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Coffee, economic fluctuations and stabilisation: an intertemporal disequilibrium model with capital market imperfections

Jesús G. Otero *

Facultad de Economía, Universidad del Rosario, Apartado Aereo 9316, Bogotá, Colombia

Abstract

This paper develops a two-period disequilibrium model of a small open economy under Keynesian unemployment to analyse the effects of temporary, anticipated, and permanent coffee price shocks. The model includes a government sector that administers a commodity price stabilisation fund, and allows for capital market imperfections. The type of capital market imperfection makes an important difference to the results of the model. In particular, when the government borrows on more favourable terms than individuals, the coffee price stabilisation fund reduces the multiplier effects of temporary and permanent shocks not only in the first, but also in the second period. By contrast, when individuals face an upward-sloping supply of capital curve, the stabilisation fund shifts some of these effects from the first to the second period.

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1. Introduction

The Colombian economy has been characterised by the importance of the coffee sector as one of the main sources of foreign exchange, employment, and

* Tel.: +571-344-57-50 ext. 661; fax: +571-3445763.
E-mail address: jotero@claustro.urosario.edu.co (J.G. Otero).

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value added. Since 1927, the National Federation of Coffee Growers, a private non-profit organisation of coffee producers, has been charged by the government with directing coffee policy. Among other functions, the Federation administers the National Coffee Fund (NCF), a public account originally created, in 1940, with the purpose of purchasing excess production over the international export quota arrangement between the United States and the main Latin American producers. Since the 1950s, the Federation has been using the NCF as a price stabilisation device, keeping the variations in the domestic price paid to farmers proportionally lower than the variations in the world price.

Several studies have identified coffee as the primary driving force of the business cycle in Colombia. [1] Cárdenas (1991) presents evidence that the business cycle in Colombia is highly correlated with the business cycles in Costa Rica, Ivory Coast and Kenya, which are also coffee producers. Further, he finds that economic fluctuations tend to be less pronounced in Colombia, and argues that this can be explained by the degree to which the domestic coffee price is stabilised, and by the countercyclical response of government expenditure. The NCF thus helps prevent a highly procyclical output response during a coffee boom, as it generates surpluses (deficits) when the world coffee price is higher (lower) than the internal price.

Despite the extensive empirical evidence, relatively few studies have attempted to formalise the theoretical relationship between the world coffee price and the business cycle. Cárdenas (1991) presents two models of export-led business cycles. The first model focuses on the real aspects, and is based on the Keynesian view of macroeconomic fluctuations. The distinctive feature of the model is that government expenditure responds endogenously to external shocks; the response of the government is thus crucial in the model, since a procyclical (countercyclical) government expenditure reinforces (reduces) the effect of a coffee price shock on output. The second model, a modified version of the models used by Eastwood and Venables (1982), Neary and Van Wijnbergen (1984, 1986), and Edwards (1986), focuses on the effects of foreign exchange accumulation on the money supply, and emphasises the role of the real exchange rate in determining the production structure of the economy. Another theoretical model is that of Montenegro (1991), who addresses the effects of external shocks and stabilisation policy measures on the allocation of resources (more precisely labour) in a small open economy, which is assumed to have some of the characteristics of the Colombian economy. Montenegro's starting point is the (static) tradables–nontradables model with microeconomic foundations, in both its flexible and fixed

[1] See Díaz-Alejandro (1976), Carkovic (1986), Cuddington (1986), Ocampo (1989) and Gaviria and Uribe (1993).

price versions; the model is augmented with the inclusion of a ''booming'' tradable sector, as in standard Dutch disease models (see e.g. Corden and Neary, 1982; Neary and Van Wijnbergen, 1986).

The theoretical models of Cárdenas and Montenegro are clearly important, since they intend to provide a formal theory of the possible transmission mechanism from export prices to output fluctuations. Nonetheless, their models have important drawbacks. First, in the models of Cárdenas the functional forms are ad-hoc in the sense that they are not derived from microeconomic principles. Second, Montenegro models in a relatively simple way the utility maximising problem, since consumers do not take into account their whole life-time utility functions and budget constraints. Third, both the Cárdenas and Montenegro models are static, so that it is not possible to distinguish between temporary, anticipated and permanent coffee price shocks; that is, intertemporal issues are not treated. Lastly, in none of their models does the coffee price stabilisation fund play a role in reducing the amplitude of output fluctuations, whereas this is precisely one of the aspects we want to model.

This paper develops an intertemporal (two-period) disequilibrium model of a small open economy to analyse the effects of coffee price shocks. The basic model, built on previous work by Cuddington and Viñals (1986) and Fender and Nandakumar (1987), assumes that some prices are fixed above their market clearing levels, so that agents on the long side of the market will be rationed. We opt for the disequilibrium (or quantity-constrained) approach, in preference to the more classical view of Walrasian equilibrium in all markets, because it adds the realism of unemployment.[2] The intertemporal dimension of the model implies that there will be at least 12 possible market configurations, depending on the type of disequilibrium in the labour and goods markets. Instead of analysing all possible rationing regimes, which might become tedious, we assume that the economy has short- and long-run wage-price stickiness that gives rise to Keynesian unemployment. This configuration may well capture some of the characteristics not only of the Colombian economy, but also of other developing countries that rely on exports of primary commodities.[3]

The basic model is then extended by including a government sector that is in charge of the administration of a coffee price stabilisation fund, which is aimed at reducing the effects of commodity price instability on the economy. In addition,

[2] In Colombia, the unemployment rate has fluctuated around 11%, slightly above the average of Latin America, and since 1994 it has been increasing reaching 15.9% in June 1998.

[3] In a longer version of this paper, we discuss two additional disequilibrium regimes: (a) Keynesian unemployment in the short-run and Walrasian equilibrium in the long-run; and (b) *orthodox* Keynesian unemployment in the short- and long-run (under this regime all goods prices are flexible). See Cuddington et al. (1984) for other disequilibrium regimes considered in the literature.

we allow for the presence of capital market imperfections, motivated by the belief that this is a relevant assumption for a country such as Colombia, where the fraction of income accruing to consumers who are liquidity constrained varies between 60% and 75%, providing not much support for the permanent income hypothesis nor for the Ricardian equivalence proposition (see Haque and Montiel, 1989; Vaidyanathan, 1993; López, 1994). With reference to the earlier static models of Cárdenas (1991) and Montenegro (1991), one might argue that their assumption that agents cannot borrow and lend at all is too strong, in view of the major liberalising reforms that the Colombian government has been implementing since 1989.[4] But, on the other hand, to assume perfect borrowing and lending opportunities is also too strong.

Capital market imperfections are initially modelled as in Van Wijnbergen (1987). That is, we assume that the government can borrow on more favourable terms in international capital markets than individuals. In a subsequent stage of the analysis, we use an alternative modelling strategy in which we assume that individuals face an upward-sloping supply of capital funds. As will be seen, under the Van Wijnbergen assumption, the private sector's intertemporal budget constraint is nevertheless still linear, so that there is no impediment to ''consumption smoothing'' by private agents. On the other hand, when individuals face an upward-sloping supply of capital funds, the private sector's intertemporal budget constraint turns out to be non-linear.

The type of capital market imperfection makes an important difference to the results of the model. Assuming preferential government borrowing, the coffee price stabilisation fund reduces the multiplier effects of a first-period shock in both periods. By contrast, assuming an upward-sloping capital supply schedule, the coffee price stabilisation fund shifts some of these effects from period 1 to period 2; in this case, the fund is less successful at stabilising output since it dampens but also prolongs the coffee price shock. The model also predicts that when both the government and individuals borrow on the same terms, the stabilisation fund is not able to smooth out output fluctuations resulting from variations in the world coffee price.

The paper proceeds as follows. Section 2 describes the structure of the basic model, and analyses the effects of temporary, anticipated and permanent coffee price shocks on a small open economy under Keynesian unemployment. Section 3 extends the basic model, by including a coffee price stabilisation fund, and capital market imperfections as modelled by Van Wijnbergen (1987). Section 4 examines the basic model in the presence of a coffee price stabilisation fund, and an upward-sloping supply of capital funds. Section 5 offers some concluding remarks.

[4] See Urrutia (1994) for a description of these reforms.

2. The basic model

The model is a two-period disequilibrium model with microeconomic foundations of a small open economy.[5] Throughout the analysis, we occasionally refer to period 1 as the present and period 2 as the future, although they can be alternatively thought of as the short and long run, respectively. The economy produces nontradable goods, tradable goods, and a booming tradable good which we refer to as coffee. All three goods are assumed to be non-storable[6] and used for final consumption. Given that we are not interested in the effects of monetary policy, we assume that there is no money in the economy, which implies that all prices will be relative. The price of tradables is chosen as the numeraire. Initially, there is no public sector, although this assumption is relaxed later on by incorporating a government that is in charge of the administration of a coffee price stabilisation fund. All economic agents are assumed to have perfect foresight.

The small open economy assumption implies not only that the country's aggregate supply of tradables (and coffee) can always be sold at the prevailing world prices, but also that the economy never faces quantity constraints when buying or selling tradable goods in the world market. In contrast, in the nontradables and labour markets prices are assumed to be arbitrarily fixed, not necessarily at the clearing market level, which brings the possibility of excess supply (or demand) in the model. In the context of our intertemporal model, there are various possible configurations depending on the type of disequilibrium in the nontradables and labour markets.[7] For our purposes, we assume that in periods 1 and 2 the wage rate and the relative price of nontradables are fixed above their market clearing levels, which implies excess supply in these markets (that is, there is Keynesian unemployment in the short and long run).

2.1. The household sector

Consumers derive utility from consuming nontraded and traded goods in periods 1 and 2; coffee is not consumed domestically but exported to the rest of the world. In order to ease the derivation of the results, we assume, as is often the case in intertemporal disequilibrium models, that consumers' preferences can be

[5] See Rankin (1994) for a survey of two-period disequilibrium models of open economies.

[6] Assuming that coffee is non-storable is not unrealistic since in practice it can be stored for up to six months and, in our model, each period should be thought of as lasting significantly longer (half a business cycle or so).

[7] Neary (1980) pioneered the disequilibrium version of the tradables–nontradables model.

adequately summarised with an additive time-separable, log linear utility function (U):

$$U = \alpha \log C_{N1} + (1-\alpha)\log C_{T1} + \beta\{\alpha \log C_{N2} + (1-\alpha)\log C_{T2}\}, \qquad (1)$$

where C_{N1} (C_{N2}) represents consumption of the nontraded good in period 1 (2); C_{T1} (C_{T2}) denotes consumption of the traded good in period 1 (2); $\beta = (1+\delta)^{-1}$, where δ is the time preference rate which is assumed to be constant; and $0 < \alpha < 1$. As is well-known, the use of this particular functional form implies zero cross-price effects in the resulting commodity demand functions.

The household's budget constraint restricts the present value of consumption spending on nontradables and tradables to equal the present value of output, that is:

$$p_{N1}C_{N1} + C_{T1} + \frac{1}{\bar{R}}\{p_{N2}C_{N2} + C_{T2}\}$$

$$= p_{N1}Y_{N1} + Y_{T1} + p^{*}_{C1}Y_{C1} + \frac{1}{\bar{R}}\{p_{N2}Y_{N2} + Y_{T2} + p^{*}_{C2}Y_{C2}\} = W \qquad (2)$$

where, $Y_{N,t}$, $Y_{T,t}$, and $Y_{C,t}$ ($t = 1,2$) denote output of nontradables, tradables and coffee, respectively; $\bar{R} = 1 + \bar{r}$ is the gross interest rate ($\bar{r}$ is the world interest rate in terms of tradables); $p_{N,t}$ and $p^{*}_{C,t}$ ($t = 1,2$) denote the relative price of nontradables and coffee, respectively; and W is wealth.

The household's problem reduces then to maximising Eq. (1) subject to Eq. (2), which yields the following demand functions for nontradables in periods 1 and 2:

$$C_{N1} = \frac{\alpha}{(1+\beta)}\frac{W}{p_{N1}} \qquad (3a)$$

and

$$C_{N2} = \frac{\alpha\beta\bar{R}}{(1+\beta)}\frac{W}{p_{N2}}, \qquad (3b)$$

respectively (the corresponding demands for tradables are also a function of wealth).

2.2. The production sector

In each of the two periods nontradables, tradables and coffee are produced using labour, which constitutes the only variable factor of production; diminishing returns to labour are assumed. The problem faced by producers is that of choosing

labour input to maximise profits, subject to the sector's production function. Taking first the case of non-tradable producers in $t = 1,2$, the firm's supply is:

$$Y_{N,t} = Y_{N,t}\left(\overset{(-)}{w_t/p_{N,t}}\right),$$

which depends negatively on the wage rate, and positively on the product's price. This supply function is presented for purposes of comparison, since it is only relevant in the hypothetical case in which prices are flexible, but we will later be concerned with the case of Keynesian unemployment.

The output of tradables is a decreasing function of the wage rate, that is:

$$Y_{T,t} = Y_{T,t}\left(\overset{(-)}{w_t}\right),$$

where, it should be noticed that $Y_{T,t}$ is exogenous as long as w_t is exogenous.

Lastly, in the coffee sector the demand for labour is assumed to be completely inelastic to changes in the real wage rate, i.e. $L_{C,t} = \bar{L}_{C,t}$, so that the firm's supply of coffee becomes independent of the real wage rate, i.e. $Y_{C,t} = Y_{C,t}(\bar{L}_{C,t})$. This assumption aims at capturing the idea that once coffee trees have been planted, coffee producers will employ in each period the labour force required to collect the coffee fruits, no matter the real wage rate. In terms of Corden and Neary's (1982) analysis of the Dutch disease phenomenon, this assumption allows us to focus on the so-called ''spending effect'', and rule out the ''resource movement effect'' (i.e. the latter can be regarded as negligible). Hence, in the model the coffee sector may be alternatively thought of as an ''enclave''-type sector, that is, a sector that uses very specific factors of production, so that it does not compete for production factors (in this case labour) with the other sectors of the economy.

2.3. Market equilibrium

Since we assume Keynesian unemployment in the short and long run, nontradables output will be demand determined; more formally, the (IS1) equation

$$Y_{N1} = C_{N1}, \tag{4a}$$

denotes the market equilibrium condition in period 1, and the (IS2) equation

$$Y_{N2} = C_{N2}, \tag{4b}$$

is the corresponding expression in period 2. Substituting the commodity demand functions for nontradables given in Eqs. (3a) and (3b), and the expression for wealth given in Eq. (2) into the (IS1) and (IS2) equations we obtain:

$$p_{N1}Y_{N1} = \frac{\alpha}{(1+\beta)}\left\{p_{N1}Y_{N1} + p^*_{C1}Y_{C1} + \frac{p_{N2}Y_{N2} + p^*_{C2}Y_{C2}}{\bar{R}} + \bar{Y}_T\right\} \tag{5a}$$

and

$$p_{N2}Y_{N2} = \frac{\alpha\beta\bar{R}}{(1+\beta)}\left\{p_{N1}Y_{N1} + p^*_{C1}Y_{C1} + \frac{p_{N2}Y_{N2} + p^*_{C2}Y_{C2}}{\bar{R}} + \bar{Y}_T\right\}, \qquad (5b)$$

where tradables output is treated as constant since w_1 and w_2 are assumed to be exogenous, i.e. $\bar{Y}_T = Y_{T1} + \bar{R}^{-1}Y_{T2}$.

Fig. 1 presents a diagrammatic representation of the model in (Y_{N1}, Y_{N2}) space. The IS1 and IS2 equations give a pair of upward-sloping curves, so that there are two possibilities depending on whether the IS1 locus is steeper than the IS2 locus. Throughout the analysis, we consider the case where the former is steeper than the latter, as required for the system to have a stable equilibrium (see Appendix A).

The initial equilibrium of the economy is depicted as point E in Fig. 1. Consider now the effects of a temporary increase in the world coffee price (i.e. $\mathrm{d}p^*_{C1} > 0$, $\mathrm{d}p^*_{C2} = 0$). This shifts the IS1 schedule to the right, and also induces an upward shift in the IS2 schedule. The new equilibrium of the economy is reached at point T, where the IS1* and the IS2* schedules cross each other, and this point is characterised by a greater level of nontradables output in both the current period and the future. The transition of the economy from E to T can be explained following similar lines to that of Neary and Stiglitz (1983). In particular, a temporary increase in the world price of coffee raises people's income, which in turn raises demand for nontradables consumption in period 1, and we thus have a ''first round'' multiplier effect because we have excess supply of labour and home goods; the process already described corresponds to the movement from E to F depicted in Fig. 1. The problem at point F is that people's expectations about domestic output in period 2 are too pessimistic because domestic output in period 1 has gone up, and it is part of households' wealth; when households get more wealth, they would like to spend some of it in the future. Hence, when people adjust their expectations the economy moves from F to G. The increase in domestic output in period 2, by increasing households' wealth, induces higher

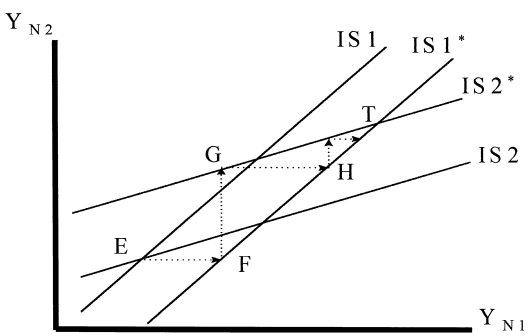

Fig. 1. Effect of a temporary increase in the coffee price under Keynesian unemployment.

Table 1
Comparative statics
Note: $0 < R^{D} = (R^{G}/\bar{R}) = (1 + r_{g}/1 + \bar{r}) < 1$, provided $r_{g} < \bar{r}$.

	Type of price shock	Perfect capital markets (1)	Preferential government borrowing (2)	Upward-sloping capital supply curve (3)
Effect on Y_{N1}	Temporary	$\frac{\alpha Y_{C}}{(1-\alpha)(1+\beta)p_{N1}} > 0$	$\frac{\alpha Y_{C}\left[\mu(1-R^{D})+R^{D}\right]}{(1-\alpha)(1+\beta)p_{N1}} > 0$	$\frac{\alpha Y_{C}\left[\bar{R}+2\rho\beta Y_{1}\mu(1-\alpha)\right]}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_{1}(1-\alpha)\right]p_{N1}} > 0$
	$(\mathrm{d}p^{*}_{C1} > 0,\ \mathrm{d}p^{*}_{C2} = 0)$			
	Anticipated	$\frac{\alpha Y_{C}}{(1-\alpha)(1+\beta)\bar{R}p_{N1}} > 0$	$\frac{\alpha Y_{C}}{(1-\alpha)(1+\beta)\bar{R}p_{N1}} > 0$	$\frac{\alpha Y_{C}}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_{1}(1-\alpha)\right]p_{N1}} > 0$
	$(\mathrm{d}p^{*}_{C1} = 0,\ \mathrm{d}p^{*}_{C2} > 0)$			
	Permanent	$\frac{\alpha(1+\bar{R})Y_{C}}{(1-\alpha)(1+\beta)\bar{R}p_{N1}} > 0$	$\frac{\alpha Y_{C}\left\{\left[\mu(1-R^{D})+R^{D}\right]\bar{R}+1\right\}}{(1-\alpha)(1+\beta)\bar{R}p_{N1}} > 0$	$\frac{\alpha Y_{C}\left[1+\bar{R}+2\rho\beta Y_{1}\mu(1-\alpha)\right]}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_{1}(1-\alpha)\right]p_{N1}} > 0$
	$(\mathrm{d}p^{*}_{C1} = \mathrm{d}p^{*}_{C2} = \mathrm{d}p^{*}_{C} > 0)$			
Effect on Y_{N2}	Temporary	$\frac{\alpha\beta\bar{R}Y_{C}}{(1-\alpha)(1+\beta)p_{N2}} > 0$	$\frac{\alpha\beta\bar{R}Y_{C}\left[\mu(1-R^{D})+R^{D}\right]}{(1-\alpha)(1+\beta)p_{N2}} > 0$	$\frac{\alpha\bar{R}Y_{C}\left[\beta\bar{R}+2\rho\beta Y_{1}(1-\mu)(1-\alpha)\right]}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_{1}(1-\alpha)\right]p_{N2}} > 0$
	$(\mathrm{d}p^{*}_{C1} > 0,\ \mathrm{d}p^{*}_{C2} = 0)$			
	Anticipated	$\frac{\alpha\beta Y_{C}}{(1-\alpha)(1+\beta)p_{N2}} > 0$	$\frac{\alpha\beta Y_{C}}{(1-\alpha)(1+\beta)p_{N2}} > 0$	$\frac{\alpha Y_{C}\left[\beta\bar{R}+2\rho\beta Y_{1}(1-\alpha)\right]}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_{1}(1-\alpha)\right]p_{N2}} > 0$
	$(\mathrm{d}p^{*}_{C1} = 0,\ \mathrm{d}p^{*}_{C2} > 0)$			
	Permanent	$\frac{\alpha\beta(1+\bar{R})Y_{C}}{(1-\alpha)(1+\beta)p_{N2}} > 0$	$\frac{\alpha\beta Y_{C}\left\{\left[\mu(1-R^{D})+R^{D}\right]\bar{R}+1\right\}}{(1-\alpha)(1+\beta)p_{N2}} > 0$	$\frac{\alpha Y_{C}\left\{\beta\bar{R}(1+\bar{R})+2\rho\beta Y_{1}(1-\alpha)\left[\bar{R}(1-\mu)+1\right]\right\}}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_{1}(1-\alpha)\right]p_{N2}} > 0$
	$(\mathrm{d}p^{*}_{C1} = \mathrm{d}p^{*}_{C2} = \mathrm{d}p^{*}_{C} > 0)$			

spending in period 1, and the economy then moves from G to H (''intertemporal'' multiplier effect), and so on until it reaches T. A temporary increase in the world coffee price thus has a spill-over effect in raising domestic output in the future.

Turning to the effects of anticipated (i.e. $\mathrm{d}p^*_{C1} = 0,\ \mathrm{d}p^*_{C2} > 0$) and permanent (i.e. $\mathrm{d}p^*_{C1} = \mathrm{d}p^*_{C2} = \mathrm{d}p^*_{C} > 0$) increases in the world coffee price, it can be shown that these two types of shocks induce changes in the same direction in the IS1 and IS2 schedules, so that domestic output increases in the current period and the future (the adjustment process could be described in the same terms as for the temporary shock). The first column of Table 1 summarises the results of the above-mentioned experiments. The multiplier effects show that when the economy is under Keynesian unemployment an increase in the world coffee price (whether temporary, anticipated, or permanent) raises domestic output in periods 1 and 2.[8] Also notice that under the (mild) condition that $Y_{C1} = Y_{C2} = Y_C$, the effect of an anticipated coffee price shock on both Y_{N1} and Y_{N2} is less than that of a temporary shock, and this in turn is less than the effect of a permanent shock.

3. The role of capital market imperfections and a coffee price stabilisation fund

Perhaps the central notion of the intertemporal, maximising model developed in the previous section is that current consumption (on both tradables and nontradables) depends on lifetime resources (W), and not on current resources (Y_1); the latter only affects consumption insofar as it affects the former. This result relies on the assumption that individuals can borrow (or lend) as much as they desire at a fixed rate of interest, so long as the intertemporal budget constraint (Eq. 2) is satisfied. Nonetheless, as indicated by Deaton (1990), to assume that individuals are able to borrow freely to smooth their consumption does not seem to be appropriate in the context of developing countries, since consumers in these countries are likely to be subject to borrowing constraints.

Engel and Meller (1993) indicate that the existence of borrowing constraints, and the fact that developing countries derive a substantial part of their income from the sale of primary commodities, whose prices are extremely volatile in the world markets, motivate considering mechanisms like commodity price stabilisation funds, because the incentives to save in ''good'' times are even greater, for there will be limited access to international borrowing in ''bad'' times.

Taking these aspects into consideration, in this section we augment the basic model by incorporating a government sector that is in charge of the administration

[8] A similar result is obtained when we assume (a) Keynesian unemployment in the short-run and Walrasian equilibrium in the long-run; and (b) *orthodox* Keynesian unemployment in the short- and long-run (these results are not presented, but are available from the author upon request).

of a coffee price stabilisation fund, which is aimed at reducing the effects of commodity price instability on the national economy. The structure of the government sector is highly simplified as we abstract from taxes and government expenditure; hence, the government's only role is to manage the stabilisation fund. The fund buys coffee at price $p_{C,t}$ and sells it in the world market of coffee at $p^*_{C,t}$, which is assumed given. A further simplifying assumption is that coffee producers sell the totality of their product to the stabilisation fund, although the model can be easily modified to deal with the case where coffee producers sell part of their crop in the world market.

In addition, we allow for the presence of capital market imperfections, which are initially modelled as in Van Wijnbergen (1987). That is, we assume that the government can borrow, on behalf of the fund, on more favourable terms in international capital markets than households; more formally, $r_g < \bar{r}$ and both interest rates are in terms of tradables.[9] The intertemporal budget constraint of the commodity stabilisation fund simply restricts the present value of the purchases of coffee made by the fund to equal the present value of its sales in the world market; that is:

$$(p_{C1} - p^*_{C1})Y_{C1} + \frac{(p_{C2} - p^*_{C2})Y_{C2}}{R^G} = 0, \tag{6}$$

where $R^G = 1 + r_g$ denotes the gross interest rate at which the government can borrow and lend. Setting $Y_{C1} = Y_{C2} = Y_C$, in order to simplify the algebra, yields

$$(p_{C1} - p^*_{C1}) + \frac{(p_{C2} - p^*_{C2})}{R^G} = 0. \tag{6a}$$

In Eq. (6) (or (6a)) p^*_{C1} and p^*_{C2} are treated as exogenous, since the country is small in the world market of coffee, and p_{C1} and p_{C2} are the set of policy instruments. It is worth noting that the possibility of systematic taxation of coffee producers does not arise in the model, since the fund is assumed to break even at the end of the second period; put another way, if the government lowers the domestic price of coffee by $\mathrm{d}p_{C1}$ on date 1, it must raise it by $(1 + r_g)\mathrm{d}p_{C1}$ on date 2.

For the purposes of the analysis that follows, we consider the case where the government sets p_{C1}, so that p_{C2} acts as the residual that guarantees that the fund's intertemporal budget constraint holds. Solving for p_{C2}, Eq. (6a) can be rewritten as:

$$p_{C2} = p^*_{C2} + R^G(p^*_{C1} - p_{C1}). \tag{6b}$$

In addition, we introduce the policy rule $\mathrm{d}p_{C1} = \mu \mathrm{d}p^*_{C1}$, $0 \le \mu \le 1$, so that in the initial equilibrium, the government is not intervening at all, and instead

[9] In Van Wijnbergen's (1987) paper, the assumption that $r_g < \bar{r}$ breaks down Ricardian equivalence. See also Rankin's (1994) variant of the Van Wijnbergen model.

government intervention only occurs in response to the shock in the world price of coffee. This policy rule for the domestic price of coffee gives rise to three possibilities: (a) when $\mu = 0$, the domestic price is independent of the world price, which implies an extreme form of stabilisation; (b) when $\mu = 1$, variations in the world price are fully transferred to domestic producers, which implies that stabilisation is not pursued; and (c) when $0 < \mu < 1$, variations in the world price of coffee are partially transferred to domestic producers. Cárdenas (1991, 1994) estimated the value of the elasticity of the domestic price of coffee with respect to the world price for four coffee producer countries. He obtained a value close to 1 in Kenya and Costa Rica, a small value in Ivory Coast, and an intermediate value (around 0.5) in Colombia.[10]

The presence of the coffee price stabilisation fund modifies the expression for wealth given in Eq. (2), since individuals now sell coffee to the fund at $p_{C,t}$, and not in the world market at $p^*_{C,t}$. Consequently, the equilibrium conditions of the economy are:

$$p_{N1}Y_{N1} = \frac{\alpha}{(1+\beta)}\left\{p_{N1}Y_{N1} + p_{C1}Y_C + \frac{p_{N2}Y_{N2} + p_{C2}Y_C}{\bar{R}} + \bar{Y}_T\right\} \tag{7a}$$

and

$$p_{N2}Y_{N2} = \frac{\alpha\beta\bar{R}}{(1+\beta)}\left\{p_{N1}Y_{N1} + p_{C1}Y_C + \frac{p_{N2}Y_{N2} + p_{C2}Y_C}{\bar{R}} + \bar{Y}_T\right\}. \tag{7b}$$

Substituting Eq. (6b) into the pair of Eqs. (7a) and (7b), we obtain the following set of ''augmented'' (IS1) and (IS2) schedules:

$$p_{N1}Y_{N1} = \frac{\alpha}{(1+\beta)}\left\{p_{N1}Y_{N1} + p_{C1}Y_C + \frac{p_{N2}Y_{N2}}{\bar{R}} + \frac{\left[p^*_{C2} + R^G(p^*_{C1} - p_{C1})\right]Y_C}{\bar{R}} + \bar{Y}_T\right\}$$

and

$$p_{N2}Y_{N2} = \frac{\alpha\beta\bar{R}}{(1+\beta)}\left\{p_{N1}Y_{N1} + p_{C1}Y_C + \frac{p_{N2}Y_{N2}}{\bar{R}} + \frac{\left[p^*_{C2} + R^G(p^*_{C1} - p_{C1})\right]Y_C}{\bar{R}} + \bar{Y}_T\right\}.$$

[10] Ocampo (1989) estimated a value for this elasticity equal to 0.68.

Rearranging terms, differentiating, substituting the policy rule $\mathrm{d}p_{C1} = \mu \mathrm{d}p^*_{C1}$, and setting $\mathrm{d}Y_C = \mathrm{d}\bar{Y}_T = 0$, we obtain:

$$\left[1 - \frac{\alpha}{(1+\beta)}\right] p_{N1}\mathrm{d}Y_{N1} - \frac{\alpha}{(1+\beta)\bar{R}} p_{N2}\mathrm{d}Y_{N2}$$

$$= \frac{\alpha Y_C}{(1+\beta)}\left\{\left[\mu(1-R^D) + R^D\right]\mathrm{d}p^*_{C1} + \frac{\mathrm{d}p^*_{C2}}{\bar{R}}\right\}$$

and

$$-\frac{\alpha\beta\bar{R}}{(1+\beta)} p_{N1}\mathrm{d}Y_{N1} + \left[1 - \frac{\alpha\beta}{(1+\beta)}\right] p_{N2}\mathrm{d}Y_{N2} = \frac{\alpha\beta\bar{R}Y_C}{(1+\beta)}$$

$$\times\left\{\left[\mu(1-R^D) + R^D\right]\mathrm{d}p^*_{C1} + \frac{\mathrm{d}p^*_{C2}}{\bar{R}}\right\},$$

where $0 < R^D = (R^G/\bar{R}) = (1 + r_g/1 + \bar{r}) < 1$, provided $r_g < \bar{r}$.

This set of equations can be used to investigate the response of Y_{N1} and Y_{N2} to variations in the world price of coffee, which can be either temporary, anticipated or permanent. The formal expressions are presented in the second column of Table 1, and should be compared with the multiplier effects when stabilisation is not pursued, which are presented in column one. The following results are particularly interesting. To begin with, the coffee price stabilisation fund reduces the multiplier effect of temporary and permanent coffee price shocks not only on Y_{N1} (as one might expect), but also on Y_{N2}: to see this, notice that when $0 < \mu < 1$, the multipliers in the case of preferential government borrowing are smaller than those obtained when $\mu = 1$. The stabilisation fund does not have any effect on the presence of anticipated coffee price shocks, because variations in the world coffee price on date 2 are fully translated to the domestic price in that period (see Eq. (6b)). The ineffectiveness of the stabilisation fund in the presence of anticipated price shocks is an artefact of only having two periods in the model; in a t-period model, a shock at time $t - n$ is smoothed in the remaining n periods, except when it occurs at time t since there are no periods left.

In the second place, the coffee price stabilisation fund does not play any role when the assumption of capital market imperfections is lifted: notice that when $r_g = \bar{r}$, so that $R^D = 1$, the multiplier effects presented in column two are identical to the ones reported in column one. Thus, the model predicts that when both the private sector and the government (on behalf of the fund) can borrow on the same terms in international capital markets, the presence of the stabilisation fund is redundant as far as its macroeconomic implications are concerned; of course, the stabilisation fund still serves the microeconomic purpose of stabilising the domestic price of coffee.

As indicated above, one surprising result is that the stabilisation fund dampens the multiplier effect of p^*_{C1} (or p^*_C) on Y_{N2}. By contrast, one might have expected that since the government has to raise p_{C2} in order to satisfy its intertemporal budget constraint, the effect of the fund would be to shift some of the effect of the increase in p^*_{C1} (or p^*_C) from period 1 to period 2. What the model predicts is that in the presence of the stabilisation fund, output increases by less in both periods; as a result, with the fund the country is worse off, since the present value of its income is lower with it than without it. On further reflection, this paradoxical result can be explained by the Van Wijnbergen method of modelling capital market imperfections. Notice that the presence of the fund means that when there is an increase in p^*_{C1} (or p^*_C), the government lends some of the additional revenue in period 1; nonetheless, given that $r_g < \bar{r}$, it gets a worse return on it than the private sector would. This reduces the lifetime wealth of the country and, hence, reduces demand and output in both periods.[11] If we look instead at the case of a decrease in p^*_{C1} (or p^*_C), the country would gain from the stabilisation fund, since the government would have to borrow in period 1, and it could do so at a lower interest rate than the private sector.

4. The basic model with a coffee price stabilisation fund and an upward-sloping capital supply curve

In the previous section, we argued that the reason why the stabilisation fund rather surprisingly succeeded in dampening the effects of a coffee price shock in both periods was related to the form in which we modelled capital market imperfections. In what follows, we re-examine this by modelling capital market imperfections in an alternative way. In particular, we assume that the private sector faces an upward-sloping supply of capital funds or, put another way, that the interest rate at which private agents can borrow, is an increasing function of the amount borrowed. Within this framework, it turns out that private agents face a non-linear intertemporal budget constraint; it should be remembered that when we assumed that $r_g < \bar{r}$, the private sector's intertemporal budget constraint remained linear, so that there was no impediment to ''consumption smoothing'' by private agents.

We start off by stating the problem of the consumers (Eq. 1), who maximise

$$U = \alpha \log C_{N1} + (1-\alpha)\log C_{T1} + \beta\{\alpha \log C_{N2} + (1-\alpha)\log C_{T2}\},$$

[11] If we assume that both the government and individuals lend at the same rate, the stabilisation fund is not able to smooth out temporary and permanent fluctuations in the world coffee price.

where $\beta = (1+\delta)^{-1}$, subject to the intertemporal budget constraint

$$C_2 - Y_2 = -R(C_1 - Y_1), \tag{8}$$

where $C_t = p_{N,t}C_{N,t} + C_{T,t}$, for $t = 1, 2$.

The domestic gross interest rate (R) is assumed to be an increasing function of the amount borrowed by private agents due to risk of default, so that

$$R = \bar{R} + \rho(C_1 - Y_1), \tag{9}$$

where $\bar{R} = (1+\bar{r})$ is the intercept parameter in the capital supply function, and $\rho > 0$. The reason why the capital supply function slopes upwards should be thought of as risk of default, where the slope parameter ρ reflects the incentives of individuals to default, although we do not model default explicitly. In other words, as an individual borrows more, his incentive to, and likelihood of, defaulting increases, and the interest rate he has to pay compensates the lender for this risk. The slope parameter ρ can, hence, be thought of as a measure of capital market imperfection. In particular, there are two extreme cases worth considering. On the one hand, $\rho \to \infty$ can be regarded as the case where borrowing becomes impossible. On the other hand, $\rho = 0$ is the case with perfect capital markets, so that private agents can borrow at the world gross interest rate $\bar{R}$.[12]

Substituting Eq. (9) into Eq. (8) yields the non-linear intertemporal budget constraint

$$C_2 - Y_2 = -\bar{R}(C_1 - Y_1) - \rho(C_1 - Y_1)^2, \tag{10}$$

which is drawn in Fig. 2. As can be seen, this constraint is an inverted parabola with a maximum at $Y_1 - \bar{R}/2\rho$; moreover, the slope at the point $C_1 = Y_1$, that is, where private agents neither borrow nor lend in the first period, is equal to $-\bar{R}$.[13]

[12] It is worth noting that Eq. (9) also implies that when private agents are lenders in the first period (i.e. $Y_1 > C_1$), then the domestic gross interest rate would fall the more they lend, which is not particularly plausible. In order to overcome this difficulty, one might postulate a quadratic version of Eq. (9). Nonetheless, this would unnecessarily complicate the algebra, since the intertemporal budget constraint faced by the private agents would no longer be quadratic but of third order. Therefore, our analysis will be focused on the case where private agents are borrowers in the first period.

[13] It should be noticed that the budget constraint facing borrowers is such that they are assumed to repay the loan with certainty in the next period, which seems inconsistent with the assumption made about lender's beliefs. However, one might think of a situation in which there are good-risk and bad-risk countries, and lenders are unable to observe the countries' default risk. In this case, lenders would charge an ''average'' interest rate so that all countries are treated identically. As a result, good-risk countries end up borrowing at a higher interest rate that reflects the risk of default faced by lenders. The country we are analysing can then be thought of as a ''good-risk'' country where individuals do not default, even though lenders do not know this.

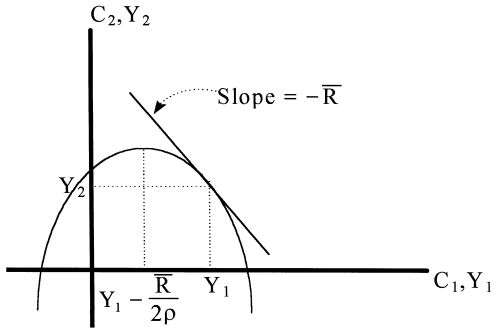

Fig. 2. Intertemporal budget constraint in the presence of an upward-slopping supply of capital funds.

Mathematically, the household's problem is to maximise Eq. (1) subject to the non-linear budget constraint stated in Eq. (10). This problem is solved in Appendix B, and the solutions for C_{N1} and C_{N2} can be written in compact form as:

$$C_{N1} = C_{N1}(Y_1, Y_2, \boldsymbol{v}) \tag{11a}$$

and

$$C_{N2} = C_{N2}(Y_1, Y_2, \boldsymbol{v}), \tag{11b}$$

where $\boldsymbol{v}$ is a vector that comprises the set of relative prices p_{N1} and p_{N2}, as well as the parameters β, ρ and $\bar{R}$. The relative prices and the parameters are omitted from the analysis since they are assumed constant. One relevant comment to make about Eqs. (11a) and (11b) is that unlike in the earlier model, Y_1 and Y_2 cannot be aggregated into a single ''lifetime wealth'' variable, W.

For analytical convenience, we assume that the initial equilibrium is at the point where the economy neither lends nor borrows in the first period, i.e. $C_1 = Y_1$. Using the implicit function rule, we can look at the effect of a change in Y_1 and Y_2 on C_{N1} in the neighbourhood of the initial equilibrium (see Appendix B):

$$\left.\frac{\partial C_{N1}}{\partial Y_1}\right|_{C_1 = Y_1} = \frac{\alpha\left(\bar{R} + 2\rho\beta Y_1\right)}{p_{N1}\left[\bar{R}(1+\beta) + 2\rho\beta Y_1\right]} \tag{12a}$$

and

$$\left.\frac{\partial C_{N1}}{\partial Y_2}\right|_{C_1 = Y_1} = \frac{\alpha}{p_{N1}\left[\bar{R}(1+\beta) + 2\rho\beta Y_1\right]}. \tag{12b}$$

The economic interpretation of this pair of equations is particularly interesting. To begin with, Eq. (12a) shows that the marginal propensity to consume out of current income is less than one. Moreover, dividing both numerator and denomina-

tor by ρ, we can see that as the degree of capital market imperfections increases (i.e. $\rho \to \infty$), the marginal propensity to consume out of current income tends to one.[14] Turning to Eq. (12b), current consumption is expected to increase in response to a change in future income, and this response tends to zero as $\rho \to \infty$; put another way, as the degree of capital market imperfections increases, private agents' consumption behaviour turns out to be linked only to current income rather than to past or future income.

The effect of a change in Y_1 on C_{N2} is:

$$\left.\frac{\partial C_{N2}}{\partial Y_1}\right|_{C_1 = Y_1} = \frac{\alpha\beta\bar{R}^2}{p_{N2}\left[\bar{R}(1+\beta) + 2\rho\beta Y_1\right]},$$

which tends to zero as $\rho \to \infty$. Similarly, the effect of a change in Y_2 on C_{N2} is:

$$\left.\frac{\partial C_{N2}}{\partial Y_2}\right|_{C_1 = Y_1} = \frac{\alpha\left(\bar{R}\beta + 2\rho\beta Y_1\right)}{p_{N2}\left[\bar{R}(1+\beta) + 2\rho\beta Y_1\right]},$$

which tends to one as $\rho \to \infty$.

Turning to the functioning of the coffee price stabilisation fund, we assume that it faces its own individual supply of capital curve. In addition, we assume that the stabilisation fund is perceived as a good risk, so that the supply of capital curve can be approximated as horizontal; that is, the stabilisation fund can borrow and lend at the world gross interest rate $\bar{R}$, and the fund's intertemporal budget constraint is:

$$p_{C2} = p^*_{C2} + \bar{R}\left(p^*_{C1} - p_{C1}\right), \tag{13}$$

where we are assuming that $Y_{C1} = Y_{C2} = Y_C$ (to simplify the algebra), and that p_{C2} acts as the residual that guarantees that the fund's intertemporal budget constraint holds.

Since we assume Keynesian unemployment in the short and long run, the market equilibrium conditions can be stated as:

$$Y_{N1} = C_{N1}\left(p_{N1}Y_{N1} + \bar{Y}_{T1} + p_{C1}Y_C, p_{N2}Y_{N2} + \bar{Y}_{T2} + p_{C2}Y_C\right)$$

and

$$Y_{N2} = C_{N2}\left(p_{N1}Y_{N1} + \bar{Y}_{T1} + p_{C1}Y_C, p_{N2}Y_{N2} + \bar{Y}_{T2} + p_{C2}Y_C\right),$$

where this pair of equations is determining Y_{N1} and Y_{N2}.

[14] Flemming (1973) reached a similar result modelling capital market imperfections as a divergence between lending and borrowing rates of interest.

These equations jointly with the policy rule that $\mathrm{d}p_{C1} = \mu \mathrm{d}p^*_{C1}$ can be used to look at the effect of changes in the world coffee price on Y_{N1} (or Y_{N2}) in the neighbourhood of the initial equilibrium $C_1 = Y_1$. The third column of Table 1 presents the effects of a temporary increase in the coffee price on Y_{N1} (row one) and Y_{N2} (row four). Before discussing the role of the commodity stabilisation fund, it is worth noting that these multipliers reveal something about the basic properties of the model prior to government intervention. In particular, when fluctuations in the world coffee price are fully transferred to domestic producers (i.e. $\mu = 1$), the response of Y_{N1} is increasing in ρ whereas the response of Y_{N2} is decreasing in ρ (the latter tends to zero as $\rho \to \infty$). Consequently, capital market imperfections shift some of the effects of temporary coffee price variations from period 2 to period 1. In other words, it is the capital market which shifts some of the effects of a temporary coffee price shock from period 1 to period 2; introducing the imperfection just blocks this.

These multiplier effects also show that in the presence of capital market imperfections (i.e. $\rho > 0$), the stabilisation fund changes the time-profile of output as it reduces the multiplier of p^*_{C1} on Y_{N1}, but increases the multiplier of p^*_{C1} on Y_{N2}. In other words, the stabilisation fund shifts some of the effects of a temporary coffee price shock from period 1 to period 2. The multiplier effects further reveal that when there is no impediment to consumption smoothing by private agents (i.e. $\rho = 0$), the stabilisation fund is redundant; indeed, notice that in this case the multipliers do not depend on the parameter μ, and are identical to those obtained with perfect capital markets.

The stabilisation fund is not able to stabilise output in response to an anticipated coffee price shock, since a change in p^*_{C2} results in a proportional change in the domestic price in that period (see rows two and five); compared to earlier results with perfect capital markets, the response of Y_{N1} is smaller and the response of Y_{N2} is larger. Lastly, in the case of a permanent shock the stabilisation fund shifts some of the effects from period 1 to period 2 (see rows three and six).

The welfare effects of a temporary (permanent) coffee price shock in the presence of the stabilisation fund can be investigated by calculating the derivative of lifetime utility with respect to p^*_{C1} (p^*_C). Results not presented here show that the response of lifetime utility to a temporary (permanent) change in the coffee price is positive or negative as the sign of the shock is, respectively, positive or negative. In addition, the response of lifetime utility does not depend upon the parameter μ, so that the welfare effect of the coffee price shock is identical to that obtained when stabilisation is not pursued. This conclusion is a result of looking at infinitesimal-sized shocks, but it may not be true for larger shocks; however, it is beyond the scope of this paper to analyse fully the latter case.

Thus far, we have assumed that both private agents and the government face individual supply of capital curves, so that the rate at which an individual can borrow depends only on the amount of his own borrowing, not also on that of

others. If, on the other hand, we assume that both the private sector and the government face an aggregate supply of capital curve, implying that extra borrowing by one individual raises the rate of interest which another individual must pay,[15] the model predicts that the stabilisation fund will be redundant (this result is not demonstrated here but is available on request).

5. Concluding remarks

In this paper, we have developed a two-period disequilibrium model of a small open economy under Keynesian unemployment to analyse the effects of temporary, anticipated, and permanent coffee price shocks. The model includes a government sector that administers a coffee price stabilisation fund, and allows for capital market imperfections, initially in the form of a government that can borrow (on behalf of the stabilisation fund) on more favourable terms in international capital markets than individuals. One surprising result of this version of the model is that the commodity price stabilisation fund reduces the multiplier effects of temporary shocks not only in the first, but also in the second period. Moreover, when there is an increase (decrease) in the coffee price the country loses (gains) from the stabilisation fund, compared to the case where it is not present.

We argued that the reason why the fund rather surprisingly succeeded in dampening the effects of a coffee price shock in both periods was related to the Van Wijnbergen method of modelling capital market imperfections. In a second version of the model, we re-examined this by using an alternative modelling strategy in which individuals face an upward-sloping supply of capital curve. Under this alternative modelling strategy, the commodity stabilisation fund shifts some of the effects of a temporary coffee price boom from the first to the second period.

We also found that when both the private sector and the government can borrow on the same terms in international markets, either because the capital market is perfect or because the private sector and the government face the same upward-sloping supply of capital curve, the stabilisation fund is not able to smooth out temporary fluctuations in the world coffee price. In other words, the stabilisation fund only neutralises part of the short-term macroeconomic effect of coffee price fluctuations, to the extent that it is able to borrow on different terms with respect to households in international capital markets.

The two models we have looked at provide useful analytical frameworks for explaining fluctuations in economic activity arising from changes in commodity

[15] One possible reason why the country as a whole may face an aggregate supply of capital curve, is that borrowers' decisions may not be made independently. For example, the government may implicitly act to coordinate defaulting behaviour, by nationalising or expropriating foreign assets.

prices. Both models, built on the traditional Keynesian theories that emphasise the roles of aggregate demand and market failure in causing the business cycle, capture one of the most salient features of the Colombian economy: the fact that economic fluctuations have been mainly driven by the behaviour of the world coffee price. The models also illustrate that in the presence of capital market imperfections, a coffee price stabilisation fund neutralises part of the short-term effect of a temporary coffee price shock. Thus, commodity price stabilisation funds allow countries to resist pressures to overspend in affluent times, since access to foreign credit decreases sharply when these are over.

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Appendix A. Stability analysis of the model

The dynamic behaviour of the model is depicted by the equations:

$$\dot{Y}_{N1} = \theta_1(C_{N1} - Y_{N1})$$

and

$$\dot{Y}_{N2} = \theta_2(C_{N2} - Y_{N2}),$$

where $0 < \theta_1 < 1$ and $0 < \theta_2 < 1$ constitute adjustment coefficients. Substituting the commodity demand functions for nontradables given in Eqs. (3a) and (3b), and the expression for wealth given in Eq. (2), we have:

$$\dot{Y}_{N1} = \theta_1\left\{\frac{\alpha}{(1+\beta)\,p_{N1}}\left[p_{N1}Y_{N1} + \frac{p_{N2}Y_{N2}}{\bar{R}} + \Omega\right] - Y_{N1}\right\}$$

and

$$\dot{Y}_{N2} = \theta_2\left\{\frac{\alpha\beta\bar{R}}{(1+\beta)\,p_{N2}}\left[p_{N1}Y_{N1} + \frac{p_{N2}Y_{N2}}{\bar{R}} + \Omega\right] - Y_{N2}\right\},$$

where $\Omega = p^*_{C1}Y_{C1} + (p^*_{C2}Y_{C2}/\bar{R}) + Y_{T1} + (Y_{T2}/\bar{R})$.

This pair of equations can be rewritten in matrix form as:

$$\begin{bmatrix}\dot{Y}_{N1}\\ \dot{Y}_{N2}\end{bmatrix}=\begin{bmatrix}\theta_1\left[\dfrac{\alpha}{(1+\beta)}-1\right] & \dfrac{\theta_1\alpha p_{N2}}{p_{N1}(1+\beta)\bar{R}}\\ \dfrac{\theta_2\alpha\beta\bar{R}p_{N1}}{p_{N2}(1+\beta)} & \theta_2\left[\dfrac{\alpha\beta}{(1+\beta)}-1\right]\end{bmatrix}\times\begin{bmatrix}Y_{N1}\\ Y_{N2}\end{bmatrix}+\begin{bmatrix}\dfrac{\theta_1\alpha\Omega}{p_{N1}(1+\beta)}\\ \dfrac{\theta_2\alpha\beta\bar{R}\Omega}{p_{N2}(1+\beta)}\end{bmatrix}$$

Denoting the right hand side matrix as A, stability of the system requires tr $A<0$, and det $A>0$. The first condition is easily met as the terms in parentheses along the diagonal are both negative. On the other hand, the second condition is also satisfied since det $A=1-\alpha>0$. Also, it follows directly from these requirements that the IS1 schedule is steeper than the IS2 schedule.

Appendix B. Utility maximisation subject to an upward-sloping capital supply curve

The consumer maximises

$$U=\alpha\log C_{N1}+(1-\alpha)\log C_{T1}+\beta\{\alpha\log C_{N2}+(1-\alpha)\log C_{T2}\},$$

subject to $C_2-Y_2=-R(C_1-Y_1)$, where $R=\bar{R}+\rho(C_1-Y_1)$, and $C_t=p_{N,t}C_{N,t}+C_{T,t}$, for $t=1, 2$.

From the first order conditions of this constrained maximisation problem, we establish the following relationships:

$$C_{T1}=\frac{(1-\alpha)}{\alpha}C_{N1}p_{N1}$$

$$C_{N2}p_{N2}=\beta KC_{N1}p_{N1}$$

and

$$C_{T2}=\frac{(1-\alpha)}{\alpha}\beta KC_{N1}p_{N1},$$

where $K=\bar{R}+2\rho(p_{N1}C_{N1}+C_{T1}-Y_1)$.

Substituting these relationships in the intertemporal budget constraint yields the following (implicit) equation for C_{N1}:

$$(1+2\beta)\rho\left(\frac{p_{N1}C_{N1}}{\alpha}-Y_1\right)^2+\left[(1+\beta)\bar{R}+2\rho\beta Y_1\right]\left(\frac{p_{N1}C_{N1}}{\alpha}-Y_1\right)+\beta\bar{R}Y_1-Y_2=0.$$

For analytical convenience, we assume that $\beta\bar{R}Y_1-Y_2=0$, so that one of the solutions of the previous equation is at the point where the economy neither lends nor borrows in the first period, i.e. C_1-Y_1. Using the rule of the implicit function, we then look at the effect of a change in Y_1 and Y_2 on C_{N1} and C_{N2} in the neighbourhood of the initial equilibrium, that is:

$$\left.\frac{\partial C_{N1}}{\partial Y_1}\right|_{C_1=Y_1}=\frac{\alpha\left(\bar{R}+2\rho\beta Y_1\right)}{p_{N1}\left[\bar{R}(1+\beta)+2\rho\beta Y_1\right]} \tag{A2.1a}$$

$$\left.\frac{\partial C_{N1}}{\partial Y_2}\right|_{C_1=Y_1}=\frac{\alpha}{p_{N1}\left[\bar{R}(1+\beta)+2\rho\beta Y_1\right]} \tag{A2.1b}$$

$$\left.\frac{\partial C_{N2}}{\partial Y_1}\right|_{C_1=Y_1}=\frac{\alpha\beta\bar{R}^2}{p_{N2}\left[\bar{R}(1+\beta)+2\rho\beta Y_1\right]} \tag{A2.1c}$$

and

$$\left.\frac{\partial C_{N2}}{\partial Y_2}\right|_{C_1=Y_1}=\frac{\alpha\left(\bar{R}\beta+2\rho\beta Y_1\right)}{p_{N2}\left[\bar{R}(1+\beta)+2\rho\beta Y_1\right]}. \tag{A2.1d}$$

The solutions for C_{N1} and C_{N2} can be written in compact form as:

$$C_{N1}=C_{N1}(Y_1,Y_2,\boldsymbol{\upsilon}) \tag{A2.2a}$$

and

$$C_{N2}=C_{N2}(Y_1,Y_2,\boldsymbol{\upsilon}) \tag{A2.2b}$$

where $\boldsymbol{\upsilon}$ is a vector that comprises the set of relative prices p_{N1} and p_{N2}, as well as the parameters β, ρ and $\bar{R}$. The relative prices and the parameters are omitted from the analysis since they are assumed constant.

The intertemporal budget constraint of the coffee price stabilisation fund is:

$$p_{C2}=p^*_{C2}+\bar{R}(p^*_{C1}-p_{C1}), \tag{A2.3}$$

Since we assume Keynesian unemployment in the short and long run, the market equilibrium conditions are:

$$Y_{N1}=C_{N1}\left(p_{N1}Y_{N1}+\bar{Y}_{T1}+p_{C1}Y_C, p_{N2}Y_{N2}+\bar{Y}_{T2}+p_{C2}Y_C\right)$$

and

$$Y_{N2} = C_{N2}\left(p_{N1}Y_{N1} + \bar{Y}_{T1} + p_{C1}Y_C, p_{N2}Y_{N2} + \bar{Y}_{T2} + p_{C2}Y_C \right),$$

where this pair of equations is determining Y_{N1} and Y_{N2}.

Substituting Eq. (A2.3) into the market equilibrium conditions, totally differentiating, using the policy rule $\mathrm{d}p_{C1} = \mu \mathrm{d}p^*_{C1}$, and setting $\mathrm{d}Y_C = \mathrm{d}\bar{Y}_T = 0$, yields:

$$\left(1 - \frac{\partial C_{N1}}{\partial Y_1} p_{N1}\right)\mathrm{d}Y_{N1} - \frac{\partial C_{N1}}{\partial Y_2} p_{N2}\mathrm{d}Y_{N2}$$
$$= Y_C\left\{\left[\mu\frac{\partial C_{N1}}{\partial Y_1} + \bar{R}(1-\mu)\frac{\partial C_{N1}}{\partial Y_2}\right]\mathrm{d}p^*_{C1} + \frac{\partial C_{N1}}{\partial Y_2}\mathrm{d}p^*_{C2}\right\} \qquad \text{(A2.4a)}$$

and

$$-\frac{\partial C_{N2}}{\partial Y_1} p_{N1}\mathrm{d}Y_{N1} + \left(1 - \frac{\partial C_{N2}}{\partial Y_2} p_{N2}\right)\mathrm{d}Y_{N2}$$
$$= Y_C\left\{\left[\mu\frac{\partial C_{N2}}{\partial Y_1} + \bar{R}(1-\mu)\frac{\partial C_{N2}}{\partial Y_2}\right]\mathrm{d}p^*_{C1} + \frac{\partial C_{N2}}{\partial Y_2}\mathrm{d}p^*_{C2}\right\} \qquad \text{(A2.4b)}$$

These two equations can be used to look at the effect of temporary, anticipated and permanent changes in the price of coffee on Y_{N1} (or Y_{N2}) in the neighbourhood of the initial equilibrium (i.e. $C_1 = Y_1$). For example, the effects of a temporary increase in the coffee price on Y_{N1} and Y_{N2} are:

$$\left.\frac{\mathrm{d}Y_{N1}}{\mathrm{d}p^*_{C1}}\right|_{C_1 = Y_1}$$
$$= Y_C\left\{\frac{\left[\mu\frac{\partial C_{N1}}{\partial Y_1} + \bar{R}(1-\mu)\frac{\partial C_{N1}}{\partial Y_2}\right]\left(1 - \frac{\partial C_{N2}}{\partial Y_2}p_{N2}\right) + \left[\mu\frac{\partial C_{N2}}{\partial Y_1} + \bar{R}(1-\mu)\frac{\partial C_{N2}}{\partial Y_2}\right]\frac{\partial C_{N1}}{\partial Y_2}}{\left(1 - \frac{\partial C_{N1}}{\partial Y_1}p_{N1}\right)\left(1 - \frac{\partial C_{N2}}{\partial Y_2}p_{N2}\right) - \frac{\partial C_{N2}}{\partial Y_1}p_{N1}\frac{\partial C_{N1}}{\partial Y_2}p_{N2}}\right\}$$

and

$$\left.\frac{\mathrm{d}Y_{N2}}{\mathrm{d}p^*_{C1}}\right|_{C_1 = Y_1}$$
$$= Y_C\left\{\frac{\left[\mu\frac{\partial C_{N2}}{\partial Y_1} + \bar{R}(1-\mu)\frac{\partial C_{N2}}{\partial Y_2}\right]\left(1 - \frac{\partial C_{N1}}{\partial Y_1}p_{N1}\right) + \left[\mu\frac{\partial C_{N1}}{\partial Y_1} + \bar{R}(1-\mu)\frac{\partial C_{N1}}{\partial Y_2}\right]\frac{\partial C_{N2}}{\partial Y_1}}{\left(1 - \frac{\partial C_{N1}}{\partial Y_1}p_{N1}\right)\left(1 - \frac{\partial C_{N2}}{\partial Y_2}p_{N2}\right) - \frac{\partial C_{N2}}{\partial Y_1}p_{N1}\frac{\partial C_{N1}}{\partial Y_2}p_{N2}}\right\}$$

respectively. After substituting in the partial derivatives of C_{N1} and C_{N2} with respect to Y_1 and Y_2 given in Eqs. (A2.1a)–(A2.1d), the multiplier effects can be

conveniently simplified to the expressions reported in the first and fourth rows of the third column of Table 1, that is:

$$\left.\frac{dY_{N1}}{dp^{*}_{C1}}\right|_{C_1=Y_1} = \frac{\alpha Y_C\left[\bar{R}+2\rho\beta Y_1\,\mu(1-\alpha)\right]}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_1(1-\alpha)\right]p_{N1}} > 0$$

and

$$\left.\frac{dY_{N2}}{dp^{*}_{C1}}\right|_{C_1=Y_1} = \frac{\alpha\bar{R}Y_C\left[\beta\bar{R}+2\rho\beta Y_1(1-\mu)(1-\alpha)\right]}{(1-\alpha)\left[\bar{R}(1+\beta)+2\rho\beta Y_1(1-\alpha)\right]p_{N2}} > 0.$$

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