A Post-Keynesian Macro Model with Endogenous Money

*Karsten Kohler**

Leeds University Business School, k.kohler@leeds.ac.uk.

https://karstenkohler.com

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1 Overview

Post-Keynesian Economics is an economic paradigm that was developed in the 1930s and 1940s by Joan Robinson, Nicholas Kaldor and others.[1] The early post-Keynesian economists sought to develop further key ideas of John Maynard Keynes. They were critical of the Neoclassical Synthesis that introduced neoclassical elements into the Keynesian framework. Among many other points, post-Keynesians argued that money is created by commercial banks. Money creation is determined by the demand for credit rather than being under the control of the central bank, and should thus be considered endogenous. Post-Keynesians further assigned a key role to financial factors in the determination of economic activity, but also considered finance as a source of instability. They abandoned the neoclassical approach of deriving labour demand and supply from optimising behaviour and instead assumed oligopolistic market structures. Firms set prices by charging a mark-up on costs and workers set nominal wages based on their bargaining power.

Fontana & Setterfield (2009) present a simple model that could be regarded as a post-Keynesian alternative to the Neoclassical Synthesis. The model highlights the endogenous money creation process. Money is being created when commercial banks make loans to accommodate the demand for credit by creditworthy borrowers. The demand for credit is driven by aggregate demand. The interest rate on loans is determined by the base rate, set by the central bank, on which commercial banks charge a mark-up. Although credit creation is demand-driven, some borrowers will be credit constrained. In times of financial crises, banks tighten credit constraints, which can depress economic activity.

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[1] See Lavoie (2006, chap.1) and Exploring Economics for introductions.

In this short-run model, prices are flexible but the capital stock is fixed. The focus is thus on goods market equilibrium rather than economic growth. As all endogenous variables adjust instantaneously, the model is static. We consider a version of the model due to Fontana & Setterfield (2009) with linear functions.

2 The Model

$$Y = ND + cD \tag{1}$$
$$ND = bY, \qquad b \in (0,1) \tag{2}$$
$$D = d_0 - d_1 r, \qquad d_1 > 0 \tag{3}$$
$$i = i_0 + i_1 P, \qquad i_1 > 0 \tag{4}$$
$$r = (1+m)i, \qquad m > 0 \tag{5}$$
$$dL = cD \tag{6}$$
$$dM = dL \tag{7}$$
$$dR = k dM, \qquad k \in (0,1) \tag{8}$$
$$P = (1+n)aW, \qquad a, n > 0 \tag{9}$$
$$W = W_0 - hU, \qquad h > 0 \tag{10}$$
$$w = \frac{1}{(1+n)a} \tag{11}$$
$$N = aY \tag{12}$$
$$U = 1 - \frac{N}{N^f} \tag{13}$$

where Y, ND, D, r, i, P, dL, dM, dR, W, w, N, U, and N^f are output, the not debt-financed component of aggregate demand, the desired debt-financed component of aggregate demand, the lending rate, the policy rate, the price level, the change in loans, the change in money (bank deposits), the change in bank reserves, the nominal wage, the real wage, employment, the unemployment rate, and full employment (or total labour supply), respectively.

Equation (1) is the goods market equilibrium condition. Aggregate supply (Y) accommodates to the level of aggregate demand which is the sum of a not debt-financed component (ND) and a (desired) debt-financed component (D). The coefficient c is the proportion of loan applications that are deemed creditworthy and thus captures credit rationing by banks. By equation (2), the not debt-financed component of aggregate demand is a function

of current income. In equation (3), the debt-financed component of aggregate demand has an autonomous component (d_0)[2] and is otherwise negatively related to the lending rate r. Equation (4) specifies the monetary policy rule, where it is assumed that the central bank raises the policy rate i when the price level increases.[3] The lending rate in equation (5) is given by a mark-up m that banks charge on the policy rate (which is the rate at which they can borrow reserves). The change in loans in equation (6) is equal to the creditworthy demand for loans (cD). This captures the demand-driven nature of credit creation. The changes in loans translates one-to-one into a change in money, which are bank deposits in this model (equation 7). This reflects the endogenous money creation process where commercial banks create new deposits when they make new loans. By equation (8), banks obtain new reserves from the central bank to maintain a constant reserve-to-deposit ratio k. Thus, the causality in this model runs from debt-financed demand to loans, to deposits, and finally to reserves.

By equation (9), the price level is set by firms based on a mark-up (n) on unit labour cost (which are the product of the nominal wage W and the labour coefficient a). Nominal wages are set by workers based on their bargaining power, which is declining in the unemployment rate (equation 10). The real wage in equation (11) is derived from the pricing equation (9), i.e. through their price setting power, firms ultimately determine the real wage. The level of employment in equation (12) is determined residually based on economic activity and a constant-coefficient production function $(Y = \frac{N}{a})$. Finally, the level of employment in conjunction with an exogenously given labour force N^f (or total available labour time) can be used to obtain an unemployment rate in equation (13).

3 Simulation

Table 1 reports the parameterisation used in the simulation. Besides a baseline (labelled as scenario 1), five further scenarios will be considered. Scenario 2 is a rise in credit rationing in the form of a fall in c. In scenario 3, autonomous credit-financed demand (d_0) increases. Scenarios 4 and 5 consider a rise in the interest rate (or bank) mark-up (m) and in the price (or firm) mark-up (n), respectively. Scenario 6 considers a rise in productivity reflected in a fall of the labour coefficient a.

[2]For simplicity, it is assumed that all autonomous demand is debt-financed, i.e. there is no spending out of wealth.

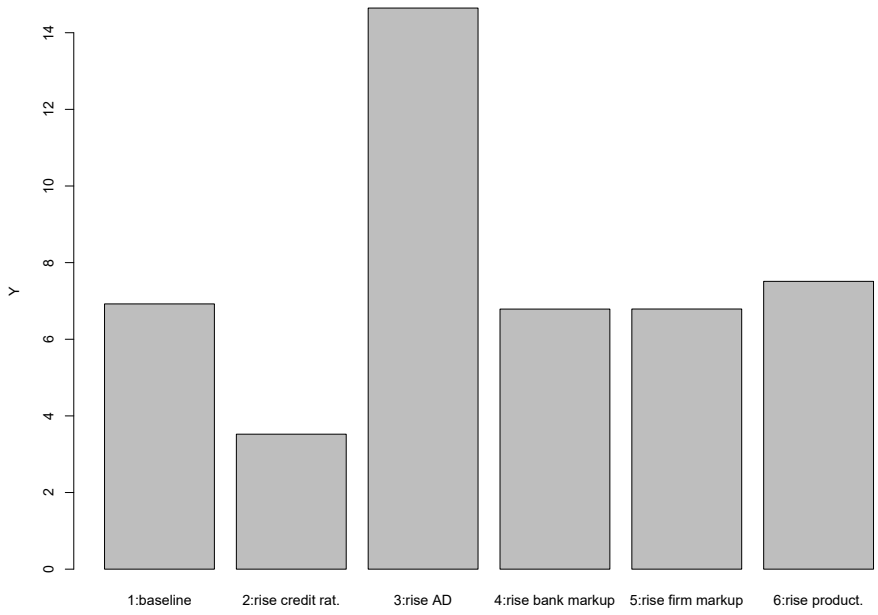
[3]This specification is somewhat unrealistic given that most modern central banks target a positive rate of inflation. However, it allows for an AS-AD representation of the model, which facilitates the comparison with the Neoclassical Synthesis model.

Table 1: Parameterisation

Scenario	b	c	d_0	d_1	i_0	$i1$	m	k	n	W_0	h	a	N^f
1: baseline	0.5	0.8	5	0.8	0.01	0.5	0.15	0.3	0.15	2	0.8	0.8	12
2: rise in credit rationing (c)	0.5	0.4	5	0.8	0.01	0.5	0.15	0.3	0.15	2	0.8	0.8	12
3: rise in autonomous demand (d_0)	0.5	0.8	10	0.8	0.01	0.5	0.15	0.3	0.15	2	0.8	0.8	12
4: rise in bank mark-up (m)	0.5	0.8	5	0.8	0.01	0.5	0.3	0.3	0.15	2	0.8	0.8	12
5: rise in firm mark-up (n)	0.5	0.8	5	0.8	0.01	0.5	0.15	0.3	0.3	2	0.8	0.8	12
6: rise in productivity (a)	0.5	0.8	5	0.8	0.01	0.5	0.15	0.3	0.15	2	0.8	0.4	12

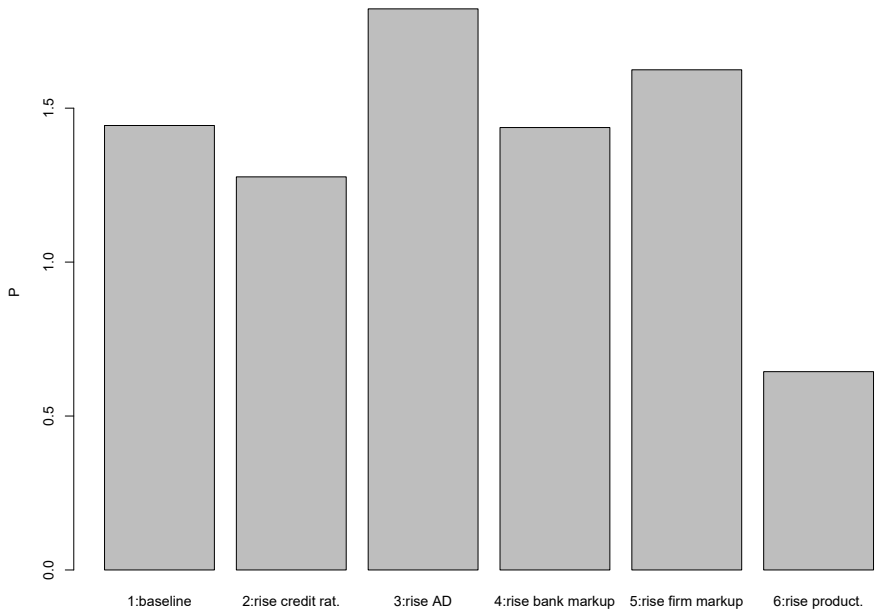
Figures 1-7 depict the response of the model's key endogenous variables to various shifts.

Figure 1: Output



An increase in credit rationing (scenario 2) reduces deposit money creation as well as actual (as opposed to desired) aggregate demand. This drags down output and employment. The rise in unemployment reduces workers' nominal wage demands and thus the price level. The lending rate falls as the central bank reduces the policy rate.

Figure 2: Price level



An increase in (debt-financed) autonomous demand (scenario 3) has expansionary effects on output and employment. The money stock accommodates through increased loan creation. The increase in workers' bargaining power leads to higher nominal wages and prices. The central bank reacts by raising the policy rate but this does not completely offset the expansionary effect.

Figure 3: Lending rate

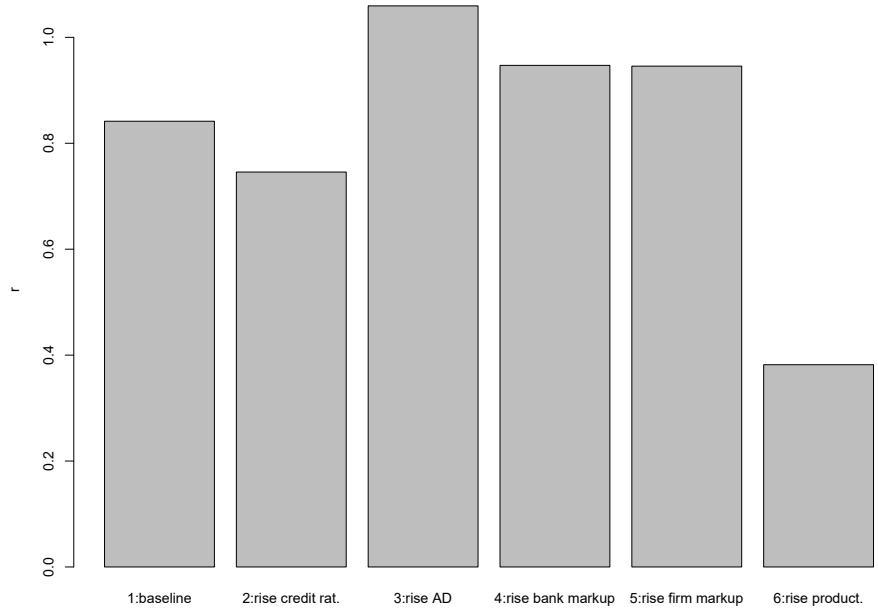
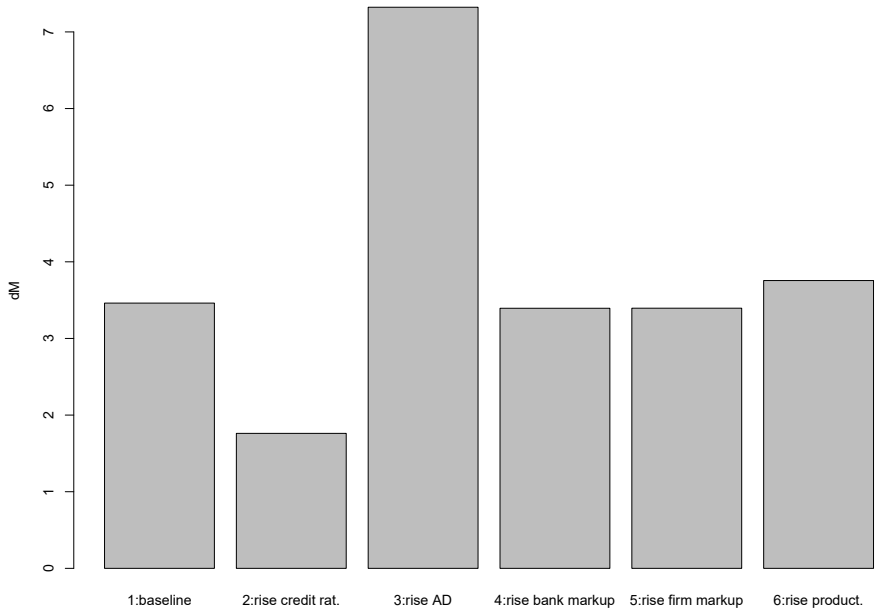


Figure 4: Deposit money creation



In scenarios 4 and 5, the interest rate (or bank) mark-up and the price (or firm) mark-up

increase, respectively. The increase in the bank mark-up raises the lending rate, which has a contractionary effect. The increase in the firm mark-up raises the price level, which has a contractionary effect through the monetary policy response. Notably, the rise in the price mark-up reduces the real wage.

Figure 5: Unemployment rate

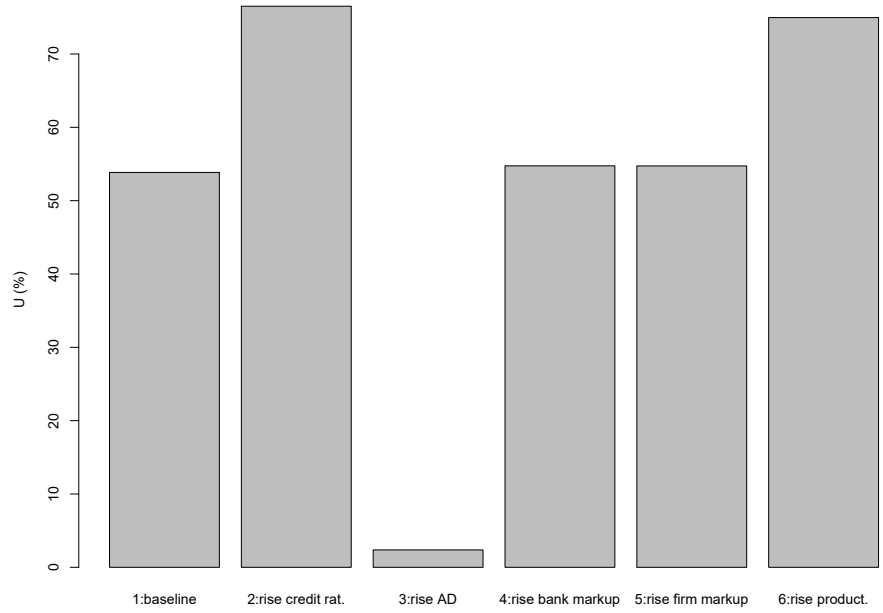
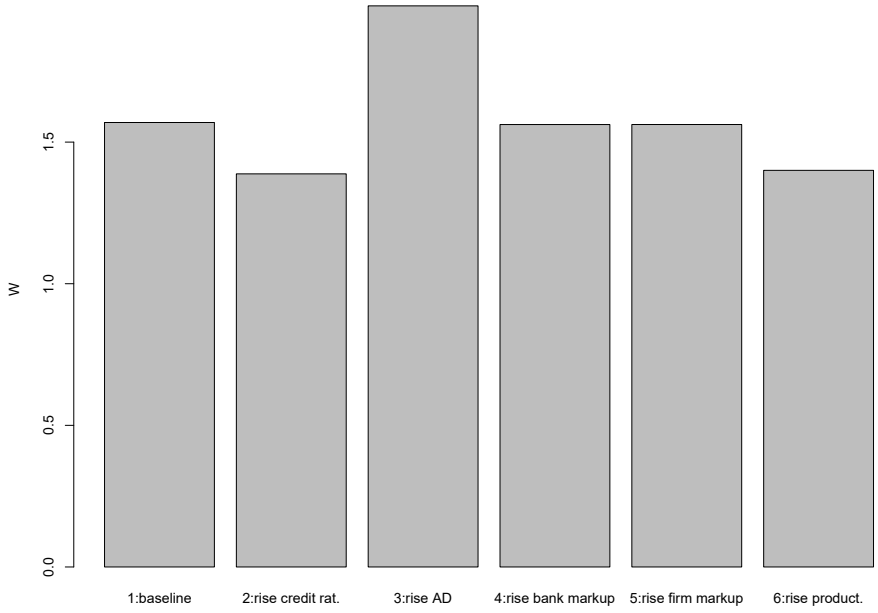
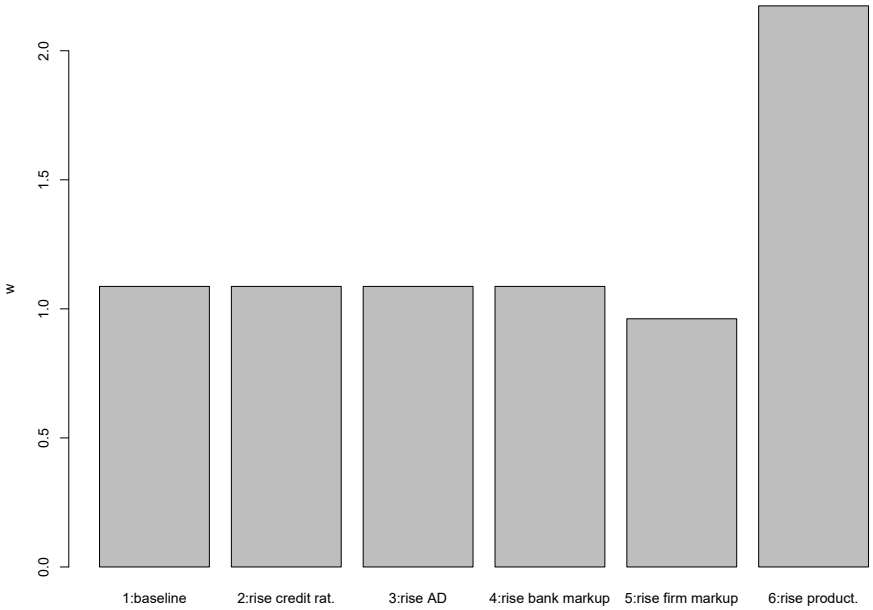


Figure 6: Nominal wage



Finally, an increase in productivity (scenario 6) reduces the price level, which induces a lower policy rate, leading to a small expansionary effect. However, it increases the unemployment rate as fewer workers are needed to produce the same level of output. This reduces the nominal wage, but raises the real wage.

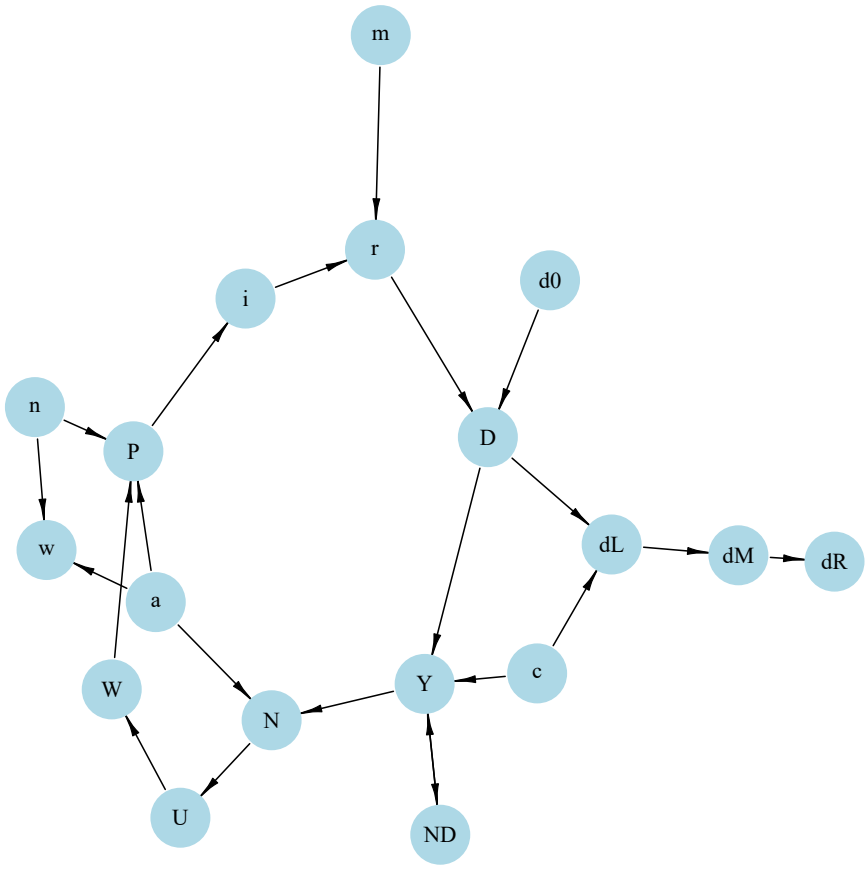
Figure 7: Real wage



4 Directed graph

Another perspective on the model's properties is provided by its directed graph. A directed graph consists of a set of nodes that represent the variables of the model. Nodes are connected by directed edges. An edge directed from a node x_1 to node x_2 indicates a causal impact of x_1 on x_2.

Figure 8: Directed graph of post-Keynesian endogenous money model



In Figure 8, it can be seen that credit rationing (c), productivity (a), the price mark-up (n), the interest rate mark-up (m), and autonomous demand (d_0), are the key exogenous variables of the model. All other variables are endogenous, and many of them form a closed loop (or cycle) within the system. The lower-right part of the graph captures the goods market: debt- and not debt-financed aggregate demand determine output. The outer right part depicts the endogenous money creation process: creditworthy debt-financed demand determines credit creation, which translates into deposit money creation. Bank reserves are a residual. The lower-left part of the graph represents the labour market. The goods market feeds into the labour market via employment, which determines nominal wages and the price level. The real wage is a residual. The price level feeds into interest rate determination in the upper part of the model, which establishes a causal feedback link from the labour market to the goods market.

Appendix

A Analytical solution

Like the Neoclassical Synthesis model, the post-Keynesian macro model can be represented as an AS-AD model. First, we will derive an IS and an MP curve in the (Y, r)-space, the latter representing monetary policy instead of the money market (the conventional LM curve). Then we obtain the AS-AD representation of the model in the (Y, P)-space. Finally, we obtain equilibrium solutions for Y and P.

To obtain the IS-curve, substitute (2)-(5) into (1) and solve for Y:

$$Y = \left(\frac{1}{1-b}\right)\Big[c(d_0 - d_1 r)\Big]. \tag{IS}$$

To obtain the MP-curve, substitute (4), (9), (10), (12), and (13) into (5):

$$r = (1+m)\Big[i_0 + i_1(1+n)a[W_0 - h\big(1 - \frac{aY}{N^f}\big)]\Big]. \tag{MP}$$

It can readily be seen that the IS-curve is downward-sloping and the MP-curve is upward-sloping in the (Y, r)-space

To obtain the AD-curve, substitute (5) and (4) into the IS-curve:

$$Y = \left(\frac{1}{1-b}\right)\Big[c(d_0 - d_1(1+m)(i_0 + i_1 P))\Big]. \tag{AD}$$

Finally, to obtain the AS-curve, substitute (10) and (13) into (9):

$$P = (1+n)\,a\Big[W_0 - h\big(1 - \frac{aY}{N^f}\big)\Big]. \tag{AS}$$

It can readily be seen that the AD-curve is downward-sloping in the (Y, P)-space, whereas the AS-curve is upward-sloping.

Finally, by substituting (AS) and (AD) into each other, we obtain the following equilibrium

solutions for output and the price level:

$$Y^* = \frac{c[d_0 - d_1(1+m)(i_1(1+n)a(W_0 - h))]}{1 - b + cd_1(1+m)i_1(1+n)a^2h(N^f)^{-1}}$$
$$P^* = \frac{(1+n)a[(1-b)(W_0 - h) + ha(N^f)^{-1}c(d_0 - d_1(1+m)i_0)]}{1 - b + cd_1(1+m)i_1(1+n)a^2h(N^f)^{-1}}.$$

B Construction of directed graph

The directed graph can be derived from the model's Jacobian matrix.[4] Let $\mathbf{x}$ be the vector containing the model's variables.[5] The system of equations representing the model can be written as $\mathbf{f}(\mathbf{x}) = \mathbf{0}$. The Jacobian matrix is then given by $\mathbf{J} = \frac{\partial \mathbf{f}}{\partial \mathbf{x}}$.

Next, construct an 'auxiliary' Jacobian matrix $\mathbf{M}$ in which the non-zero elements of the Jacobian are replaced by ones, whereas zero elements remain unchanged, i.e.

$$M_{ij} = \begin{cases} 1 & \text{if } J_{ij} \neq 0, \\ 0 & \text{otherwise.} \end{cases}$$

Finally, taking the transpose of the 'auxiliary' Jacobian matrix yields the adjacency matrix ($\mathbf{M^T} = \mathbf{A}$), which is a binary matrix whose elements (A_{ji}) indicate whether there is a directed edge from a node x_j to node x_i. From the adjacency matrix, the directed graph is constructed.

[4] See Fennell et al. (2015) for a neat exposition.

[5] Exogenous variables that are supposed to appear in the directed graph can readily be added to the Jacobian by an appropriate extension of rows and columns.

References

Fennell, P. G., O'Sullivan, D. J. P., Godin, A. & Kinsella, S. (2015), 'Is it possible to visualise any stock flow consistent model as a directed acyclic graph?', *Computational Economics* **48**(2), 307–316.

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Lavoie, M. (2006), *Introduction to Post-Keynesian Economics*, Palgrave Macmillan.