Reproduction, Innovation and the Profit Rate: Towards an Heterogenous Agent-Based Approach

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Introduction

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- **Method:** quantitative, comparative dynamics exercises. Reaction to changes (shocks) in key exogenous variables.
- **Foundations:** Marx's accounting and complexity approach shows clear resemblance to recent techniques in non-neoclassical macro (notably, SFC and AB).

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- Marx defines equilibrium conditions in terms of **interdependences** between industries: flows of goods which must be supplied by each industry to meet exactly other industries' demand for inputs.
- RS do not aim to prove that capitalist economies meet equilibrium conditions. On the contrary, **disequilibrium** or sub-optimal equilibria are the normal state.

Literature review

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- A few exceptions: **Olsen 2015**, **Cockshott 2016**, **MVP 2019**.

The basic RS model

The investment in **variable capital** is:

$$V_j - V_{j,-1} = \frac{S_{j,-1} \cdot \theta_j}{1 + q_j} \tag{1}$$

where $j = C, I$ identifies the sector.

The value of **constant capital** is:

$$C_j = V_j \cdot q_j \tag{2}$$

where q_j is the OCC.

The basic RS model (cont'd)

The mass of **surplus-value** created in the production is:

$$S_j = \epsilon_j \cdot V_{j,-1} \tag{3}$$

where ϵ_j is the **exploitation rate**.

The (non-contestable) **sectoral profit rate** is:

$$r_j = \frac{S_j}{C_j + V_j} \tag{4}$$

The **rate of growth** (accumulation) is:

$$g_j = \frac{\frac{\theta_j \cdot S_j}{1+q_j}}{V_j} = \epsilon_j \cdot \theta_j \cdot \frac{1}{1+q_j} \tag{5}$$

Enlarged reproduction

The **accumulation of constant capital** in C-sector is:

$$S_C \cdot \theta_C \cdot \frac{q_C}{1+q_C} + C_C = Y_I - C_I - S_I \cdot \theta_I \cdot \frac{q_I}{1+q_I} \qquad (6)$$

where Y_I is the I-sector output value (assumption: realised value = value created *in potentia* in the production).

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$$\begin{aligned} S_C \cdot \theta_C \cdot \frac{1}{1+q_C} + C_C = \\ = \left(Y_I - C_I - S_I \cdot \theta_I \cdot \frac{q_I}{1+q_I} - C_C \right) \cdot \frac{1}{q_C} \end{aligned} \qquad (7)$$

Enlarged reproduction (cont'd)

The **equilibrium rate of growth** (accumulation) of C-sector's capitalists is:

$$g_C = \frac{S_C \cdot \theta_C \cdot \frac{q_C}{1+q_C}}{C_C} = \frac{Y_I - C_I - S_I \cdot \theta_I \cdot \frac{q_I}{1+q_I}}{C_C} - 1 \qquad (8)$$

This condition assures **consistency** of C-sector capitalists' investment plans with I-sector capitalists' production & accumulation plans.

So it guarantees **gravitation** of the economy towards the (enlarged) reproduction equilibrium.

But such a state is extremely **unlikely** to be matched and maintained in practice. RS allow Marx to argue that real-world capitalist economies are always in disequilibrium (or sub-optimal equilibria).

Enlarged reproduction (cont'd)

The economy-wide **balanced growth rate** is:

$$g = g_C = g_I = \epsilon_I \cdot \theta_I \cdot \frac{1}{1 + q_I} = \theta_I \cdot r_I \tag{9}$$

Using $g_C = \epsilon_C \cdot \theta_C/(1 + q_I)$, one obtains the (reproduction) **equilibrium condition**:

$$\frac{\theta_C}{\theta_I} = \frac{\epsilon_I}{\epsilon_C} \cdot \frac{1 + q_C}{1 + q_I} \tag{10}$$

The sectoral retention rate ratio must be a direct function of sectoral OCCs, given turnover and exploitation rates.

Since these variables are **independent** of each other, nothing ensures that condition (10) is met.

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- This leads to a **disproportional development** of the two sectors, which is the form taken by the inner tendency of capitalism to over-accumulation and crisis.
- ER conditions are matched if sectors grow all at the same pace. This bears resemblance to the **Cambridge distributive equation** $r = g/\theta$, interpreted as a dynamic investment function in a 2-sector economy.

Some familiar findings (cont'd)

While I-sector retention rate is an exogenous, the C-sector retention rate(s) must behave like a **buffer** to ensure the equilibrium:

$$\theta_{iC} = \frac{g_{iC} \cdot (1 + q_{iC})}{\epsilon_{iC}} \tag{11}$$

Historically, this 'stabilising' role can be identified with **State** ('Big Government' and 'Big Bank') and the **foreign sector** (imperialism).

Some familiar findings (cont'd)

Fig. 1 - Impact of a fall in the retention rate of I-capitalists on growth rates

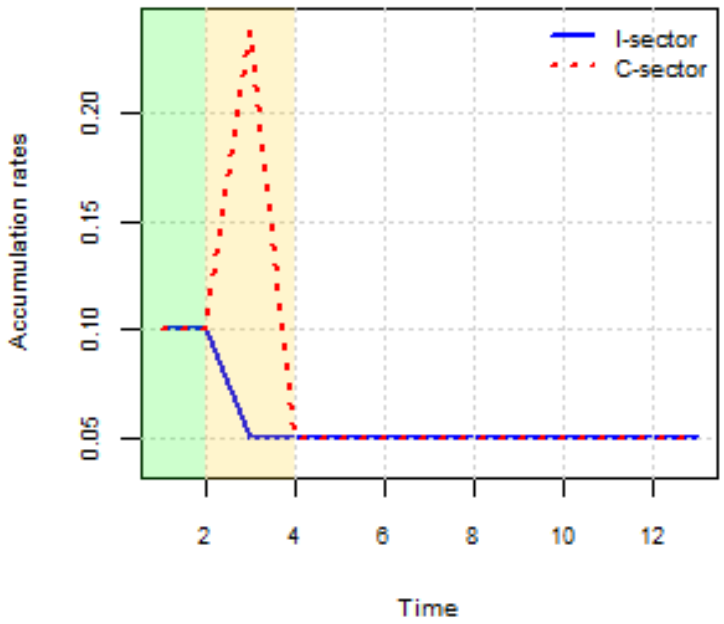
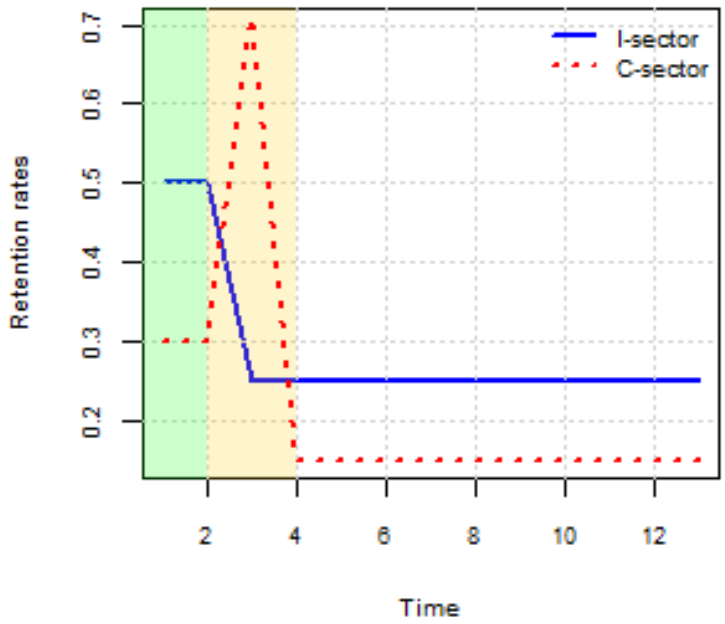


Fig. 2 - Impact of a fall in the retention rate of I-capitalists on retention rates



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- However, three aspects are not covered:
  1) Role of banks and finance.
  2) Cross-sector investment, prices and uniform r.
  3) Heterogeneity and interaction between and within classes. Laws of motion as emerging behaviours of complex systems (e.g. TPRF).

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- Initial values and parameters taken from Marx's own examples (and literature).

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- C-capitalists adjust their own production plans correspondingly.
- In each period prices are set in such a way to clear each individual market, but real production adjusts to demand in the long run.

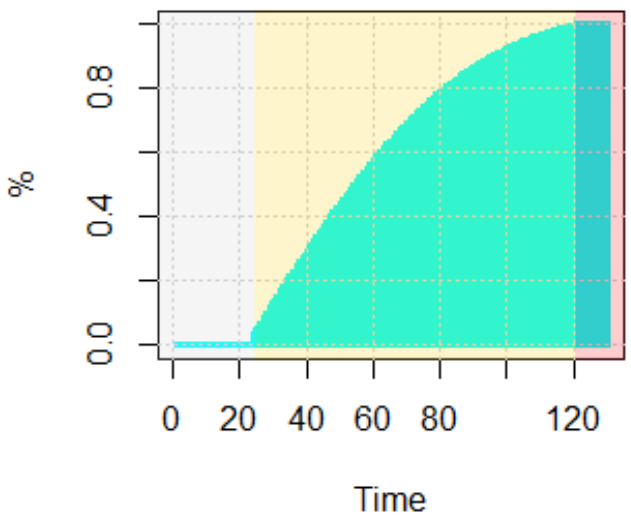
The amended model (cont'd)

Innovation spread is defined as the percentage of I-capitalists who get aware of and use the new technique of production:

$$\rho = \rho_0 + ERF\left(\frac{t - t_0}{\rho_1}\right) \tag{12}$$

where $0 < \rho_0 < 1$, $\rho_1 > 0$, $ERF(\cdot)$ is the error function and t_0 is the shock period.

Fig. A7 - Percentage of innovators



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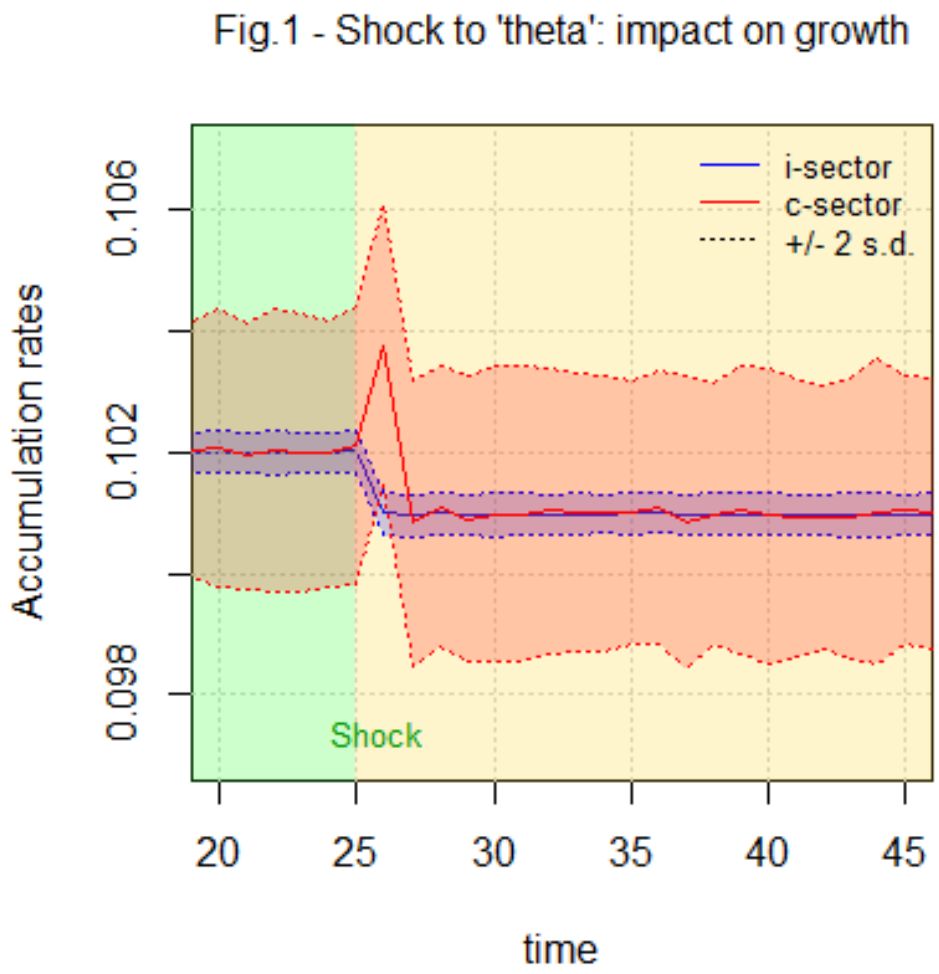
- C-sector must adjust to meet new demand for consumer goods (?)

Adjustment via retention rate (cont'd)



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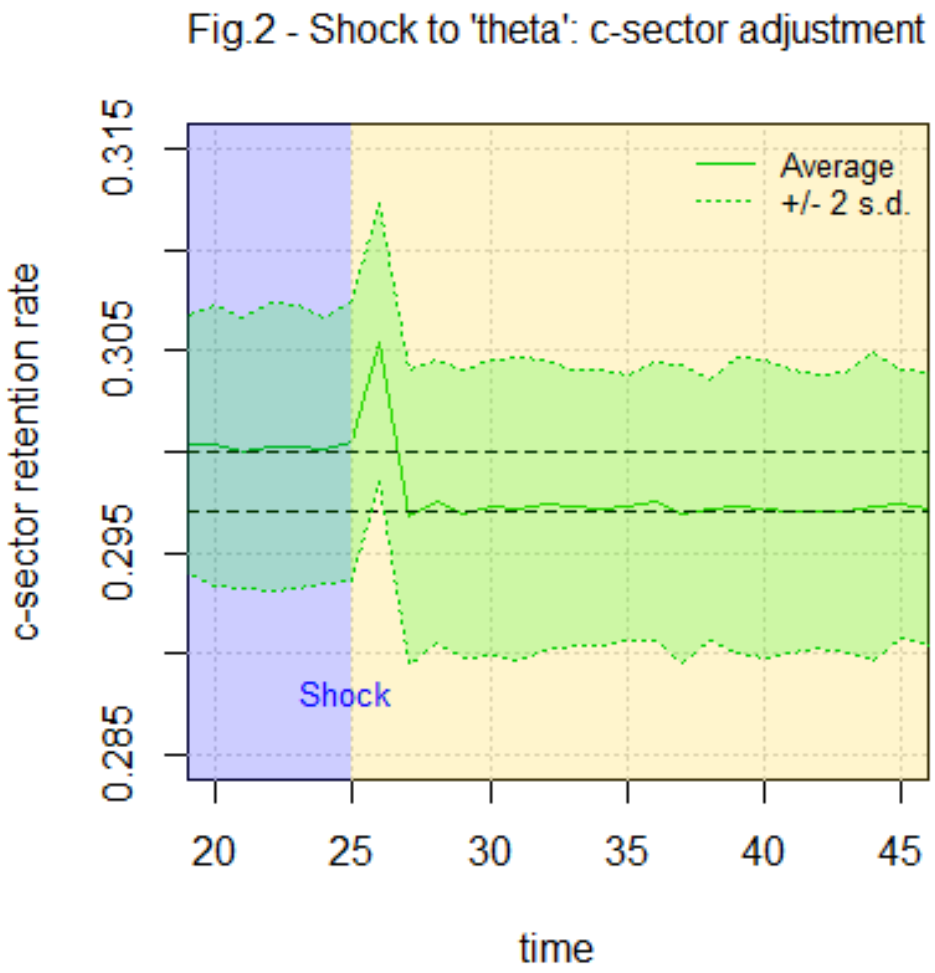

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  - B) **Unchanged RWs** for employees, lower RW for the class / higher exploitation / lower wage share

Increase in innovators' OCC (cont'd)

In formal terms, innovators' **constant capital** is:

$$C^*_{ij} = C_{ij} \tag{13}$$

Innovators' **variable capital** is:

$$V^*_{ij} = \frac{C^*_{ij}}{q^*_{ij}} \tag{14}$$

where $q^*_{ij} > q_{ij}$, and **surplus value** 'created' by innovators is:

$$S^*_{ij} = \epsilon_{ij} \cdot V^*_{ij} \tag{15}$$

Note: X_{ij} keeps growing at the same pace. Innovation entails a **higher labour productivity**: $a^*_{ij} > a_{ij}$, where $a_{ij} = X^*_{ij}/L^*_{ij}$ and $L_{ij} = (V_{ij} + S_{ij})/m_0$.

Increase in innovators' OCC (cont'd)

A. What if a **class-based** definition of subsistence is used?
(constant wage share)

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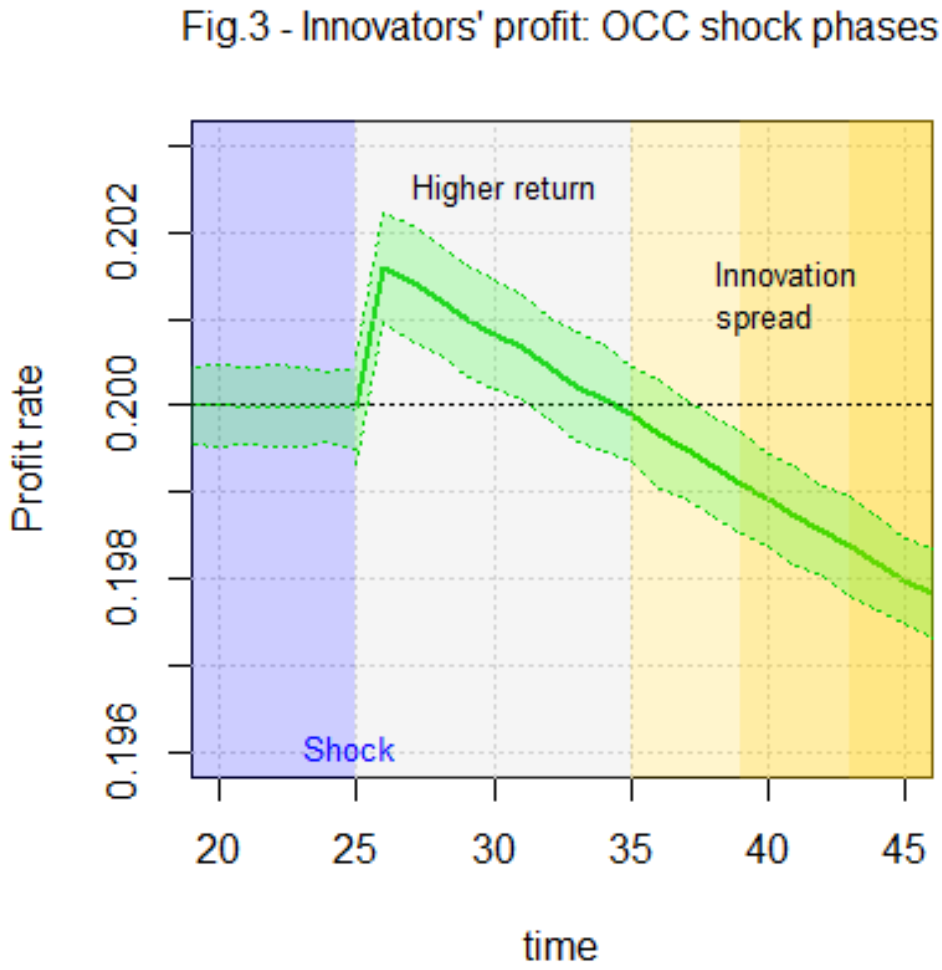

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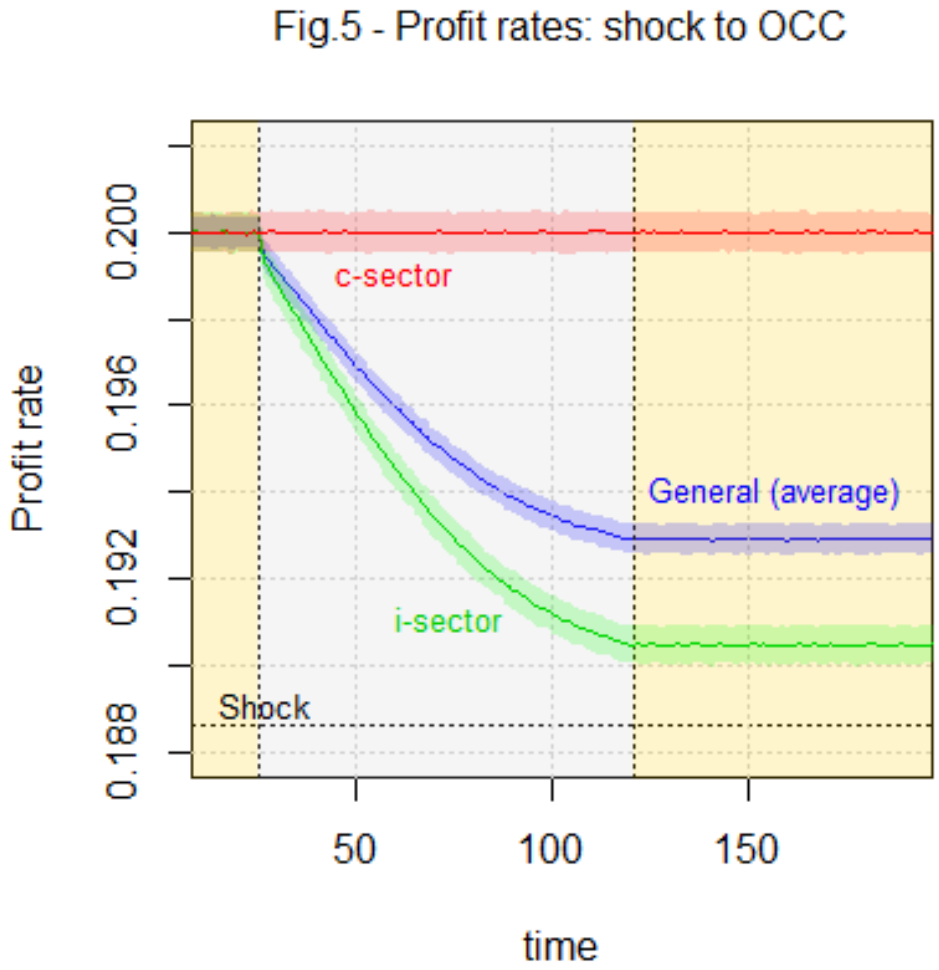

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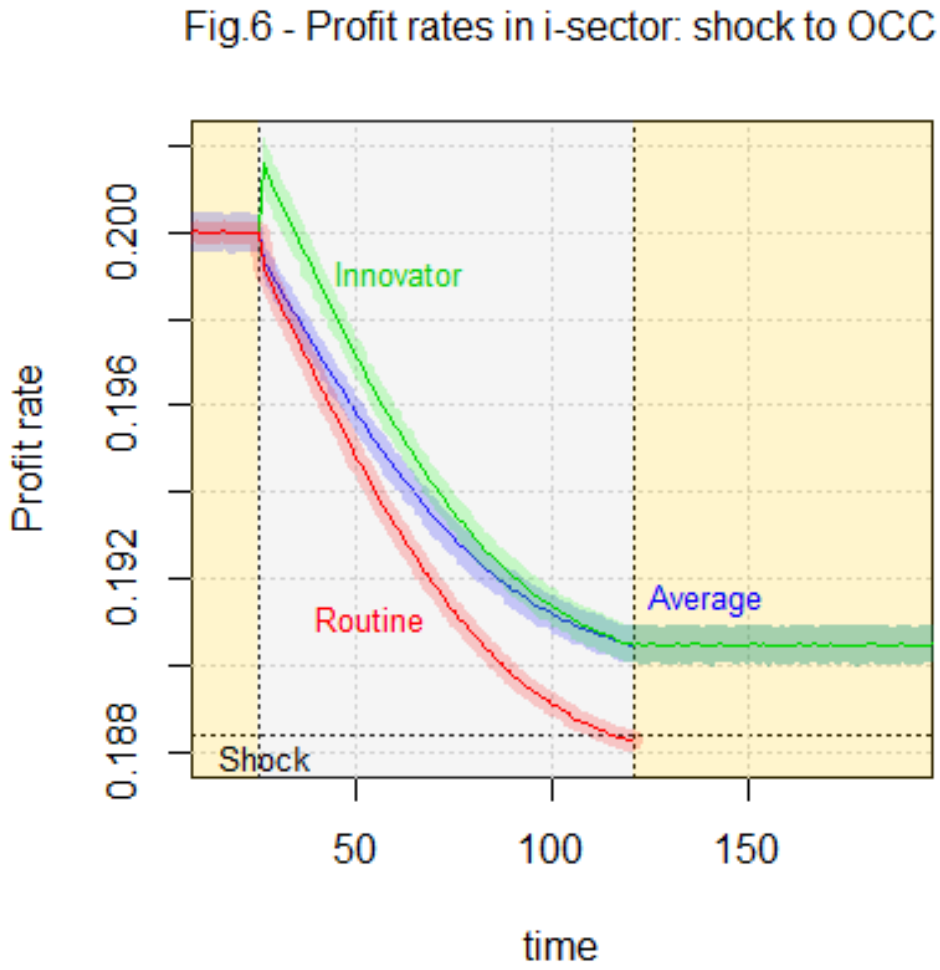

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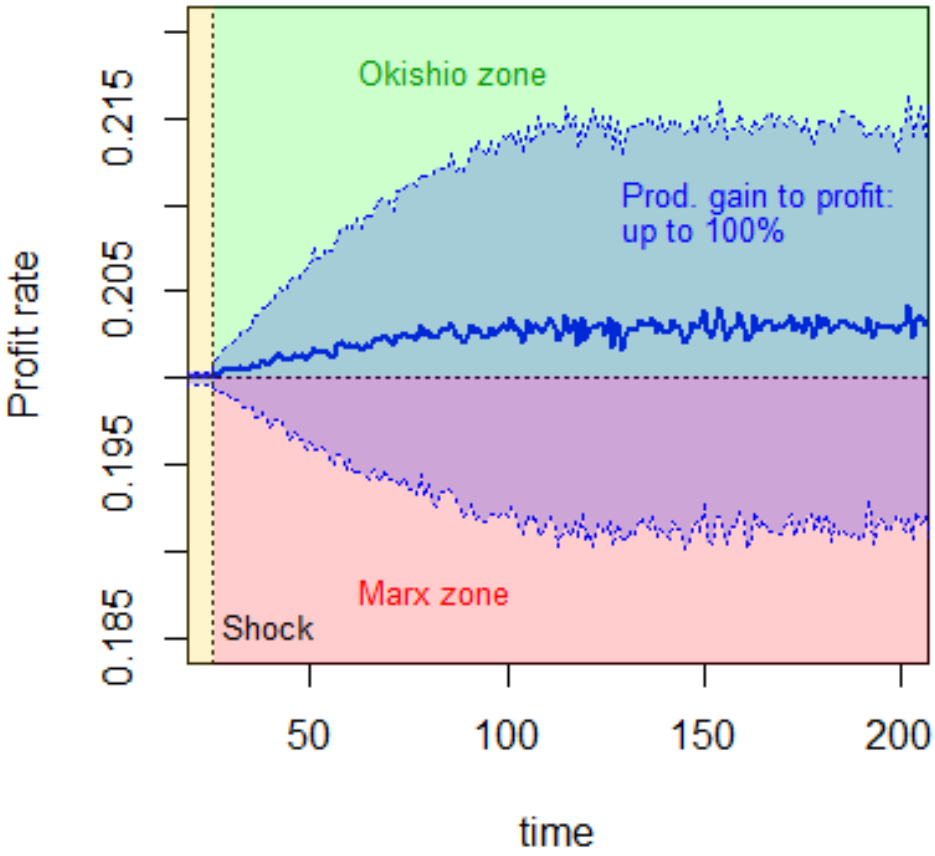
- Employed workers enjoy a higher real wage (due to higher productivity and lower prices)
- But no improvement for working class as a whole!

Increase in innovators' OCC (cont'd)

B. What if **individual-based** definition of subsistence? (capitalists can get up to 100% of productivity earnings, so declining wage share)

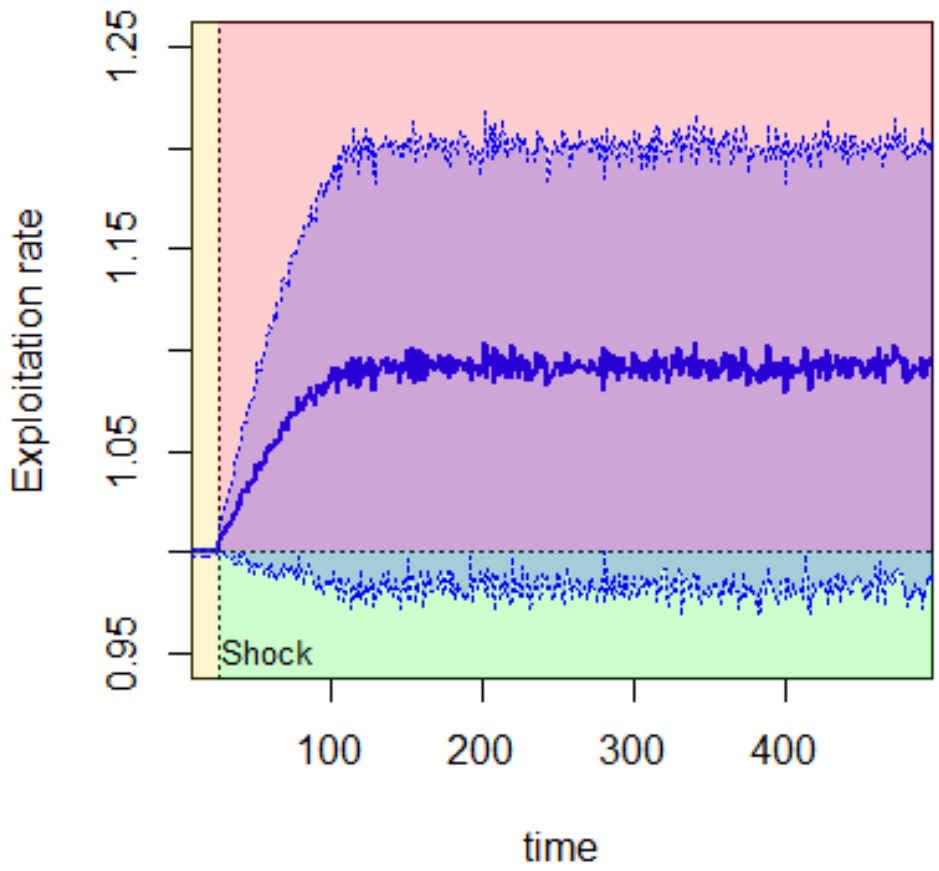
Increase in innovators' OCC (cont'd)

Fig.11 - General profit rate: individual subsistence



Increase in innovators' OCC (cont'd)

Fig.12 - Actual exploitation rate: individual subsistence



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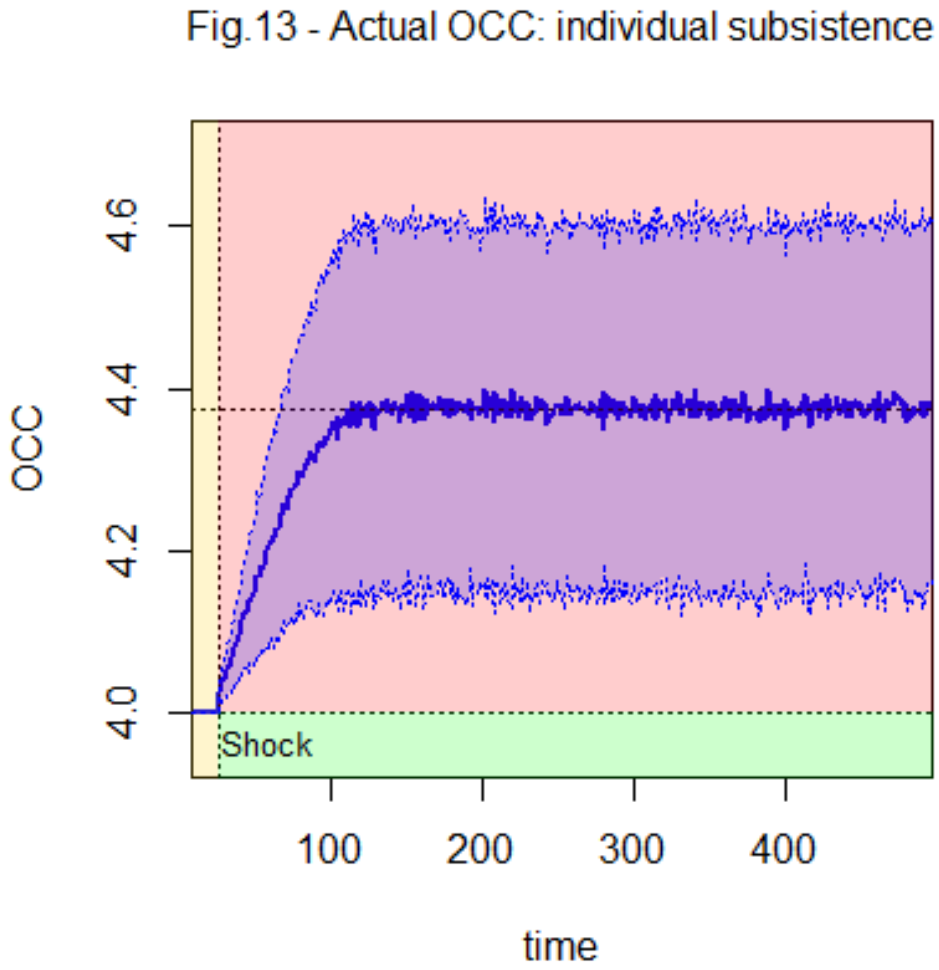

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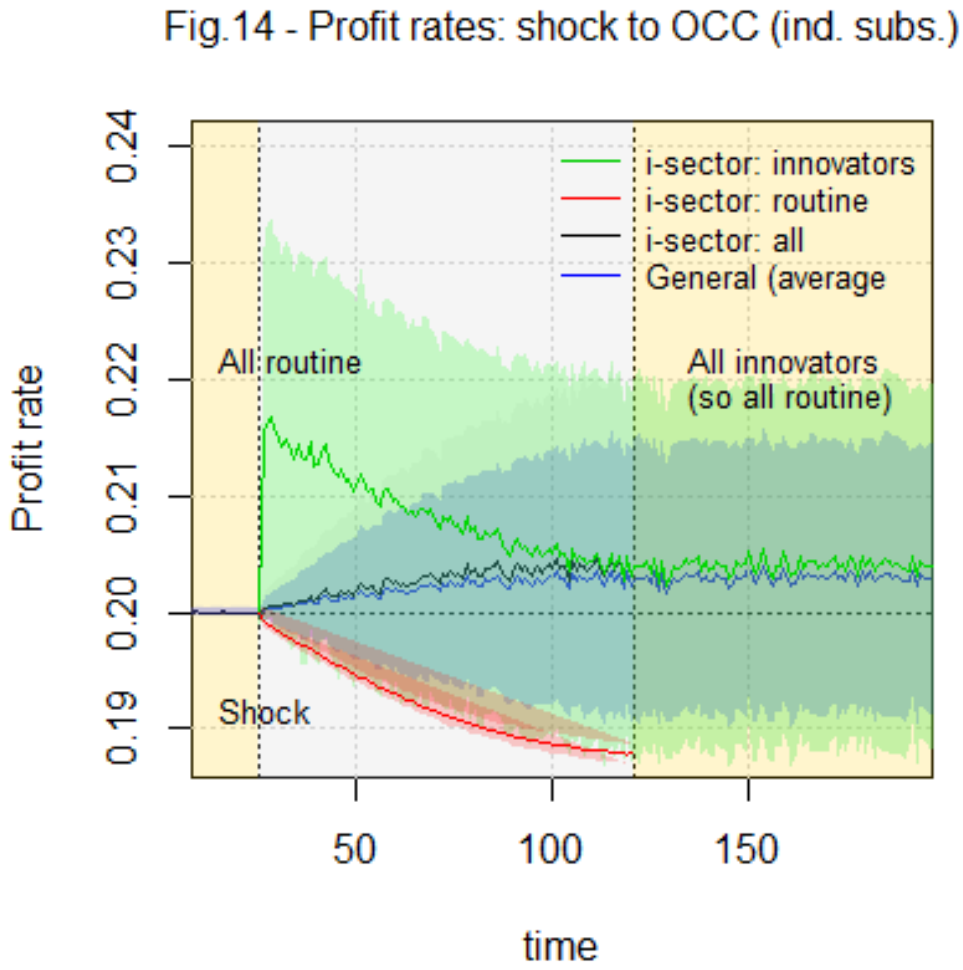

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- Corollary 2: if subsistence = primary needs, **working-class reproduction conditions are endangered**...

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Okishio (1961): if w/p is constant then r must rise following the introduction of a *viable* technique of production (that cuts production costs) – subscenario (B)

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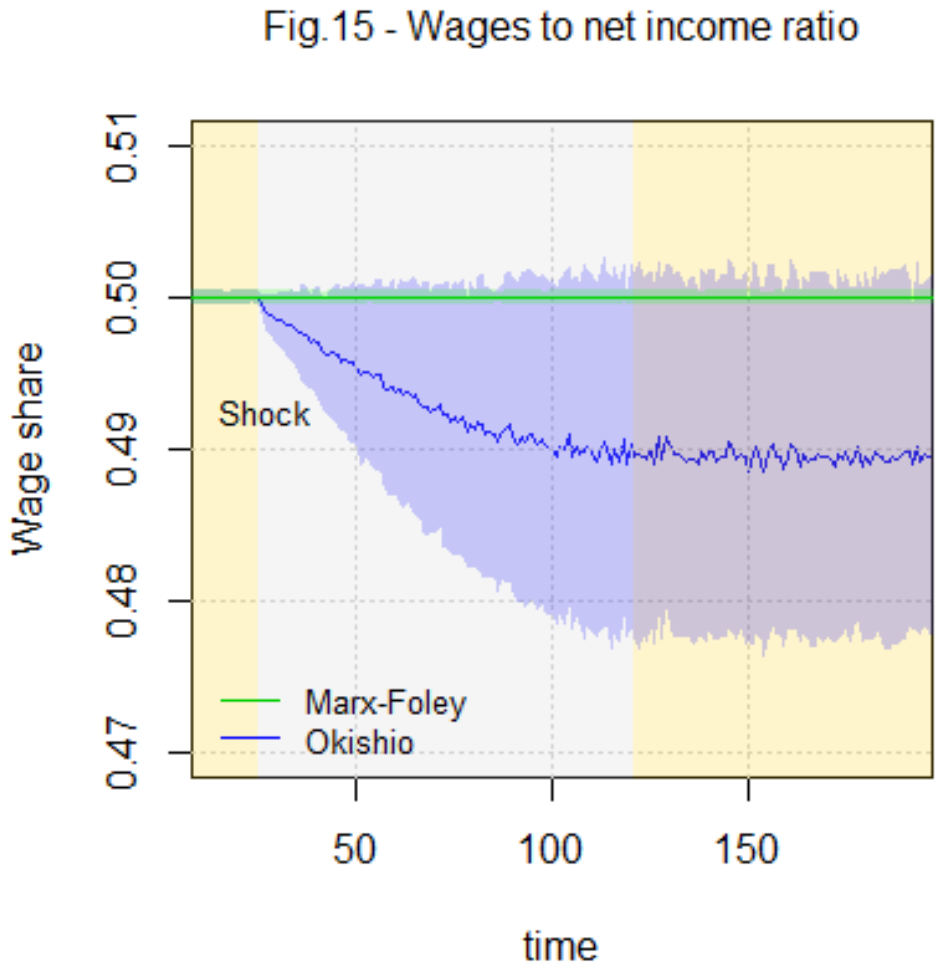
However, incentive to introduce labour-saving innovation is not necessarily at odds with TPRF! Okishio's findings are not generalisable.

Okishio's Theorem (cont'd)



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    - Foley-Marx and Okishio as poles of a **spectrum**...
- Marx's simple OCC story shows that there is no necessary contradiction between individual incentive to innovate and TPRF. On the contrary, TPRF can be an unintended consequence of individual innovations.

Thank You

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