A STATIONARY ECONOMY AND ITS EFFECT ON INFLATION



Source: Prepared by the author.

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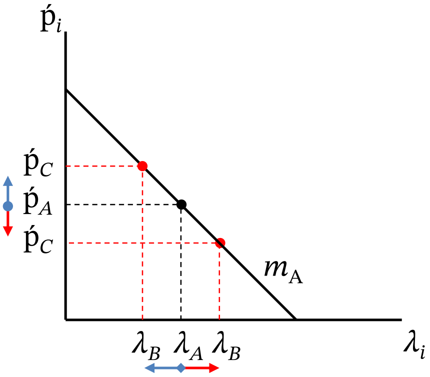
clear notion of what is meant by time. We have to take into consideration the fact that those of our conceptions, in which time plays a part, are always conceptions of synchronism" (Einstein, 1920, p. 3).

FIGURE 2
PRODUCTION GROWTH IN A STATIONARY ECONOMY
AND ITS EFFECT ON INFLATION



Source: Prepared by the author (based on Figure 1).

The expected inflation rate is the result of projected fluctuations of m, λ (Hayek, 1931; Friedman, 1982):

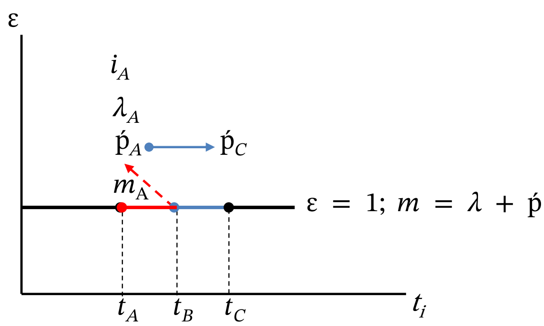
$$ṕ = (1/\varepsilon)\, m - f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] \qquad (55)$$

Assuming $\upsilon = 1/\varepsilon$ then:

$$ṕ = \upsilon m - f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] \qquad (56)$$

At $m = 0, -ṕ = \lambda$ expresses the direction of these variables at different magnitudes and times (Figure 1) or even if $\upsilon m < \lambda$ due to handy increments of M, but preventing inflation means $ṕ \cong 0$; $\lambda \cong \upsilon m$. $m = \lambda; [ṕ/\lambda = (\upsilon - 1)\,]$ computes relative changes in inflation at small changes in production growth alone, and $ṕ = \lambda; [m/\lambda = 2\varepsilon]$ denotes relative changes in the velocity of money at small changes in production growth alone. At changes in m (Figure 3) we denote $2m_B = m_A + ṕ_A \therefore m_B = 1/2(m_A + ṕ_A)$ and if this occurs, then $m_B \gtrless \lambda_A + ṕ_A$ such that $1/2(m_A + ṕ_A) = \lambda_A + ṕ_A \therefore m_A < 2\lambda_A + ṕ_A$. So m-changes could shift *the direction of production not justified by changes in the "real" factors* [...] *in the structure of production* (Hayek, 1931).

FIGURE 3
MONEY GROWTH IN A STATIONARY ECONOMY
AND ITS EFFECT ON INFLATION



Source: Prepared by the author.

VII. THRIFT AND CAPITAL ACCUMULATION

Money could reflect or induce changes in the *mode of production* toward a more capitalist system and/or movement of the economy toward new productive activities, likely enhancing productivity and changing the process of income distribution. Hayek's (1931) concern about M is in relation to its role in shifting *the direction of production not justified by changes in the "real" factors* [...] *in the structure of production.*[15] In equation (56), *ceteris paribus,* decreases in n will lower μ, which in turn will increase α and cause λ to decline. These variable changes might cause ṕ in increase and labor contribution to production growth to decrease, whereas capital contribution will rise. The decrease of n implies less employment of a given labor force at each given instant, but it is the decline in λ induced by a lesser n that causes the effective increase of ṕ; the lower n, *ceteris paribus,* the lesser λ and the greater ṕ.

Ceteris paribus, declines in k could cause μ to rise and α to fall as well as λ to rise and ṕ to fall. As capital contribution to production growth increases, it diminishes labor while increasing the financial capital share. Such relationships between ṕ and n, k are not prolific at all. Inserting $n = \mu k$ into equation (56) we get:

$$\acute{p} = \upsilon m - f[\alpha\beta\kappa, (1-\alpha\beta\kappa)\mu]k \qquad (57)$$

Ceteris paribus, increments in μ may cause λ to rise, lessening ṕ and driving up α which, in turn, eases the path of ṕ depending on the intensity of q demand, and it is here that the money mechanism must play its role on m.

The thrift rate s is a fraction of *effective* $V = pq$ at a specific time period[16] such that $s = S/pq \therefore S = spq$ and *effective* capital accumulation at each given instant is $\rho\varsigma\underline{K}$ such that:

$$\rho\kappa\underline{K} = spq \qquad (58)$$

which when differentiated results in $\rho k\varsigma\underline{K} = sp\tilde{\lambda}q$ where k is the rate of new capital accumulation and $\tilde{\lambda}$ is the *actual* rate of production growth, hence:

$$k = (1/\alpha)\,(1/\kappa)\,(p/\rho)\,s\tilde{\lambda} \qquad (59)$$

Per equations (59) and (6), we can transform (57) as follows:

$$\acute{p} = \upsilon m - 2f[\beta]\,(p/\rho)\,s\tilde{\lambda} \qquad (60)$$

ṕ will also be influenced by $s, \tilde{\lambda}$ given that thrift is supposed to be at the service of the capital accumulation process. *Ceteris paribus,* driving up m could result in steady ṕ increments at expected λ; thus, the instant money balance is:

$$\upsilon m - \acute{p} = 2f[\beta]\,(p/\rho)\,s\tilde{\lambda} \qquad (61)$$

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15 Hayek refers to different stages of production—lower = consumers' goods; higher = producers' goods—in an economy where he assumes there exist different ε.

16 At each given instant, s represents the effective *ability*, compared to the *willingness*, *to save of certain classes of people a certain proportion of a given income*, which may result from the change in the distribution of incomes or product (Hayek, 1931/2009, p. 343) and k denotes the relative rate of capital accumulation for the future increment of production or income.

Potential economic growth is a function of *effective* economic growth at a given state of production processes and market conditions at each given instant:

$$\lambda = 2f[\beta](p/\rho)s\text{ƛ} = 2f(p/c)s\text{ƛ} \qquad (62)$$

p is expected to fluctuate in part by the anticipated λ; $\alpha\beta\varkappa\lambda = (p/\rho)\,\beta s\text{ƛ} \therefore s\text{ƛ}p = \alpha\lambda\rho\varkappa$ and thus the level of thrift is $sp\text{ƛ}q = \alpha\varkappa\rho\lambda q$ and calling $\acute{S} = sp\text{ƛ}q$ the effective thrift added at each given instant and $\acute{K} = \alpha\varkappa\rho\lambda q$ the potential—wanted—value of additional capital accumulation, then $\acute{K} = \acute{S}$ if $\text{ƛ} = \lambda$ such that $sp = \alpha\rho\varkappa$ in order for $\acute{K} = \acute{S} = sp\text{ƛ}q$; additional capital accumulation could differ from further thrifting due to changes in $(\text{ƛ}, \rho, p, \text{ɪ}, \pi, \varkappa)$.

VIII. THE ROLE OF INTEREST RATE

The terms capital and interest are so closely connected with monetary phenomena (Hayek, 1931) that we are setting out to investigate them here. Variations in interest rate can be obtained from equations (46), (29) and (26) and given $m = \dot{m}/pq$ then:

$$i = [1 - e[f[\alpha\beta\varkappa k, (1 - \alpha\beta\varkappa)n] + \acute{p}](1 - \text{ɪ})/m\,]\,\pi; \quad \{\forall: m > 0\} \qquad (63)$$

In a dynamic economy $\lambda, \acute{p}, \pi$ are measured at each given instant and we suppose that they are affected by changes in m. Rises in $\acute{p}$ could tempt lenders to raise ɪ to offset their purchasing power and i could vary at changes in π.[17] According to Gottfried (1946), in addition to the *expansion of the circulating medium*, which changes e, there is an *increase in the velocity of circulation*, which influences ε. This is revealed per the above equation as:

$$i = [1 - \upsilon e(1 - \text{ɪ})]\pi \qquad (64)$$

Given π, e increases at the rate m, meaning $e_t = (1 + m)e_\tau$ at $\upsilon = 1$ given that m is absorbed into the economy, which might elicit a decline in i; however, a *constantly increasing* e *depresses* i. For $i = 0$, meaning i remains the same, m must rise into the limit $\varepsilon \approx e(1 - \text{ɪ})$ or if $m \approx e(\lambda + \acute{p}) \therefore m/(\lambda + \acute{p}) \approx e \therefore \varepsilon \approx e$ such that $i = \text{ɪ}\pi$.[18]

Let us transmute equation (63) into:

$$i = [1 - e[f[\beta, ((1 - \alpha\beta\varkappa)/\alpha\varkappa)\,\mu]\,(p/\rho)\,s\text{ƛ} + \acute{p}]\,(1 - \text{ɪ})/m]\pi; \quad \{\forall: m > 0\} \qquad (65)$$

At $e = 1$ in the equation above, an increase in i owing to a rise of ɪ will reduce m given that the demand for money will fall and $\acute{p}$ will decline:

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17 Central banks could affect i by the so-called *reference interest rate, bank reserves,* and *open market* to influence ɪ. Per the simplified equation (64), let's assume $\upsilon e = 1$ in a stationary economy and after multiplying both sides of the equation by stocks at market price $\dot{P}$, we obtain $i\dot{P} = \text{ɪ}\pi\dot{P}$ and let $r = i\dot{P}$ be the yields for stocks such that $r = \text{ɪ}\pi\dot{P}$ and thus $\dot{P}$ is related to $i = \text{ɪ}\pi$ showing that, *ceteris paribus,* variations in $(\text{ɪ}, \pi)$ will induce $\dot{P}$-oscillations through i, and thus: $r/\text{ɪ}\pi = \dot{P}$.

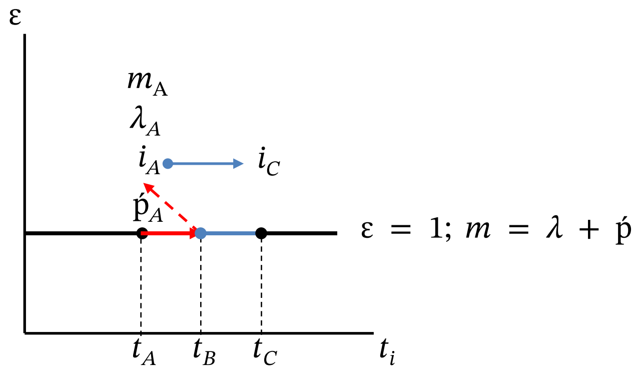
18 From footnote 5 above, the series of expected $\bar{g}$ at each instant given $i = [1 - \upsilon e(1 - \text{ɪ})]\pi$ can be improved per equation (64): $c = \bar{g}_1/(\upsilon e(1 - \text{ɪ})\pi) + \cdots + \bar{g}_n/[\upsilon e(1 - \text{ɪ})\pi]^n; (0 < \text{ɪ} \leq 1); (\pi, \varepsilon) > 0)$, and thus, within limits, the greater ε ceteris paribus the higher c, thereby discouraging investment at a given instant. In general, per equation (65) $c = \bar{g}_1/((1 - e[f[\beta, ((1 - \alpha\beta\varkappa)/\alpha\varkappa)\,\mu]\,(p/\rho)\,s\text{ƛ} + \acute{p}]\ (1 - \text{ɪ})/m)\pi) + \cdots + \bar{g}_n/[(1 - e[f[\beta, ((1 - \alpha\beta\varkappa)/\alpha\varkappa)\,\mu]\,(p/\rho)\,s\text{ƛ} + \acute{p}]\,(1 - \text{ɪ})/m)\pi]^n; (0 < \text{ɪ} \leq 1); (\pi, m, \text{ƛ}) > 0)$ it is obvious that μ influences π and through it, ceteris paribus, $\bar{g}$, causing c to reverse direction.

$$\acute{p} = -[f[\beta, ((1-\alpha\beta\kappa)/\alpha\kappa)\mu]\,(p/\rho)\,s\tilde{\lambda} + [i/\pi - 1]\,m/(1-\iota)e] \qquad (66)$$

Further, changes in i could modify the structure of production through μ; the lesser i, *ceteris paribus,* the greater m and the lesser μ, causing a higher $(\alpha, \lambda, \acute{p})$. Income will rise and perhaps the level of thrifting, and higher prices will motivate producers to borrow and m and λ will increase. Higher prices mean greater π, *ceteris paribus,* and it will induce i to rise and thus $\acute{p}$ will revert, m will decline and $\acute{p}$ will fall, and if λ declines $\acute{p}$ will also drop. Keeping $\acute{p} = 0$ in a steady growing economy, $i = m = \lambda$, which is unlikely when $\mu > 1$; in a dynamic economy price stabilization will occur at $\{\mu: (1/2,1)\}$.

Let us assume, *ceteris paribus,* a rise of $\acute{p}$ in our stationary economy from time t_A to time t_B, the distance of which is measured in the direction $\acute{p}_B - \acute{p}_A$ in red on line ε (Figure 4). This change in $\acute{p}$ is expected to be reflected on i_A given at t_A to induce its variation, whose distance is measured in the direction $i_A - \acute{p}_B$ along the dotted red line.

FIGURE 4
INFLATION IN A STATIONARY ECONOMY AND ITS EFFECT ON INTEREST RATE



Source: Prepared by the author.

The resulting equation is:

$$2\acute{p}_B = i_A + \acute{p}_A \qquad (67)$$

And $2\acute{p}_B/(i_A + \acute{p}_A) = (\varepsilon = 1)$. Further:

$$\acute{p}_B = 1/2\,(i_A + \acute{p}_A) \qquad (68)$$

And we know that:

$$m_A = \lambda_A + \acute{p}_B \qquad (69)$$

After inserting equation (68) into (69) we obtain $m_A = \lambda_A + 1/2\,(i_A + \acute{p}_A)$ from which the following *crucial equation* is derived: [19]

$$i = 2(m - \lambda) - \acute{p} \qquad (70)$$

19 This equation differs from Taylor's (1993) *policy rule* equation. In our *critical equation* (70) the interest rate i must be equal to zero for that $2(m - \lambda) = \acute{p}$ in a stabilized economy.

At $m = \lambda$; $i = -\acute{p}$ in *nominal* terms (the signal $(-)$ indicates the direction i may follow in order to evaluate the *real* interest rate i) meaning that increases in $\acute{p}$ could reduce the value $i = i - \acute{p}$, by definition[20].

Ceteris paribus, the interest rate depends [...] on a relationship [...] between *variations* in the *investment structure*, what we call elasticity of resource composition μ, and *changes in the size of the output* computed per λ which account for *how the productivity of investment reacts to changes in the range of investment periods* (Hayek, 1931, pp. 139–140). *Ceteris paribus,* at $\mu > 1$ the higher the labor demand intensity relative to capital the lower $(m, \lambda, \acute{p}, \alpha, \pi, i)$ and $s\text{ƛ}$. At $(0 < \mu < 1)$ the greater the capital demand intensity (if available) relative to labor the higher $(\pi, i, m, \lambda, \acute{p}, \alpha)$ and $s\text{ƛ}$. Moreover, *an improvement in the expectations of* π *may drive* i above *its previous level* due to a rise in thrift demand, *ceteris paribus*, and it confirms that *a decrease in the rate of saving* [...] *may drive the 'natural rate'* (*at which the demand for and the supply of saving are equal*) *above its previous level* (Hayek, 1933, p. 147). This denotes that the *cause* of changes in i is not *the total amount of capital existing nor the whole existing stock* but *the amount of free capital available for new investment* (Hayek, 1933, pp. 207–208). It also illustrates the effect of $s(\text{ƛ}/m)$ on i and capital accumulation and through it on μ and λ.

The larger $\acute{S} = sp\text{ƛ}q$, *ceteris paribus,* the greater $\acute{K}$ and labor employment could rise, and eventually λ will grow and q increase at the end of the next period of production. Thus, increases in q will provide a new level of $\acute{S} = sp\text{ƛ}q \geq \acute{K}$ and thus another similar event: it could induce changes in $(\rho, \imath, \pi)$. It is likely that increments in $\acute{S} = sp\text{ƛ}q$ will cause i to decrease as it is added to M but, in turn, increases in $\acute{K}$ might cause it to rise. In the real world, fluctuations in $\acute{p}$ might occur and m might need to be adjusted to prevent economic growth instability. Hayek (1933, p. 102) pointed out that *when the volume of money is elastic, there may exist a lack of rigidity in the relationship between saving and the creation of real capital.* If $\acute{S} = sp\text{ƛ}q \therefore s\text{ƛ} = \acute{S}/pq$ then the desirable equilibrium or special *instantaneous* result is $s\text{ƛ} = \acute{K}/pq = \acute{S}/pq = m = \dot{m}/pq$ such that $m = s\text{ƛ}$. A big mistake can be made if per equation (65) $s\text{ƛ} < \varepsilon[f[\alpha\beta\kappa k, (1 - \alpha\beta\kappa)n] + \acute{p}]$ from which $(0 \leq \varepsilon < 1)$.

Furthermore, if $M = epq$ and $S = spq$ is equal to $S = \rho\kappa\underline{K}$ then $spq = \rho\kappa\underline{K} \therefore s = \kappa(\rho/p)(\underline{K}/q) = \alpha\kappa(\rho/p)$ and per equation (58) let $S = \hat{I} = \rho\kappa\underline{K}$, where $\hat{I}$ is the value of capital accumulated at each given instant. M-volume must be equal to S-volume plus the remaining income volume G in the economy for other purposes: $M = S + G = \hat{I} + G$ and thus $epq = spq + G$ such that $G = (e - s)pq \therefore G/pq = e - s$ and let $\hat{g} = G/pq$ such that $\hat{g} = e - s$ and thus $e \cong \hat{g} + s$ at any given instant.[21] Thus, per the above equation $s\text{ƛ} < m = (\hat{g} + s)(\lambda + \acute{p})$. A dynamic money velocity can be derived from function (19) after replacing $spq = \rho\kappa\underline{K}$ obtaining $pq = F(spq, wl\underline{L})(1 + \pi)$ and if $1 = F(s, wl\underline{L}/pq)(1 + \pi)$ then $1 - s(1 + \pi) = F(wl\underline{L}/pq)(1 + \pi)$ and after differentiating function (19), we get $(\lambda + \acute{p}) = [s(\lambda + \acute{p}), (wl\underline{L}/pq)\, n]\,(1 + \pi)$, from which $m = [sm, (wl\underline{L}/pq)\, n](1 + \pi)$ such that $m = n$ at constant returns of scale and $n = \mu k$ will describe:

$$\mu = (\lambda + \acute{p})/k = m/k \qquad (71)$$

20 Investors can assess how inflation, money elasticity, and production growth could affect their earnings; after multiplying both sides by $\dot{P}$ and calling $r = i\dot{P}$ then $\dot{P} = r/[2(m - \lambda) - \acute{p}]$. A rise of λ or $\acute{p}$ alone will reduce i and raise $\dot{P}$, while a rise in m will raise i which reduce $\dot{P}$. Inserting (62) into the above equation will result in $\dot{P} = r/[2[m - 2f(p/c)s\text{ƛ}] - \acute{p}]$, which denotes that an increment in s or a fall in c could reduce i and probably cause $\dot{P}$ to rise. Of course, the return risk differs between short-term and long-term investments.

21 In Keynes' (1930, p. 123) fundamental equation $\Pi = E/o + (I - S)/o$ if $I = S$ then $E = \Pi o$ (see Keynes, 1931; Robertson, 1931; Villard, 1948) and defining $M = (E - S) + I$ (in money terms) and dividing both sides of this identity by Πo results in $M/\Pi o = (E - S)/\Pi o + I/\Pi o$. Now let $G = E - S$ such that $M/\Pi o = G/\Pi o + I/\Pi o$ and assuming $I = S$ will result in $e \cong \hat{g} + s$.

Meaning that the slope of the production growth curve will match the slope of the money growth curve when $e = 1$. Thus, $(\lambda, \acute{p}, m)$ are mutually exhaustive forces and so, within limits, $\acute{p} > 0$ could indirectly enhance λ, for which we could need $(n, k) > 0$: $\lambda = n - \acute{p} \therefore \mu k = m = \lambda + \acute{p}$ and at $\mu = 1; (n = k = m = \lambda + \acute{p})$.[22] Hence, '*forced saving*' (Hayek, 1932a, 1935) (savings above *natural* saving or *current saving*, as could be given by *easy* or *cheap* money) described as $e > (s + \hat{g}) \therefore e > \left(\hat{g} + \alpha\kappa\frac{\rho}{p}\right)$ *is probably the cause of economic crisis*, as Hayek (1931, 1932c, p. 40, 1933) reasoned[23] and Neisser (1934) criticized.

Assuming $\acute{p} = 0$ in the right expression of equation (68), we get:

$$i = [1 - ef[\beta, ((1 - \alpha\beta\kappa)/\alpha\kappa)\mu]\,(p/\rho)\,(s\bar{\lambda}/m)\,(1 - \imath)]\pi \quad \{\forall\colon m > 0\} \tag{72}$$

which shows that $(1 - \imath)s\bar{\lambda} = s\bar{\lambda} - \imath s\bar{\lambda}$ identifies the distribution of the economy's thrift rate among producers and financial capital, which at the same time expresses the share of the expected rate of profit $s\bar{\lambda}\pi - \imath s\bar{\lambda}\pi = s\bar{\lambda}\pi - is\bar{\lambda}$. If $\lambda = 0$ in equation (65) then $i = [1 - e\acute{p}((1 - \imath)/m)\ ]\pi$ from which $e(\acute{p}/m)(1 - \imath)\pi$ suggests that the rate of inflation might act as a mechanism for transferring part of the economy's income through prices as profit and interest, and increases in m will inflate it. Meanwhile, $(\lambda = 0, \acute{p} > 0)$, *ceteris paribus,* might change the interest rate depending on the correction of m.

Assuming $m = \bar{\lambda}$ in equation (72), we have:

$$i = [1 - ef[\beta, ((1 - \alpha\beta\kappa)/\alpha\kappa)\mu]\,(p/\rho)(1 - \imath)s]\pi \tag{73}$$

And thus, rises in ρ induce λ to decline and (p, i) to climb. If $m = \acute{p}$ per equation (57), then:

$$i = [1 - e[f[\beta, ((1 - \alpha\beta\kappa)/\alpha\kappa)\mu](p/\rho)(s\bar{\lambda}/m) + 1](1 - \imath)]\pi \tag{74}$$

So, increases in m, *ceteris paribus,* might induce i to rise, which, in turn, could deter investment, reducing κ and capital and labor velocities, while production growth diminishes and inflation rates climb. The economy's income will decline implying lesser q-demand and lower q-supply which in turn could halt the demand for money and thus cause i to fall slowly; this last effect depends on the adjustment of m keeping $i, \acute{p}$ stable, providing energy for dynamic economic growth.

If a policymaker desired $i = 0$, per equation (65) we can denote how money velocity could be managed:

$$m = e[f[\beta, ((1 - \alpha\beta\kappa)/\alpha\kappa)\mu](p/\rho)s\bar{\lambda} + \acute{p}](1 - \imath) \tag{75}$$

Ceteris paribus, fluctuations in $\bar{\lambda}, \acute{p}, \imath$ can be counteracted by reasonable monetary or/and fiscal policies keeping $i \cong 0$. Yet μ, α, β influences λ, with which we can determine s:

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22 "Even if we had never noticed cyclical fluctuations, even if all the actual fluctuations of history were accepted as the consequences of natural events, a consequential analysis of the effects which follow from the peculiar workings of our existing credit organization would be bound to demonstrate that fluctuations caused by monetary factors are unavoidable" (Hayek, 1933, pp. 184–185).

23 If we replace I with $\hat{I}$ in Keynes' (1930) fundamental equation, we get $\Pi = E/o + (\rho\kappa\underline{K} - S)/o \therefore \Pi = E/o + \rho\kappa\underline{K}/o - s\Pi o/o \therefore (1 + s)\Pi = E/o + \rho\kappa\underline{K}/o$ and thus $(1 + s)\Pi = E/o + \alpha\kappa\rho$ and if $s\Pi = \alpha\kappa\rho$ it follows that $E = \Pi o$; all we need is $\alpha\kappa\rho \gtreqless s\Pi$; in this connection, when $\Pi = \alpha\kappa\rho/s$ is inserted into $E = \Pi o$ we get $\alpha\kappa\rho \gtreqless sE/o$ meaning that the rate of investment can differ from the rate of thrift, which is feasible through easy money, cheap money or forced saving: $M/\Pi o = E/\Pi o + (\rho\kappa\underline{K} - S)/\Pi o \therefore e = E/\Pi o + \alpha\kappa\,\rho/\Pi - s$ from which $E = e\Pi o = M$ or even $e = E/\Pi o = M/\Pi o$ so $\alpha\kappa\rho \gtreqless es\Pi$ and also $\alpha\kappa\rho \gtreqless sM/o$ or $\alpha\kappa\rho \gtreqless s\Pi$. For Hayek (1932c, p. 40) [...] artificial stimulus to investment, which makes it exceed current saving, may cause a dis-equilibrium in the real structure of production which, sooner or later, must lead to a reaction."

$$s = \rho\lambda/[f[\beta, ((1-\alpha\beta\varkappa)/\alpha\varkappa)\mu]p\lambdabar] \text{ ; } \textit{at constant returns}\text{: } s = \rho\lambda/[2f[\beta]p\lambdabar] \tag{76}$$

This explains the required ratio of thrift to reach some expected level of λ for which at a known $\lambdabar, \acute{p}, \imath$ could be necessary to propel $(1/e)m$. Per the above equation, $\acute{K} = \acute{S} = s\lambdabar pq$ we recognize that $\rho k\varkappa\underline{K} = \acute{S} = s\lambdabar pq$ to get $k\rho\varkappa\alpha = s\lambdabar p = \alpha\lambda\rho\varkappa$ and thus $k = \lambda$ at the end of each period of production while per equation (58) $\rho\varkappa\alpha = sp$ and thus $skp = s\lambdabar p \therefore k = \lambdabar$. This result shows that from instant-to-instant capital accumulation must grow at the same rate of production growth to keep a steady path. Due to $\mu = n/k \therefore k = n/\mu$ then $n = \lambda\mu;\ n = \lambdabar\mu$ and, for instance, at $\mu = 1$ we get $n = k = \lambda;\ n = k = \lambdabar$.

We can consider how production growth and inflation might be affected by the interest rate, profit, money velocity, and money elasticity, per equation (65), obtaining:

$$2f[\beta](p/\rho)(s\lambdabar) + \acute{p} \cong (1/e)(1 - i/\pi)(m/(1-\imath)); \ \{\forall: \pi > 0; (0 \leq \imath < 1)\} \tag{77}$$

Ceteris paribus, production might grow in response to increments of π, which could, in turn, reduce $\acute{p}$; however, a decrease of π will cause a rise of $\imath, e, i$. Taking i effects alone, an increase might reduce *the volume of current production* and perhaps the *size of the productive apparatus*. This could occur because of the rise in factor prices (w, ρ), which could change μ, specifically depressing it due to the possible reduction in employment rate. Ultimately, product prices could increase due to cost increments and less production volume. Additionally, $e > 1$ will probably cause considerable changes in the structure of production, *ceteris paribus,* by artificially shrinking i as can be deduced from equation (68).

IX. CONCLUSIONS

As we affirmed in the introduction, the aim of this paper was to analyze Hayek's assumptions regarding the effects of money supply on the structure of production and the goods and services market, for which the rates of inflation and interest are of great concern. We focused this analysis by *devising* a *method of approach* for a dynamic economic growth model in search of answers to Hayek's suggestions and challenges. The set of mathematical tools measures *instantaneous* changes in production, capital, and labor, computing capital and labor contribution and share of production growth. Changes in the total money stream could incentivize changes in the production structure due to the *distortion of relative prices and a misdirection of production*.

Proportional changes in all variables compounding production and circulation processes along with changes in money flow to control inflation and the interest rate will require a model that anticipates the behavior of economic agents. In a dynamic economy, the quantity of money must change in response to transformations in the structure of production due to changes in technology and human resources, which would probably modify resource composition and resource productivity. Moreover, policymakers could stimulate the structure of production to make it more productive, which will necessitate certain monetary and fiscal policies (Kelton, 2020). A moderate distortion of relative prices, interest rates, wages, profit, and the redirection of production could be socially desirable. However, it must take into consideration the condition of the economy as discussed during COVID-19 and the Russian invasion of Ukraine in 2022 by renowned economists (Kashkari, 2021; Krugman, 2021, 2022; Summers, 2021a, 2021b) and newspaper articles (Smialek, 2022; Smith, 2022).

We believe this study could be of great interest to policymakers in making firm decisions as well as a contribution to economics.

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ADDENDUM

To demonstrate the usefulness of the model we propose in this paper, we will analyze *critical* data from the US economy provided by the BEA (https://www.bea.gov/) and the Fed (https://www.federalreserve.gov/aboutthefed.htm) working with the fundamental equations we propose above. We work with *nominal, seasonally adjusted* [millions of dollars] and *real* [millions of chained (2012) dollars], *seasonally adjusted* gross domestic product (GDP) quarterly data from 2020Q1 to 2022Q3 to calculate the GDP-deflator—the ratio of nominal GDP to real chained-GDP multiplied per 100 percent. Additionally, we work with seasonally adjusted M2 money stock computed in March, June, and September for 2021 and 2022, which includes small-denomination time deposits and retail money market funds, and seasonally adjusted M1, which includes currency, demand deposits, and other liquid deposits. The purpose of analyzing this information is to calculate the interest rate at each given instant per the *crucial equation* (70).

The table inserted below describes the results of these measurements. The bottom line is that the interest rate that the Fed needed to hit one year ago was approximately four percent (4.0%). However, the Fed only approached this rate in the third quarter of 2022 by increasing it by 0.75 percentage points. If the Fed's goal is to curb the inflation rate by two percent in the first quarter of 2023, it still has work to do on the interest rate, unless the velocity of money slows down or output grows or the intensity of demand evens out or by a combination of the above.

UNITED STATES OF AMERICA. COMPUTED AND ESTIMATED ANNUAL INTEREST RATE (2020-2022)

Gross Domestic Product (GDP) - Millions of Dollars -				Money Stock (M2) -March- - Millions of Dollars -	e= M2/GDP	λ	ṕ	$m = e(λ+ ṕ)$
Period	GDP	Real GDP	IPDGDP					
Q1-2020	21 561 100	19 010 800	113,415					
Q1-2021	22 038 200	19 055 700	115,651	19 613 900	0,8900	0,0024	0,0197	0,0197
Q1-2022	24 740 500	19 924 100	124,174	21 739 700	0,8787	0,0456	0,0737	0,1048
			Q1-2021	Measured annual	0,0149	FED funds rate.		0,0025
			Q1-2022	interest rate í :	0,0448	Computed í :		0,0050
Gross Domestic Product (GDP) - Millions of Dollars -				Money Stock (M2) -June- - Millions of Dollars -	e= M2/GDP	λ	ṕ	$m = e(λ+ ṕ)$
Period	GDP	Real GDP	IPDGDP					
Q2-2020	19 520 100	17 302 500	112,817					
Q2-2021	22 741 000	19 368 300	117,414	20 460 100	0,8997	0,1194	0,0407	0,1441
Q2-2022	25 248 500	19 895 300	126,907	21 607 700	0,8558	0,0272	0,0809	0,0925
			Q2-2021	Measured annual	0,0086	FED funds rate.		0,0050
			Q2-2022	interest rate í :	0,0497	Computed í :		0,0100
Gross Domestic Product (GDP) - Millions of Dollars -				Money Stock (M2) -Sept- - Millions of Dollars -	e= M2/GDP	λ	ṕ	$m = e(λ+ ṕ)$
Period	GDP	Real GDP	IPDGDP					
Q3-2020	21 138 600	18 560 800	113,888					
Q3-2021	23 550 400	19 672 600	119,712	20 460 100	0,8688	0,0599	0,0511	0,0965
Q3-2022	25 663 300	20 021 700	128,177	21 503 400	0,8379	0,0177	0,0707	0,0741
			Q3-2021	Measured annual	0,0220	FED funds rate.		0,0050
			Q3-2022	interest rate í :	0,0420	Computed í :		0,0400

Source: Prepared by the author.