Toward a Synthesis of Non-Mainstream Economic Models: From the Perspective of a Marxian Circuit of Capital Model

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ABSTRACT. The aim of this paper is to provide a Marxian Circuit of Capital Model (MCCM) with analytical foundations, from which we can derive the four non-mainstream economic models of Marx-Morishima, Keynes-Robinson, Marris-Wood and Kalecki-Steindl, and to examine the conditions under which a wage-led regime occurs within the MCCM. The MCCM is composed of three equations: Cambridge equation which is a common characteristic shared by non-mainstream economic models, a capital turnover constraint which is derived from the characteristic equation of the system, and a Marxian investment function which is given by the first order condition to maximize the value of capital with respect to the growth rate. We prove that all non-mainstream models are special cases of the MCCM. We also demonstrated that a wage-led regime is accommodated within the MCCM, which is not compatible with Marx-Morishima model. An economy is in a wage-led regime when the utilization rate elasticity of the profit rate is greater than the utilization rate elasticity of the marginal profit rate with respect to the growth rate. The wage-led regime holds when capitalists try to increase the growth rate through aggressively raising the utilization rate in order to recapture the loss of profit share.

Key Words: *wage-led, profit-led, circuit of capital, valorization, metamorphose*

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Introduction

Not only Marxian economics but also post-Keynesian economics have tried to examine how the capitalism works. And they tried to explain how the growth rate is determined in capitalism. But we can find many different answers to this one simple question. Heterodox economics have not still reached a consensus on the issue of the dynamic motion of capital.

One of the aim of this paper is to establish a Marxian circuit of capital model (hereafter MCCM) in order to synthesize some influential heterodox economics on a higher plane. In section 1, I first provide a basic model. It contains the common features which four heterodox models share. The basic model has four unknown variables: the rate of profit, growth, real wage and capital turnover. But it has only two equations: the price formation and the Cambridge equation. In order to complete the model, it is necessary to add two more equations. Second, I will outline the four approaches. In the case of the Marx-Morishima model, the constant conventional wage is introduced and full capacity is asssumed. According to the Keynes-Robinson model, the model should be closed by an Robinsonian investment function with assuming full capacity. The Marris-Wood model, to which little attention has been given, insists that it should be closed by what Marris calls the "growth-profitability function" with a fixed markup rate. The Kalecki-Steindl mode asserts that it should be closed by the Kaleckian investment function with a fixed markup rate. Thus before us are four influential different models in a somewhat disjointed state. Therefore, a simple question is raised: which is correct?

In section 2, we will lay out a synthesized MCCM in a constructive way, which takes explicitly into account the fact that it takes time for capital to move through its circuit.[1] And we demonstrate all four heterodox models are derived from MCCM if we add some assumptions to MCCM. We indicate four heterodox models are just a special case of MCCM.

[1] This is an expanded model of Foley (1982), inspired by Marx's circuit of capital.

In section 3, we investigate whether a wage-led regime can emerge or not in a MCCM. In Marx-Morishima model, the wage-led regime never occurs, because if the real wage increases, the exploitation rate decreases so that the profit rate also decreases. We will explore what conditions are needed to make the wage-led regime exist.

1. Non-mainstream economic models

In this section, we formalize non-mainstream economic models. At first, let us summarize assumptions and notations in this paper.

(A1) Government and international trade are abstract.

(A2) Only one good is produced in this economy.

(A3) Technology exhibits fixed coefficients and constant return to scale.

(A4) Wage is paid at the end of period.

Notations are

a: circulating capital coefficient

l: direct labor coefficient

T: turnover time

τ: turnover rate ($\tau = 1/T$)

p: price

w: nominal wage

ω: real wage ($\omega \equiv w/p$)

b: conventional wage (given a priori)

x: output level

π: profit rate

r: mark-up

g: growth rate

s: capitalist propensity to save

1.0. A basic model

A basic model is constructed based on two following equations:

(Basic Model)

$$\pi = \frac{p - pa - wl}{paT} = \frac{1 - a - \omega l}{a}\tau \cdots\cdots \text{(B1)}$$

$$g = s\pi \cdots\cdots \text{(B2)}$$

(B1) is a price formation. It is noteworthy that the fixed capital is taken into account.[2] A fixed capital is expressed as $aT = a\tau^{-1}$, where T is a turnover period and τ is a turnover rate. The markup on physical cost is defined as

$$r = \frac{1 - a - \omega l}{a},$$

then $\pi = r\tau$. If $T = \tau = 1$, then $\pi = r$.

(B2) is a Cambridge equation. It insists that the increment of capital springs from the proportion of the profit.[3]

In the basic model, there are four unknown variables: π, ω, g, and τ, but there are only two equations: the price formation and Cambridge equation. Two equations should be added in order to close the basic model. What kind of equations should be added?

The answer is not the only one. We have, at least, four answers in the heterodox tradition: Marx-Morishima, Keynes-Robinson, Marris-Wood, Kalecki-Steindl models. We examine these models in the following subsections.

[2] This formation is established by Lange (1957). See also Roemer (1981) as for the existence of the solution in the case of n-goods economy.
[3] See Pasinetti (1974).

1.1. Marx-Morishima model

Marx-Morishima model is obtained if it is assumed that the turnover rate is assumed to be unity and the real wage is determined as constant conventional wage.

(MM1: full utilization)[4]

The economy fully utilizes its fixed capital. The level of full utilization can be normalized as unity:

$$\tau = 1.$$

(MM2: conventional wage)[5]

The real wage is determined to be necessary for the production of a unit of labor power.

$$\omega = b.$$

Marx-Morishima model is constituted by the basic model and the assumptions of MM1 and MM2. These assumptions substantially mean that the Cambridge equation and the price formation in the basic model determine the profit rate and growth rate with two constant parameters. This model has a unique solution if we assume $1 - a - bl > 0$. Hereafter we employ this assumption.

1.2. Marris-Wood model

In the place of the investment function, Marris-Wood approach is closed by so-called growth-profitability function.[6] And we assume capitalists set their price as a fixed markup on physical costs.

(MW1: fixed markup)[7]

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[4] See Morishima (1973, p. 12).
[5] See Morishima (1973, p. 34).
[6] See Marris (1967). And also see Marris (1971a, chap. 1) and Wood (1975).

The price level is set by the fixed markup on physical cost.

$$r = \bar{r}.$$

(MW2: growth-profitability function)

$$\pi = \pi(g), \qquad \pi'(g) < 0, \pi'' < 0.$$

This function states that there is negative relationship between the profit rate and the growth rate. This is because, in order to achieve faster growth rate, the firm must spend higher "development expenditure," which is, for example, the cost for R&D and/or advertisement.

This system consists of four equations: B1, B2, MW1 and MW2. and four variables: π, ω, g, and τ. It is in essence that B2 and MW2 determine π and g. On the other hand, MW1 determine ω. In the end, τ is determined by B1.

1.3. Keynes-Robinson model

In a Keynes-Robinson model, the system is closed the by assumptions of the full capacity and the long-run investment function:

(KR1: normal rate of utilization)[8]

The rate of utilization is assumed to return to its normal level. Suppose the normal lever of utilization as τ^*, then

$$\tau = \tau^*.$$

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[7] As we will see, this assumption is basically the same as in the Kalecki-Steindl model. MW1 is slightly different form the formulation of Bhaduri and Marglin (1990), Blecker (2002), Dutt (1990) and Lavoie (2014). It is, however, essentially no different from the assumption that the price level is determined by markup only on wage cost, which is a popular formulation of the Kalecki-Steindl model. Assume $p = (1 + m)wl$ and the markup on wage costs, m, is constant. In this case, $\omega = 1/(1 + m)l$ is constant so that $r = (1 - a - \omega l)/a$ is also constant. It means that KS1 is the same assumption to MM2. And they are also no different from the assumption that the profit share is constant. Define the profit share as $\theta = (1 - a - \omega l)/(1 - a)$. And $r = \theta\,(1 - a)/a$ is also constant.

[8] See Dutt (1990, p.20) and Lavoire (2014, p. 361).

(KR2: Robinsonian investment function)[9]

The higher the desired rate of growth is going to be, the higher a rate of profit is going to be.

$$g = g(\pi), \qquad g'(\pi) > 0, g''(\pi) < 0.$$

This investment function shows that the rate of growth is determined by the rate of profit. More precisely, this equation should be written as $g = g(\pi^e)$ where π^e is the expected rate of profit. Because the higher the expected profit rate is going to be, the higher the growth rate is going to be. In order to close the model, the static profit expectations are employed, then $\pi^e = \pi$.

If (KR1) and (KR2) are simultaneously valid, they can be transformed into (KR2').

(KR2': Robinsonian investment function under the normal capacity)

Suppose the economy is under the normal capacity. The higher the desired rate of growth is going to be, the higher a rate of markup is going to be.

$$g = g(r), \qquad g'(r) > 0, g''(r) < 0.$$

There are four equations in the Keynes-Robinson model in which two assumptions of KR1 and KR2 are added to the basic model. Four equations are enough to determine four unknown variables: π, ω, g, and τ. Or rather, it is essential that B2 and KR2 determine r (not π) and g with a constant parameters τ. The Keynes-Robinson model is completed.[10]

1.4. Kalecki-Steindl model

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[9] This equation is formulated by Robinson (1962). Also see Roemer (1981, chap. 9). As for the linearized one, see Bhaduri and Marglin (1990), Dutt(1990) and Lavoie(2014).

[10] We have to add the assumption that $g'(0) > 1/s$ and $\lim_{\pi\to\infty} g'(\pi) < 1/s$ to guarantee the existence of g.

In the contrast to other models, the Kalecki-Steindl model allows excess capacity. And more, we assume capitalists set their price as a fixed markup on physical costs as we did in the Marris-Wood model.

(KS1: fixed markup)[11]

The price level is set by the fixed markup on physical cost.

$$r = \bar{r}.$$

(KS2: Kaleckian investment function)[12]

A desired investment depends positively on the rate of capacity utilization. [13]

$$g = g(\tau; \bar{r}), \qquad g'(\tau) > 0.$$

In the Kalecki-Steindl model, B1 and KS2 determine g and τ with assuming KS1. And then the profit rate is determined by B2.

1.4. Heterodox Economic Models

Now we obtain four models to complete the basic model. But all these models are incompatible, because each approach has their own entirely different closures. In $\pi \times g$ space, as shown in Figure 1, Marx-Morishima, Keynes-Robinson Marris-Wood and Kalecki-Steindl models are closed by the horizontal, upward, downward and vertical line, respectively. There is thus an enormous difference among their models, and each claims to be the most fundamental approach in the construction of the theory of the dynamics of capitalism.

Before us are four different models in a somewhat disjointed state. Therefore, a simple question is raised: which is correct?

[11] KS1 is exactly the same as MW1.

[12] See Dutt (1990) and Lavoire (2014).

[13] The rate of turnover can be identified with the rate of capacity utilization. The same treatment is found in Blecker (2002). Note that $\pi = ((1 - a - \omega l)/a)(x/x^*)(pax^*/paTx)$. x/x^* is the ratio of actual to potential output (the true utilization). ax^*/aTx is the ratio of potential real cost to the capital stock. The unit of time is arbitrary, so that we can normalize x^*/Tx as unity. Thus we can get $\tau = x/x^*$.

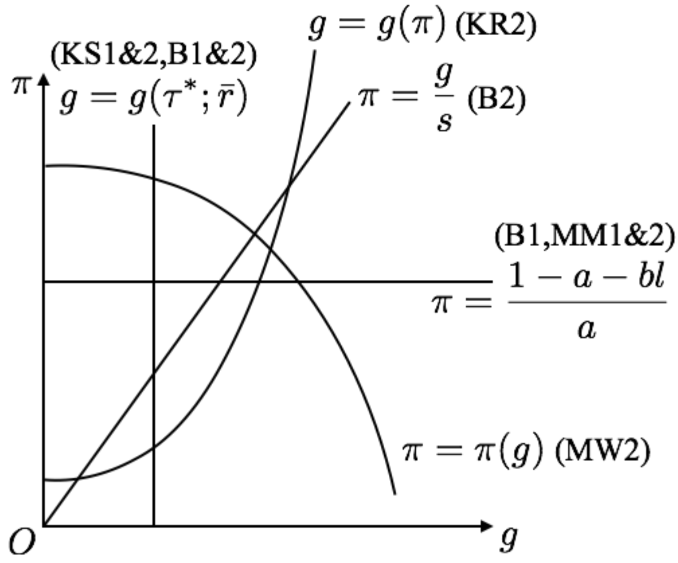

Figure 1: Four closures of non-mainstream economic models

In the next section, we provide a synthesized model, we call Marxian Circuit of Capital Model (MCCM), from which the four approaches can be derived.

2. The Basic Model of Circuit of Capital

2.1. Marx's Circuit of Capital

The circuit of capital, in *Capital*, volume II, chapter 1, provides a basic idea to establish a new Marxian model. Marx represents the circular motion of capital in the following formula:

$$\mathrm{M} - \mathrm{C} \cdots \mathrm{P} \cdots \mathrm{C}' - \mathrm{M}'.$$

For Marx, capital is not given the same meaning as in modern economic literature. Capital undergoes the metamorphosis which transforms M, money-capital, successively into P, productive capital, C', commodity-capital yet again and finally money-capital when the cycle is completed.

This formulation of capital movement is, however, controversial. M, P, and C' are all formulated as an element of capital movement in Marx's formulation. But on the other hand, there is only one exceptional element not formulated as capital: that is C. Why? The answer is simple: M, P and C’ are stock variables in the sequence of capital movement. But it is only C that represents a flow variable, which means that C is an object of exchange transaction. [14]

Therefore, we should distinguish stock variables from flow variables in the alternative formulation. We formulate nodes in the formulation as stock variables and arrows between each node as flow variables in the following manner:

$$M \xrightarrow{C} P \cdots\cdots > C' \longrightarrow M'.$$

Our formulation will leave less room for misunderstanding than Marx's formulation. The biggest difference is that C is moved to the upper part of the first arrow between M and P. The reason of this movement is that C in Marx's formulation represents the transaction of commodities. In other words, M, P, and C' are stock variables but C is exceptionally a flow variable. In our formulation, we can distinguish between stock and flow variables: each of the nodes correspond to the stocks, and the arrows between each node correspond to the flows. According to this simple idea, we provide our complete formula of capital circuit with giving the mathematical expression to all transaction of each arrow in the next subsection.

2.2 The Basic Formulation of Circuit of Capital

We formulate the circuit of capital based upon the simple rule as seen in Figure 2.

$$\xrightarrow{+\text{Inflow}} \text{Stock} \xrightarrow[-\text{Outflow}]{}$$

Figure 2: The Basic Concept of Stock and Flow

In Figure 2, the element above the arrow represents the amount of flow increasing the right-side stock, and the element below the arrow represents the amount of flow decreasing

[14] Indeed C may be viewed either from the stock or flow point of view consistently, since there are inventories of raw materials awaiting production. But the inventories of raw materials should be viewed as a part of the productive capital P.

the left-side stock. The increment of stock can be calculated as the difference between inflow and outflow. We call this rule “bookkeeping rule.”

According to the bookkeeping rule, our formulation of the circuit of capital is as Figure 2.[15]

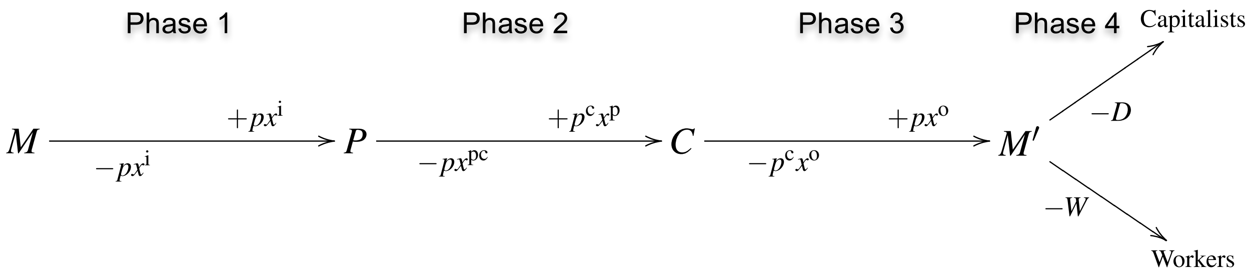

Figure 3: The formula of capital in diagrammatic form

The phase 1 represents the transformation from money-capital M into productive capital P, in short, the phase of purchase. Purchasing commodities, say, raw materials, means increasing the amount of productive capital and decreasing the amount of money-capital. Let the inflow of commodities denoted by x^{i}, so that the amount of productive capital is increased by $+px^{\mathrm{i}}$ in price term, and money-capital is decreased by $-px^{\mathrm{i}}$. Naturally, if the transaction is a so-called asset exchange transaction, the sum of the two elements above and below the same arrow must equal zero.

The phase 2 represents the transformation from productive capital P into commodity-capital C, in other words, the phase of production[16]. In this phase, the products are produced and the raw materials are productively consumed. Let x^{p} be the amount of production, and x^{pc} be the amount of productive consumption, so that $x^{\mathrm{pc}}/x^{\mathrm{p}} \equiv a$ by definition of Leontief coefficient. The products should be measured at cost price, which is denoted by p^{c}. Then P is

[15] The Basic idea is established by Foley (1982, 1986). The extended version of this model can be seen in Basu (2014) and dos Santos (2011).
[16] Henceforth in this paper we denote the commodity-capital as C, not C', for the symbol of the prime may be misunderstood as the derivation.

decreased by px^{pc}, and C is increased by $p^{\mathrm{c}}x^{\mathrm{p}}$. Applying the rule of an asset exchange transaction, it must be held that $p^{\mathrm{c}}x^{\mathrm{p}} = px^{\mathrm{pc}}$, so that we get $p^{\mathrm{c}} = pa$.

The phase 3 represents the transformation from commodity-capital C into money-capital M', in other words, the phase of sale. It decreases C which is interpreted as the merchandise inventory and increases M' as the fund reserve. Let x^{o} be the outflow of commodities, then the total amount of commodities' outflow is $-p^{\mathrm{c}}x^{\mathrm{o}}$, and the gross amount of cash inflow is $+px^{\mathrm{o}}$. It is noteworthy that this transaction is not an asset exchange transaction, but an asset source transaction, which provide revenue to the capitalist. In other words, the sum of the two elements above and below the arrow is not zero, but more than zero. The amount of that difference is called "yield," which is defined as $py \equiv px^{\mathrm{o}} - p^{\mathrm{c}}x^{\mathrm{o}} = p(1-a)x^{\mathrm{o}} > 0$.

The phase 4 represents the processes of distribution. The yield is distributed, by definition, into two parts: one is wage, W, and the other is profit, Π. It is mathematically expressed as $py = W + \Pi$. The wage can be expressed as wlx^{o}, where w is the nominal wage rate and the l is the labor coefficient. By definition, $\Pi = py - W = (p - pa - wl)x^{\mathrm{o}}$. The profit is also divided into two parts. One part is recommitted as capital, i.e. it is accumulated. The other part is transferred to the capitalist as capitalists' revenue. Some fraction of the profit is recommitted in the case of expanded reproduction. This fraction is the capitalists' propensity to accumulate. We denote this retained fraction as s, then the amount of recommitted profit is $s\Pi$. On the other hand, the revenue of capitalists, hereafter we call it dividends, D, can be mathematically expressed as $D \equiv (1-s)\Pi$. And then the circuit of capital will restart without stopping.

In the next subsection we will derive relational expressions of capital circuit from Figure 2.

2.3. Accumulation of Capital

At first, we investigate how the capital stocks increase in the circuit. The stocks in the circuit, M, P and C, are governed by the following rule:

$$\begin{aligned} \dot{P}(t) &= px^{\mathrm{i}}(t) - pax^{\mathrm{p}}(t) \\ \dot{C}(t) &= pax^{\mathrm{p}}(t) - pax^{\mathrm{o}}(t) \\ \dot{M}(t) &= px^{\mathrm{o}}(t) - W(t) - D(t) - px^{\mathrm{i}}(t) \end{aligned} \quad \cdots\cdots(1)$$

where

$$\begin{aligned} W(t) &= wlx^{\mathrm{o}}(t) \\ D(t) &= (1-s)\Pi(t) \\ \Pi(t) &= (p - pa - wl)x^{\mathrm{o}}(t) \end{aligned}$$

These equations follow from the bookkeeping rule. They represent that each capital is increased by the inflow and decreased by the outflow, and then each capital is accumulated when the inflow is more than the outflow. If we define the total volume of capital as $K(t) \equiv P(t) + C(t) + M(t)$, then the increment of capital is denoted by $\dot{K}(t) = \dot{P}(t) + \dot{C}(t) + \dot{M}(t)$. Reasoning from (1), we can easily get:

$$\dot{K}(t) = \dot{P}(t) + \dot{C}(t) + \dot{M}(t) = s(p - pa - wl)x^{\mathrm{o}}(t) \cdots\cdots(2)$$

We concentrate on analyzing the stationary state, then the growth rate is $g(t) \equiv \dot{K}(t)/K(t)$ and the profit rate is $\pi(t) \equiv \Pi(t)/K(t)$, which are independent of time t.

The scale of output is arbitrary. Dividing (2) by the volume of capital $K(t)$, we get:

$$g = \frac{s(p - pa - wl)x^{\mathrm{o}}(t)}{K(t)} = s\pi \cdots\cdots(3)$$

As we can see, the Cambridge equation (B1) is not only hold in the basic model, but also hold in the MCCM. Summing up.

[Proposition 1-1] We can derive the Cambridge equation from the bookkeeping rule in the MCCM. It is hold that

$$g = s\pi.$$

■

This relationship insists that the accumulation of capital springs from its profit. We have one equation and two variables: the profit rate and the growth rate. We have to investigate to obtain one more equation to complete the circuit of capital model.

2.4. Turnover of Capital

In the previous subsection, we evaluate the increasing amount of the total volume of capital, $\dot{K}(t)$. In this subsection, we evaluate the amount of the total volume of capital, $K(t)$. To that end, we consider the transfer process and formulate the ratio of capital turnover. The inflow and outflow are related by the convolution:

$$\begin{aligned} ax^{\mathrm{p}}(t) &= \int_{-\infty}^{t} x^{\mathrm{i}}(t')\alpha(t-t')\,\mathrm{d}t' \\ x^{\mathrm{o}}(t) &= \int_{-\infty}^{t} x^{\mathrm{p}}(t')\beta(t-t')\mathrm{d}t' \qquad \cdots\cdots (4) \\ px^{\mathrm{i}}(t) &= \int_{-\infty}^{t} (px^{\mathrm{o}}(t') - W(t') - D(t'))\gamma(t-t')\,\mathrm{d}t \end{aligned}$$

$\alpha(\cdot)$ represents a distributed lag in the process of production, interpreted as the proportion of commodity inflow at time t, that are consumed productively at time $t+t'$. $\beta(\cdot)$ is a distributed lag in the process of sale, interpreted as the proportion of products at time t, that are sold at time $t+t'$. $\gamma(\cdot)$ is also a distributed lag in the process of purchase, which is also interpreted as the proportion of money inflow obtained by selling at time t, which are paid to get in a stock at time $t+t'$. α, β and γ are nonnegative and integrate to 1 over the positive half-line.

Under stationary state, the initial conditions must satisfy the following equations.[17] Reasoning from three equations (4),

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[17] We omit the initial time subscript such as $x(0) = x$.

$$
\begin{aligned}
ax^{\mathrm{p}} &= x^{\mathrm{i}}\alpha^* \\
x^{\mathrm{o}} &= x^{\mathrm{p}}\beta^* \qquad \cdots\cdots (5) \\
px^{\mathrm{i}} &= \big(1 - \omega l - (1-s)(1 - a - \omega l)\big)px^{\mathrm{o}}\gamma^*
\end{aligned}
$$

where

$$\alpha^*(g) = \int_0^\infty \alpha(t)e^{-gt}\,\mathrm{d}t,$$

which is the Laplace transform of the lag function $\alpha(\cdot)$ and similarly for $\beta^*(g)$ and $\gamma^*(g)$. The Laplace transform has specific properties as follows:

$$\alpha^*(0) = 1, \qquad \frac{d\alpha^*(g)}{dg} < 0, \qquad \lim_{g\to\infty} \alpha^*(g) = 0.$$

By successive substitution of (5), we reach:

$$1 = (1 + sr)\alpha^*(g)\beta^*(g)\gamma^*(g) \cdots\cdots (6)$$

This is one of the key results of this paper. This equation is the characteristic function of the system. It has a unique positive real root g.[18] What does it mean in the economic sense? It may be hard directly to interpret the equation (6) as such, but if we look more carefully at this equation, it is easy to find that this equation is a solution of the following simultaneous equations.

$$
\begin{cases}
\pi^* = g/s \cdots\cdots (3) \\
\pi^{**} = \pi(g) = r\,\tau(g) \cdots\cdots (7) \\
\pi^* = \pi^{**}
\end{cases}
$$

where

$$
\begin{cases}
r = (1 - a - \omega l)/a \\
\tau = \tau(g) = g\alpha^*(g)\beta^*(g)\gamma^*(g)/\big(1 - \alpha^*(g)\beta^*(g)\gamma^*(g)\big)
\end{cases}
$$

It is obvious that (3) is the Cambridge equation. It is not necessary to mention more.

How do we get (7)? At first, we should drive the stock variables: P, C, and M. Noting that all stock variables grow at the rate of g, and substituting (5) to (1), we get:

[18] As for the proof of the existence of the root g, see Foley (1982, 1986).

$$
\begin{aligned}
P &= pax^{o}\left[\left(1-\alpha^{*}(g)\right)/g\alpha^{*}(g)\beta^{*}(g)\right] \\
C &= pax^{o}\left[\left(1-\beta^{*}(g)\right)/g\beta^{*}(g)\right] \qquad \cdots\cdots (8) \\
M &= pax^{o}\left[\left(1-\gamma^{*}(g)\right)/g\alpha^{*}(g)\beta^{*}(g)\gamma^{*}(g)\right]
\end{aligned}
$$

then we get

$$K = P + C + M = pax^{o}T(g) \cdots\cdots (9)$$

where

$$T(g) \equiv \left(1-\alpha^{*}(g)\beta^{*}(g)\gamma^{*}(g)\right)/g\alpha^{*}(g)\beta^{*}(g)\gamma^{*}(g).$$

$T(g)$ represents the time of capital turnover, which is calculated by dividing the total volume of capital K with the total sale cost pax^{o}. We also define $\tau(g)$ as the ratio of capital turnover: $\tau(g) \equiv T^{-1}(g)$. Finally we get the equation (7) from the definitions of $\Pi = (p - pa - wl)x^{o}$ and $K = pax^{o}T(g)$.

This equation (7) states that the profit rate is divided into two parts: The first part is the markup rate, r and the rate of turnover, τ. The markup rate could be constant if we assumed the conditions of (MM1), (KR1) or (MW1). The rate of turnover is, however, not a constant parameter, but a variable whose value depends on the growth rate. What is important is that it is not arbitrarily assumed, but is properly derived from the characteristic function of the system. The function $\tau = \tau(g)$ is established on analytical foundations.

Why does the turnover rate depend upon the growth rate? It is thought that capitalists have to reserve various kinds of stocks to maintain the continuity of production and circulation so that they can keep the growth rate to be enough high. The reserve of these stocks allows capitalists to be able to struggle with fluctuations in the timing of the inflows and outflows. Roughly speaking, the higher capitalists want to keep the growth rate, the larger they have to keep the amount of capital.[19] That is because the rate of turnover depends

[19] Correctly speaking, if in the case of an increasing return to scale, the smaller amount of capital may be enough to keep the higher growth rate. In other words, we can say the turnover rate is the function of the growth rate, but we cannot say anything about the sign of the function. It is ambiguous that $\tau'(g) \gtreqless 0$.

on the growth rate. We call this equation (7) the "capital turnover constraint." It means that capitalists cannot decide the level of the turnover rate independently of the growth rate.

It is obvious that the capital turnover constraint can be identified with the growth-profitability function in the Marris-Wood model. Both models insist that capitalists cannot obtain the higher profit rate without spending additional costs. Summing up,

[Proposition 2] The growth-profitability function (MW2) is derived from the characteristic equation of the MCCM as "capital turnover constraint," i.e.,

$$\pi = \pi(g) = r\tau(g),$$

where

$$\tau(g) = g\alpha^*(g)\beta^*(g)\gamma^*(g)/\big(1 - \alpha^*(g)\beta^*(g)\gamma^*(g)\big).$$

■

Now let us pose a simple question: how can we derive the basic model from the MCCM? We should prove the following lemma in order to derive the basic model.

[Lemma 1] Under simple reproduction, the time of turnover exactly equals to the average turnover time.

[Proof] Under simple reproduction, $g = 0$. Using L'Hôpital's rule, we obtain

$$\lim_{g\to 0} T(g) = \int_0^\infty t\alpha(t)\mathrm{d}t + \int_0^\infty t\beta(t)\mathrm{d}t + \int_0^\infty t\gamma(t)\mathrm{d}t.$$

This is nothing but the sum of the average turnover time of production, commodity and money capital those which we define as T_α, T_β and T_γ, respectively. In this case, $T = T_\alpha + T_\beta + T_\gamma$ is constant.

■

It is trivial that the following proposition holds from Lemma 1.

[Proposition 1-2-1] In the case of simple reproduction, Capital turnover constraint is deduced to (B1).

■

How about the case of the expanded reproduction? Does (B1) hold in that case? We can answer "Yes" if we employ the following assumptions.

[Assumption 1] The lag functions of the circulation process are all the Dirac delta function $\delta\ (t)$:

$$\beta(t) = \gamma(t) = \delta\ (t) = \begin{cases} +\infty, & t = 0 \\ 0, & t \neq 0 \end{cases} \cdots\cdots \text{(A1)}$$

and which is also constrained to satisfy the identity

$$\int_{-\infty}^{\infty} \delta(t)\, \mathrm{d}t = 1.$$

In this case, Laplace transforms of β and γ are known to become unity, i.e., $\beta^* = \gamma^* = 1$. In other words, we abstract the circulation process.

[Assumption 2] The lag function of the production process is an exponential distribution function.

In this case, the time of capital turnover is the same to the average of the exponential distribution.

Let

$$\alpha(t) = \lambda e^{-\lambda t} \cdots\cdots \text{(A2)}$$

then for some manipulation,

$$\alpha^*(g) = \lambda/(g + \lambda),\ T(g) = 1/\lambda = E[X = t].$$

The parameter λ is exactly equivalent to the ratio of capital turnover τ. In the case of the exponential distribution function, the capital turnover constraint is not effective so that the rate of capital turnover no longer depends upon the growth rate. Therefore, we get the following proposition.

[Proposition 1-2-2] In the case of expanded reproduction, the capital turnover constraint is deduced to (B1) if (A1) and (A2) are assumed. [20]

We can derive the basic model from the MCCM through the propositions 1-1, 1-2-1. 1-2-2. And we can also derive the Marx-Morishima model if we assume (MM1) and (MM2) to the MCCM.

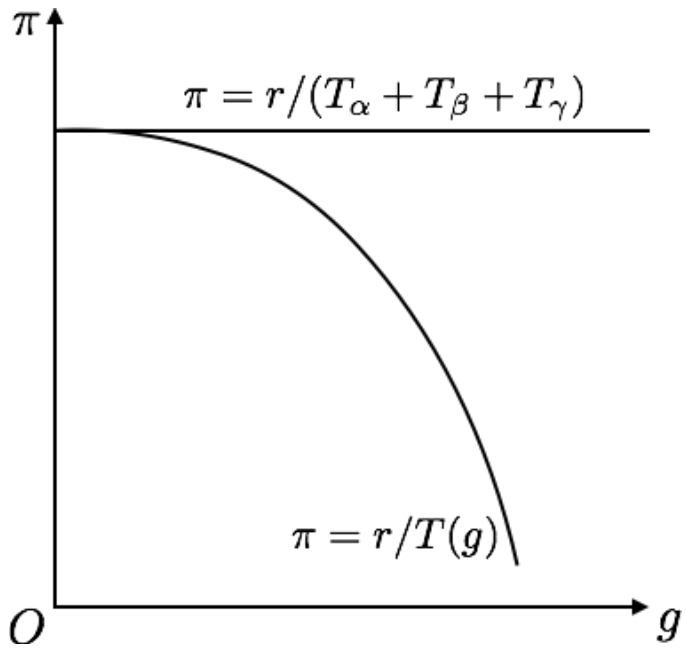

Figure 4: Marx-Morishima model and Marris-Wood model

It may be true that the profit rate depends generally upon the growth rate, but its sign is ambiguous. For example, for fixed $0 < \lambda < 1$, assume that the function

[20] Hereafter We assume (A1), but do not assume (A2).

$$\alpha^* = e^{-g^\lambda}$$

which is the Laplace transformation of a stable distribution. We obtain

$$\pi(g;\lambda) = r\left(\frac{g}{e^{g^\lambda}-1}\right).$$

As shown in the case of Figure 4, it is hold that $\partial\pi/\partial g > 0$ while the growth rate is sufficiently small (and vice versa). In this region, when capitalists invest more, they can reduce their costs of production and increase their profit rate. However, with even faster growth "Penrose effect" overweighs the effect of the cost reduction.

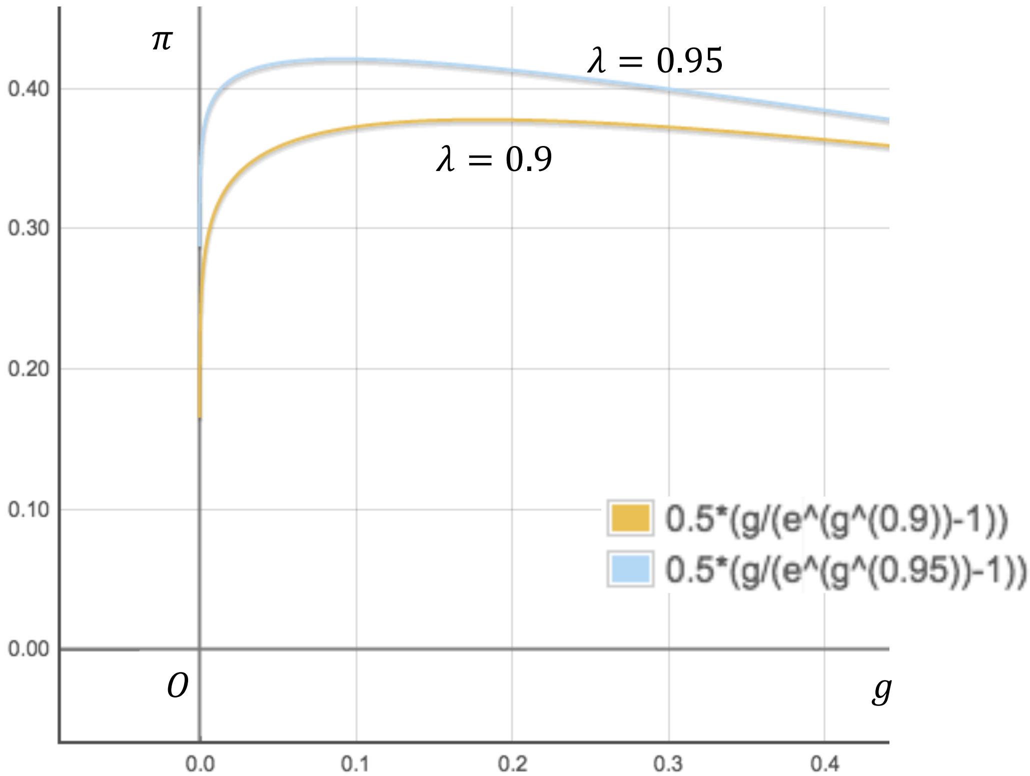

Figure 5: the profit rate with a stable distribution ($\lambda = 0.9$ or $0.95, r = 0.5$)

What does the parameter λ mean? The answer is that λ is a shift parameter which summarizes the necessary information (except for the growth rate g) to decide the level of turnover rate. Capitalists can raise the level of the turnover rate because they decide to do so. λ represents the capitalists' subjective attitude to how high (or low) the turnover rate should be. And τ is an objective result after capitalists' decision. We can formulate the ratio of capital turnover as

$$\tau = \tau(g;\ \lambda), \qquad \frac{\partial\tau}{\partial\lambda} > 0$$

And then, *ceteris paribus*,

$$\lambda \uparrow\ \longrightarrow\ \text{Turnover rate } \tau\ \uparrow\ \longrightarrow\ \text{Profit rate } \pi \uparrow.$$

Therefore, let us assume

$$\pi \equiv \pi(g; \lambda), \cdots\cdots (9)$$

where

$$\partial\pi/\partial g < 0, \qquad \partial^2\pi/\partial g^2 < 0, \qquad \partial\,\pi/\partial\lambda > 0, \qquad \partial\pi/\partial\lambda\partial g > 0.$$

What is important is that the volume of capital varies depending on the rate of growth, as the rate of growth is a variable in the system of the equations. In the Kalecki-Steindle model, the rate of capacity utilization is derived as an independent variable from the assumption that the ratio of potential real output to the capital stock is technologically given. It is, however, enormously doubtful. It is because the capital turnover time depends on the growth rate so that the ratio of potential real output to the capital stock is a dependent variable to change. Consequently, the capacity utilization rate is also a dependent variable responding to the independent variable of the growth rate. It makes a Keleckian analysis difficult

One question arises: should we abandon the analysis of the capacity utilization in the Kalecki-Steindle model?

The answer is, of course, "No." It perfectly acceptable that we treat the parameter λ as an independent variable and simultaneously as the proxy variable of the utilization rate. It is adequate that the utilization rate is increased as a consequence of increasing λ. Hereafter we just call λ the utilization rate, and τ the capital turnover rate.

Now we've prepared to solve the problem how to establish a Marxian investment function. We can investigate how the growth rate is endogenously determined in the next section.

2. Marxian Investment Function

2.1. Valorization and Metamorphosis

We investigate a Marxian investment function to determine the growth rate. At first we should reconsider the logic of capital.

What is capital? Capital is an ongoing process oriented to the expansion of its value, passing through the circuit of its metamorphoses: from money to productive to commodity capital, and back. We can point out two moments in this movement. One is the so-called valorization, which means the expansion of the value, and the other is the metamorphosis, which means changing its forms through the movement of capital.

We can interpret the expansion of the value as the objective of capital movement. The expansion of value is generally identified with the profit maximization. That is true in case of statistic model, but it is not correct in dynamic model we employ here. In dynamic context, the aim of capital movement is to maximize the value of capital in the long run, which is measured by the capitalization of the dividends, in short, the discounted present value of the net profit, which equals the profit minus the capital increment.

On the other hand, what a role does the metamorphosis play in the capital movement? In the circuit of capital, the value of capital cannot grow directly from M to M' without passing through metamorphosis from M to P, P to C and C to M'. The movement of capital cannot eliminate such circular restrictions altogether. The metamorphosis of capital is, therefore, interpreted as the constrained conditions for the expansion of its value. We have already formulated these constraints as "capital turnover constraint."

Now we can formulate the motion of capital as constrained maximization problem: the objective of capital is to maximize the value of capital, and the constraints are the capital turnover constraint. Let V be the value of capital and i be the interest rate, capitalists maximize the following objective function:

$$V = \int_0^\infty D(t)e^{-it}\,\mathrm{d}t.$$

subject to the capital turnover constraints (7). Substituting Cambridge equation (2) and the capital turnover constraints (7) to the above objective function and after some manipulation, we get:

$$V = K + \int_0^\infty (\pi(g) - i)\,K(t)e^{-it}\,\mathrm{d}t$$

The value of capital, V, equals the sum of the volume of capital, K, plus the discounted value of the difference between the profit and the opportunity cost of capital. This discounted value is called promoter's profit by Hilferding in *Finance Capital*. Therefore, the value of capital equals the sum of the volume of capital plus the promoter's profit.

V should be normalized. Let v be the value of capital per unit of the volume of capital, V/K. Dividing V by K and after some manipulation,[21] we get:

$$v = \frac{V}{K} = 1 + \frac{\pi(g) - i}{i - g} = \frac{\pi(g) - g}{i - g}.$$

Capitalists try to maximize this rate.[22] We will finally obtain a Marxian investment function to solve this simple maximization problem.

2.2. Marxian Investment Function

[21] We assume that $\lim_{t\to\infty} K(t)e^{-it} = 0$. In other words, the discounted value of the volume of capital at infinite horizon approaches zero. And we also assume $i > g$.
[22] It is called the valuation ratio by Richard Kahn. This notion is the same as Tobin's q.

Setting $v'(g) = 0$, we get the following first-order condition for capital-value maximization:

$$-\pi'(g) = \frac{\pi(g) - i}{i - g} = v - 1 \quad \cdots\cdots (10).$$

This equation states that the marginal profit rate with respect to growth rate (MPG) equals the promoter's profit per unit of capital. MPG represents the marginal opportunity cost incurred by increasing growth rate.[23] Promoter’s profit per unit of capital represents a kind of the marginal revenue that an additional growth will bring to capitalists. Then the growth rate is determined when this equation is hold. We can interpret this equation (10) as Marxian investment function (MIF), which determines the dynamics of capital movement.

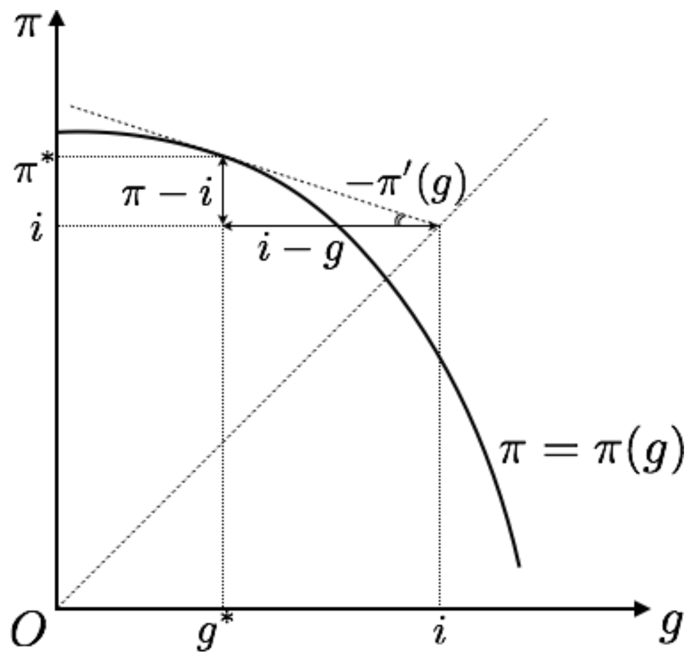

Figure 6: Marxian investment function

[23] Some scholars call this “adjustment cost” of investment.

Now we can answer how two Keynesian investment functions can be derived from MCCM. From (10), the growth rate can be expressed as

$$g = g(r, \lambda; i),$$

where

$$\frac{\partial g}{\partial r} = \frac{ir^{-1}}{-\pi_{gg}(i-g)} > 0, \qquad \frac{\partial g}{\partial \lambda} = \frac{\pi_\lambda + (i-g)\pi_{g\lambda}}{-\pi_{gg}(i-g)} > 0, \qquad \frac{\partial g}{\partial i} = \frac{-v}{-\pi_{gg}(i-g)} < 0.$$

We can easily obtain the following two propositions.

[Proposition 3] a Robinsonian investment function (KR2') can be driven from the Marxian investment function if we assume λ and i are constant.

$$g = g(r \colon \bar{\lambda}, \bar{i})$$

■

[Proposition 4] a Kaleckian investment function (KS2) can be driven from the Marxian investment function if we assume r and i are constant.

$$g = g(\lambda \colon \bar{r}, \bar{i})$$

■

We will examine in the next section what mathematical conditions can make the wage-led regime occur.

3. Marxian circuit of capital model and the wage-led regime

MCCM is constituted from 3 equations.

$$\begin{aligned} g &= s\pi & \cdots\cdots (2) \\ \pi &= \pi(g; \lambda), & \cdots\cdots (9) \\ -\pi_g(g; \lambda) &= (\pi - i)/(i - g) & \cdots\cdots (10) \end{aligned}$$

where $\pi_g \equiv \partial\pi/\partial g$. It may be over-determined if we only count π and g as unknown variables. We need one more unknown variable to close the entire model. We have luckily two major candidates for closure in the system of these equations: the interest rate i and the parameter of utilization rate λ. In this paper, we would like to concentrate on the parameter of the utilization rate to examine the possibility of existence of the wage-led regime in a Marxian circuit of capital model. We assume the interest rate is a constant parameter. Substituting (9) to (2) and (10), we obtain

$$g^s = s\pi(g^s, \lambda)\,, \qquad \cdots\cdots (11)$$
$$\pi(g^i, \lambda) = -\pi_g(g^i; \lambda)(i - g^i) + i \cdots\cdots (12)$$

The equation (11) is a saving function which determines the growth rate made possible by realized saving as $g^s \equiv s\pi$, and the equation (12) is an investment function which determines the growth rate of investment demand, g^i, under the circuit of capital model. We interpret $g(= g^s = g^i)$ and λ (not π) as unknown variables, and r and i as constant parameters.

We examine what conditions make the wage-led regime occur when the wage share increases. In order to avoid terminological confusion, we would like to define the term "wage-led regime" as the negative effect of r on g, i.e., $\mathrm{d}g/\mathrm{d}r < 0$. The growth rate inversely related to the profit share (note that the profit mark-up rate, r, positively related to the profit share).

From (11) and (12),

$$\begin{pmatrix} 1 - s\pi_g & -s\pi_\lambda \\ -\pi_{gg}(i-g) & -(\pi_{g\lambda}(i-g) + \pi_\lambda) \end{pmatrix} \begin{pmatrix} \mathrm{d}g/\mathrm{d}r \\ \mathrm{d}\lambda/\mathrm{d}r \end{pmatrix} = \begin{pmatrix} s\pi_r \\ \pi_{gr}(i-g) + \pi_r \end{pmatrix} \cdots\cdots (13)$$

We can obtain the Keynesian stability condition when the determinant is assumed to be positive.

$$\Delta > 0 \iff \frac{\mathrm{d}g^s}{\mathrm{d}\lambda}\frac{\lambda}{g^s} > \frac{\mathrm{d}g^i}{\mathrm{d}\lambda}\frac{\lambda}{g^i}$$

In other words, the stable condition in a good market is that the utilization elasticity of the supply-side growth rate is larger than the elasticity of the demand-side growth rate. This condition is the denominator of the $\mathrm{d}g/\mathrm{d}r$, and consequently the same to the Keynesian stability condition.

The sign of $\mathrm{d}g/\mathrm{d}r$ depends only upon the numerator if the Keynesian stable condition applies. The numerator is:

$$\left(1-s\pi_g\right)\left(-\pi_{gg}(i-g)\right)\frac{g}{r}\left(\frac{\mathrm{d}g^{\mathrm{i}}}{\mathrm{d}r}\frac{r}{g^{\mathrm{i}}}-\frac{dg^{\mathrm{s}}}{dr}\frac{r}{g^{\mathrm{s}}}\right)$$

And the sign of $\mathrm{d}g/\mathrm{d}r$ depends only upon the sign of the last bracket, i.e.,

$$\mathrm{d}g/\mathrm{d}r \lesseqgtr 0 \iff \frac{\mathrm{d}g^{\mathrm{i}}}{\mathrm{d}r}\frac{r}{g^{\mathrm{i}}} \lesseqgtr \frac{dg^{\mathrm{s}}}{dr}\frac{r}{g^{\mathrm{s}}}$$

There is no critical difference between this formulation and the formulation proposed by Post Keynesian such as Bhaduri and Marglin (1990). With some manipulation, the above condition can be rewritten in the following form:

$$\mathrm{d}g/\mathrm{d}r \lesseqgtr 0 \iff \frac{\mathrm{d}(-\pi_g)}{\mathrm{d}\lambda}\frac{\lambda}{(-\pi_g)} \lesseqgtr \frac{d\pi}{d\lambda}\frac{\lambda}{\pi} \cdots\cdots (14)$$

This (14) is the key result of this paper. The economy is the wage-led regime when $d\ln(-\pi_g)/\mathrm{d}\ln\lambda < d\ln\pi/\mathrm{d}\ln\lambda$ expressed in logarithmic (elasticity) form, and the profit-led regime when $d\ln(-\pi_g)/\mathrm{d}\ln\lambda > d\ln\pi/\mathrm{d}\ln\lambda$.

This expression is simple, but this interpretation is complicated. The left hand side can be interpreted as the utilization elasticity of the adjustment cost. If capitalists try to increase the utilization rate 1% more, they have to spend this elasticity's percent more for the adjustment cost. The right hand side can be interpreted, on the contrary, as the utilization elasticity of profit. If the utilization rate increases 1% more, the profit rate is expected to increase this elasticity percent more. This inequality represents the relationship how the cost and the benefit change when the utilization rate changes.

Suppose the profit share decreased to explore the possibility of wage-led regime. If capitalists want to keep the level of growth rate to be constant, they try to increase the level of capital utilization to recover the loss of the profit share. The scenario of this story diverges from here.

At first, let us consider 1st scenario: Assume that the elasticity of cost is higher than benefit, i.e., $d\ln(-\pi_g)/\mathrm{d}\ln\lambda > d\ln\pi/\mathrm{d}\ln\lambda$ holds. What is going to happen this case? If capitalists raised the rate of utilization in realty, it would be costly because of the relatively higher elasticity of cost. Consequently, capitalists decide to reduce the rate of utilization to cut down on their losses at a minimum so that the growth rate also decreases. This is the normal scenario of profit-led regime.

Let us consider 2nd scenario: Assume that the elasticity of benefit is higher cost, i.e., $d\ln(-\pi_g)/\mathrm{d}\ln\lambda < d\ln\pi/\mathrm{d}\ln\lambda$. In this case, capitalists try to aggressively raise the utilization rate to recapture the loss of profit share, because capitalists are expected to obtain the higher profit rate if they raise the rate of utilization. Eventually, capitalists raise the rate of utilization so that the growth rate also increases, even though the profit share initially decreases. This is the strange, but simultaneously rational scenario of the wage-led regime.

We can conclude that it is possible that wage-led regime occurs in the Marxian circuit of capital model.

Concluding Remarks

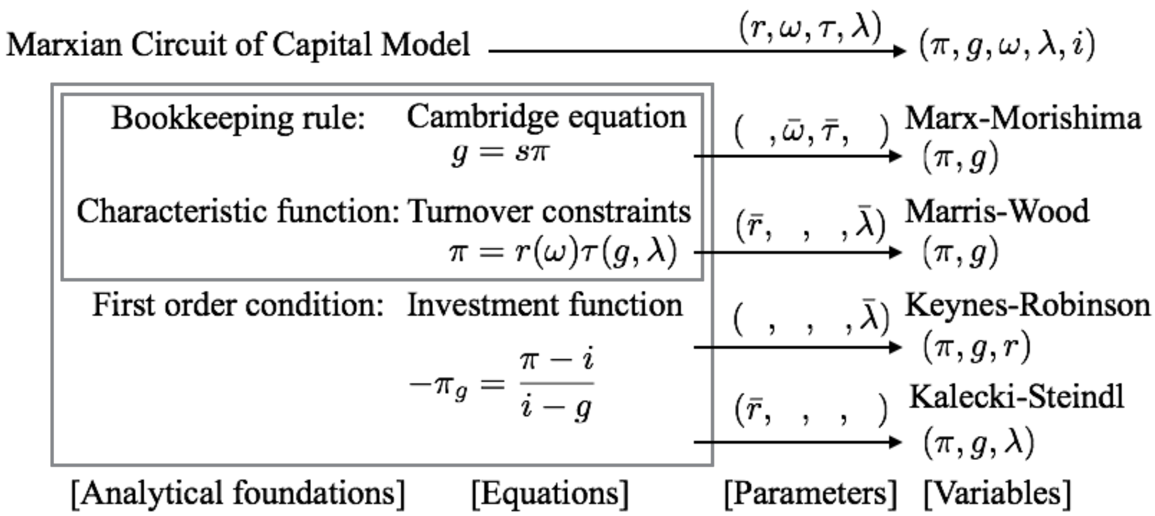

Figure 5: MCCM and other non-mainstream economic models

There are three significant features worth mentioning that are observed in the MCCM. Let us explain the three features according to the Figure 5.

First of all, all equations of the MCCM are based on the solid analytical foundations. The Cambridge equation is guided by the bookkeeping rule. The capital turnover constraint is derived from the characteristic function of the system. The Marxian investment function is introduced by solving the maximization problem. The derivation of these equations with analytical foundations does not necessarily mean that capitalists' behavior is explained in terms of rational choices or methodological individualism. It means that the motion of capital is logically explained, based not on mere intuition of the economists, but on the grounds of economic principle.

Secondly, it is worthy to note that the MCCM is not just one of many economic models in non-mainstream tradition, but rather, it is a sort of platform, where a number of economic models are executed. As shown in Figure x, all non-mainstream economic models are available if some economic conditions are specified in the MCCM. More precisely, non-mainstream economic models are obtained if some candidates of variables are assumed to be fixed as parameters. All non-mainstream economic models are interpreted as just special cases of the MCCM.

Thirdly, it is highly characteristic that the MCCM is "open-ended" enough to allow non-mainstream economists to mold the solution to fit their own specific interests. The model builders can choose what variables they want the MCCM to explain. There exist five candidates of endogenous variables; the profit rate π, the growth rate g, the real wage rate ω, the utilization rate λ and the interest rate i. On the other hand, there exist only three equations; the Cambridge equation, the capital turnover constraints and the Marxian investment function. The easiest way to close the model is that the model builders assume two variables are constant.

In other words, the variables whose levels the model builders want to explain are set as endogenous variables. For example, Kaleckian would set the utilization rate as an endogenous variable because they are interested in the quantity adjustment in capitalism. Robinsonian would set it as an exogenous parameter because they are interested in the long run analysis so that they think the utilization rate converge into the normal utilization rate in the long run, and so forth.

Finally, let us point out an important element missing in this paper. We did not mention which parameters should be treated as endogenous variables from the standpoint of Marxian economics. It is because it seems to us that every parameter should be endogenously determined. It means that the MCCM is not still closed as a complete model. What should we do for it? One of the best way to complete the MCCM is not to explore which variables are endogenous in the model, but to extend the area of study out of the model. To be more precise, we should introduce the analysis of the labor market and the financial market into the model. The real wage rate would be determined by the power game between capitalists and workers. The interest rate, strangely ignored by many non-mainstream economists, would be determined by the interaction between the real and the financial side in a capitalist economy. Therefore, it is needed to introduce at least two more equations with analytical foundations in order to close the MCCM. In this sense, the investigation of problems within the circuit of capital model has been only halfway developed yet.

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