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A behavioural finance model of exchange rate expectations within a stock-flow consistent framework

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Abstract: The paper combines behavioural finance to a stock-flow consistent model of a two-country economy in the portfolio tradition, with imperfect asset substitutability. 'Fondamentalists' and 'chartists' set their expectations of changes in exchange rates based on some assessed fundamental value and past trends respectively. We find that exchange rate expectations have a significant effect on exchange rate movements and trade account balances during the traverse and in steady states. A flexible exchange rate regime will continue to provide stabilizing properties, as long as the proportion of chartist actors relative to fundamentalist agents is not overly large. However, if chartists dominate fundamentalists, any shock will provoke cyclical changes of ever greater magnitude.

Key words: behavioural finance, exchange rates, portfolio choice, instability, persistence

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A behavioural finance model of exchange rate expectations within a stock-flow coherent framework

Since the collapse of the Bretton Woods system in the early 1970s, economists have produced a vast pool of theories and models devoted to explaining exchange rate fluctuations. However, these models have been shown to perform very poorly in out-of-sample empirical studies (Meese and Rogoff, 1983; Obstfeld and Rogoff, 2000). This suggests that they are either invalid or at the very least incomplete. Furthermore, as is the case with most areas of economic research, foreign exchange markets have been modeled as stand-alone processes rather than being modeled as part of a complete, self-contained, economic system. This limits the policy relevance of these models and often relegates them to being simple forecasting tools.

Taylor (2004) and Godley and Lavoie (2005-6) have argued in favour of the use of stock-flow consistent models, which insure a coherent and comprehensive account of all economic mechanisms at work, including stocks of internationally-traded assets as well as flows of trade, income, expenditures and output. The open-economy stock-flow coherent models, where the exchange rate is determined by a confrontation between the demand and supply of some internationally-traded asset, do have some similarity with the older open-economy portfolio models *à la* Branson and Henderson (1985), which are becoming popular again as can be seen with the favourable review of new portfolio models such as that of Blanchard *et al*. (2005). In all these models, assets are heterogeneous enough for uncovered interest parity not to hold. While there may be perfect capital mobility, there is imperfect asset substitutability, a feature often associated with home country bias in portfolio choice. From a post-Keynesian point of view, this may arise because of fundamental uncertainty, as investors or speculators may believe that some higher returns can be earned, while lacking the 'the conviction to act' (Harvey, 2004, p. 22). A major difference between standard open-economy portfolio models and stock-flow consistent models however is that while the former establish timeless

equilibria, the latter track stocks of assets and flow variables through time, in a sequential manner.

The Godley and Lavoie (2005-6) models are a pedagogical version of a series of more complicated models that can be found in chapter 12 of Godley and Lavoie (2007). However, a drawback of both sets of models is that they do not incorporate exchange rate expectations. In other words, in the portfolio equations of these models, it is assumed that asset holders do not expect any change in exchange rates.[1] While this may be acceptable as a first approximation, it would certainly be desirable to find out what impact exchange rate expectations can have on the results achieved within a stock-flow consistent framework, especially in light of the fact that some post-Keynesian authors have argued that exchange rate expectations of portfolio investors play a key role in the determination of exchange rates, both in the short and in the long run (Harvey, 2003, p. 132). This is the main motivation of the paper.

Mainstream models often introduce expectations through the covered interest parity hypothesis, as do even some heterodox authors (Taylor 2004). It is then claimed that the forward rate represents the expectations of the market regarding the future value of the spot rate. This is the so-called unbiased efficiency hypothesis. We shall not pursue this avenue here. As argued by Lavoie (2000, p. 172), "the forward exchange rate is not an expectational variable, but rather the result of a simple arithmetic operation". Banks set the forward rate by adding the interest differential to the spot exchange rate. This has been confirmed by empirical evidence, which supports a contemporaneous relationship between the spot and forward exchange rate instead of a lagged one. Since the unbiased efficiency hypothesis would imply a lagged relationship, the evidence clearly points to the failure of unbiased efficiency (Moosa, 2004).

Instead we will introduce expectations of future exchange rate movements in the Godley and Lavoie (2007) stock-flow consistent flexible exchange rate model by adding elements of behavioural finance – a promising approach to modelling exchange rates. The single most important contribution made by behavioural finance is the development of an alternative to the rational agent paradigm, rational expectations and the market

[1] More precisely, Godley and Lavoie (2007, ch. 12) do have a variable that represents expected changes in the exchange rate, but the value of this variable is set to zero.

efficiency hypothesis. Behavioural finance draws its inspiration from the behavioural heuristics approach of Kahneman and Tversky (2000). Various post-Keynesian economists have argued that post-Keynesian economics should engage with recent experimental developments in behavioural economics (Fontana and Gerrard, 2004), more specifically in the domain of exchange rate determination (Harvey, 1991, 2003). This is the route that we shall follow.

Godley and Lavoie (2007, p. 489) have claimed that flexible exchange rates in their model turn out to stabilize external disequilibria "as long as speculative capital markets are not taken into consideration". The present paper investigate the impact of exchange rate expectations on an open-economy stock-flow consistent model, and in particular it will investigate the impact of speculative behaviour.

We begin in section 1 with a brief description of the Godley and Lavoie (2007) model. In section 2 we present the exchange rate expectation specification that is drawn from the behavioural finance literature. The other crucial features of the trade section of the model are highlighted in section 3, as a preliminary for the experiments that we conducted. For comparison purposes, based on an increase in the propensity to import of one country, we present in section 4 a simulation with the baseline model, that is, the model without exchange rate expectations. Section 5 repeats the experiment, but while taking exchange rate expectations into account, Section 6 does the same, but considers the case of destabilizing exchange rate expectations. Finally, section 7 analyzes what happens if the propensity to import reverts back to its initial value, thus checking the possibility of path dependence. It will be found that the model with exchange rate expectations can be said to exhibit persistence, but not hysteresis.

1. A Stock-flow consistent framework

The stock-flow consistent framework used in this paper is informed by the belief that economic models ought to be comprehensive and fully coherent. To do this, stock-flow consistent models are constructed from a series of transaction flow and balance sheet matrices, as well as a revaluation matrix. The transaction flow matrices describe national income and product accounts as well as the value of the changes in stock variables

between the beginning and end of a given period. For each sector they involve the equivalent of a budget constraint. The balance sheet matrices measure the levels of all stock variables at a given point in time. The revaluation matrix tracks capital gains. The relationships between these matrices are described by a series of equations and accounting identities which ensure that the model is fully consistent, thus imposing a kind of discipline to the researcher. Besides this feature, there are two further advantages to the method. First, the real and the monetary sectors are truly integrated into a single system. Second, the properties of a complete, self-contained, economic system are studied as opposed to considering one aspect at a time and ignoring feedback effects from the rest of the system.

The specific model used in the rest of this paper is presented in chapter 12 of Godley and Lavoie (2007). The key features specific to this model are the ability of agents to trade for foreign assets, the dependence of international trade on both domestic and foreign output as well as relative prices, and the endogeneity of prices. The model features a large number of endogenous variables. Import prices, export prices, domestic sales deflators, GDP deflators and the exchange rate are all endogenous variables. So are real quantities such as exports, imports, output, consumption, domestic sales, and disposable income. Other endogenous variables include taxes, interest payments, the supply of money, holdings of foreign and domestic bills, household wealth, and of course the government deficit and the government debt. Standard balance of payment measures, such as the trade balance, the current account balance, the capital account balance and the value of foreign reserves are endogenous as well. Still, simplifying assumptions needed to be made to keep the model under 100 equations. There is no domestic or foreign investment in fixed or working capital. As a consequence, the model, when it converges, tends toward a stationary state. Also there is no wage inflation, no commercial banking, and as pointed out already, the treatment of exchange rate expectations is more than rudimentary.

This description of the Godley and Lavoie (2007) open-economy model is admittedly brief. But since we wish to focus here on exchange rate expectations, the reader is referred to a full description of the model that can be found either in the book or

on the web.[2] We shall say more however about portfolio choice and the equations that describe international trade, starting now with the portfolio equations.

First it should be pointed out that the Godley and Lavoie (2007) model already has exchange rate expectations built into its structure. It was decided however, as a preliminary step, to set all expectations about exchange rate changes to 0. This is tantamount to assuming that expectations about the probability of appreciation and of depreciation are balanced which means that the expectation of the future change in the exchange rate is 0. This assumption will serve as a base case for the experiments that will follow in later sections.

Because the model contains three assets and two countries (branded as the United States and the United Kingdom), there are six equations governing how agents choose to allocate their wealth between the different asset types, namely, domestic bills, foreign bills and domestic currency. The first three equations define the behaviour of economic agents (households) located in the UK (with the £ sign), while the last three equations concern households located in the US (with the $ sign) :

(1) $$B^{£}_{£d} = V^{£} \cdot (\lambda_{10} + \lambda_{11} \cdot r^{£} - \lambda_{12} \cdot (r^{\$} + dxr^{\$}_{e}))\,,$$

(2) $$B^{\$}_{£d} = V^{£} \cdot (\lambda_{20} - \lambda_{21} \cdot r^{£} + \lambda_{22} \cdot (r^{\$} + dxr^{\$}_{e}))\,,$$

(3) $$H^{£}_{d} = V^{£} - B^{£}_{£d} - B^{\$}_{£d}\,,$$

(4) $$B^{\$}_{\$d} = V^{\$} \cdot (\lambda_{40} + \lambda_{41} \cdot r^{\$} - \lambda_{42} \cdot (r^{£} + dxr^{£}_{e}))\,,$$

(5) $$B^{£}_{\$d} = V^{\$} \cdot (\lambda_{50} - \lambda_{51} \cdot r^{\$} + \lambda_{52} \cdot (r^{£} + dxr^{£}_{e}))$$

(6) $$H^{\$}_{d} = V^{\$} - B^{\$}_{\$d} - B^{£}_{\$d}$$

$B^{£}_{£d}$ stands for the demand for UK bills in the UK, $B^{\$}_{£d}$ is the demand for US bills in the UK, $H^{£}_{d}$ is the demand for UK currency; all these demands for assets are denominated in the UK currency, that is in the currency where the asset is held, which explains why the exchange rate does not enter in the portfolio equations; $B^{\$}_{\$d}$ is the

[2] The model is fully available in an E-views version graciously provided by Gennaro Zezza, at the following address : http://gennaro.zezza.it/software/eviews/gl2006.php. Our extension of the model is itself based on the model found at that address.

demand for US bills in the USA, $B^{£}_{\$d}$ is the demand for UK bills in the USA, $H^{\$}_{d}$ is the demand for US currency, this time all expressed in the US currency; $V^{£}$ is wealth in the UK, $V^{\$}$ is wealth in the USA, $r^{£}$ is the interest rate in the UK, $r^{\$}$ is the interest rate in the US and $dxr^{\$}_{e}$ and $dxr^{£}_{e}$ stand for the expectations of the market regarding future changes in the USA and UK currencies respectively, expressed in percentage terms.

In the case of the US, equations (1) and (2) describe explicitly the behaviour of US households, while equation (3) insures, as is usual in such a theoretical framework, that the lambda parameters respect Tobin's adding-up conditions, so that the shares of the assets held in each country sum to one whatever change occurs to the variables.

As said earlier, both $dxr^{\$}_{e}$ and $dxr^{£}_{e}$ are set to 0 in Godley and Lavoie (2007) and in our base case. We now move on to explain how aspects of behavioural finance can be appended to the model.

2. Chartists and fundamentalists

In order to model the way in which agents form expectations on future exchange rate movements, we slightly modify the simple model presented in chapter 2 of De Grauwe and Grimaldi (2006). They define two types of economic agents using simple forecasting rules to form expectations about exchange rate movements. Agents of the first type – called fundamentalists – always trade in a manner that will put pressure on the exchange rate to go back to some exogenously defined fundamental rate.[3] Fundamentalist trader expectations are therefore defined as:

$$(7) \qquad dxr^{£,f}_{e,t} = -\psi \cdot (xr^{£}_{t-1} - xr^{£}*)$$

where $dxr^{£,f}_{e,t}$ is the fundamentalist trader's expected change in the dollar per pound exchange rate at time t, ψ is a parameter which can be interpreted as a proxy for the

[3] De Grauwe and Grimaldi (2006) actually define the fundamental exchange rate as a stochastic process. However, it is more convenient to define it as an exogenously defined value for the purposes of this paper.

expected speed of convergence to the fundamental exchange rate, $xr^{£}_{t-1}$ is the dollar per pound exchange rate at time $t-1$ and $xr^{£}*$ is the exogenously determined fundamental exchange rate.

It is important to note that the fundamental rate here simply means the rate towards which the fundamentalists think the exchange rate should converge. Therefore, although $xr^{£}*$ is referred to as the fundamental rate in this paper, it should really be thought of as the fundamentalist trader's assessment of where the exchange rate should be.

Traders of the second type – called chartists – always expect the latest change in the exchange rate to be repeated in the next period. This behaviour is related to an anchoring heuristic, often identified and described in experimental economics. These traders can also be interpreted as being trend-following speculators who continuously push the price up after an initial price increase and continuously push the price down after an initial price decrease. This type of trend-following behaviour is at the root of financial bubbles and is typical of traders who rely on technical analysis, or chart analysis, thus the name – chartist. Chartist exchange rate expectations are formed by the following equation:

$$(8) \qquad dxr^{£,c}_{e,t} = \beta \cdot dxr^{£}_{t-1}$$

where $dxr^{£,c}_{e,t}$ is the chartist trader's expected change in the dollar per pound exchange rate at time t, β is a parameter governing the magnitude of the autoregressive process and $dxr^{£}_{t-1}$ is the change in the dollar per pound exchange rate at time $t-1$.

Market expectations about future exchange rate movements are simply a weighted average of both types of traders who make up the speculative segment of the foreign exchange market. We thus get the following equation for market expectations of future exchange rate movements:

$$dxr^{£}_{e,t} = w_c \cdot dxr^{£,c}_{e,t} + w_f \cdot dxr^{£,f}_{e,t}$$

or

$$(9) \qquad dxr^{£}_{e,t} = w_c \cdot \beta \cdot dxr^{£}_{t-1} - w_f \cdot \psi \cdot (xr^{£}_{t-1} - xr^{£}*)$$

where $dxr^{£}_{e,t}$ is the market's expected change in the dollar per pound exchange rate at time t, w_c is the proportion of chartists in the speculative segment of the foreign exchange market and w_f is the proportion of fundamentalists in the speculative segment of the foreign exchange market.

The first thing to notice in the equation above is that chartists and fundamentalists will not necessarily expect the currency to move in opposite directions. If the exchange rate is moving upwards but is still below the fundamental rate, both types of traders will expect the exchange rate to increase. Similarly, if the exchange rate is moving downwards but is still above the fundamental rate, both types of traders will expect the exchange rate to decrease.

However, if the exchange rate is moving upwards and is already above the fundamental rate, whether or not the market expectation of future exchange rate movements is positive or negative will depend on the size of the last upward move and on the distance of the exchange rate from the fundamental value, for a given set of β, ψ, w_c and w_f parameters. As the exchange rate moves further and further away from its fundamental value, the magnitude of the fundamentalist's expectation increases relative to that of the market as a whole until the movement in the exchange rate reverses. This description of foreign exchange expectations resembles very much that given by Schulmeister (1988), as summed up by Harvey (1991) in his outline of an alternative post-Keynesian explanation of the evolution of currency prices.

For example, if an exchange rate starts increasing above the fundamental rate, the move will be fuelled by the chartists' belief that it will continue. However, the upward move cannot continue indefinitely since the fundamentalists' belief that it must come down is putting downward pressure on the market expectation. To illustrate, think of a ball being thrown straight up in the air. The ball first rises at a decreasing speed and then falls at an increasing speed. In the up move, the chartists can be thought of as the ball's momentum, continuously willing it to go higher and higher. The fundamentalists can be

thought of as gravity, slowing the ball down until it comes to a complete stop in mid-air. After that critical point has been reached, the ball heads towards the ground at an increasing speed as both its momentum (chartists) and gravity (fundamentalists) are pulling it down.

Our extended version of the Godley and Lavoie (2007) model thus adds the simple model of exchange rate expectations defined by equations (7) to (9). Indeed expectations of exchange rate changes, as defined by equation (9), are simply incorporated to the asset equations that define the portfolio choices of the households of the countries, given by equations (1), (2), (4) and (5). It should be noted however that further minor changes to the original parameters of the model had to be made. Because adding exchange rate fluctuation expectations to the six equations describing wealth allocation decisions creates more of a tendency to shift bill demands from one country to another, some of the parameters in the portfolio equations of Godley and Lavoie (2007) had to be modified in order to get convergence in our simulations.

We started by decreasing the constants in the equations determining U.K. and U.S. demand for domestic bills from 0.7 to 0.5 (λ_{10} and λ_{40}), while increasing the constants in the equations determining U.K. and U.S. demand for foreign bills from 0.25 to 0.5 (λ_{20} and λ_{50}). These changes seem to eliminate the well-known home country bias effect in the decision to buy foreign or domestic bills. However, we also reduced the coefficients multiplying foreign asset returns from 5.0 to 0.5 (λ_{12}, λ_{22}, λ_{42} and λ_{52}) while leaving the coefficients multiplying domestic asset returns at 5.0 ($\lambda_{11}, \lambda_{21}, \lambda_{41}$ and λ_{51}). This second set of changes in the values of the portfolio parameters reduces the impact of foreign asset returns on the portfolio decisions of households relative to that of domestic interest rates, thus restoring home country bias (at least as long as foreign interest rates are no more than ten times higher than domestic rates, and as long as expectations of exchange rate changes are not overly large. These changes make speculators less responsive to changes in returns abroad and, therefore, much less likely to shift their bill holdings wildly. The changes give the model additional stability properties when speculator expectations are modeled, without taking too much away

from the realism of the model. The relevance of these stability properties for the convergence of the model will be discussed in section 5.

3. Further relevant features of the stock-flow consistent model

Before we move on to the simulations, a few relevant features of the stock-flow consistent model are worth discussing. First it should be noted that the dollar per pound exchange rate is determined by the supply and demand for US bills abroad:

$$(10)\quad xr^{£} = \frac{B^{\$}_{£S}}{B^{\$}_{£d}}$$

where $xr^{£}$ is the dollar per pound exchange rate, $B^{\$}_{£S}$ is the supply of US bills to the UK and $B^{\$}_{£d}$ is the demand for US bills in the UK.

Equation (10) might seem to imply that the exchange rate is uniquely determined in the market for US bills. This would be a mistaken interpretation however. What happens is that the exchange rate, like every other endogenous variable in the model, is only allowed to appear once on the left-hand side of an equation. But the model is a fully interdependent system. Since the money supply is endogenous in this model, the security supply is a function of the government surplus or deficit, which, itself, is a function of a variety of factors throughout the economy. At the same time, the demand for securities is a function of the six equations governing the allocation of wealth, of which exchange rate expectations are only a small part. These six equations, of course, are a function of the wealth accumulated in each country which, itself, is also a function of a variety of factors throughout the economy. The point here is that within this larger framework, the exchange rate expectations are not meant to determine movements in the exchange rate but rather to have an influence on how the exchange rate and other variables react to different shocks.

Because our simulations will involve a modification of the propensity to import, it may be worth checking the equations that govern trade flows in the Godley and Lavoie (2007) model. Exports and imports are determined in the standard manner:

(11) $\log(x^{£}) = \varepsilon_0 - \varepsilon_1 \cdot \log(p^{\$}_{m-1} - p^{\$}_{y-1}) + \varepsilon_2 \cdot \log(y^{\$})$

and

(12) $\log(im^{£}) = \mu_0 - \mu_1 \cdot \log(p^{£}_{m-1} - p^{£}_{y-1}) + \mu_2 \cdot \log(y^{£})$

where $x^{£}$ are UK exports, $im^{£}$ are UK imports, $p^{\$}_{m}$ are US import prices, $p^{£}_{m}$ are UK import prices, $p^{\$}_{y}$ are US domestic prices, $p^{£}_{y}$ are UK domestic prices, while $y^{\$}$ and $y^{£}$ are US and UK output. The parameters are price and income elasticities.

Of course, since the model contains only two economies, UK exports equal US imports, and vice versa:

(13) $x^{£} = im^{\$}$

and

(14) $x^{\$} = im^{£}$

Similarly, the import prices in the US are the export prices in the UK, and vice versa:

(15) $p^{\$}_{m} = p^{£}_{x} \cdot xr^{£}$

and

(16) $p^{\$}_{x} = p^{£}_{m} \cdot xr^{£}$

These equations clearly show the link between trade flows and the exchange rate. One may wonder however how the trade prices on the right-hand side are themselves determined. We assume that they vary as a function of domestic prices in both countries as well as the exchange rate, so that:

(17) $\log(p^{£}_{m}) = \nu_0 - \nu_1 \cdot \log(xr^{£}) + (1 - \nu_1) \cdot \log(p^{£}_{y}) + \nu_1 \cdot \log(p^{\$}_{y})$

and

(18) $\log(p^{£}_{x}) = \upsilon_0 - \upsilon_1 \cdot \log(xr^{£}) + (1 - \upsilon_1) \cdot \log(p^{£}_{y}) + \upsilon_1 \cdot \log(p^{\$}_{y})$

with $\upsilon_1 > \nu_1$ since it is well established empirical fact that, following depreciation, there is some deterioration in the terms of trade, implying that import prices rise faster than export prices.[4]

It is often assumed that the sum of the elasticities with respect to relative prices found in equations (11) and (12) must sum to at least one ($\varepsilon_1 + \mu_1 \geq 1$) if the trade balance is to improve following devaluation. This is the well-known Marshall-Lerner condition. But this condition seems to be based on the implicit assumption that export prices, expressed in the domestic currency, won't change following a depreciation of the home currency, while import prices will increase by the full amount of the depreciation, thus assuming a full pass-through. In other words, prices are assumed to be always fixed in the currencies of the exporters. This implies that the terms of trade go down by the full amount of the depreciation. However, if trade prices move as we have described them in equations (13) and (14), then Godley and Lavoie (2007, p. 455) point out that the trade balance can improve as long as the sum of the import and export elasticities with respect to relative prices are greater than the elasticity of terms of trade with respect to depreciation ($\varepsilon_1 + \mu_1 > \upsilon_1 - \nu_1$).

For instance, if a 10% devaluation in the value of the dollar caused import prices in the US ($p_m^{\$}$) to rise by 6% while export prices in US dollars ($p_x^{\$}$) rose by 4%, thus causing the terms of trade to fall by 2%, implying an elasticity of the terms of trade of 0.20, as is assumed in the simulations, then the sum of the import and export elasticities would need to be no greater than 0.20.

This would be true however only if we did not take feedback effects into account. With feedback effects, things are much more complicated, as the recovery in the trade balance following currency depreciation implies larger domestic income, and hence income effects on the trade balance. The stock-flow consistent model does handle all these feedback effects. It can thus be shown, at least through experimenting, that the conditions are stricter than indicated in Godley and Lavoie (2007).[5] For instance, with the

[4] Equations (17) and (18) define UK import and export prices, but through equations (15) and (16), they also define US import and export prices.

[5] We are grateful to Wynne Godley for having helped us in the design of these experiments.

parameters of the model, on the basis of an elasticity of the terms of trade of 0.20, the trade balance only started to improve when the sum of the price elasticities exceeded 0.35. Furthermore, while the trade balance may improve, this does not mean that the current account will improve, as more interest payments have to be made on the larger foreign debt. This problem is particularly acute with a flexible exchange rate regime. Our simulations have shown that the current account balance in a flexible exchange rate was still deteriorating when the sum of the price elasticities reached 0.70, even though the trade balance was improving. Thus, despite its dubious theoretical validity, the Marshall-Lerner condition can still be taken as a rule of thumb requirement that will allow the current account to improve in response to currency depreciation. In the simulations that follow, parameters are such that this condition is fulfilled.

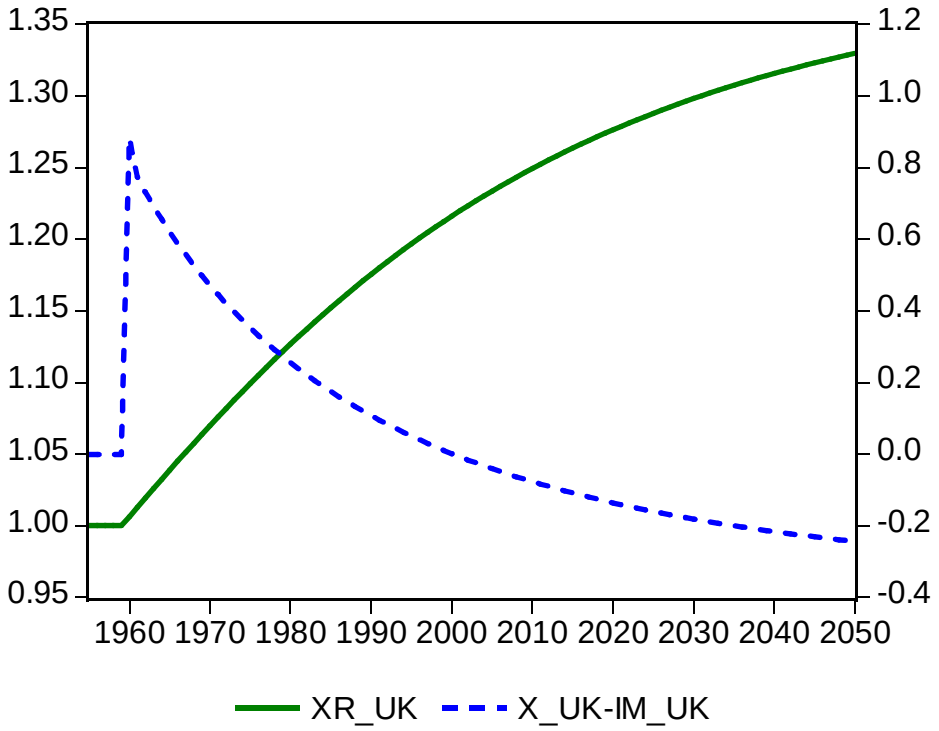
4. Baseline simulation

To study the role of expectations on the exchange rate we could modify any of the parameters or exogenous variable of the model, such as interest rates or discretionary government expenditures. As an illustration, we choose to raise the propensity to import of the US economy. In order to do so, we increase the ε_0 parameter in equation (10) that governs UK exports (and hence US imports) from -2.1 to -2. As is standard in such simulation work, we start off from a full equilibrium, which constitutes the baseline case by opposition to the baseline simulation that we are conducting. In the baseline case, the trade account, the current account and the capital account are all balanced and the exchange rate has reached a constant level, here equal to unity.

We begin our experiments with a baseline simulation where economic agents expect future currency prices to remain where they are. In other words, expectations of exchange rate changes are set to 0. The results of this baseline experiment are presented in Figure 1.[6]

[6] The years shown on the horizontal axis have no meaning; they are only indicative of periods of time, which may be weeks, months or quarters.

Figure 1: UK exchange rate (left axis) and UK trade balance (right axis) after an increase in the US propensity to import (Baseline)



When the propensity to import increases in the US, UK exports increase immediately, as shown by the dotted line of Figure 1. However, as the dollar currency depreciates, that is, as the dollar per pound exchange rate increases as shown by the continuous line in Figure 1, the UK trade balance decreases as UK goods and services become more and more expensive relative to US goods and services. These results are generally intuitive, and need little additional explanations. But how are these trade flows related to the portfolio approach to the balance of payments which supports the determination of the exchange rate, as described by equation (10)? This equation says that the price of the UK currency $xr^{£}$, that is the dollar per pound exchange rate is defined by the supply of US bills to the UK divided by the demand for US bills in the UK. Why does the price of the UK currency rise from a portfolio point of view? This can be explained by the large increase in the supply of US bills to the UK, the term that figures in the numerator of equation (10). Higher US imports generate a slowdown in the US economy, lower tax revenues and hence a US government deficit, and thus an increase in

the supply of US government bills. This larger supply cannot all be absorbed by the domestic US market and must be unloaded on foreign financial markets, thus generating the depreciation of the US currency and the appreciation of the UK currency.[7]

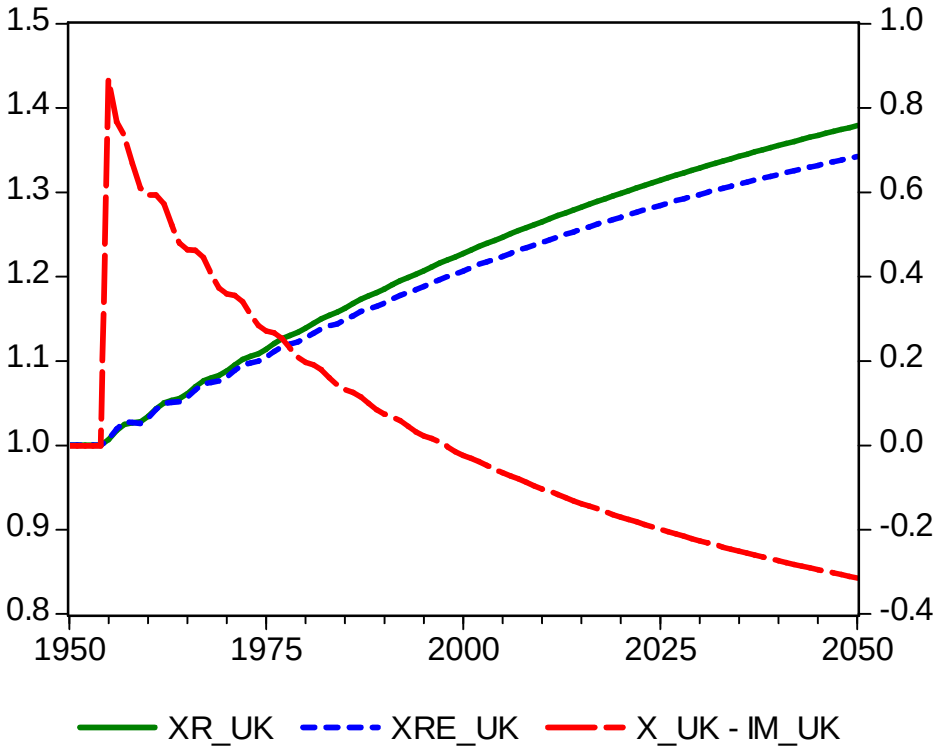
It should further be noted that the UK trade account does not converge back to a zero position. After having reached a surplus over 0.8 at its peak, it converges instead to a negative position, at −0.34. This trade account deficit can be explained by the fact that, during the transition towards the new stationary position, the UK economy has accumulated current account surpluses which have allowed UK investors to accumulate additional foreign assets. These additional assets generate extra foreign interest income, so that the current account reaches a balanced position in the new stationary equilibrium despite a deficit trade account.

5. Exchange rate expectations

Having analyzed the baseline case, we can now introduce expectations about exchange rate changes, as defined in equation (9), and see how the extended model reacts to an increase in the propensity to import of the US economy. In so doing, we set the $xr^{£}*$ variable – what fundamentalist investors consider to be the 'fundamental' value of the UK currency – equal to 1. This is the starting long-run equilibrium value of the exchange rate in the baseline case. In other words, portfolio holders believe that any change in currency prices is of a transitional nature, due to some transitional change in the fundamentals. Or they believe that the monetary authorities are likely to take some counter-measures that will bring the exchange rate back to its initial value. Once again, we shock the model by increasing the ε_0 parameter in the equation governing UK exports from -2.1 to -2. The results are presented in Figure 2.

Figure 2:UK exchange rate, expectations about the UK exchange rate (left axis) and UK trade balance (right axis) after an increase in the propensity to import in the US, with $w_c = w_f = 0.5$

[7] There are also changes in the demand for bills, but these are minor relative to the changes in the supply of bills, unless exchange rate expectations are taken into account, as we do in subsequent sections.



The first thing to notice is that the general picture that arises from the shock to the propensity to import in the model with exchange rate expectations is broadly similar to the baseline case. Once again, the UK trade balance (the broken line in Figure 2) becomes positive in the short run and negative in the long run, while once again the UK exchange rate (the continuous line) keeps appreciating, apparently converging towards a steady level. Market expectations about the exchange rate (the line with the smaller dots) keep diverging from the actual rate, as fundamentalists still believe that the initial steady-state value constitute a fundamental given of the economic system. A careful examination of Figure 2 reveals that the actual exchange rate in the model with exchange rate expectations shows some volatility, more visible in the early stages of the shock.

An examination of the steady state values reached through the simulations highlights the role played by the exchange rate expectations of the fundamentalists. Their opinion about the "fundamental" value of the exchange rate does have an impact on the actual long-run value of the exchange rate, which converges to 1.55 with fundamentalist exchange rate expectations set at $xr^{£}* = 1$, whereas the same change without

expectations had led to a steady-state exchange rate equal to 1.38 in the previous simulation. As a consequence, there is also a discrepancy in the amount of net exports reached in the steady states with and without exchange rate expectations.

Incidentally, if the fundamentalist exchange rate expectations are instead $xr^{£}* = 1.55$, then the steady-state exchange rate turns out to be 1.32. Thus, when the fundamental value of the exchange rate is being under-estimated, the economy tends towards a steady-state value of the exchange rate that is above its fundamental value without expectations; and reciprocally, when the fundamental value of the exchange rate is being over-estimated, the economy converges towards a steady-state value of the exchange rate that is below its fundamental value. Thus in this case, adaptative revisions of the estimates of the fundamental exchange rate ought to drive the economy towards the steady state exchange rate achieved without expectations. Indeed, when the exchange rate expectations of the fundamentalists correspond to the steady state value of the model without expectations, this steady state value is also realized in the model with expectations.

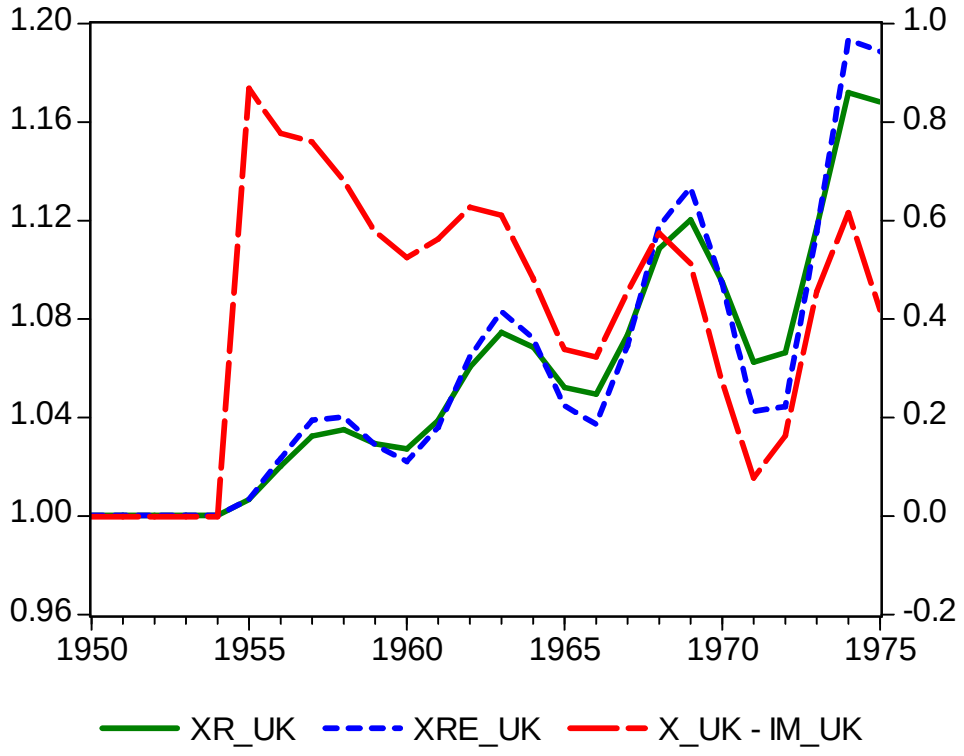
6. Destabilizing exchange rate expectations

The introduction of exchange rate expectations in the previous simulation does create some cyclical behaviour, but of a small amplitude. What happens if chartists represent a greater proportion of exchange rate traders and investors? In the previous simulation, we assumed that chartists and fundamentalists had an equal impact on exchange rate expectations, implying that the two main parameters in equation (9) were such that $w_c = w_f = 0.5$. We now redo the same experiment, but on the assumption that chartists dominate fundamentalists on exchange rate markets, with $w_c = 0.7$ and $w_f = 0.3$.

Figure 3 illustrates what occurs when, once more, the US propensity to import is hiked up in the model. The cyclical behaviour of the exchange rate, which in the early years looks rather tamed, is driven to movements of ever greater amplitude and hence there is no convergence. These cyclical movements also generate cyclical movements in the trade account, which in turn amplify the cyclical movements of the exchange rate. Interestingly, we verified through another simulation that whether or not fundamentalists

use the right long-run value of the exchange rate makes no difference whatsoever. In other words, the "fundamental" value of the exchange rate, as assessed by the fundamentalists, has no impact on whether or not the model dominated by chartists generates non-converging cycles. Once the chartists become dominant on exchange rate markets, the model becomes unstable. Indeed, the instability and the speed at which the model broke down were even greater when fundamentalists responded to the shock by using the right new long-run exchange rate value – the steady state exchange rate that would have been achieved in the model without expectations – than when they were underestimating the new fundamental exchange rate value.

Figure 3: UK exchange rate (left axis) and UK trade balance (right axis) after an increase in the US propensity to import, when chartists dominate fundamentalists ($w_c = 0.7$ and $w_f = 0.3$)



To understand the cyclical behaviour of the exchange rate, one has to remember that the portfolio demand for assets depends on the expected *change* in the exchange rate, given by $dxr^{£}_{e,t}$, and not on the *level* of the exchange rate. Following the increase in the US propensity to import goods and services, the exchange rate of the pound tends to rise. This, as explained earlier, is due to the larger amount of US dollars supplied to UK investors. As the exchange rate rises, the demand for UK assets arising from fundamentalist traders and investors tends to fall, or seen from another angle, the demand for US assets tends to rise, partially compensating for the rise in the quantity of US assets. This is because, as the UK exchange rate rises, it is getting ever further away from the rate expected by fundamentalists who still see a one to one exchange rate as the norm. In this case, the fundamentalists expect a negative change in the UK exchange rate. This negative change gets ever larger in absolute terms as long as the exchange rate keeps rising.[8]

Chartists have a contrary view. Their expected change in the UK exchange rate depends on the realized change of the previous period. So their expected change is in fact the first derivative of the realized exchange rate of the previous period which, as can be inferred from Figure 1 without expectations, tends to decrease on its own. Thus, as the UK exchange rate keeps rising, chartists think that the next change will be positive, but the expected change gets ever smaller, because, as shown in Figure 1, the past realized change gets ever smaller. Thus, whether we consider chartists or fundamentalists, we can say that the expected change in the UK exchange rate is getting ever smaller, meaning that if still positive it is moving towards zero, and if negative, its negative value is becoming more negative. As a result, the demand for UK assets is falling over time, as the demand for UK assets depends positively on the expected change in the UK exchange rate.

If chartists dominate, the demand for UK assets will be falling very quickly, so quickly that the UK exchange rate, otherwise pushed up by the surplus trade balance, will

[8] In the case where fondamentalists have the 'right' estimate of the fundamental value (the new steady state exchange rate in the model without expectations), the change in exchange rates expected by fundamentalists also gets smaller and smaller as the actual exchange rate rises. So the dynamics are similar in this case.

now be pulled down by the fall in the expected change of the UK exchange rate, that is, by the fall in the demand for UK portfolio assets. The behaviour of speculators, through the capital account, will overturn the initial rise in the UK exchange rate. What happens is that the increase in the supply of US assets, which is supposed to push up the UK exchange rate, is being eventually overcome by the speed of the reversal in the demand for assets, more specifically the reduction in the demand for UK assets and the increase in the demand for US assets. The cyclical behaviour arises from the fact that the destabilizing effects of asset demand overtake the stabilizing effects arising from the supply of assets. Naturally, all these effects get into reverse gear once the UK exchange rate has gone down for a while.

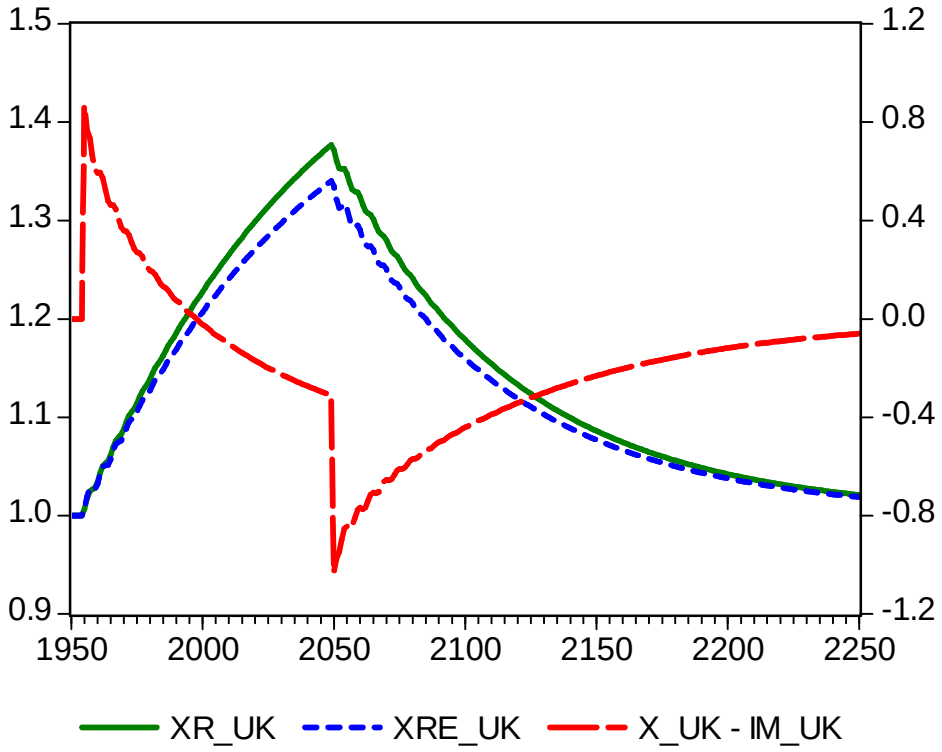
7. Path dependence?

The concept of historical time is crucial in post-Keynesian economics, as pointed out a number of times by various post-Keynesian economists (Robinson, 1980; Setterfield, 1995, p. 1; Lavoie, 2006, p. 12). Among the most important manifestations of historical time, one can certainly mention path-dependence, whereby a "long run or final value of a variable depends on the value of the variable in the past" (Setterfield, 1995, p. 14). Amable et al. (1994, p. 44) argue that one must go a bit further to argue that a path-dependent system has hysteretic properties. They define hysteresis as "a particular type of response – 'remanence' – of the endogenous variables consisting in the fact that *it does not go back to its initial value when the exogenous variable is transitorily changed*". Thus, while some systems are path-dependent, such as zero-root systems, since there is a multiplicity of possible long-run equilibria which depend on the starting point as well as the dynamics during the traverse, these systems are not necessarily hysteretic since a shock followed by an identical opposite shock would bring the system to its initial position, unless dynamic reaction parameters are time-dependent or vary depending on the whether the shock is positive or negative (these are the adjustment asymmetries of Setterfield (1995, p. 16)). On the other hand, some systems may show hysteresis even though they are not zero-root systems. Amable et al. (1994) then speak of strong hysteresis. By contrast, most mainstream economists have emphasized the notion of

persistence, whereby a variable may stray away from its long-run equilibrium value for a long time, while eventually returning to it. Within the current model, persistence would imply that exchange rate expectations slow down the convergence towards the exchange rate achieved without expectations.

In this section we show with the help of simulations that the Godley and Lavoie (2007) open-economy model exhibits persistence properties, but no hysteretic properties. We ran two sets of simulations, with and without exchange rate expectations, where we first impose an increase in the US propensity to import, only to bring it back to its initial value after 90 periods. We also assumed, as in our very first simulation, that the fundamentalist investors believe that the exchange rate is to return to its initial steady-state value, equal to unity. In both simulations, the exchange rate eventually returns to its starting value, equal to one, while the UK trade account returns to zero. Figure 4, in which the simulation period has been tripled compared to that of baseline simulation, illustrates the experiment that incorporates exchange rate expectations, thus showing that the introduction of exchange rate expectations does not modify the long-run behaviour of the model. We can thus conclude that there is no hysteretic effect in the Godley and Lavoie (2007), with or without exchange rate expectations.

Figure 4: UK exchange rate, expectations about the UK exchange rate (left axis) and UK trade balance (right axis) after an increase in the US propensity to import, followed by a decrease in the US propensity to import (with stabilizing expectations)



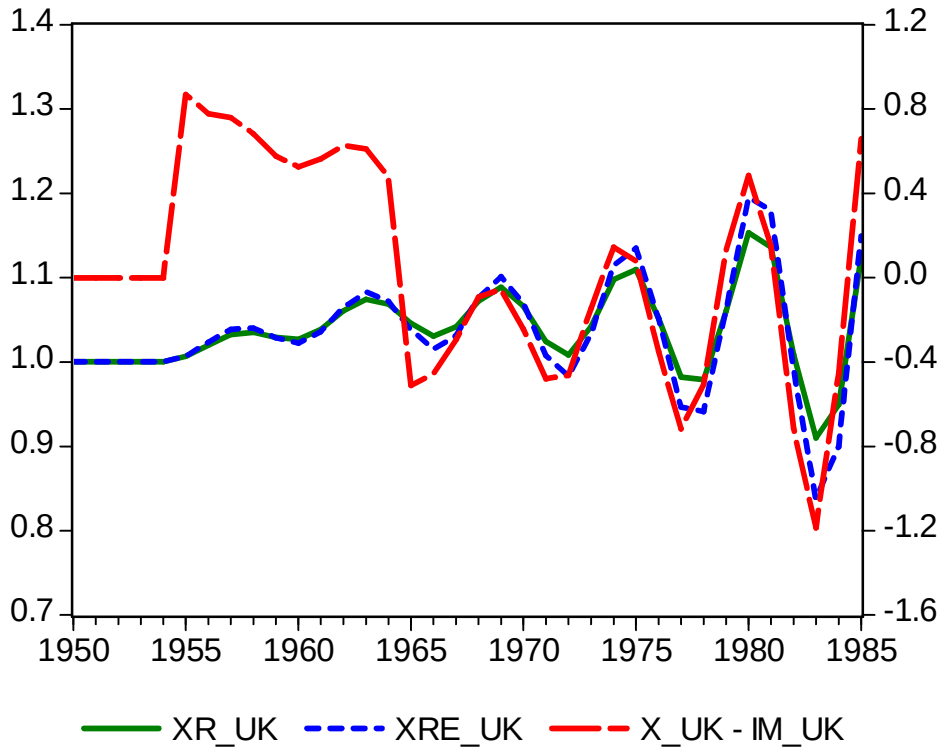
However, we can certainly infer from these two simulations that there is persistence. After 200 periods, in the simulation without exchange rate expectations, the exchange rate and the trade account are still 3% and 9% off their respective long-run values. With exchange rate expectations, still after 200 periods, the simulations reveal that the exchange rate is higher than its initial level by approximately 9% while the trade account is lower than its initial level by approximately 23%. Thus, with exchange rate expectations, although the model converges back to its long-run equilibrium value, it does so much more slowly than in the model without expectations. Indeed, in the simulations, the model with exchange rate expectations took twice as many periods to reach a steady state compared to the model without expectations.[9] One may thus argue that exchange rate expectations that incorporate the behaviour of chartists introduce a dose of persistence into the economy.

Some readers may wonder what occurs with the reversal of the shock on the propensity to import when exchange rate expectations are destabilizing. Does the

[9] More precisely it took 404 periods without expectations and 762 periods with exchange rate expections.

economy still return to its original steady state? The answer is clearly no, as illustrated by Figure 5, where a shock reversal occurs in 1965. Once the model is unstable, shock reversals won't bring back the economy to its original steady state. In this case, we may certainly speak of path dependence, as the parameters affecting the behaviour of the chartist investors do have an impact on the path taken by the economy, although we cannot speak of any steady state or long-run equilibrium anymore.

Figure 5: UK exchange rate, expectations about the UK exchange rate (left axis) and UK trade balance (right axis) after an increase in the US propensity to import, followed by a decrease in the US propensity to import (with destabilizing expectations)



Concluding remarks

The theoretical and empirical challenges presented by flexible exchange rate regimes have led economists to explore new ways of modelling agent behaviour. One of these alternatives, behavioural finance, has proven to be very useful in breaking down long-

standing assumptions in theoretical models and in getting better out-of-sample fit in empirical studies. However, behavioural finance models can seldom be used independently of other modelling approaches.

In this paper, we have used a stock-flow consistent framework in order to give our results as much realism and coherence as possible. Stock-flow consistent models use a comprehensive accounting framework that doesn't rely on traditional mainstream economics assumptions such as the rational expectations hypothesis or full employment. For this reason, the stock-flow consistent framework is ideal for the behavioural finance model presented in this paper, with a mix of some investors acting on trends while others hold on to some "fundamental" value of the exchange rate.

After running numerical simulations, we find that exchange rate expectations have a significant effect on exchange rate movements and trade account balances during the traverse and in steady states. A flexible exchange rate regime where import and export elasticities with respect to relative prices are sufficiently high compared to the elasticity of terms of trade will continue to provide stabilizing properties, as long as the proportion of chartist actors relative to fundamentalist agents is not overly large. However, if chartists dominate fundamentalists, any shock will provoke cyclical changes of ever greater magnitude. We have also found that the model does not exhibit hysteretic properties, although exchange rate expectations are a cause of persistence, with variables taking much more time to return to their steady-state values.

Our simulations, by necessity, assume that the parameters of the model are constant. But the real world is no doubt characterised by ever-changing parameters. With exchange rate markets being so much tied to rumours and the "news", the opinions of fundamentalists with regards to the "fundamental" value of the exchange rate will be changing frequently, and hence so will the steady-state value of the economy. Furthermore, the proportion of agents setting their exchange rate expectations as chartists do is likely to change endogenously, and hence the foreign exchange market may be, at least for a while, running in an unstable mode. The economy is forever in the medium run, never reaching the long run, and thus always subjected to the effects of exchange rate expectations. Thus, as Godley and Lavoie (2007, p. 489-490) conclude in their own chapter, "there is not, in general, … an equilibrium towards which economies and

exchange rates are moving. Any attempt to model econometrically the behaviour of exchange rates on the assumption that they are moving towards some underlying rate which conforms with 'fundamentals' is likely to be doomed to failure". This, as shown, is even more likely to be the case when chartists dominate fundamentalists, and hence when speculative behaviour dominates exchange rate markets.

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