Introduction to SFC Dynamic Models

Lecture C A Toy Model with Bank Money and Fixed Capital

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Download lectures' material from:

https://github.com/marcoverpas/Six_lectures_on_sfc_models

Schedule

A. Foundations of SFC Models for Economic Research
B. A Toy Model with State Money and Bills
C. **A Toy Model with Bank Money and Fixed Capital**
   1. **Model Accounting**
   2. **Simulations**
   3. **Modelling BMW in *R***
D. Multi-Country SFC Models
E. Ecological and Input-Output SFC Models
F. Empirical SFC Models (using *Bimets*)

Box 1 Steps for developing a SFC model

1. Identify sectors to be modelled (households, firms, etc.)
2. Create balance-sheet (BS) of the economy
3. Create transactions-flow matrix (TFM)
4. Write down identities from the TFM:
   i. Use columns to derive budget constraints
   ii. Use also rows with multiple entries
   iii. Identify buffer variables
5. Define behavioural equations and equilibrium conditions

Box 2 How to install *R* and run a toy model

a) Download and install *R* (free software)

b) Download and install *R-Studio Desktop* (free version)

c) Alternatively, use Posit Cloud (free online platform for *R* and *Python*)

d) Get familiar with *R* using the Cheat Sheet

e) Download toy models from my GitHub repository

f) Open the file and execute the entire code by clicking Source or run it line by line using Run

g) Check model variables (Data) and coefficients (Values) in the top-right pane, named Global Environment

h) Charts are displayed in the Plots tab in the bottom-right pane

i) Tables and Sankey diagrams are displayed in the Viewer tab in the bottom-right pane (note: always re-run the last coding block to visualise them)

1 Model Accounting

Assumptions

This is a model developed in chapter 7 of Godley and Lavoie (2007). BMW stands for bank-money world, because there is only one kind of *financial* assets: bank deposits held by households. Firms' investment in fixed capital is (partially) funded by bank loans.

Key assumptions are as follows:

- Closed economy and no ecosystem
- Three agents: households, firms, banks
- A/L: loans, deposits, tangible (or fixed) capital
- Investment funded by loans and internal funds
- Target capital to output ratio
- Fixed prices and zero net profits
- No State, no outside money (cash)

Balance-sheet

	Households	Production firms	Banks	Σ
Deposits	$+M_h$		$-M_s$	0
Loans		$-L_f$	$+L_s$	0
Fixed capital		$+K$		$+K$
Balance (net worth)	$-V_h$	0	0	$-V_h$
Σ	0	0	0	0

Notes: A '+' before a magnitude denotes an asset; a '–' denotes a liability.

Tip: unlike a financial asset, a real or tangible asset (K) is not matched by a liability, because it is not a claim of someone against someone else!

Transactions-flow matrix

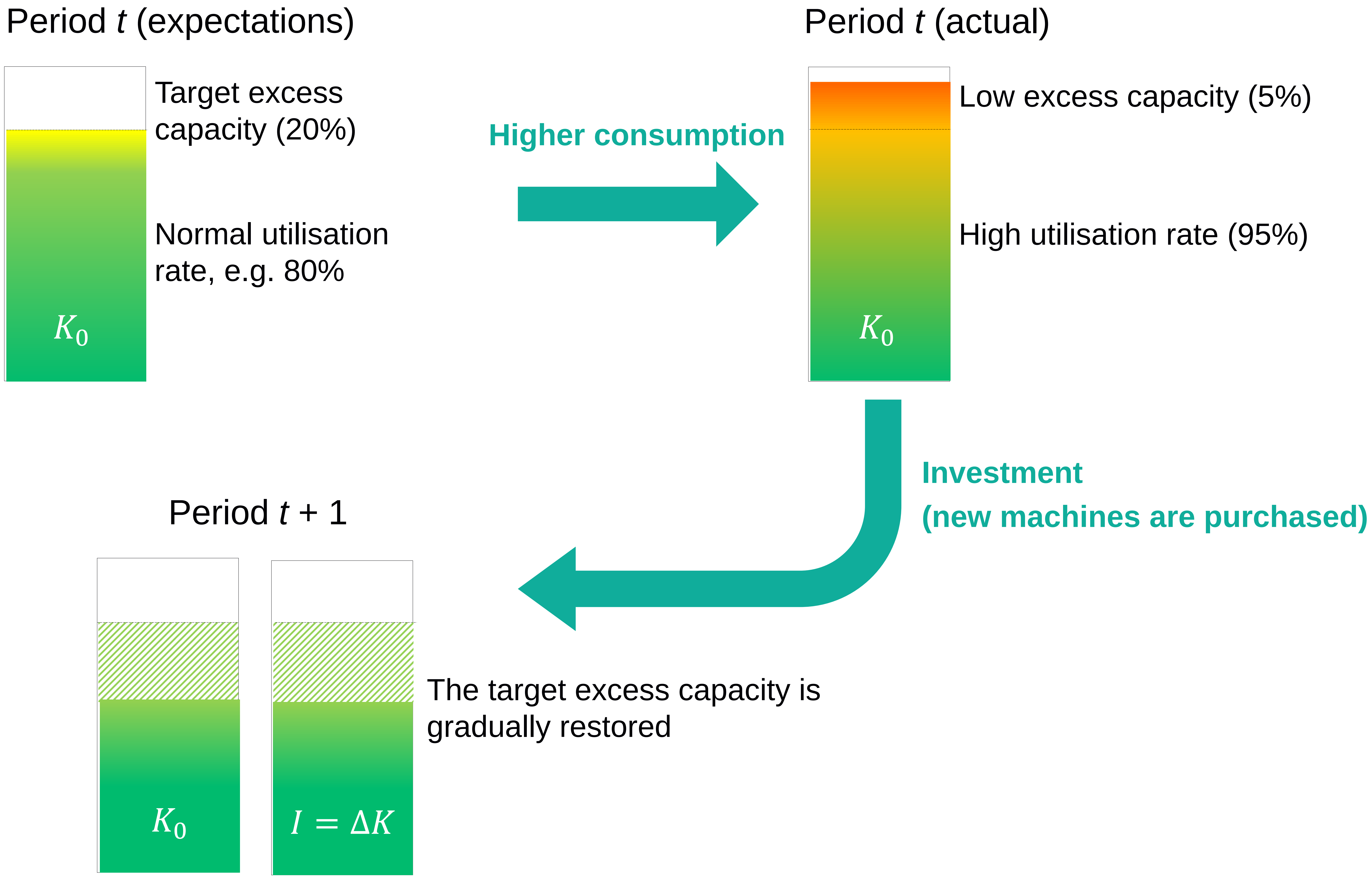
	Households	Production firms		Banks		Σ
		Current	Capital	Current	Capital	
Consumption	$-C_d$	$+C_s$				0
Investment		$+I_d$	$-I_d$			0
[Production]		$[Y]$				
Wages	$+WB$	$-WB$				0
Depreciation		$-AF$	$+AF$			0
Int. on loans		$-r_{l,-1} \cdot L_{f,-1}$		$+r_{l,-1} \cdot L_{s,-1}$		0
Int. on deposits	$+r_{m,-1} \cdot M_{h,-1}$			$-r_{m,-1} \cdot M_{s,-1}$		0
Δ in loans			$+\Delta L_f$		$-\Delta L_s$	0
Δ in deposits	$-\Delta M_h$				$+\Delta M_s$	0
Σ	0	0	0	0	0	0

Equation (8)

Notes: A '+' before a magnitude denotes a receipt or a source of funds; a '–' denotes a payment or a use of funds

Investment as a function of the utilisation rate

Target capacity



Investment decisions

Investment depends on the rate of utilisation of capacity. Firms want to keep an extra capacity to address unexpected increases in demand.

Firms keep investing as long as the capital stock to output ratio is below a target ratio, κ.

Rationale: capital stock = ∑ investments. The latter depend on output (expected demand).

The target capital stock can be simply defined as:

$$K^T = \kappa \cdot Y_{-1} \quad (19)$$

As a result, current gross investment is:

$$I_d = \gamma \cdot (K^T - K_{-1}) + DA \quad (20)$$

where γ is the speed of adjustment of K to K^T, and δ the rate of depreciation of capital (share of K that must be replaced to keep the total stock unchanged).

Capital stock and financial requirements

The total capital stock at the end of each period is:

$$K = K_{-1} + I_d - DA \qquad (17)$$

The capital stock increases as investment increases and reduces as the rate of depreciation increases.

Note: I_d is gross investment, namely, it includes the replacement of depleted or depreciated capital goods (e.g. machines).

The stock of loans is a buffer variable:

$$L_d = L_{d,-1} + I_d - AF \qquad (8)$$

Firms demand new loans to cover the amount of investment that exceeds amortisation funds (we assume that $AF = DA = \delta \cdot K_{-1}$). It is computed from firms' capital account column.

Equations

Supply of consumption goods:	$C_s = C_d$	(1)
Supply of investment goods:	$I_s = I_d$	(2)
Labour supply:	$N_s = N_d$	(3)
Supply of loans:	$L_s = L_{s,-1} + \Delta L_d$	(4)
Total gross production:	$Y = C_s + I_s$	(5)
Wage bill (as residual income):	$WB_d = Y - r_{l,-1} \cdot L_{d,-1} - AF$	(6)
Amortisation funds:	$AF = \delta \cdot K_{-1}$	(7)
Demand for loans:	$L_d = L_{d,-1} + I_d - AF$	(8)
Disposable income:	$YD = WB_s + r_{m,-1} \cdot M_{d,-1}$	(9)
Deposits held by households:	$M_h = M_{h,-1} + YD - C$	(10)
Supply of deposits:	$M_s = M_{s,-1} + \Delta L_s$	(11)

- Identity
- Equilibrium condition
- Behavioural equation

Equations (cont'd)

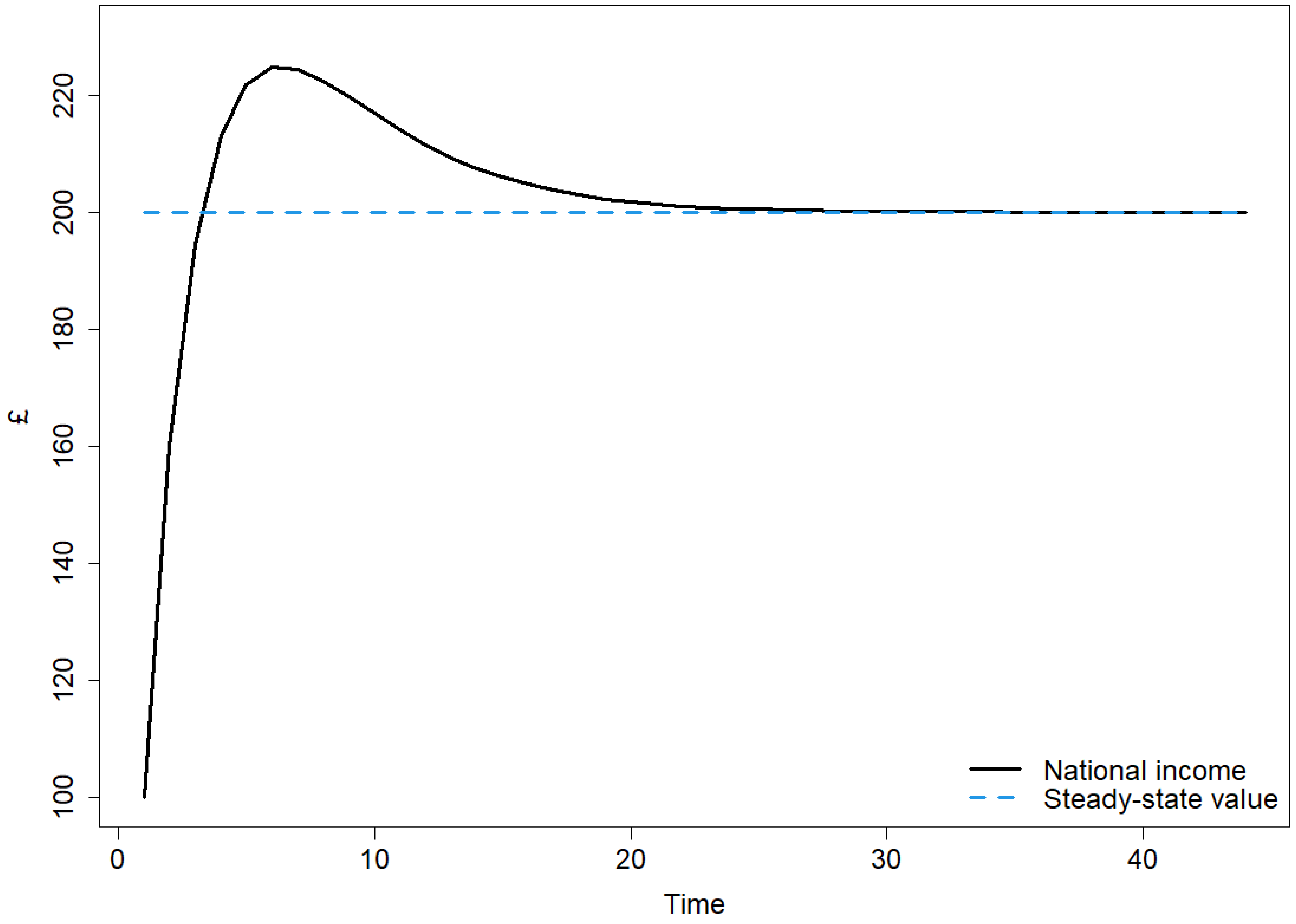
Return rate on deposits:	$r_m = r_l$	(12)
Wage bill:	$WB_s = w \cdot N_s$	(13)
Demand for labour:	$N_d = Y/pr$	(14)
Wage rate:	$w = WB_d/N_d$	(15)
Consumption:	$C_d = \alpha_0 + \alpha_1 \cdot YD + \alpha_2 \cdot M_{h,-1}$	(16)
Capital stock:	$K = K_{-1} + I_d - DA$	(17)
Depreciation allowances:	$DA = \delta \cdot K_{-1}$	(18)
Target capital stock:	$K^T = \kappa \cdot Y_{-1}$	(19)
Gross investment:	$I_d = \gamma \cdot (K^T - K_{-1}) + DA$	(20)
Interest rate on loans:	$r_l = \bar{r}_l$	(21)
Redundant equation:	$M_h = M_s$	

2 Simulations

Dynamics

Stationary (steady-state) solution: $Y^* = \dfrac{\alpha_0}{(1-\alpha_1)\cdot(1-\delta\cdot\kappa)-\alpha_2\cdot\kappa}$

Figure 1 Evolution of national income following initial autonomous consumption



$\alpha_0 = 25$
$\alpha_1 = 0.75$
$\alpha_2 = 0.40$
$\delta = 0.15$
$\kappa = 1$

$Y^* = 96$

Tip: how to find the steady-state

Use equations (1), (2), (16) and (20) in Y identity, that is, equation (5). Next, use equation (9) in Y and equation (6) in equation (9). Notice that $K = K^T = \kappa \cdot Y$ and $M = L = K$, under steady state. Replace variables with respective equations and solve for Y^*.

BS steady-state values

	Households	Production firms	Banks	Σ
Deposits	+96		−96	0
Loans		−96	+96	0
Fixed capital		+96		+96
Balance (net worth)	−96	0	0	−96
Σ	0	0	0	0

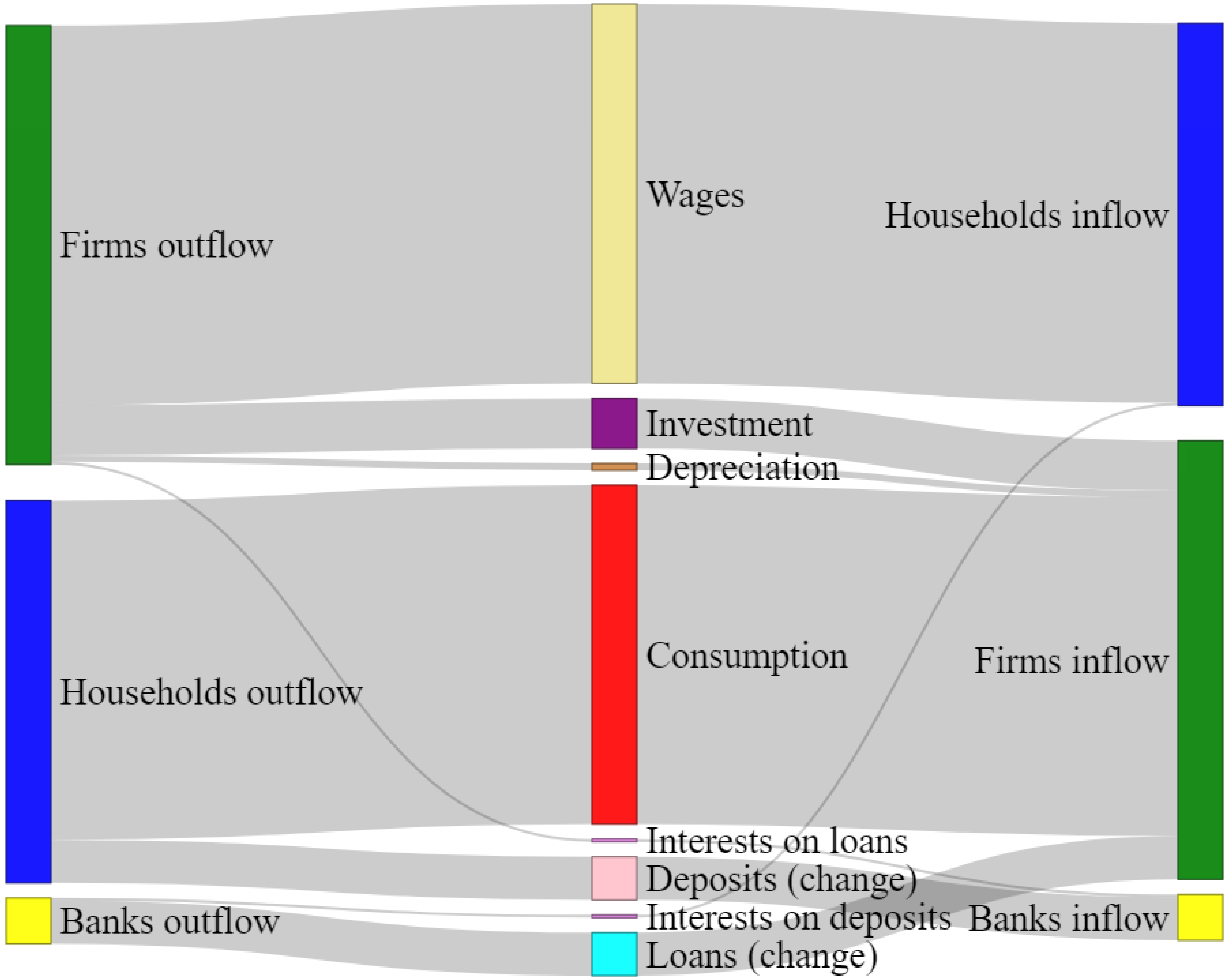
Notes: A '+' before a magnitude denotes an asset; a '–' denotes a liability.

TFM steady-state values

	Households	Production firms		Banks		Σ
		Current	Capital	Current	Capital	
Consumption	−86.4	+86.4				0
Investment		+9.6	−9.6			0
[Production]		[+96]				
Wages	+82.56	−82.56				0
Depreciation		−9.6	+9.6			0
Int. on loans		−3.84		+3.84		0
Int. on deposits	+3.84			−3.84		0
Δ in loans			0		0	0
Δ in deposits	0				0	0
Σ	0	0	0	0	0	0

Notes: A '+' before a magnitude denotes a receipt or a source of funds; a '–' denotes a payment or a use of funds

Sankey diagram of transactions (t=5)



Experiment: shock to consumption

Increase in autonomous consumption: $\alpha_0 = 28$

Figure 2 Evolution of disposable income and consumption following shock to autonomous consumption

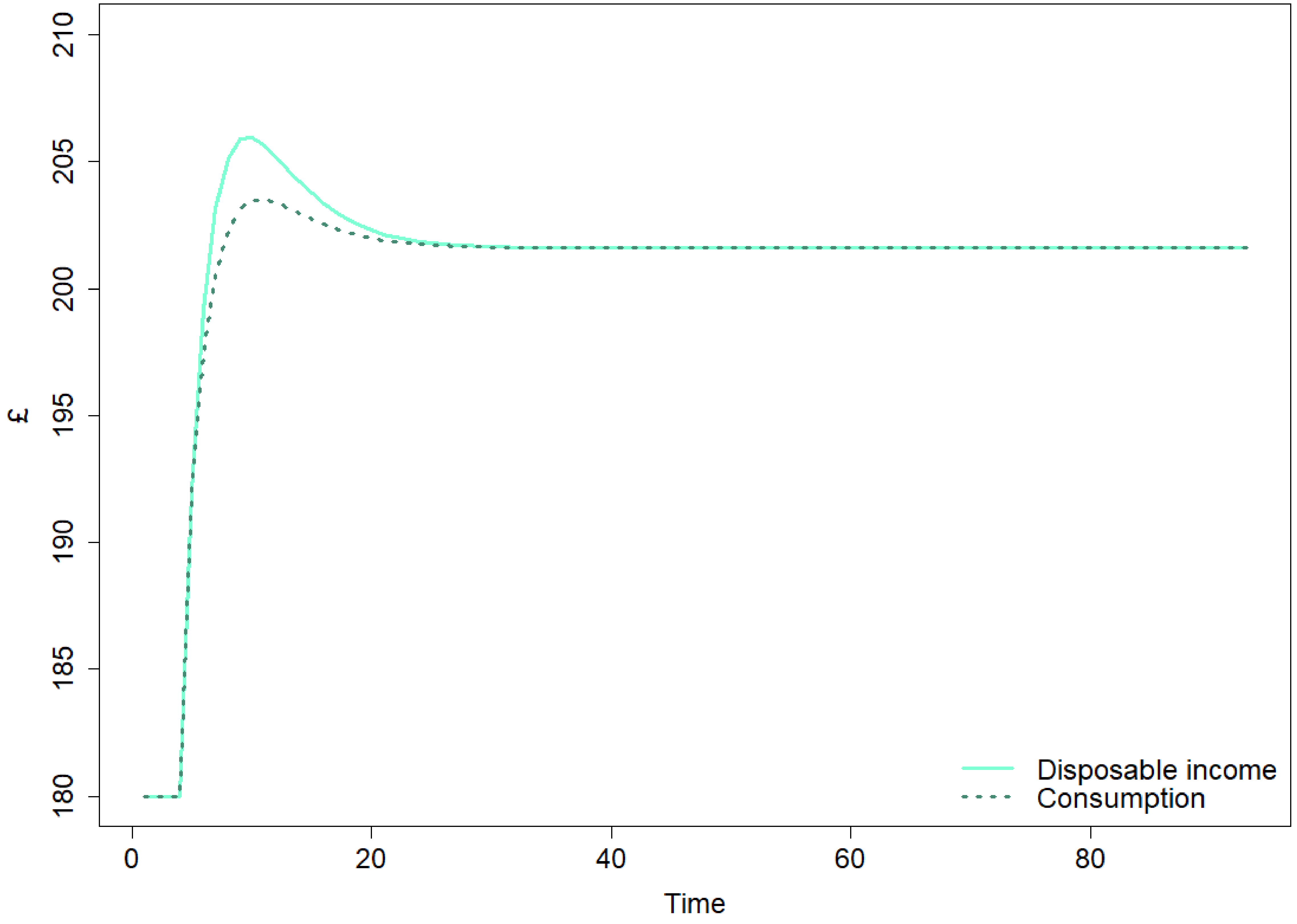
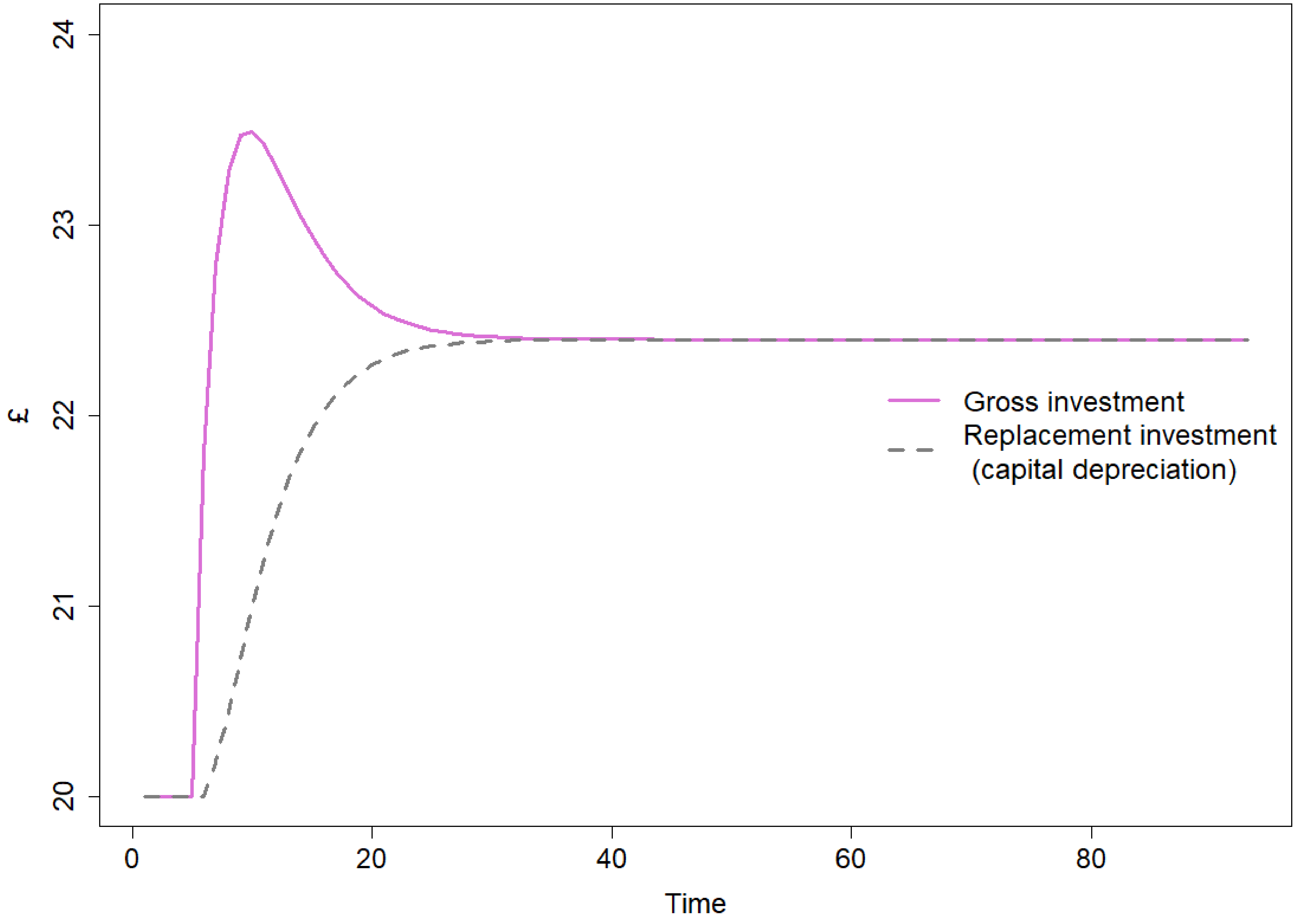


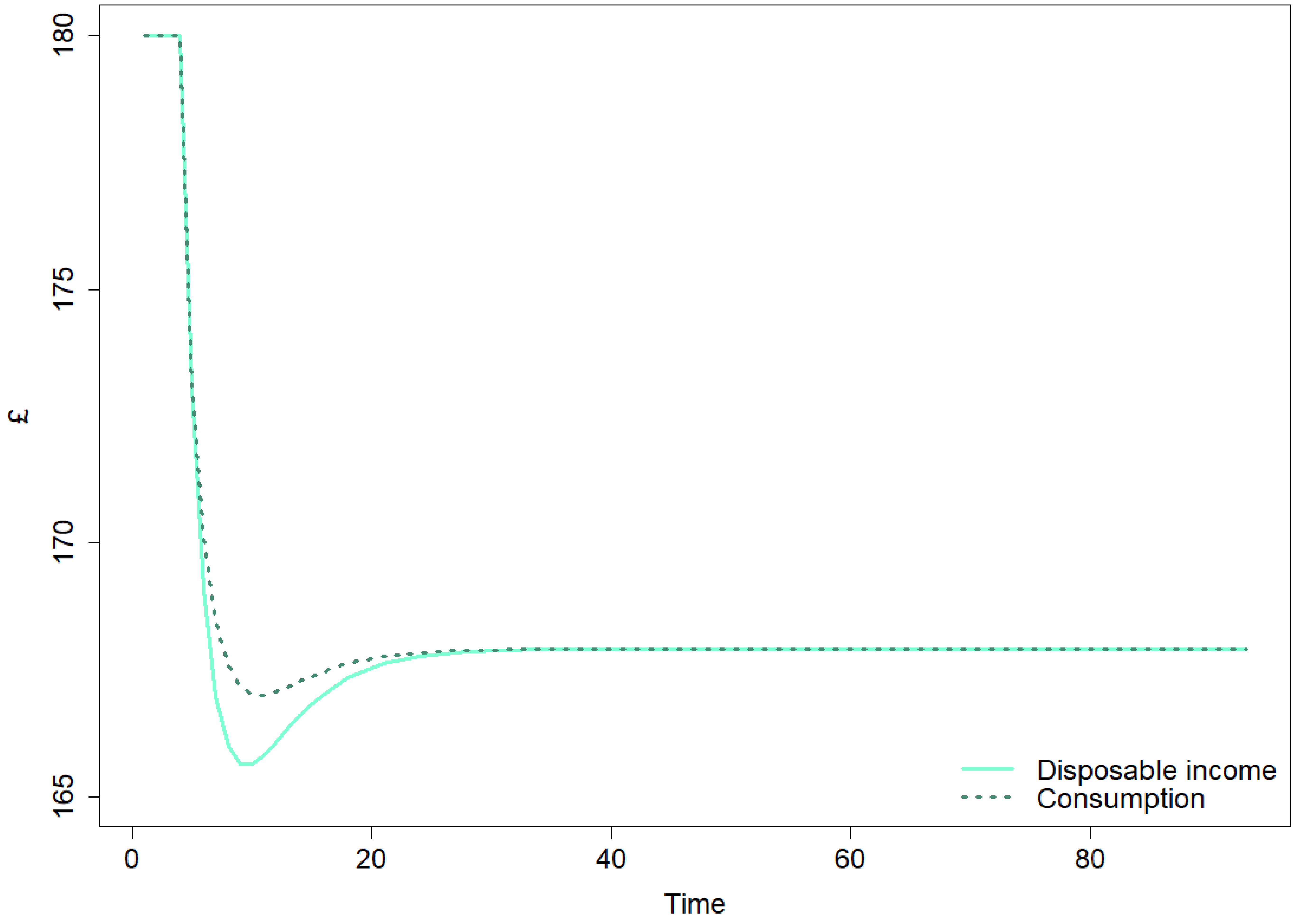
Figure 3 Evolution of investment and depreciation following shock to autonomous consumption



Experiment: higher propensity to save

Higher propensity to save out of income: $(1 - \alpha_1) = 0.26$

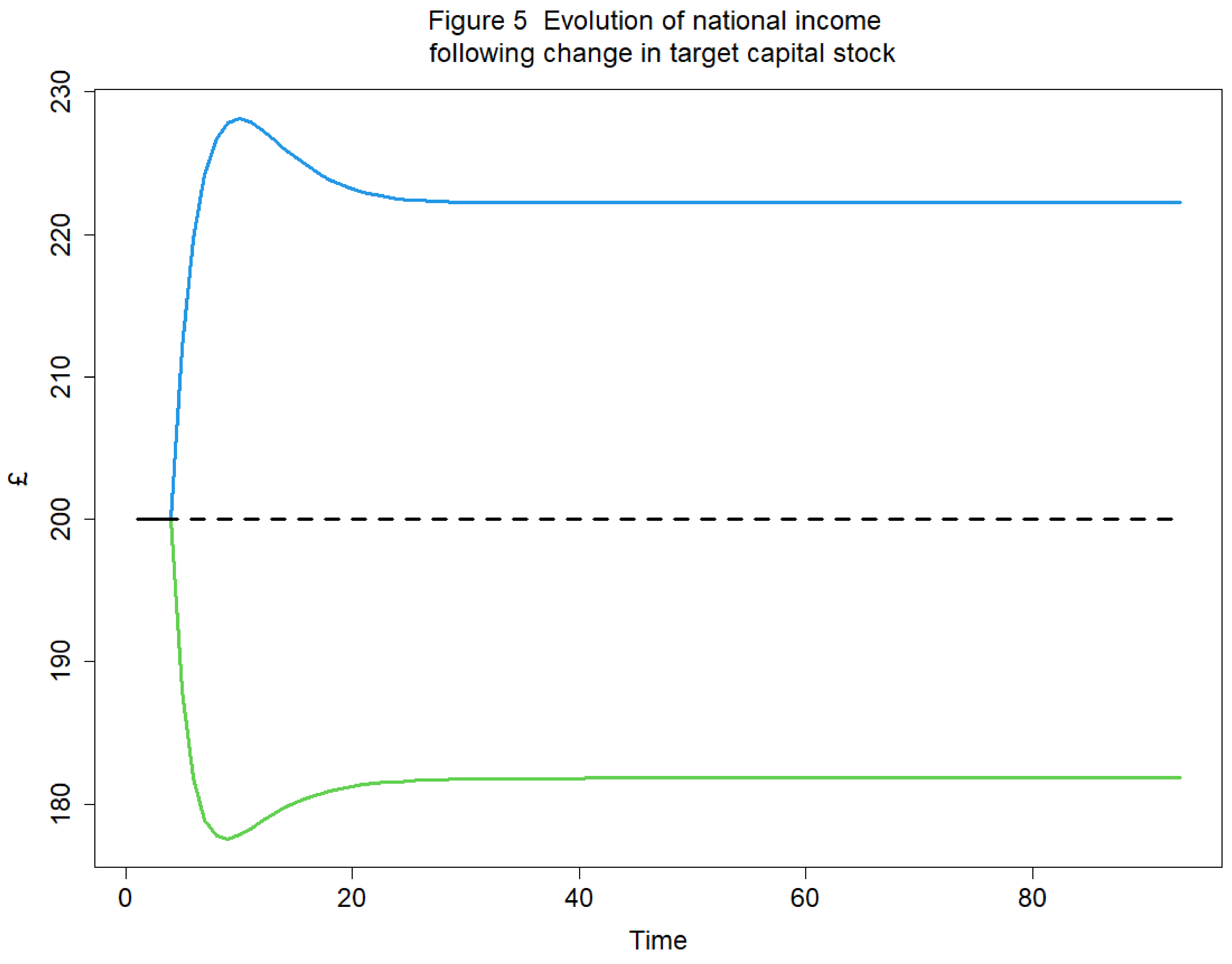
Figure 4 Evolution of disposable income and consumption following increase in propensity to save (paradox ot thrift!)

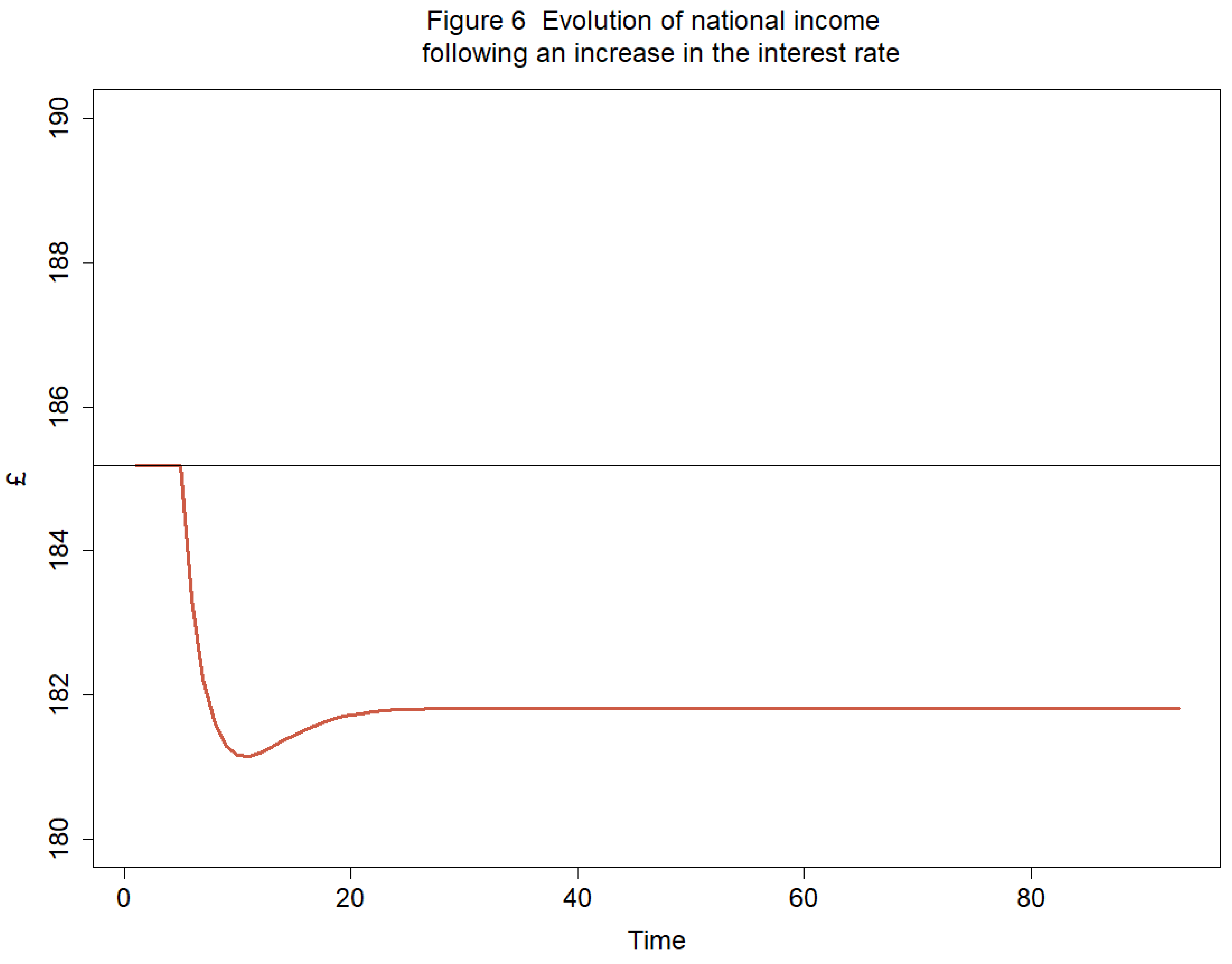


Other experiments

Change in target capital to output ratio: $\kappa_0 = 1$, $\kappa_1 = 1.1$, $\kappa_2 = 0.9$

Increase in interest rate with $c_d = c_d(r)$: $\overline{r_l} = 0.05$





3 Modelling BMW in *R*

Other shocks

- Let us code the model in an R environment and perform the following experiments:
  a) Δ in amortization rate
  b) Δ in interest rates (on deposits and on loans)
  c) Δ in propensities to consume
  d) Δ in investment speed of adjustment
  e) Δ in target capital stock

Useful web resources for SFC modellers

Authors	Description	Link
Alessandro Bramucci	**Interactive Macro** - Website collecting a series of simulators programmed in R and Shiny of some famous macroeconomic textbook models.	Link
Alessandro Caiani	**JMAB** - Simulation tool designed (with Antoine Godin) for AB-SFC macroeconomic modeling.	Link
Yannis Dafermos	**DEFINE** - Ecological stock-flow consistent model that analyses the interactions between the ecosystem, the financial system and the macroeconomy (developed with Maria Nikolaidi and Giorgos Galanis).	Link
Michal Gamrot	**Godley package** - R package for simulating SFC (stock-flow consistent) models.	Link
Antoine Godin	**SFC codes** - R and Python codes collected from seminars and lectures.	Link
Andrea Luciani	**Bimets package** - R package developed with the aim to ease time series analysis and to build up a framework that facilitates the definition, estimation, and simulation of simultaneous equation models.	Link
Joao Macalos	**SFCR package** - R package providing an intuitive and tidy way to estimate stock-flow consistent models.	Link
Jo Michell	**SFC codes** - R and Python codes collected from seminars and lectures.	Link
Franz Prante and Karsten Kohler	**DIY Macroeconomic Model Simulation** - Platform providing an open source code repository and online script for macroeconomic model simulation.	Link
Marco Veronese Passarella (marxianomics)	**SFC codes** - R, Python, Matlab and EViews codes collected from papers, seminars and lectures.	Link
Marco Veronese Passarella (GitHub)	**SFC codes** - R, Python, Matlab and EViews codes collected from papers, seminars and lectures.	Link
Gennaro Zezza	**sfc.models.net** - Repository containing original EViews (and Excel) codes that replicate experiments from Godley and Lavoie's "Monetary Economics", and additional (R and EViews) codes from the SFC literature.	Link

Selected references

KEY READINGS

- W. Godley and M. Lavoie (2007). *Monetary Economics. An Integrated Approach to Credit, Money, Income, Production and Wealth*. Palgrave Macmillan, chapters 1, 2, 3, 4, 7.

ADDITIONAL READINGS

- W. Godley (1999). Seven Unsustainable Processes. *Levy Institute Strategic Analysis*, January 1999.
- C.H. Dos Santos (2006). Keynesian Theorising During Hard Times: Stock-Flow Consistent Models as an Unexplored 'Frontier' of Keynesian Macroeconomics. *Cambridge Journal of Economics*, 30 (4), 541-565.
- M. Nikiforos and G. Zezza (2017). Stock-Flow Consistent macroeconomic Models: A Survey. *Journal of Economic Surveys*, 31 (5), 1204-1239.
- Emilio Carnevali, Matteo Deleidi, Riccardo Pariboni, Marco Veronese Passarella (2019). Stock-Flow Consistent Dynamic Models: Features, Limitations and Developments. In: Philip Arestis, Malcolm Sawyer (eds.): *Frontiers of Heterodox Macroeconomics*, Palgrave Macmillan, 2019, pp. 223-276.

Download lectures' material from:

https://github.com/marcoverpas/Six_lectures_on_sfc_models

Thanks

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