The Reproduction Schemes and the TPRF: A Simulation Approach

Marco Veronese Passarella

University of Leeds

m.passarella@leeds.ac.uk

May 3, 2018

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Introduction

- **General aim:** to revisit Marx's theories of crisis in the light of recent developments in non-neoclassical macro.

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Introduction

- **General aim:** to revisit Marx's theories of crisis in the light of recent developments in non-neoclassical macro.
- **Specific research question: does the 'original' TRPF story hold?** What is the significance of the Okishio's theorem? [to be developed with G. Bracci]

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Introduction

- **General aim:** to revisit Marx's theories of crisis in the light of recent developments in non-neoclassical macro.
- **Specific research question:** **does the 'original' TRPF story hold?** What is the significance of the Okishio's theorem? [to be developed with G. Bracci]
- **Method:** quantitative, comparative dynamics exercises. Reaction to changes (shocks) in key exogenous variables.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Introduction

- **General aim:** to revisit Marx's theories of crisis in the light of recent developments in non-neoclassical macro.
- **Specific research question: does the 'original' TRPF story hold?** What is the significance of the Okishio's theorem? [to be developed with G. Bracci]
- **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).

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Introduction (cont'd)

- Economy as a **circular flow** of payments and revenues pioneered by François Quesnay. Tableau Économique (1758): physiology of a stylised agricultural economy = blood flow in the human body.

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Introduction (cont'd)

- Economy as a **circular flow** of payments and revenues pioneered by François Quesnay. Tableau Économique (1758): physiology of a stylised agricultural economy = blood flow in the human body.
- One century later, Marx recovers and develops Quesnay's insights in the RS, defining the preconditions allowing a capitalist economy to **reproduce** over time.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Introduction (cont'd)

- Economy as a **circular flow** of payments and revenues pioneered by François Quesnay. Tableau Économique (1758): physiology of a stylised agricultural economy = blood flow in the human body.
- One century later, Marx recovers and develops Quesnay's insights in the RS, defining the preconditions allowing a capitalist economy to **reproduce** over time.
- 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.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Introduction (cont'd)

- Economy as a **circular flow** of payments and revenues pioneered by François Quesnay. Tableau Économique (1758): physiology of a stylised agricultural economy = blood flow in the human body.
- One century later, Marx recovers and develops Quesnay's insights in the RS, defining the preconditions allowing a capitalist economy to **reproduce** over time.
- 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.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Literature review

- While Marx never provided a complete mathematical model of enlarged reproduction, he left several notes and **numerical examples** (system of difference/differential equations).

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Literature review

- While Marx never provided a complete mathematical model of enlarged reproduction, he left several notes and **numerical examples** (system of difference/differential equations).
- Well-established tradition of dynamic modelling carried out by Marxist economists since the 1970s, who have been inspired by the Marxian reproduction schemes: **Harris 1972**, **Bronfenbrenner 1973**, **Morishima 1973**, etc.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Literature review

- While Marx never provided a complete mathematical model of enlarged reproduction, he left several notes and **numerical examples** (system of difference/differential equations).
- Well-established tradition of dynamic modelling carried out by Marxist economists since the 1970s, who have been inspired by the Marxian reproduction schemes: **Harris 1972**, **Bronfenbrenner 1973**, **Morishima 1973**, etc.
- Not many recent contributions though...

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Literature review

- While Marx never provided a complete mathematical model of enlarged reproduction, he left several notes and **numerical examples** (system of difference/differential equations).
- Well-established tradition of dynamic modelling carried out by Marxist economists since the 1970s, who have been inspired by the Marxian reproduction schemes: **Harris 1972**, **Bronfenbrenner 1973**, **Morishima 1973**, etc.
- Not many recent contributions though...
- A few exceptions: **Olsen 2015**, **Cockshott 2016**, **MVP 2016**.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The basic RS model

The investment in **variable capital** is:

$$V_{ij} - V_{ij,-1} = \frac{S_{ij,-1} \cdot \theta_{ij}}{1 + q_{ij}} \tag{1}$$

where $i = 1, 2, ..., N_j$ identifies the individual capitalist and $j = C, I$ identifies the sector.

The value of **constant capital** is:

$$C_{ij} = V_{ij} \cdot q_{ij} \tag{2}$$

where q_{ij} is the OCC.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The basic RS model (cont'd)

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

$$S_{ij} = \epsilon_{ij} \cdot n_{ij} \cdot V_{ij,-1} \tag{3}$$

where ϵ_{ij} is the **exploitation rate** and n_{ij} is the (intra-period) turnover rate.

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

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

where $x_j = \sum x_{ij}$. The **rate of growth** (accumulation) is:

$$g_{ij} = \frac{\frac{\theta_{ij} \cdot S_{ij}}{1+q_{ij}}}{V_{ij}} = \epsilon_{ij} \cdot \theta_{ij} \cdot n_{ij} \cdot \frac{1}{1+q_{ij}} \tag{5}$$

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Enlarged reproduction

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

$$S_{iC} \cdot \theta_{iC} \cdot \frac{q_{iC}}{1 + qiC} + C_{iC} = Y_{iI} - C_{iI} - S_{iI} \cdot \theta_I \cdot \frac{q_{iI}}{1 + qiI} \quad (6)$$

where Y_{iI} is the i-sector output value (assumption: realised value = value created *in potentia* in the production).

The **accumulation of variable capital** in c-sector is:

$$\begin{aligned} S_{iC} \cdot \theta_{iC} \cdot \frac{1}{1 + qiC} + C_{iC} = \\ = \left(Y_{iI} - C_{iI} - S_{iI} \cdot \theta_I \cdot \frac{q_{iI}}{1 + qiI} - C_{iC} \right) \cdot \frac{1}{q_{iC}} \end{aligned} \quad (7)$$

Enlarged reproduction (cont'd)

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

$$g_{iC} = \frac{S_{iC} \cdot \theta_{iC} \cdot \frac{q_{iC}}{1+q_{iC}}}{C_{iC}} = \frac{Y_{iI} - C_{iI} - S_{iI} \cdot \theta_{iI} \cdot \frac{q_{iI}}{1+q_{iI}}}{C_{iC}} - 1 \quad (8)$$

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).

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Enlarged reproduction (cont'd)

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

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

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

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

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.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Some familiar findings

- In principle, balanced growth is **possible**, as the expansion of production in one sector enlarges the market for the other.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Some familiar findings

- In principle, balanced growth is **possible**, as the expansion of production in one sector enlarges the market for the other.
- However, 'The rate of growth of production in the various branches of production is determined [also] by the **uneven development** of the conditions of production, rather than by the different rates of growth of the markets for their products'. (Clarke 1990)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Some familiar findings

- In principle, balanced growth is **possible**, as the expansion of production in one sector enlarges the market for the other.
- However, 'The rate of growth of production in the various branches of production is determined [also] by the **uneven development** of the conditions of production, rather than by the different rates of growth of the markets for their products'. (Clarke 1990)
- 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.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Some familiar findings

- In principle, balanced growth is **possible**, as the expansion of production in one sector enlarges the market for the other.
- However, 'The rate of growth of production in the various branches of production is determined [also] by the **uneven development** of the conditions of production, rather than by the different rates of growth of the markets for their products'. (Clarke 1990)
- 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.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

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:

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

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

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.
- Marx's grim predictions fit well with the history of early-industrialised countries from the end of the Victorian Era to the 2WW.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.
- Marx's grim predictions fit well with the history of early-industrialised countries from the end of the Victorian Era to the 2WW.
- RS also accounts for the stabilising function performed by the government since the 1930s.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.
- Marx's grim predictions fit well with the history of early-industrialised countries from the end of the Victorian Era to the 2WW.
- RS also accounts for the stabilising function performed by the government since the 1930s.
- However, three aspects are not fully developed:

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.
- Marx's grim predictions fit well with the history of early-industrialised countries from the end of the Victorian Era to the 2WW.
- RS also accounts for the stabilising function performed by the government since the 1930s.
- However, three aspects are not fully developed:
  1) Role of banks and finance.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.
- Marx's grim predictions fit well with the history of early-industrialised countries from the end of the Victorian Era to the 2WW.
- RS also accounts for the stabilising function performed by the government since the 1930s.
- However, three aspects are not fully developed:
  1) Role of banks and finance.
  2) Cross-sector investment, prices and uniform r.

The amended model

- RS provide a simple but insightful explanation of **instability** (contradictions) which can possibly mark unregulated capitalist economies.
- Marx's grim predictions fit well with the history of early-industrialised countries from the end of the Victorian Era to the 2WW.
- RS also accounts for the stabilising function performed by the government since the 1930s.
- However, three aspects are not fully developed:
  1) Role of banks and finance.
  2) Cross-sector investment, prices and uniform r.
  3) Granularity necessary to analyse interaction between and within classes. Laws of motion as emerging behaviour of complex system (e.g. TPRF).

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)
  - Size: 100+100=200 capitalists; 250 periods; 200 MC simulations/scenarios.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)
  - Size: 100+100=200 capitalists; 250 periods; 200 MC simulations/scenarios.
  - Capital as driving force (revolutionary subject).

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)
  - Size: 100+100=200 capitalists; 250 periods; 200 MC simulations/scenarios.
  - Capital as driving force (revolutionary subject).
  - Random components are added to a few parameters. Not just for fanciness: workers' reaction and rough sensitivity test.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)
  - Size: 100+100=200 capitalists; 250 periods; 200 MC simulations/scenarios.
  - Capital as driving force (revolutionary subject).
  - Random components are added to a few parameters. Not just for fanciness: workers' reaction and rough sensitivity test.
  - Initial values and parameters 'calibrated' using Marx's own examples (and literature).

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)
  - Size: 100+100=200 capitalists; 250 periods; 200 MC simulations/scenarios.
  - Capital as driving force (revolutionary subject).
  - Random components are added to a few parameters. Not just for fanciness: workers' reaction and rough sensitivity test.
  - Initial values and parameters 'calibrated' using Marx's own examples (and literature).
  - Method: comparative dynamics exercises inspired by AB and SFC literature.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- Focus on point 3. **Main features** of the new model:
  - A simple interacting agent-based approach is used. Workers' saving, capital depreciation and government are assumed away. Endogenous money and no interest rate & rent. (Marx's assumptions)
  - Size: 100+100=200 capitalists; 250 periods; 200 MC simulations/scenarios.
  - Capital as driving force (revolutionary subject).
  - Random components are added to a few parameters. Not just for fanciness: workers' reaction and rough sensitivity test.
  - Initial values and parameters 'calibrated' using Marx's own examples (and literature).
  - Method: comparative dynamics exercises inspired by AB and SFC literature.
- The model also deals partially with point 2 (see Appendix).

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- **Stochastic matching mechanism**: each c-capitalist selects a partner (i-capitalist) based on minimum price in $t-1$.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- **Stochastic matching mechanism**: each c-capitalist selects a partner (i-capitalist) based on minimum price in $t-1$.
- c-capitalists then adjust their own production plans correspondingly.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

The amended model (cont'd)

- **Stochastic matching mechanism**: each c-capitalist selects a partner (i-capitalist) based on minimum price in $t-1$.
- c-capitalists then adjust their own production plans correspondingly.
- In each period prices are set in such a way to clear each individual market, but real production adjust to demand in the long run.

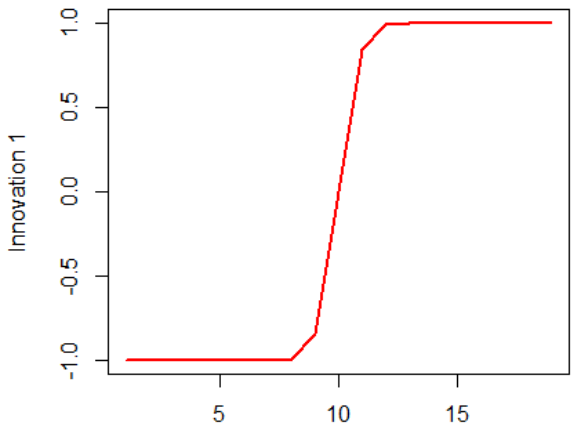
Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

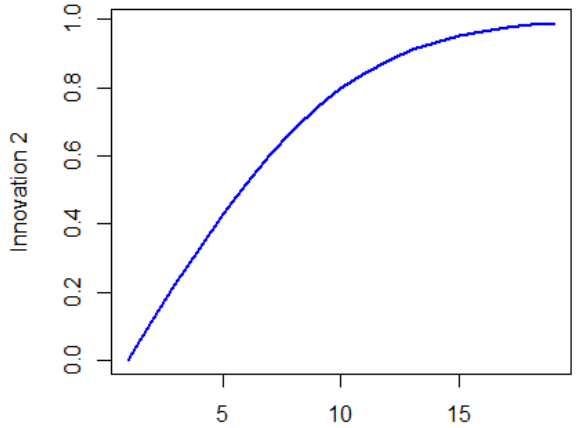
The amended model (cont'd)

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 $\rho_0 = 0.05$, $\rho_1 > 0$, $ERF(\cdot)$ is the error function and t_0 is the shock period.





Fall in i-sector retention rate

Experiment 1's features & hypotheses:

- i-sector capitalists **reduce their profit retention rate**

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Fall in i-sector retention rate

Experiment 1's features & hypotheses:

- i-sector capitalists **reduce their profit retention rate**
- c-sector must adjust to meet new demand for consumer goods

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Fall in i-sector retention rate

Experiment 1's features & hypotheses:

- i-sector capitalists **reduce their profit retention rate**
- c-sector must adjust to meet new demand for consumer goods
- Same exploitation rates but different OCCs (taken from Marx's examples)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Fall in i-sector retention rate

Experiment 1's features & hypotheses:

- i-sector capitalists **reduce their profit retention rate**
- c-sector must adjust to meet new demand for consumer goods
- Same exploitation rates but different OCCs (taken from Marx's examples)
- Tendency for equalisation within sectors but not across sectors ($r_c \neq r_i$), i.e. non-contestability (Ch. 9 vs. Ch. 10 issue stressed by Fineschi; what is the mechanism anyway?)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Fall in i-sector retention rate

Experiment 1's features & hypotheses:

- i-sector capitalists **reduce their profit retention rate**
- c-sector must adjust to meet new demand for consumer goods
- Same exploitation rates but different OCCs (taken from Marx's examples)
- Tendency for equalisation within sectors but not across sectors ($r_c \neq r_i$), i.e. non-contestability (Ch. 9 vs. Ch. 10 issue stressed by Fineschi; what is the mechanism anyway?)
- As for the rest, *ceteris paribus*

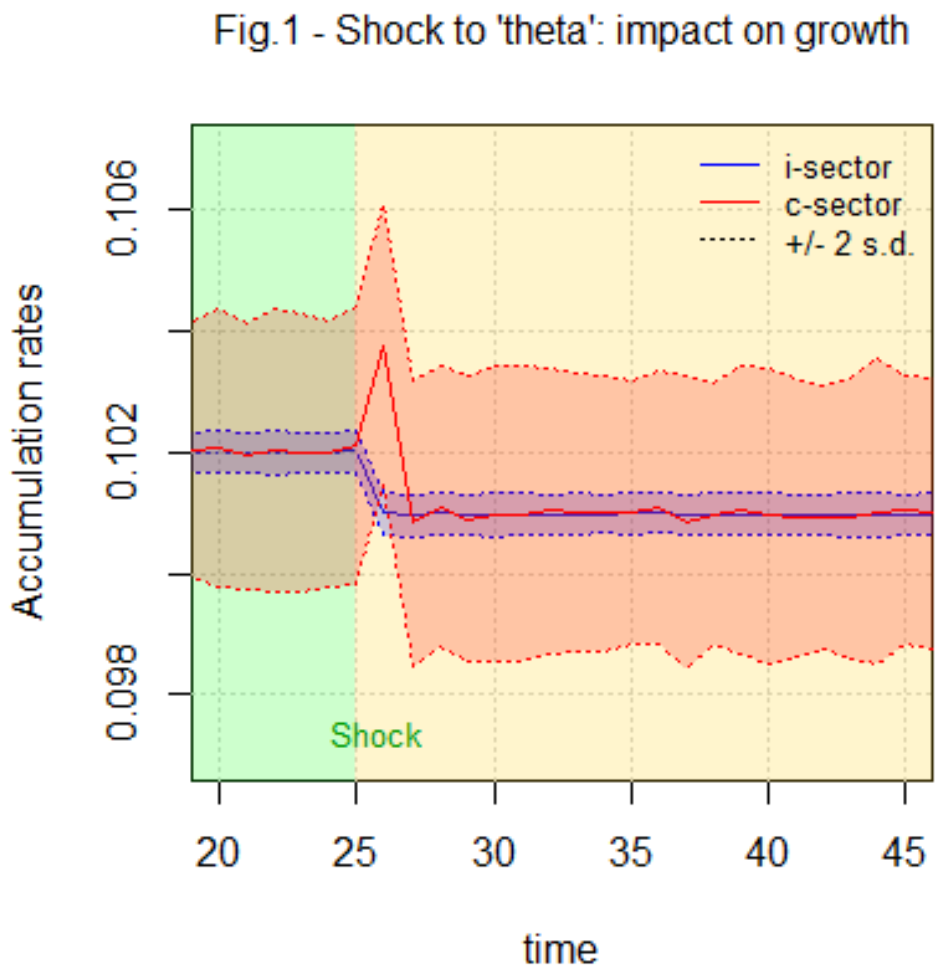
Fall in i-sector retention rate

Experiment 1's features & hypotheses:

- i-sector capitalists **reduce their profit retention rate**
- c-sector must adjust to meet new demand for consumer goods
- Same exploitation rates but different OCCs (taken from Marx's examples)
- Tendency for equalisation within sectors but not across sectors ($r_c \neq r_i$), i.e. non-contestability (Ch. 9 vs. Ch. 10 issue stressed by Fineschi; what is the mechanism anyway?)
- As for the rest, *ceteris paribus*
- Just for calibration & check

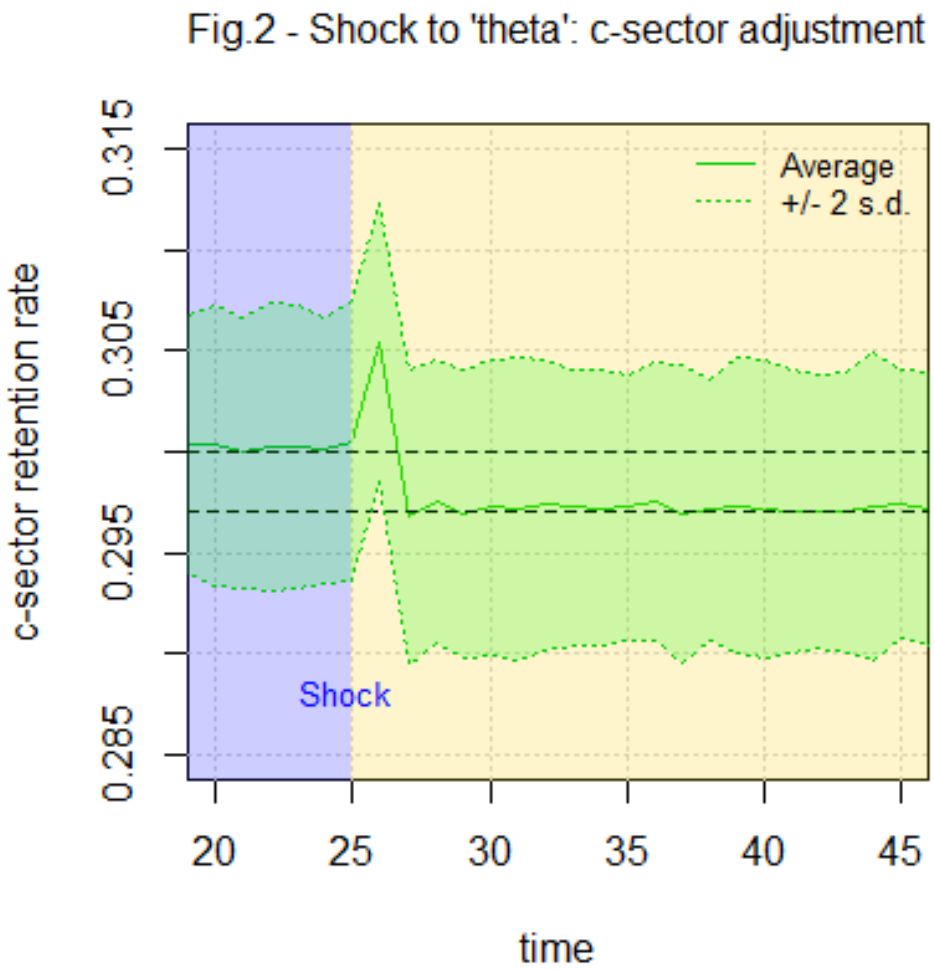
Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Fall in i-sector retention rate (cont'd)



Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Fall in i-sector retention rate (cont'd)



Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:
  A. **Higher RWs** for employees, unchanged RW for the class / unchanged exploitation

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:
  A. **Higher RWs** for employees, unchanged RW for the class / unchanged exploitation
  B. **Unchanged RWs** for employees, lower RW for the class / higher exploitation

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:
  A. **Higher RWs** for employees, unchanged RW for the class / unchanged exploitation
  B. **Unchanged RWs** for employees, lower RW for the class / higher exploitation
- Note:

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:
  A. **Higher RWs** for employees, unchanged RW for the class / unchanged exploitation
  B. **Unchanged RWs** for employees, lower RW for the class / higher exploitation
- Note:
  - No counteracting factors / implications (OCC only!)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:
  A. **Higher RWs** for employees, unchanged RW for the class / unchanged exploitation
  B. **Unchanged RWs** for employees, lower RW for the class / higher exploitation
- Note:
  - No counteracting factors / implications (OCC only!)
  - Neither supply side constraints nor lack of demand

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Experiment 2's features & hypotheses

- Same OCCs across sectors, except for innovators (same C, lower V)
- **Innovation spreads** like an error function
- Real individual supplies keep growing in line with competitors
- So higher productivity of labour for innovators
- Two scenarios for real wages and exploitation rates:
  A. **Higher RWs** for employees, unchanged RW for the class / unchanged exploitation
  B. **Unchanged RWs** for employees, lower RW for the class / higher exploitation
- Note:
  - No counteracting factors / implications (OCC only!)
  - Neither supply side constraints nor lack of demand
  - Prices adjust to clear the market in the S/R

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

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:

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

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 $L_{ij} = (V_{ij} + S_{ij})/m_0$.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

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

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

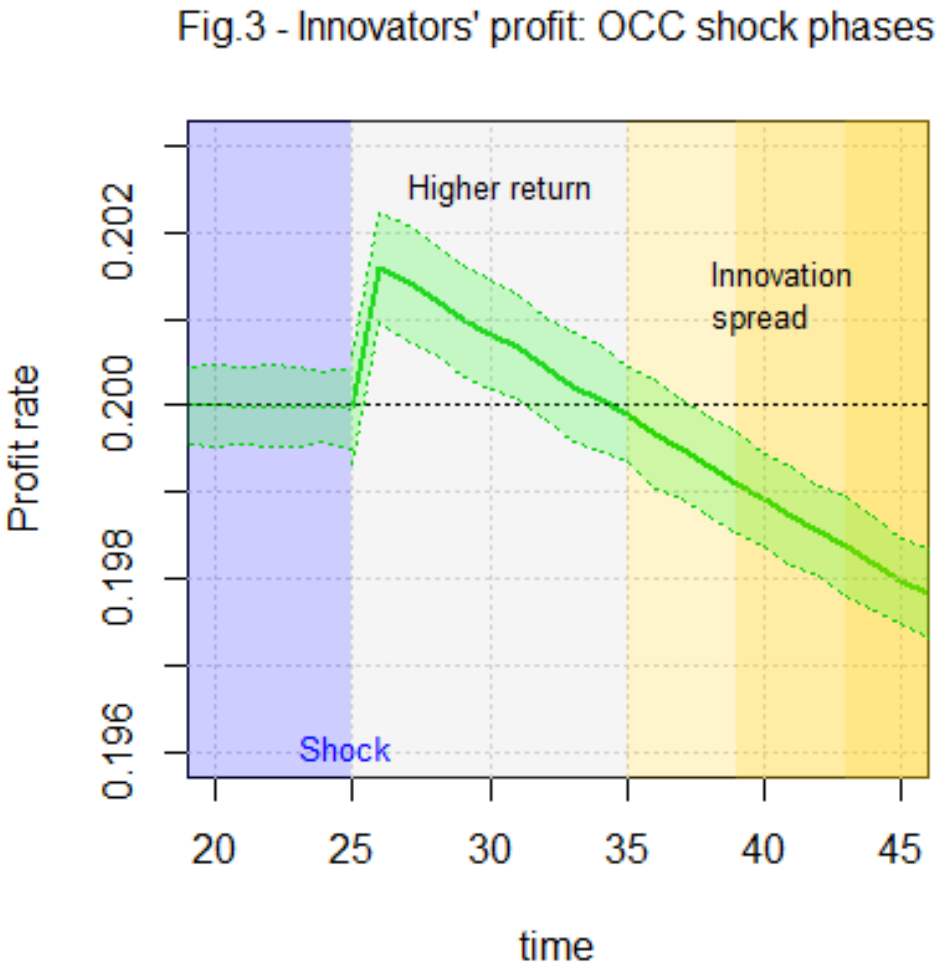
The amended model

Experiments

Final remarks

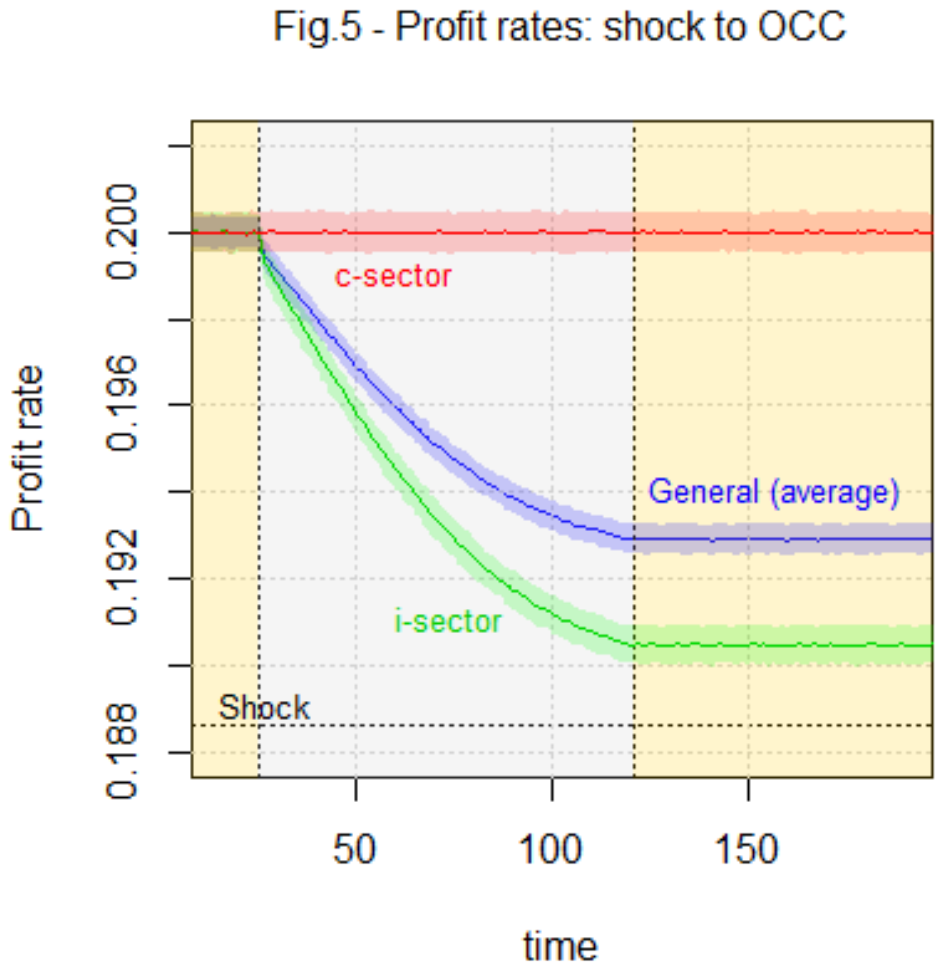
Appendix

Increase in innovators' OCC (cont'd)

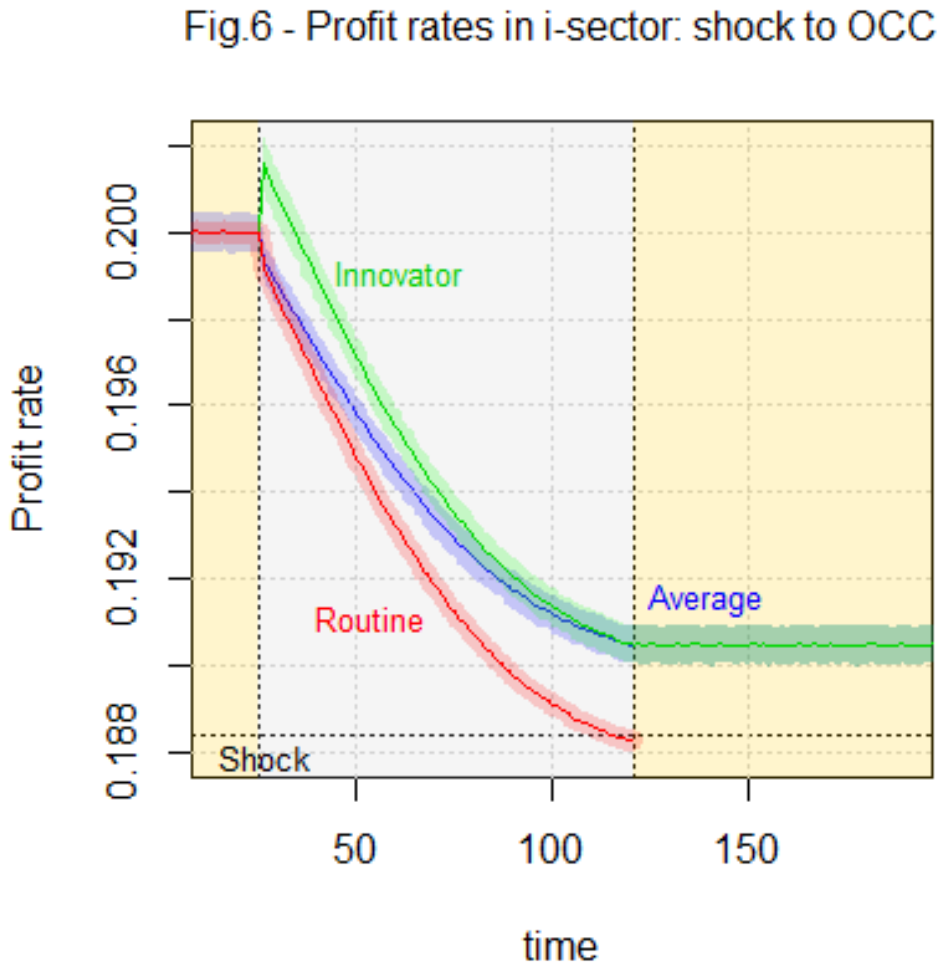


Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)



Increase in innovators' OCC (cont'd)



Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)
- Innovation assures a higher individual profit rate in the short run (due to lower wage costs)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)
- Innovation assures a higher individual profit rate in the short run (due to lower wage costs)
- The increase in innovators' profit is only temporary

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)
- Innovation assures a higher individual profit rate in the short run (due to lower wage costs)
- The increase in innovators' profit is only temporary
- As innovation spreads, innovators' profit rate declines

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)
- Innovation assures a higher individual profit rate in the short run (due to lower wage costs)
- The increase in innovators' profit is only temporary
- As innovation spreads, innovators' profit rate declines
- *Given the exploitation rate*, the general rate of profit declines, due to higher OCC

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)
- Innovation assures a higher individual profit rate in the short run (due to lower wage costs)
- The increase in innovators' profit is only temporary
- As innovation spreads, innovators' profit rate declines
- *Given the exploitation rate*, the general rate of profit declines, due to higher OCC
- Employed workers enjoy a higher real wage (due to higher productivity and lower prices)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Model's findings using **class-based** definition of subsistence:

- Individual incentive to innovate (mechanisation)
- Innovation assures a higher individual profit rate in the short run (due to lower wage costs)
- The increase in innovators' profit is only temporary
- As innovation spreads, innovators' profit rate declines
- *Given the exploitation rate*, the general rate of profit declines, due to higher OCC
- Employed workers enjoy a higher real wage (due to higher productivity and lower prices)
- But no improvement for working class as a whole!

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

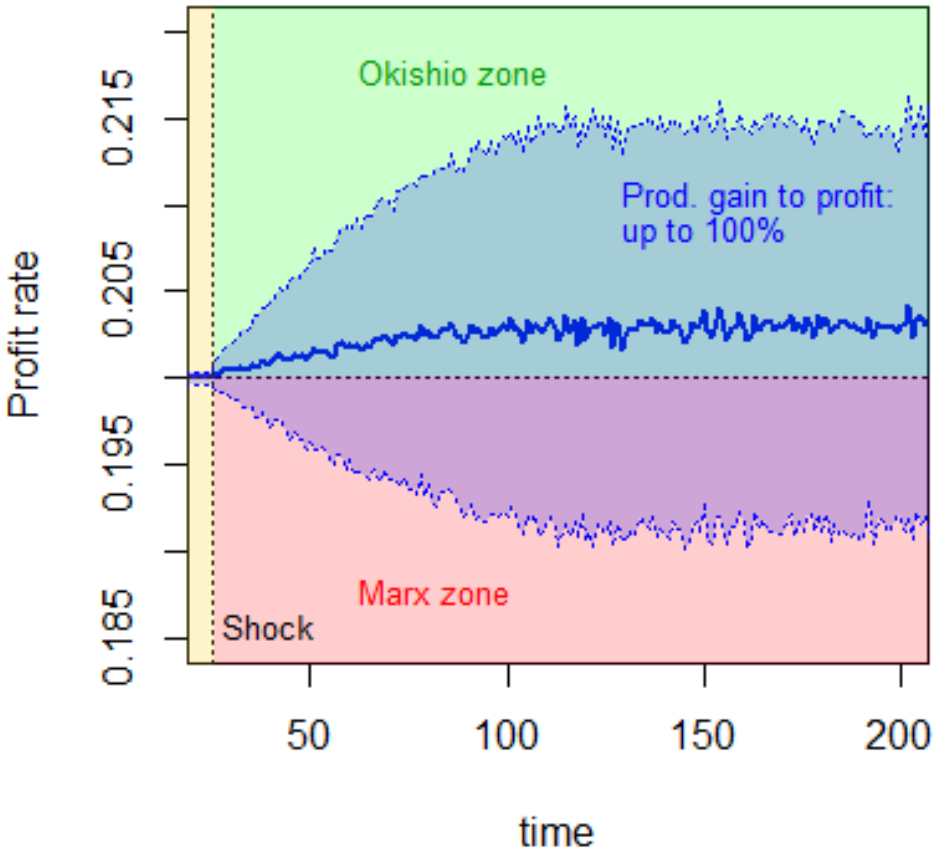
B. What if **individual-based** definition of subsistence? (capitalists can get up to 100% of productivity earnings, so declining wage share)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Appendix (cont'd)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Fig.11 - General profit rate: individual subsistence



Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

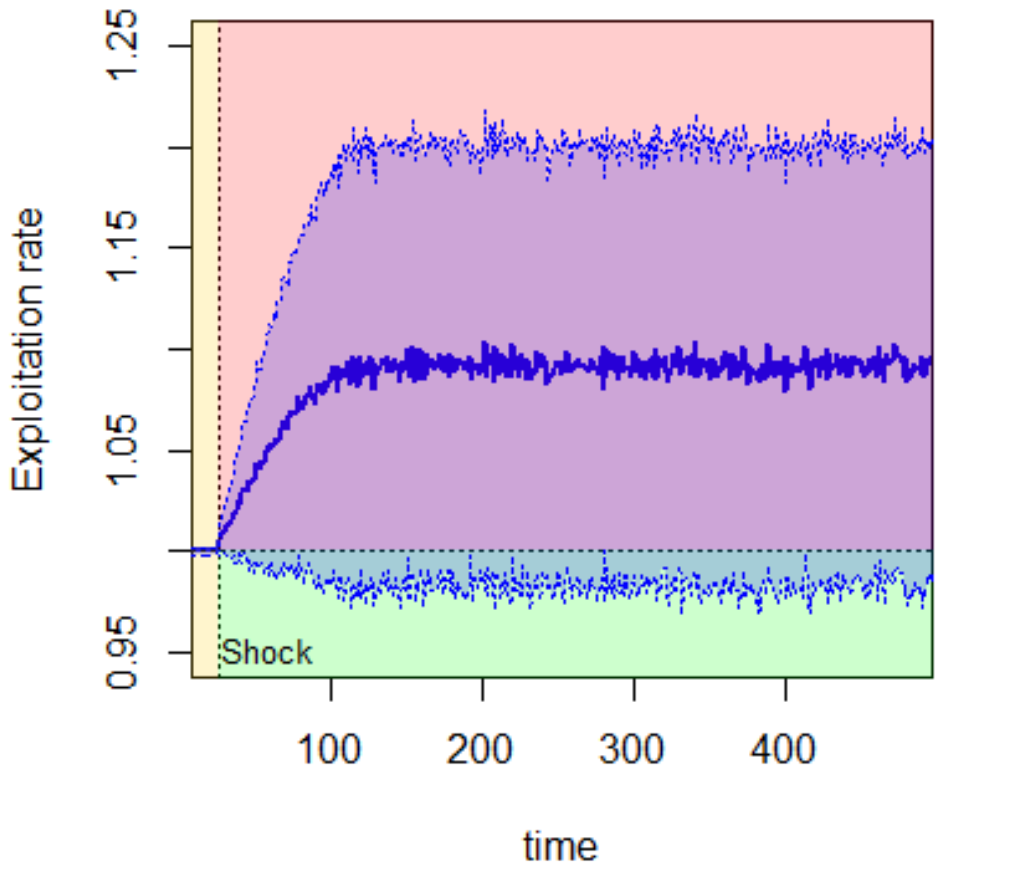
The amended model

Experiments

Final remarks

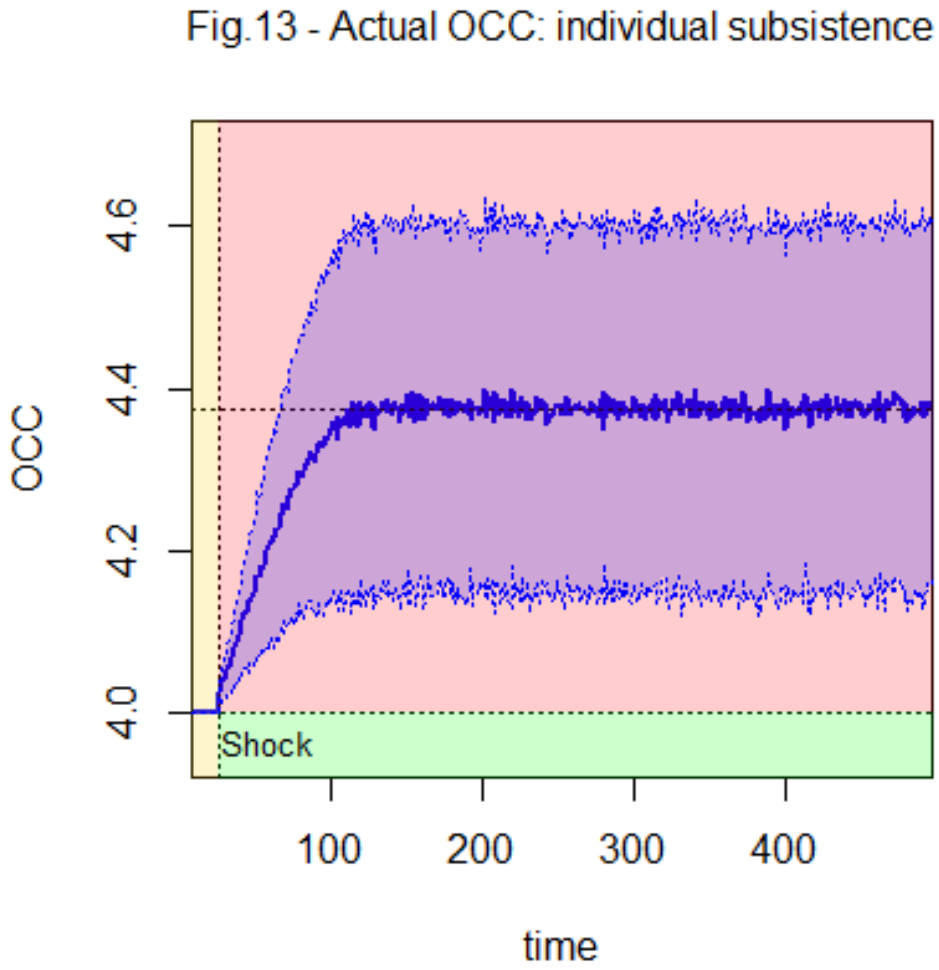
Appendix

Fig.12 - Actual exploitation rate: individual subsistence



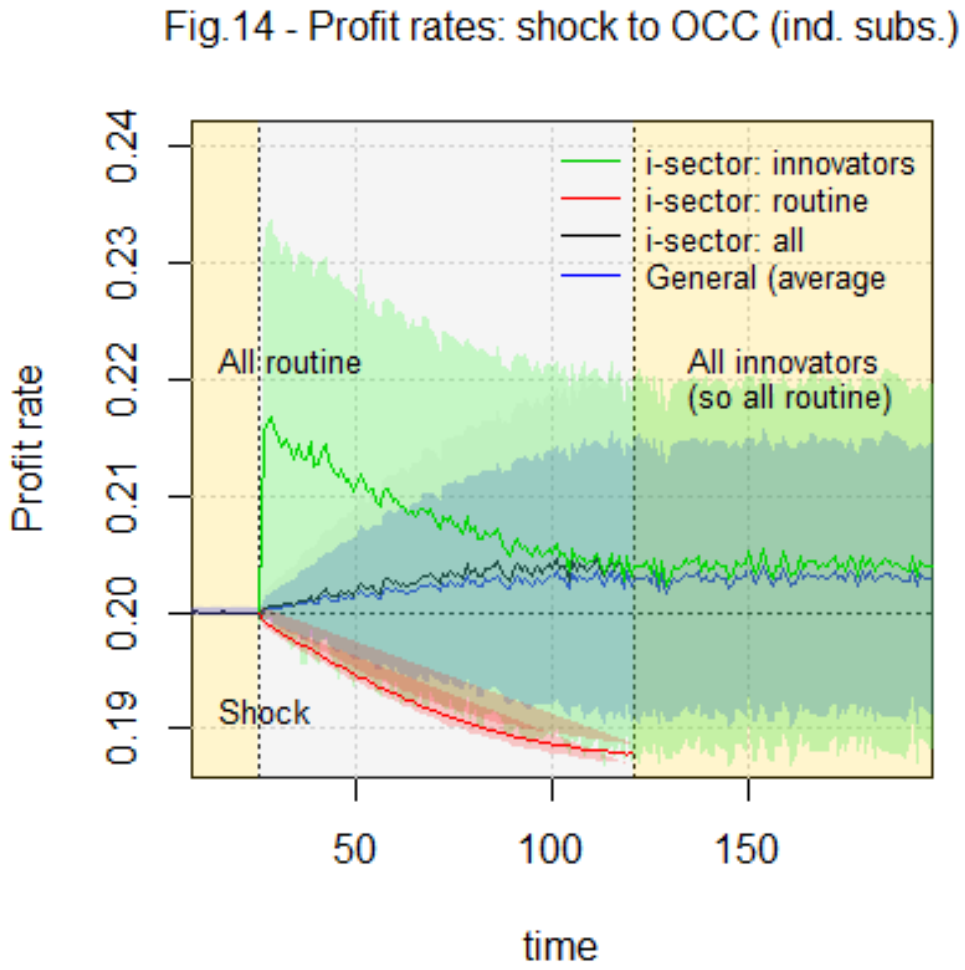
Appendix (cont'd)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix



Appendix (cont'd)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix



Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:
  - If capitalists get a large share of productivity gains, tendency to increase (rather than fall)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:
  - If capitalists get a large share of productivity gains, tendency to increase (rather than fall)
  - If capitalists get a small share of productivity gains, the profit rate increases for innovators but not for the rest

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:
  - If capitalists get a large share of productivity gains, tendency to increase (rather than fall)
  - If capitalists get a small share of productivity gains, the profit rate increases for innovators but not for the rest
- Routine capitalists (and late-innovators) are likely to be affected anyway

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:
  - If capitalists get a large share of productivity gains, tendency to increase (rather than fall)
  - If capitalists get a small share of productivity gains, the profit rate increases for innovators but not for the rest
- Routine capitalists (and late-innovators) are likely to be affected anyway
- General *r* affected by market 'contestability' (c-sector)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:
  - If capitalists get a large share of productivity gains, tendency to increase (rather than fall)
  - If capitalists get a small share of productivity gains, the profit rate increases for innovators but not for the rest
- Routine capitalists (and late-innovators) are likely to be affected anyway
- General r affected by market 'contestability' (c-sector)
- Employed workers enjoy the same real wage (no benefit from higher productivity)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Increase in innovators' OCC (cont'd)

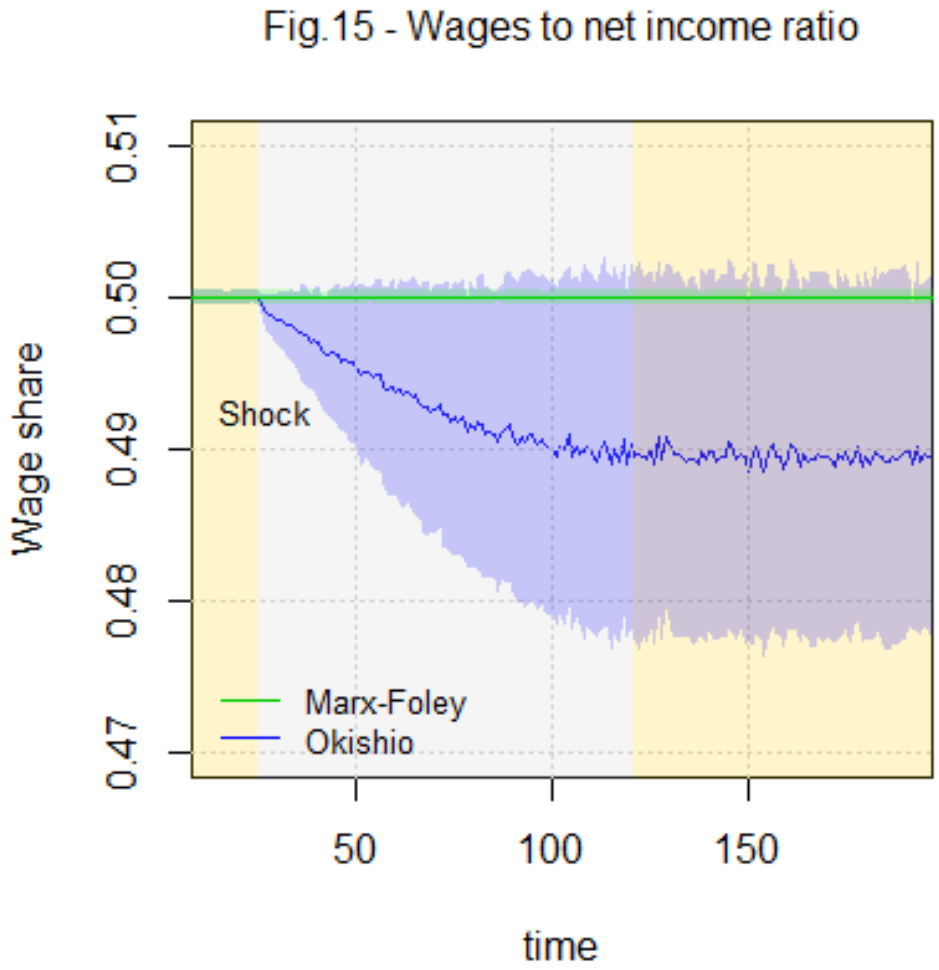
Findings using **individual-based** definition of subsistence:

- The actual exploitation rate increases, thereby supporting profitability
- Two sub-scenarios:
  - If capitalists get a large share of productivity gains, tendency to increase (rather than fall)
  - If capitalists get a small share of productivity gains, the profit rate increases for innovators but not for the rest
- Routine capitalists (and late-innovators) are likely to be affected anyway
- General r affected by market 'contestability' (c-sector)
- Employed workers enjoy the same real wage (no benefit from higher productivity)
- If close to subsistence threshold, **working-class' reproduction conditions are endangered!**

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Appendix (cont'd)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix



Final remarks

- Model's cons:

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Final remarks

- Model's cons:
  - Low interaction

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:
  - Sheds light on tendency (to then move to counteracting factors and C&C)

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:
  - Sheds light on tendency (to then move to counteracting factors and C&C)
  - Bridges gap between 'old' CPE and recent developments

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:
  - Sheds light on tendency (to then move to counteracting factors and C&C)
  - Bridges gap between 'old' CPE and recent developments
  - Two contributions:

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:
  - Sheds light on tendency (to then move to counteracting factors and C&C)
  - Bridges gap between 'old' CPE and recent developments
  - Two contributions:
    - **non-contestability** as additional counteracting factor

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:
  - Sheds light on tendency (to then move to counteracting factors and C&C)
  - Bridges gap between 'old' CPE and recent developments
  - Two contributions:
    - **non-contestability** as additional counteracting factor
    - Foley-Marx and Okishio as poles of a **spectrum**...

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Final remarks

- Model's cons:
  - Low interaction
  - No financial assets (endogenous money, but implicit)
  - Prices & competition just sketched, normal utilisation
- Model's pros:
  - Sheds light on tendency (to then move to counteracting factors and C&C)
  - Bridges gap between 'old' CPE and recent developments
  - Two contributions:
    - **non-contestability** as additional counteracting factor
    - 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, TPRF & inequality. On the contrary, TPRF as unintended consequence of **two-fold class struggle**.

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Thank You

m.passarella@leeds.ac.uk

Download presentation's material from *marxianomics*:
www.marcopassarella.it/en/

Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Appendix: real supplies & prices

The individual real supply of i-goods gradually adjusts to nominal demand:

$$X_{iI} = X_{iI,-1} + \sigma_{Ii} \cdot (Y_{iI} - P_I^0 \cdot X_{iI}) \tag{16}$$

Similalry, the individual real supply of c-goods is:

$$X_{iC} = X_{iI,-1} + \sigma_{Ci} \cdot (Y_{iC} - P_C^0 \cdot X_{iC}) \tag{17}$$

where $P_I^0 = P_C^0 = 1$. The individual price of i-goods must clear the market in the short run:

$$P_{iI}^m \cdot X_{iI} = C_{iI} + C_{iC} + \theta_{iI} \cdot S_{iI} + \theta_{iC} \cdot S_{iC} \tag{18}$$

Similarly, the individual price of c-goods is derived by:

$$P_{iC}^m \cdot X_{iC} = V_{iI} + V_{iC} + (1 - \theta_{iC}) \cdot S_{iC} + (1 - \theta_{iI}) \cdot S_{iI} \tag{19}$$

Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

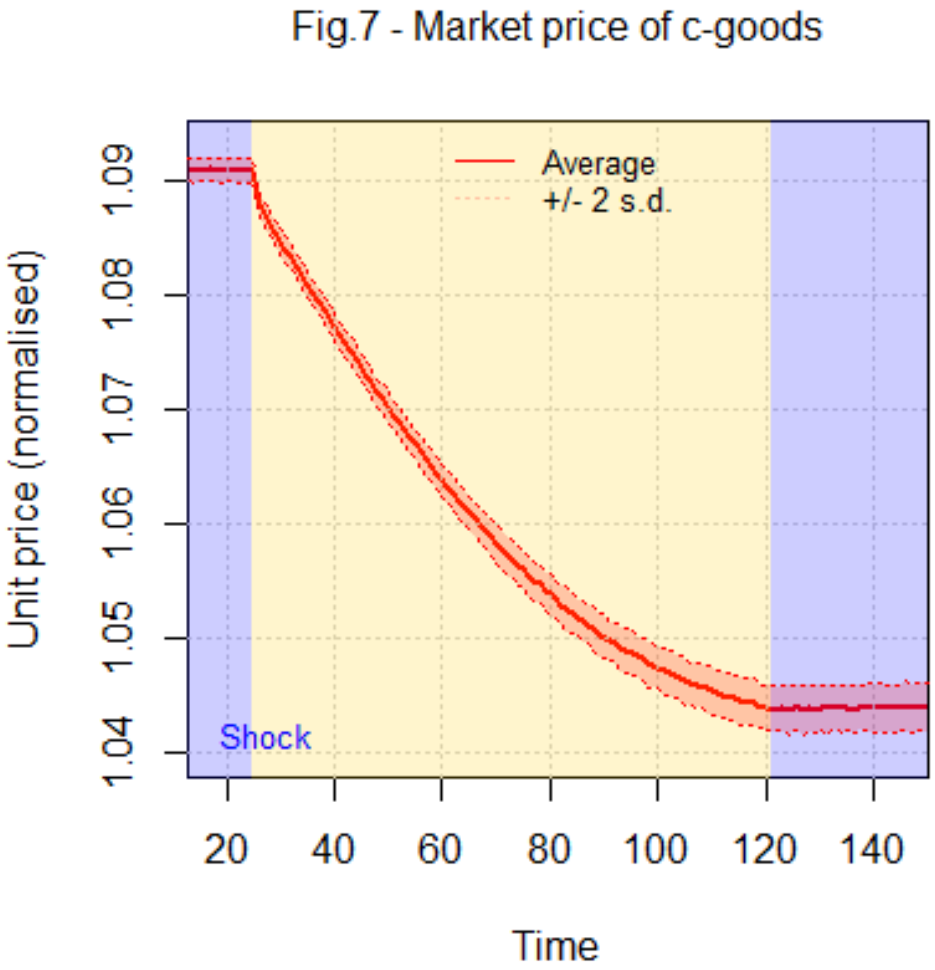
Some familiar findings

The amended model

Experiments

Final remarks

Appendix



Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

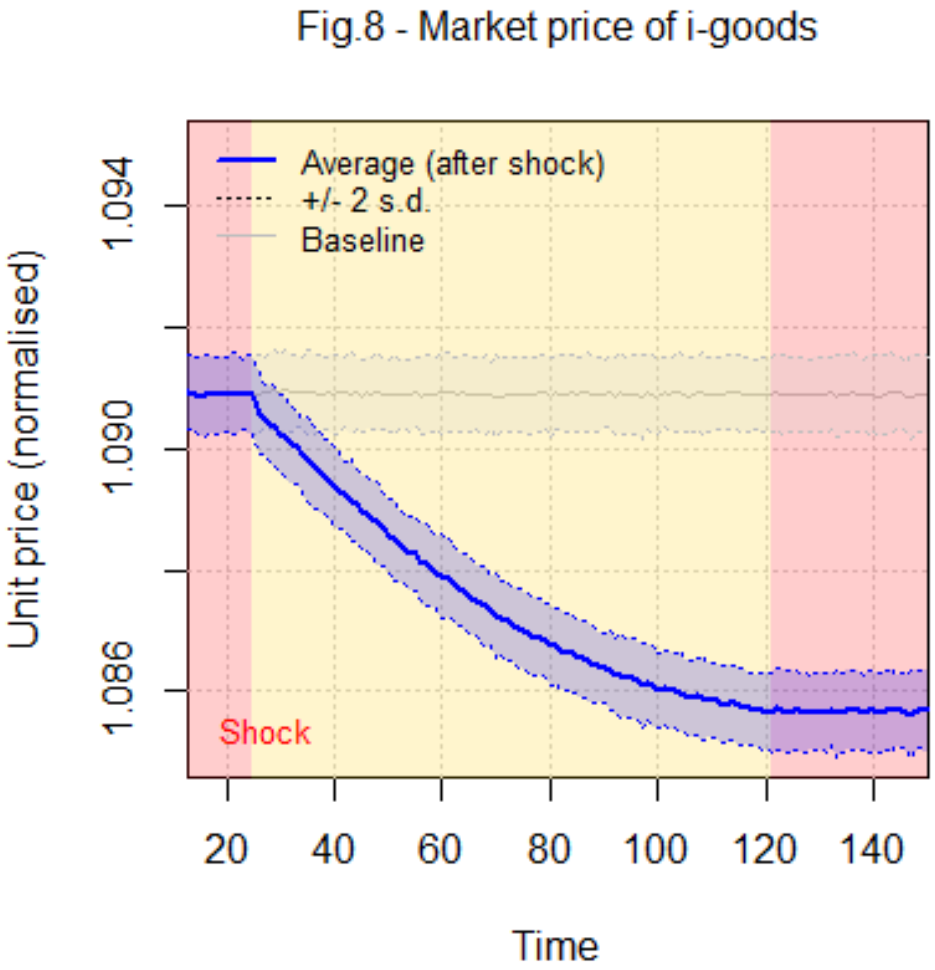
Some familiar findings

The amended model

Experiments

Final remarks

Appendix



Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

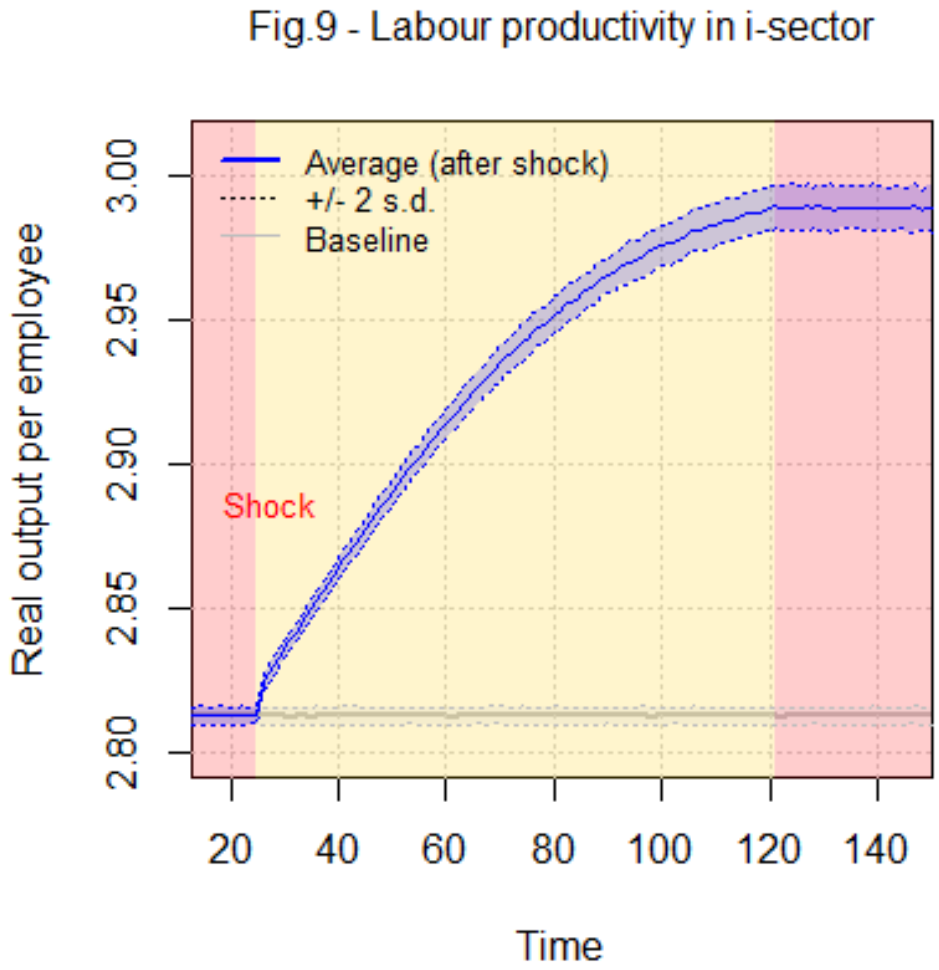
Some familiar findings

The amended model

Experiments

Final remarks

Appendix



Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

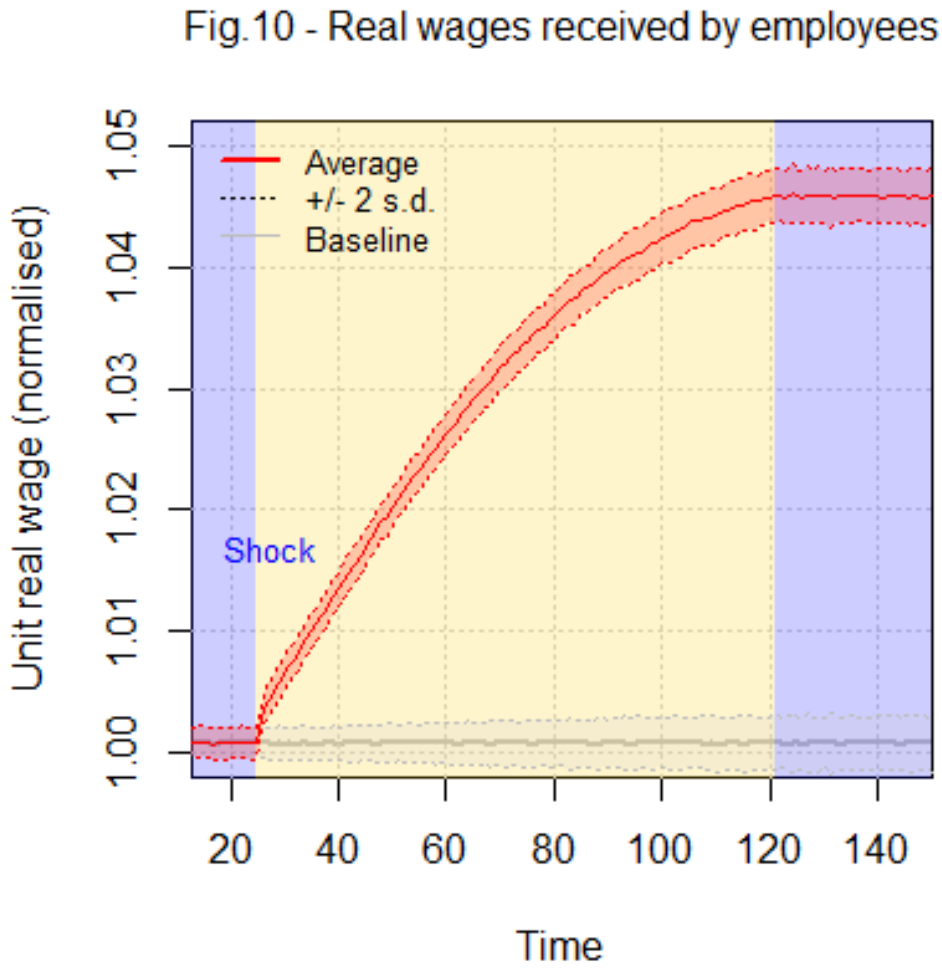
Some familiar findings

The amended model

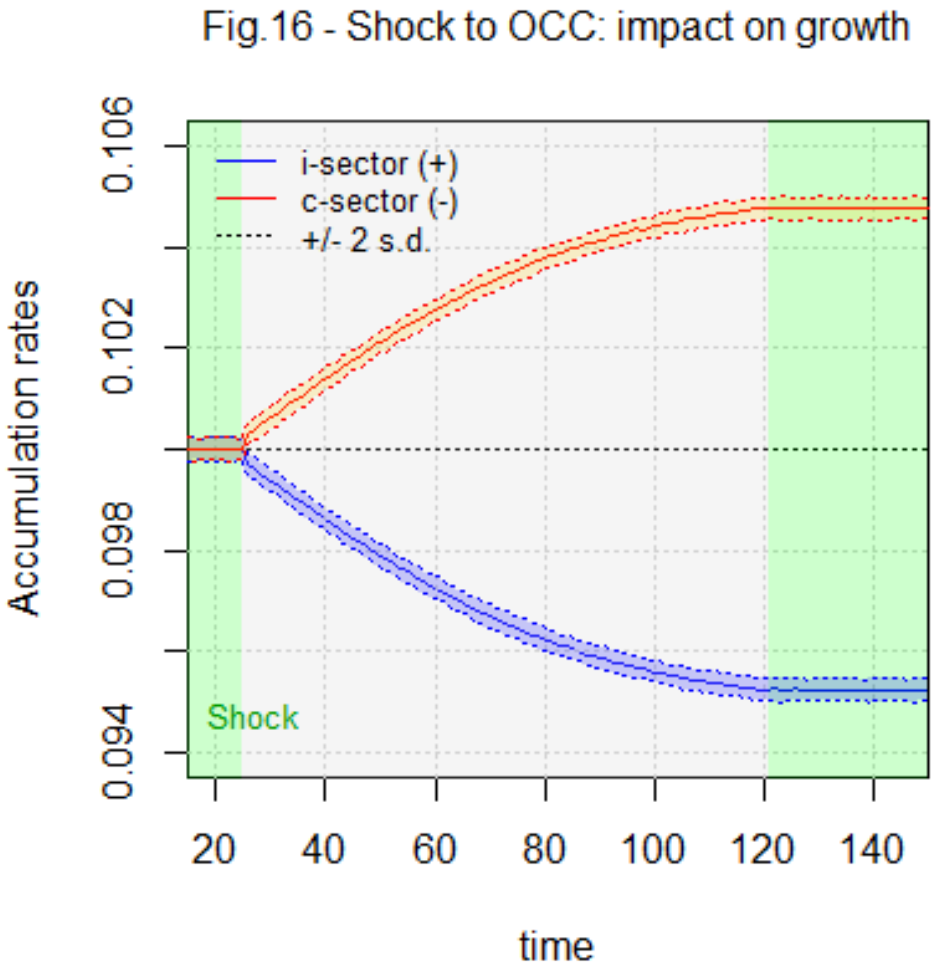
Experiments

Final remarks

Appendix

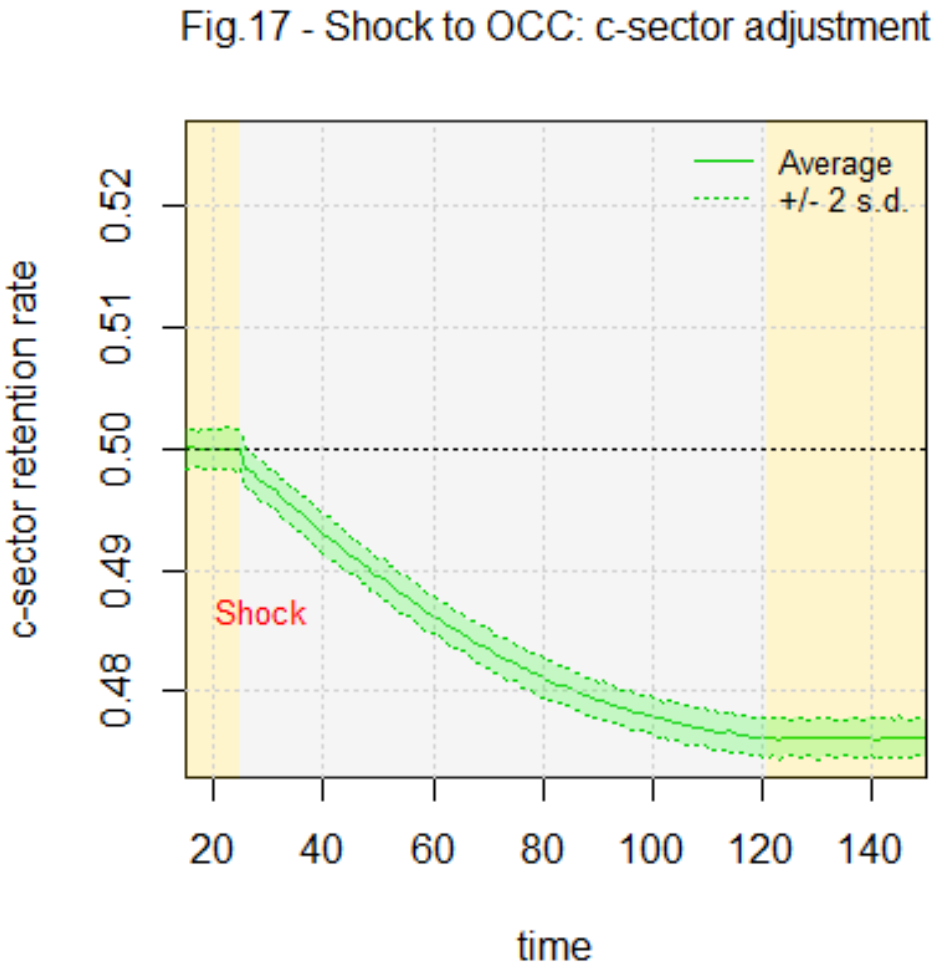


Appendix (cont'd)



Introduction
Literature review
The basic RS model
Enlarged reproduction
Some familiar findings
The amended model
Experiments
Final remarks
Appendix

Appendix (cont'd)



Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

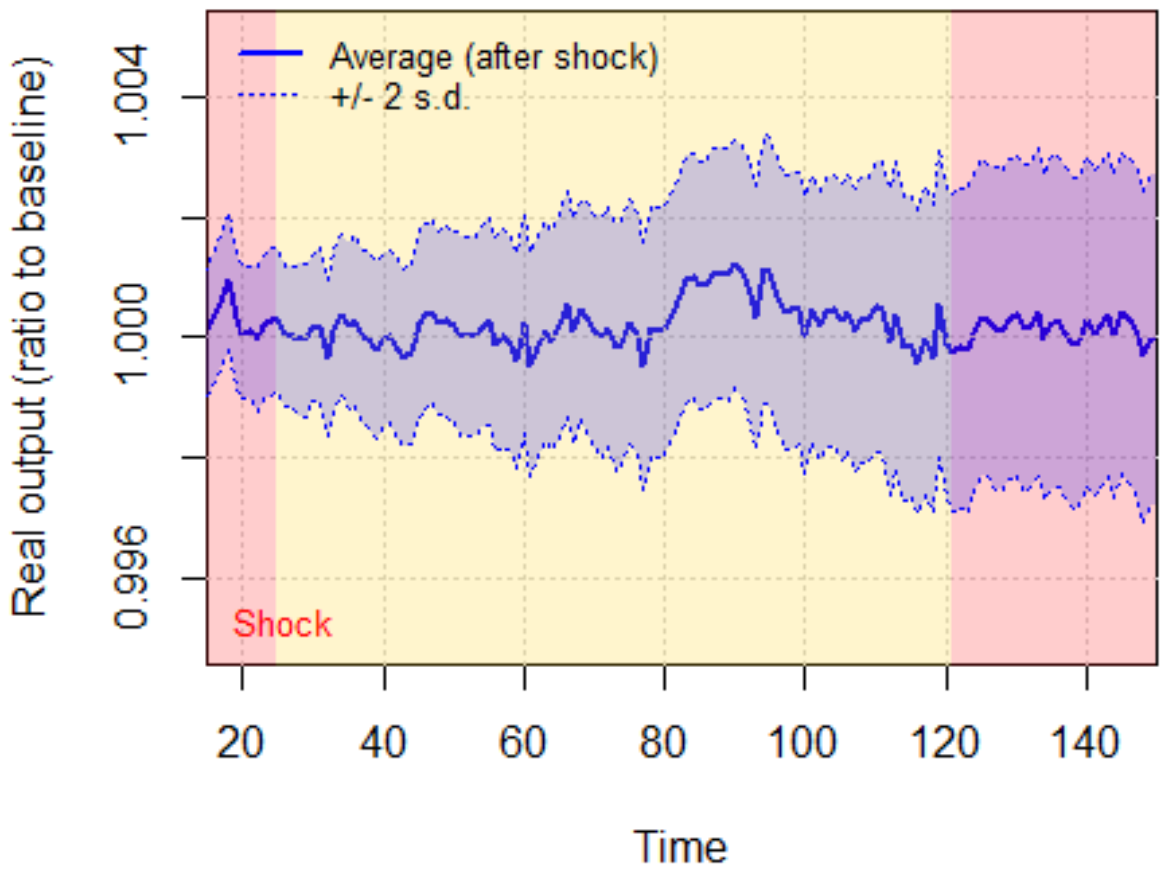
The amended model

Experiments

Final remarks

Appendix

Fig.18 - Real supply of i-goods



Appendix (cont'd)

Introduction

Literature review

The basic RS model

Enlarged reproduction

Some familiar findings

The amended model

Experiments

Final remarks

Appendix

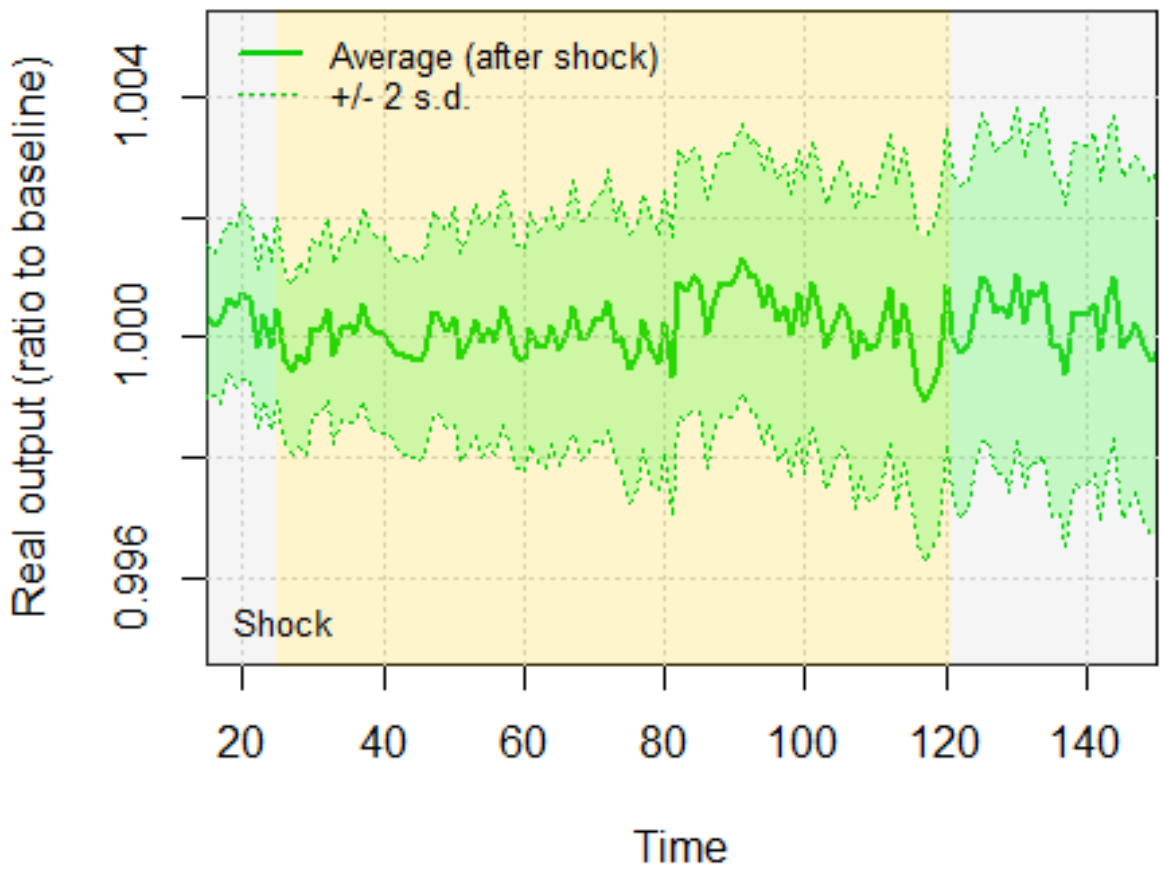



Fig.19 - Real supply of c-goods