The open economy excess sensitivity hypothesis: Theory and Swedish evidence

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Abstract
This paper extends the theory of open economy consumption behavior by applying Flavin's (1993) excess sensitivity hypothesis (ESH) to the current account. The ESH can be interpreted as a generalization of the open economy permanent income hypothesis (PIH) that allows for *any* degree of international capital mobility. As such, the ESH can account for why the PIH fails and for the related puzzle of an "excessively volatile" current account. Furthermore, the ESH suggests an alternative approach for assessing a country's degree of international capital mobility. Using annual Swedish data for the period 1951-99, the empirical evidence implies that, in contrast to the PIH, the ESH cannot be rejected.

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1. Introduction

The open economy permanent income hypothesis (PIH) implies that when a country expects a change in future income, it uses the current account to smooth consumption intertemporally. Consequently, the current account, which by definition is equal to the change in the country's net foreign assets, measures saving for the economy as a whole. In the case of an expected decline in income, the current account will be in surplus, as the PIH implies that the country will save "for a rainy day" (Campbell, 1987). Conversely, if income is expected to rise, consumption will be smoothed by means of borrowing in world capital markets, and the current account will show a deficit.

By means of a vector autoregression (VAR) for income and the current account, it is possible to test the restrictions that are implied by the PIH. Moreover, it is possible to visually characterize the fit of the model. From the VAR and the underlying theory, one can construct a prediction of the current account. An assessment of the model can then be made by comparing the actual current account with the predicted current account in a time series plot. If the PIH is true, then the two series should be identical.[1]

Empirically, the PIH usually fails, and it fails in a way that makes the actual current account fluctuate more than the predicted current account. This "excess volatility" of the current account is a puzzle that appears to be present in most industrialized countries. For instance, using postwar data for Canada, Germany, Japan, and the United Kingdom, Ghosh (1995) rejects the PIH and finds that the current accounts of these countries are excessively volatile. The United States is the only country in Ghosh's sample where the evidence is in favor of the PIH. Other

[1] The method is due to Campbell (1987) who originally applied the PIH model to investigate saving decisions of individuals subject to labor income (see also Campbell and Shiller, 1987). Such a setup is often referred to as the PIH in a closed economy context. The extension of the PIH to the open economy, i.e. the extension of the PIH to the current account, using Campbell's method is due to Sheffrin and Woo (1990), Otto (1992), and Ghosh (1995). For a survey, see Obstfeld and Rogoff (1995).

studies, including Sheffrin and Woo (1990), Otto (1992), and Obstfeld and Rogoff (1995, 1996) reach similar conclusions. For developing countries, the model appears to perform better. Ghosh and Ostry (1995) apply the model to forty-five developing countries and find that, for a majority, the PIH cannot be rejected. Still, for most countries in their study, the results indicate, at least visually, that the actual current account is more volatile than the predicted current account.

The purpose of this paper is to try to account for the failure of the PIH and the related puzzle of an excessively volatile current account by applying Flavin's (1993) excess sensitivity hypothesis (ESH) to the open economy setting. Flavin's work, which follows from Hall's (1978) seminal paper, is concerned with studying consumption and total financial saving of individuals subject to labor income. As Hall shows, given strict restrictions on tastes, the PIH implies that consumption follows a martingale and thus is orthogonal to lagged changes in other variables. By contrast, the ESH posits that consumption exhibits sensitivity to current income. The corresponding income measure in the open economy setting is *national cash flow*, defined as output less investment less government consumption. Consequently, the open economy version of the ESH posits that consumption exhibits sensitivity to current national cash flow.

Section 2.1 extends Flavin's (1993) work on the ESH to the open economy setting, i.e., to the current account. The application is straightforward, since the method of extending the ESH to the current account closely follows that of extending the PIH to the current account. This is because, just as Flavin points out, the PIH can be regarded as a special case of the ESH. The section discusses the main properties of the ESH and then, Section 2.2 shows how these properties translate into testable cross-equation VAR restrictions. It is also shown how the method of constructing the predicted current account directly carries over to the ESH framework.

Section 2.3 shows that the ESH is a generalization of the PIH that can be interpreted as relaxing the assumption of perfect international capital mobility. In contrast to the PIH, the ESH allows for *any* degree of international capital mobility that is consistent with the fundamental objective of smoothing consumption intertemporally. From this, it follows that the theoretical properties of the ESH can be reconciled with Ghosh's (1995) argument that the failure of the PIH and the excess volatility of the current account is due to "too much" capital mobility. Accordingly, the ESH offers a formal solution to the puzzle of an excessively volatile current account. Furthermore, the ESH suggests an alternative approach to Ghosh's method for measuring the degree of a country's international capital mobility.[2]

Section 3 uses Swedish postwar data to test the PIH and the ESH. Sweden is a small open economy that clearly illustrates what is common when the PIH is applied to an industrialized country's current account.[3] Although the model provides a reasonable fit, the restrictions implied by the PIH can be rejected, and the current account is excessively volatile. By contrast, this paper shows that when it is assumed that consumption is generated by the ESH, the model cannot be rejected, and the actual and predicted current account series are almost identical. That is, when consumption is assumed to be generated by the ESH, the puzzle of an excessively volatile current account is solved. Section 4 provides some concluding remarks.

2. The open economy excess sensitivity hypothesis

2.1 The model

The extension of the ESH to the open economy builds on work by Campbell (1987), Campbell and Deaton (1989), and most notably, by Flavin (1993). Compared to the closed economy setting, the open economy setting focuses on a broader measure of income and a narrower category of assets. The income measure in the open economy

[2] An approach for assessing a country's degree of international capital mobility that is similar to the one explored in this paper is given by Shibata and Shintani (1998). However, a direct comparison with their work is difficult because they use a slightly different underlying theory for consumption, a different line of theoretical reasoning, and a different empirical method (see f.n. 11).

[3] Obstfeld and Rogoff (1995, 1996) present visual evidence for Sweden and other industrialized countries including Belgium, Canada, Denmark, and the United Kingdom.

setting is national cash flow, Z_t, defined as

$$Z_t = Q_t - G_t - I_t, \tag{1}$$

where Q_t is the level of real per capita output; G_t is the level of real per capita government consumption; and I_t is the level of real per capita investment. It is assumed that national cash flow follows an exogenous stochastic process that is stationary in first differences. The asset category of interest is real per capita net foreign claims, B_t, which evolve over time according to

$$B_{t+1} = (1 + r)B_t + Z_t - C_t, \tag{2}$$

where r denotes the world rate of real interest (assumed constant) and C_t denotes the level of real per capita consumption. The current account, CA_t, is then defined as the change in net foreign assets, i.e.,

$$CA_t = B_{t+1} - B_t = rB_t + Z_t - C_t. \tag{3}$$

Taking the first difference and rearranging, gives

$$\Delta C_t = (1 + r)CA_{t-1} - CA_t + \Delta Z_t. \tag{4}$$

To test the model, one can impose on the identity (4) the derived form for CA_t implied by the ESH, and then use a VAR for CA_t and ΔZ_t to evaluate the resulting restrictions. The details regarding this are outlined in Section 2.2. Just as with the PIH, it is also possible to use the VAR to construct a prediction of the current account and then compare it to the actual current account series. If the ESH is true, the two series should be identical. However, as Section 2.3 argues, the economic interpretation of this comparison is very different from when consumption is assumed to be generated by the PIH.

In its original form, the ESH is a statement about consumption in levels. In order to derive it, consider first the open economy counterpart of Flavin's (1981) permanent income, i.e. *permanent national cash flow,* Z_t^P, which is defined as the annuity value of the sum of net foreign assets and the present discounted value of expected future national cash flow. That is,

$$Z_t^P = rB_t + \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t Z_s, \tag{5}$$

where E_t is the expectations operator, conditional on the agent's complete information set at t, I_t. Next, define *transitory national cash flow*, Z_t^T, as the residual

$$Z_t^T = V_t - Z_t^p = Z_t + rB_t - Z_t^p, \tag{6}$$

where V_t is total cash flow defined as $Z_t + rB_t$, i.e. the sum of national cash flow and interest earned on previously acquired assets. In this open economy setting, Flavin's (1993) excess sensitivity hypothesis of consumption behavior becomes

$$C_t = \beta Z_t^T + Z_t^P, \tag{7}$$

where β is the excess sensitivity parameter. Thus, when β is different from zero, consumption is excessively sensitive in the sense that it depends not only on permanent but also on transitory national cash flow. In the special case when $\beta = 0$, there is no excess sensitivity, and the result is the PIH, i.e.

$$C_t = Z_t^P. \tag{8}$$

It follows from Hall (1978) that the PIH stated as in (8) is the optimal solution for an agent with quadratic utility who sets the subjective discount rate equal to the real interest rate.

While permanent national cash flow follows a martingale under the PIH, this is not true under the ESH. To see this, substitute (7) into (2), lag one period, and then substitute the resulting expression for B_t into (5). After some manipulation, the result is

$$Z_t^P = Z_{t-1}^P - r\beta Z_{t-1}^T + \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}(E_t - E_{t-1})Z_s. \tag{9}$$

It is evident from (9) that the presence of the term $r\beta Z_{t-1}^T$ destroys the martingale property. However, regardless of whether β is different from zero, the innovation in permanent national cash flow is given by

$$\varepsilon_{zpt} = Z_t^P - E_{t-1}Z_t^P = \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}(E_t - E_{t-1})Z_s. \tag{10}$$

Because both permanent and transitory national cash flow depend on expectations about future national cash flow, it is difficult to use (7) to determine the restrictions that the fundamental assumption of consumption smoothing behavior places on the excess sensitivity parameter, β. Furthermore, as shown below, transitory national cash flow is by definition proportional to expected *declines* in national cash flow. As a consequence, it can also be difficult to use (7) to determine the exact impact of expected future changes in national cash flow on current consumption. Fortunately, expressing the ESH as a statement about saving, CA_t, allows for a clear interpretation of both the economic and time series properties of the hypothesis.[4] Hence, before investigating the properties of the ESH further, (7) is transformed into a statement about saving.

Intuitively, the fraction of transitory national cash flow that is not consumed in the current period is saved. To see this formally, substitute (6) and (7) into (3), so that

$$CA_t = Z_t^T + Z_t^P - \beta Z_t^T - Z_t^P = (1-\beta)Z_t^T. \tag{11}$$

Transitory national cash flow can be expanded in an informative way. First, substitute (5) into (6) in order to obtain

4 For further elaboration on this point, see Campbell (1987).

$$Z_t^T = Z_t - \frac{r}{1+r} \sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} E_t Z_s. \tag{12}$$

After some manipulation, this yields

$$Z_t^T = - \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} E_t \Delta Z_s, \tag{13}$$

where $\Delta Z_s = Z_s - Z_{s-1}$. Thus, as claimed above, transitory national cash flow is proportional to expected declines in national cash flow. Substituting (13) into (11), the ESH can be stated as

$$CA_t = (1-\beta) \left[- \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} E_t \Delta Z_s \right]. \tag{14}$$

Thus, according to the ESH, the current account is equal to the present discounted value of expected declines in national cash flow times a scaling factor that depends on the magnitude of the excess sensitivity parameter, β.

Equation (14) is a generalization of Campbell's (1987) "saving-for-a-rainy-day" equation, and it reveals the restriction that the assumption of consumption smoothing behavior places on the excess sensitivity parameter, β. It follows that consumption smoothing behavior is only consistent with any value of β that is *less* than unity. That is, when $\beta < 1$, (14) implies that when future national cash flow is expected to fall, the current account is in surplus, i.e., the agent saves in order to smooth consumption over time. On the other hand, when the agent expects an increase in future national cash flow, the current account is in deficit, i.e., the agent borrows in order to smooth consumption over time. By contrast, when $\beta = 1$, the current account is closed and can therefore not be used to smooth consumption. When $\beta > 1$, the expectation of, say, a future increase in national cash flow implies a current account surplus. It is evident that saving abroad and consuming relatively less today when future income is expected to *increase,* can never be consistent with at least some degree of consumption smoothing behavior. Hence, in an open consumption smoothing economy, an estimate of β that is equal or larger than unity cannot be justified.

Substituting (14) into (3), the ESH can now be restated as

$$C_t = rB_t + Z_t + (1-\beta) \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t \Delta Z_s. \qquad (15)$$

Thus, in contrast to (7), (15) shows that consumption can be decomposed into one part that is equal to total *current* income, i.e. total cash flow, $V_t = rB_t + Z_t$, and into one part that is dependent on expectations about *future* income, i.e. the current account deficit. Simply put, present consumption is the sum of total current income and dissaving. Of course, (15) just illustrates the flip side of the saving decision; it explicitly shows how consumption is smoothed by means of the current account whenever the economy is open (i.e., whenever $\beta < 1$). When national cash flow is expected to rise at some point in the future, consumption smoothing behavior implies that present consumption always increases above current total cash flow by the amount that is borrowed abroad. Conversely, when national cash flow is expected to fall, consumption smoothing behavior implies that present consumption always falls below current total cash flow by the amount that is saved abroad.

2.2 Empirical method for evaluating the ESH

Because (14) is conditional on the information set I_t which contains *all* information available to the agent, using it to test the ESH may look impossible. However, this problem can be solved by assuming that the information set used by the econometrician, H_t, is contained in I_t. Taking expectations of (14) conditional on H_t gives

$$\begin{aligned} E\{CA_t|\, H_t\} &= CA_t = E\left\{E\left\{(1-\beta)\left[-\sum_{s=t+1}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}\Delta Z_s\right]\middle|\, I_t\right\}\middle|\, H_t\right\} \\ &= (1-\beta)\left[-\sum_{s=t+1}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E(\Delta Z_s|H_t)\right], \end{aligned} \qquad (16)$$

since CA_t is observable and therefore contained in H_t and $H_t \subseteq I_t$. Thus, in forming expectations about future changes in national cash flow, the agent is likely to use superior information, i.e. information that is not available to the econometrician. But the use of superior information is reflected in the observable current account, and including it when predicting future changes in national cash flow makes it possible for the econometrician to control for information beyond past changes in national cash flow. Hence, an econometric implication of the ESH is that when CA_{t-1} Granger-causes ΔZ_t, there is statistical evidence that the agent has superior information.

The empirical vehicle for evaluating the ESH is the VAR

$$\begin{bmatrix} \Delta Z_t \\ CA_t \end{bmatrix} = \begin{bmatrix} \Psi_{11} & \Psi_{12} \\ \Psi_{21} & \Psi_{22} \end{bmatrix} \begin{bmatrix} \Delta Z_{t-1} \\ CA_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{\Delta zt} \\ \varepsilon_{cat} \end{bmatrix}, \tag{17}$$

where the means of ΔZ_t and CA_t have been removed.[5] Before estimating this VAR, besides verifying that Z_t is I(1), it is standard procedure to verify that the components of the vector $(V_t,\, C_t)$ are cointegrated such that CA_t is stationary. That is, by theory, V_t and C_t should both be I(1) such that the linear combination $(1, -1)(V_t,\, C_t)' = V_t - C_t = CA_t$ is I(0).[6] In matrix notation, (17) becomes

$$X_t = \Psi X_{t-1} + \varepsilon_t. \tag{18}$$

Following Campbell (1987), there are two equivalent approaches for evaluating the ESH by means of the VAR (17). The first is to impose the ESH (16) on the identity (4), and then test the implied cross-equation restrictions of the VAR. The second is to write the ESH (16) directly in terms of the VAR and then test the resulting cross-equation restrictions.

To show the first approach, use the ESH (16) to write the right-hand side of (4)

[5] For the annual data used in this paper, a one lag VAR is sufficient to capture the time series properties. However, if necessary, the VAR can easily be extended to incorporate several lags.

[6] Note that (14) implies that CA_t is I(0) since it is a linear combination of expected changes in national cash flow. For additional details of the cointegration properties in this setting, see Campbell (1987).

as

$$
\begin{aligned}
& (1+r)CA_{t-1} - CA_t + \Delta Z_t \\
= \; & \beta \Delta Z_t + (1-\beta) \sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} \left[E(\Delta Z_s \,| H_t) - E(\Delta Z_s \,| H_{t-1}) \right]. \qquad (19)
\end{aligned}
$$

If we define $e_1' = (1,0)$ and $e_2' = (0,1)$ such that $e_1' X_t = \Delta Z_t$ and $e_2' X_t = CA_t$, the left-hand side of (19) can be written in VAR notation as

$$
\begin{aligned}
& (1+r)CA_{t-1} - CA_t + \Delta Z_t \\
= \; & (1+r)e_2' X_{t-1} - e_2' X_t + e_1' X_t \\
= \; & ((e_1' - e_2')\Psi + (1+r)e_2')X_{t-1} + (e_1' - e_2')\varepsilon_t. \qquad (20)
\end{aligned}
$$

Using the same notation on the right-hand side of (19) yields

$$
\begin{aligned}
& \beta \Delta Z_t + (1-\beta) \sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} \left[E(\Delta Z_s \,| H_t) - E(\Delta Z_s H_{t-1}) \right] \\
= \; & \beta e_1' \Psi X_{t-1} + \beta e_1' \varepsilon_t + (1-\beta) \sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} e_1' \Psi^{s-t} \varepsilon_t. \qquad (21)
\end{aligned}
$$

If the ESH is true, the left-hand side of (20) should be equal to the left-hand side of (21). Consequently, in terms of the VAR, i.e., in terms of the right-hand sides of (20) and (21), the following set of restrictions must be satisfied:

$$
\begin{aligned}
(e_1' - e_2')\Psi + (1+r)e_2' &= \beta e_1' \Psi \qquad (22) \\
e_1' - e_2' &= \beta e_1' + (1-\beta) \sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} e_1' \Psi^{s-t}. \qquad (23)
\end{aligned}
$$

When $\beta \neq 0$, the restrictions in (22) imply that the change in consumption responds to predictable changes in national cash flow, i.e., consumption responds to lagged changes in national cash flow and lagged current account. They represent the formally testable implications of the ESH and can be evaluated by means of a likelihood-ratio test. As pointed out by Flavin (1993), from the restricted model that underlies the calculation of the likelihood-ratio statistic, an estimate of the excess sensitivity parameter, β, can be obtained. The restrictions in (23) imply that the innovation in the change in consumption depend on both the innovation in the change in national cash flow and the innovation in permanent national cash flow; they are algebraically equivalent to the ones in (22). To see this, note that (22) can be written as

$$\begin{aligned}(1-\beta)e_1' &= ((1-\beta)e_1' - e_2')(I-(1+r)^{-1}\Psi) \\ &\Leftrightarrow \\ (1-\beta)e_1'(I-(1+r)^{-1}\Psi)^{-1} &= ((1-\beta)e_1' - e_2'), \end{aligned} \tag{24}$$

which is equivalent to (23).[7]

To show the second approach for evaluating the ESH, note that the predicted current account, $\widehat{CA}_t$, is calculated from (16) as

$$\begin{aligned}\widehat{CA}_t &= (1-\beta)\left[-\sum_{s=t+1}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E(\Delta Z_s|H_t)\right] \\ &= -\frac{1-\beta}{1+r}e_1'\Psi(I-\frac{1}{1+r}\Psi)^{-1}X_t. \end{aligned} \tag{25}$$

If the ESH is true, the restrictions in (22) hold and can be rearranged to yield

$$-\frac{1-\beta}{1+r}e_1'\Psi(I-\frac{1}{1+r}\Psi)^{-1} = e_2'. \tag{26}$$

Substituting this into (25) gives

[7] In the case of the PIH, the restrictions (22) and (23) are known as the orthogonality and smoothness condition, respectively. That is, if β is forced to zero, the restrictions in (22) guarantee that the change in consumption is independent of either lagged current account or lagged changes in national cash flow. The restrictions in (23) then ensure that the change in consumption is equal to the innovation in permanent national cash flow; if they are satisfied, consumption cannot be "excessively smooth". For an elaboration, see Campbell and Deaton (1989) and Flavin (1993).

$$\widehat{CA}_t = e_2' X_t = CA_t. \tag{27}$$

That is, if the restrictions implied by the ESH are satisfied, the predicted and actual current account series are identical. Ghosh (1995) and Sheffrin and Woo (1990), among others, base their evaluation of the PIH on testing the nonlinear restrictions in (26) by means of a Wald test. Although (26) is equivalent to (22), it must be emphasized that nonlinear transformations of restrictions can change the values and power of Wald statistics (see Campbell and Shiller, 1987; and Gregory and Veall, 1985). Section 3 reports Wald test results for both versions of the restrictions.[8]

2.3 Excess sensitivity and international capital mobility

Under the assumption of the PIH, which implicitly includes the assumption of perfect international capital mobility, Ghosh's (1995) *capital mobility hypothesis* posits that the *variances* of the predicted and actual current account series should be equal. In terms of the ESH model, this means forcing the excess sensitivity parameter, β, to zero in (25), and positing that

$$var(\widehat{CA}_t) = var(CA_t). \tag{28}$$

If $A = -(1+r)^{-1} e_1' \Psi (I - (1+r)^{-1}\Psi)^{-1}$, then the capital mobility null hypothesis can alternatively be written as

$$A var(X_t) A' = e_2' var(X_t) e_2, \tag{29}$$

where $var(X_t)$ is the variance-covariance matrix of ΔZ_t and CA_t. The current account is said to be excessively volatile if

$$A var(X_t) A' < e_2' var(X_t) e_2. \tag{30}$$

[8] The likelihood-ratio statistic is invariant to the transformation and is therefore not reported for the test of the restrictions in (26).

The common approach is to calculate the variance or standard deviation *ratio* between the predicted and actual current account series and then test whether it is significantly different from unity. It follows that one case in which the capital mobility hypothesis holds, is when the PIH is true, because then, by (26), $A = e_2'$. Using the PIH framework, Ghosh then argues that if the capital mobility hypothesis fails in a way that makes the actual current account fluctuate more than the predicted current account, as in (30), it indicates that the degree of capital mobility is higher than the degree that is perfect according to the PIH. On the other hand, if the inequality in (30) is reversed so that the actual current account fluctuates less than the predicted current account, the degree of capital mobility is lower than the degree that is perfect according to the PIH. In addition, Ghosh also argues that excessive capital flows can be due to speculation, and that relatively small capital flows can be due to effective barriers to international capital mobility (see also Ghosh and Ostry, 1995).

As Ghosh (1995) notes, the main caveat to his analysis is that if the capital mobility hypothesis is rejected in the PIH framework, its failure can be attributed to *any* of the underlying assumptions, with perfect capital mobility being just one among several others. Differently put, given that the capital mobility hypothesis fails, assessments about the degree of international capital mobility can in fact be useless because it is entirely possible that the assumption of perfect capital mobility still holds. It is evident that if one sets out to measure the degree of international capital mobility, it would be better to use a hypothesis that, under the null, can allow for any degree of capital mobility, rather than using a hypothesis, such as the PIH, that assumes that the degree of capital mobility is always perfect.

It turns out that the ESH is an alternative to the PIH that allows for any degree of international capital mobility. As such, the ESH can be interpreted as a formalization of Ghosh's argument. In the open economy setting, the excess sensitivity parameter can capture the extent to which the degree of international borrowing and lending, i.e., the degree of international capital mobility, deviates from the degree that is perfect according to the PIH. To clarify, consider the following three cases which can occur when the ESH is true:

If $\beta = 0$, then there is no excess sensitivity, and the result is the PIH. This is the case of optimal consumption smoothing and perfect international capital mobility. For instance, a suddenly expected increase in future national cash flow implies that current consumption is revised upward to *exactly* equal permanent national cash flow by borrowing an amount *exactly* equal to the present discounted value of expected changes in national cash flow. The borrowed amount is the amount needed to smooth consumption *perfectly*, i.e. the amount making expected consumption constant. In this sense, it is natural to consider the PIH a benchmark case.

It should be emphasized that in the PIH model, i.e. when $\beta = 0$, "perfect" international capital mobility is not necessarily synonymous with a capital market with no regulations for international capital flows. In this framework, perfect international capital mobility merely means the specific degree of capital mobility that allows the agent to always smooth consumption perfectly (i.e. optimally) by setting the current account exactly equal to the present discounted value of expected declines in national cash flow. In general, empirical studies using Ghosh's (1995) capital mobility hypothesis suggest that it is entirely possible to smooth consumption perfectly by means of the current account even in countries where capital markets are subject to mobility constraints.[9]

As a second case, assume that the degree of international capital mobility is *lower* than the degree that is perfect according to the PIH. To see how excess sensitivity is generated, assume that in period t, national cash flow is suddenly expected to rise in the future so that the present discounted value of expected changes in national cash flow becomes positive (and larger than previously expected). As (15) implies, in response to the expected increase, actual consumption is revised upward by means

[9] See for instance Ghosh and Ostry (1995).

of borrowing abroad. However, due to the relatively lower degree of international capital mobility, it is not possible to borrow and consume as much as would have been possible if the degree of capital mobility had been perfect. Accordingly, *relative* to what would have occurred if the PIH had been true, consumption is *reduced* by the amount that cannot be borrowed, and excess sensitivity is thereby generated in the form of a positive β. Specifically, as shown in (15), the excess sensitivity parameter, β, captures the fraction of the present discounted value of the expected increase in national cash flow that cannot be borrowed and consumed.[10] The lower the degree of international capital mobility, the higher the β, i.e., the higher the fraction that cannot be borrowed. In the borderline case when $\beta = 1$, the current account is closed and present consumption cannot be smoothed and revised upward at all by borrowing abroad. One can use analogous reasoning to conclude that when national cash flow is expected to decrease, consumption smoothing behavior in combination with relatively low capital mobility implies a positive excess sensitivity parameter and less saving relative to what is optimal according to the PIH.

As a third case, assume that the degree of international capital mobility is *higher* than the degree that is perfect according to the PIH. Assume again that national cash flow is suddenly expected to rise in the future. In response, just as when capital mobility is relatively low, consumption smoothing behavior implies that present consumption increases above total cash flow by the amount that is borrowed. However, since there is more borrowing taking place than the borrowing that is needed for smoothing consumption perfectly, consumption is increased by more *relative* to what would have occurred if the PIH had been true. Thus, excess sensitivity is generated in the form of a negative β. In (15), $-\beta$ measures the fraction of the present discounted value of the expected increase in national cash flow that is borrowed in

[10]That is, according to (15), when future national cash flow is expected to increase, consumption smoothing behavior implies that present consumption increases above total cash flow by $(1 - \beta) \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t \Delta Z_s$. *Relative* to what would have occurred if the PIH had been true, however, consumption (and borrowing) is reduced by $\beta \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t \Delta Z_s$.

excess of what would have occurred if the PIH had been true. One can use analogous reasoning to conclude that when national cash flow is expected to decrease, consumption smoothing behavior, in combination with relatively high capital mobility, implies a negative excess sensitivity parameter and more saving relative to what is optimal according to the PIH.

Obviously, the ESH implies a very different economic interpretation of the capital mobility hypothesis (28). From (26) and (27) it follows that (28) holds not only when PIH is true, but also when the ESH is true. However, since the ESH allows for *any* degree of capital mobility that is consistent with consumption smoothing behavior, it no longer takes on the same interpretation as when the PIH is assumed. That is, if the ESH is true, the variance of the predicted current account is equal to the variance of the actual current account *even if the degree of international capital mobility is lower or higher than the degree that is perfect according to the PIH.*

As an example, if the inequality (30) is the outcome under the failure of the PIH, with the true reason being excessive capital flows, then the puzzle of an excessively volatile current account can be explained by the ESH. When the ESH is assumed, the left-hand side of (30) becomes

$$(1 - \beta)^2 Avar(X_t)A'. \tag{31}$$

From the above, we know that when capital mobility is relatively high, $\beta < 0$. Accordingly, expression (31) is always larger than $Avar(X_t)A'$, and the predicted current account series under the ESH fluctuates more than the predicted current account series under the PIH. Thus, if the ESH is true, the left-hand side of (30) is replaced by (31), the inequality becomes an equality, and the puzzle of an excessively current account is solved.

Analogous reasoning can also solve the puzzle of the PIH failing in a way that makes the actual current account too smooth. In such a case, if the failure is due to relatively low capital mobility, β is positive and less than unity and the ESH holds.

Consequently, the variance of the predicted current account under the ESH (31) is lower than the variance under the PIH, $Avar(X_t)A'$, and equal to the variance of the actual current account, $e_2'var(X_t)e_2$.

Accordingly, in sum, if one attributes excess sensitivity to the degree to which international borrowing and lending deviates from the degree that is optimal according to the PIH, the ESH suggests an alternative measure of international capital mobility. This measure is based on the sign and magnitude of the excess sensitivity parameter, β. Specifically, β is inversely related to the degree of international capital mobility and has an upper bound equal to unity. The closer β is to unity, the more closed the economy. In the interval $0 < \beta < 1$, the degree of capital mobility is lower than the degree that is perfect according to the PIH. In an optimal consumption smoothing sense, when $\beta = 0$, capital mobility is perfect. Finally, when $\beta < 0$, the degree of capital mobility is higher than the degree that is perfect according to the PIH.[11]

3. Empirical estimation and results

The annual Swedish national account data used in this section are taken from *International Financial Statistics* and cover the period 1951-99. Specifically, government consumption, G_t, is derived from line 91F; investment, I_t from lines 93E+93I; GNP_t from line 99A; current GDP, Q_t from line 99B; real GDP from line 99BV; and population from line 99Z. Following Ghosh (1995), the current account is calculated as $CA_t = GNP_t - I_t - G_t - C_t$. Thus, it follows from definition (3) above that $GNP_t = rB_t + Q_t$ such that $V_t = GNP_t - G_t - I_t$. All variables are converted into

[11] The consumption function generated in the interval $0 < \beta < 1$ is similar to the one that Shibata and Shintani (1998) build their model and test of international capital mobility around. In contrast to this paper, they use a slightly different theory for consumption that includes the autarky case ($B_t = 0$, $C_t = Z_t$) in which consumption smoothing by means of the current account is impossible. Also in contrast to this paper, they use a different empirical method that leaves out the way of evaluating model fit by comparing actual and predicted current accounts. Although they obtain negative estimates of the excess sensitivity parameter in some cases, they do not consider the possibility that the degree of international capital mobility may be higher than the degree that is perfect according to the PIH.

real terms per capita by dividing by the implicit GDP deflator and population.

Before estimation of the VAR (17), it must be verified that V_t and C_t are I(1) and cointegrated such that $V_t - C_t = CA_t$ is I(0). Furthermore, the model also rests on the assumption that Z_t is I(1). To verify non-stationarity of V_t, C_t, and Z_t, augmented Dickey-Fuller (DF) tests are performed (see Dickey and Fuller, 1981). To verify that V_t and C_t are cointegrated, a DF test of a unit root in CA_t is reported. Then, by means of the Johansen (1988) procedure, the DF test for CA_t, V_t, and C_t is supplemented by a cointegration analysis of the linear combination $(\delta_1, \delta_2)(V_t, C_t)'$. In contrast to the augmented DF test, the Johansen (1988) procedure specifies I(0) as a null hypothesis for CA_t, V_t and C_t.

Table 1

Unit root tests

Variable	DF t-statistic	LM
V_t	-2.93	0.08
C_t	-2.40	1.37
Z_t	-3.45	0.09
CA_t	-2.23^{*}	0.36
ΔV_t	-7.77^{**}	0.28
ΔC_t	-5.39^{**}	0.98
ΔZ_t	-8.33^{**}	0.21

Notes: LM is the Lagrange multiplier test for residual correlation from lags 1 to 2. "**" and "*" indicate rejection at the 1 and 5 percent level of significance, respectively.

Table 1 reports the results of the augmented DF unit root tests. The validity of the DF method rests heavily on the assumption of uncorrelated residuals, and to verify this, Lagrange multiplier tests for residual autocorrelation are performed. The results are also shown in Table 1. By lag-length selection tests and diagnostic checking, it was concluded that regressing the first difference of each variable V_t, C_t, and Z_t on a constant, a trend, and the lagged level of the variable was enough to avoid residual autocorrelation. In the case of CA_t, the simplest DF regression $\Delta CA_t = \gamma CA_{t-1} + u_t$ appeared to be enough to ensure serially uncorrelated residuals.

The null hypothesis of a unit root is not rejected for V_t, C_t, and Z_t, while it is rejected for CA_t. The augmented DF test is also performed for the first difference of V_t, C_t, and Z_t. In each case, the null hypothesis is strongly rejected, which suggests that there is no unit root in any of the differenced series.

The test results from the Johansen (1988) procedure are summarized in Table 2. The first two columns of the table specify the restriction on the vector (δ_1, δ_2). The third column shows the χ^2 statistic from the likelihood-ratio test of the null hypothesis that the specified vector belongs to the cointegrating space. The last column shows this test statistic's p-value. The test result of the main hypothesis, i.e., whether $(\delta_1, \delta_2) = (1, -1)$ belongs to the cointegrating space such that $(1, -1)(V_t, C_t)' = CA_t$ is I(0), is displayed in the first row of the table: $\chi^2 = 0.80$ and the corresponding p-value 0.372 imply that the null hypothesis cannot be rejected. The last two rows display results from the test of stationarity of V_t and C_t. For each variable, the null hypothesis is strongly rejected. Hence, the results of the unit root and cointegration tests indicate that Z_t is I(1), and that V_t and C_t are both I(1) and cointegrated such that CA_t is I(0).

Table 2

Restricted cointegration tests

H$_0$:			
δ_1	δ_2	$\chi^2(1)$	p-value
1	-1	0.80	0.372
1	0	8.74	0.003
0	1	8.56	0.003

Notes: The null hypothesis is that the vector (δ_1, δ_2) belongs to the cointegrating space such that $(\delta_1, \delta_2)(V_t, C_t)' = \delta_1 V_t + \delta_2 C_t$ is I(0). In the prior VAR estimation, one lag was sufficient to capture the time series properties and to assure no serial correlation among the residuals.

The next step is to estimate the VAR and test the restrictions on the parameters implied by the PIH and the ESH. Lag-length selection tests and diagnostic checking indicated that a one-lag VAR was sufficient to capture the time series properties. The results of the VAR estimation are shown in the top panel of Table 3. The coefficient for CA_{t-1} in the regression for ΔZ_t is negative as expected, but the hypothesis that CA_{t-1} does not Granger cause ΔZ_t cannot be rejected. Thus, statistically, it is not possible to conclude that agents have superior information.

Turning to the bottom panel of the table, recall from (22) that testing the PIH implies forcing β to zero and testing the restrictions

$$\begin{aligned} \Psi_{21} &= \Psi_{11} \\ \Psi_{22} &= (1+r) + \Psi_{12}. \end{aligned} \tag{32}$$

On the other hand, if the ESH is true, it follows from (22) that

$$\begin{aligned} \Psi_{21} &= (1-\beta)\Psi_{11} \\ \Psi_{22} &= (1+r) + (1-\beta)\Psi_{12}. \end{aligned} \tag{33}$$

Following Flavin (1993), both Wald and likelihood-ratio tests for each of the restrictions (32) and (33) are reported, and the results in Table 3 are based on 4 and 14 percent rates of interest.[12] In addition, the Wald statistic of the transformed version of the restrictions (26) for each assumed hypothesis and interest rate is reported.

[12]Previous studies of the PIH usually specify r to be somewhere in the interval $0.04 \leq r \leq 0.14$.

Table 3

VAR estimation and tests of restrictions

VAR estimation					
	ΔZ_t	CA_t			
ΔZ_{t-1}	-0.120	-0.156	t_{NG}	-1.01	
s.e.	(0.150)	(0.156)	p-value	0.319	
CA_{t-1}	-0.107	0.796			
s.e.	(0.106)	(0.111)			

Tests of restrictions					
PIH:	4%	14%	ESH:	4%	14%
$\chi^2_{W1}(2)$	6.55	18.76	$\chi^2_{W1}(1)$	0.24	0.50
p-value	0.038	< 0.001	p-value	0.621	0.478
$\chi^2_{LR}(2)$	5.15	13.22	$\chi^2_{LR}(1)$	0.19	0.35
p-value	0.076	0.001	p-value	0.662	0.557
$\chi^2_{W2}(2)$	8.63	20.67	$\chi^2_{W2}(1)$	0.09	0.13
p-value	0.013	< 0.001	p-value	0.762	0.715
			$\widehat{\beta}$	-0.943	-1.641
			s.e.	0.644	0.958

Notes: In the top panel, column variables are regressed on row variables (standard errors in parentheses). The sample period is 1951-99. t_{NG} is the test statistic for the null hypothesis that CA_{t-1} does not Granger cause ΔZ_t. In the bottom panel, χ^2_{W1} is the Wald statistic for the test of the restrictions implied by the PIH (32) and the ESH (33); χ^2_{LR} is the corresponding likelihood-ratio statistic. χ^2_{W2} is the Wald statistic for the test of the restrictions when they have been transformed according to (26).

Regardless of the interest rate used or the version of restrictions tested, statistical support for the PIH is at best very weak. For the likelihood-ratio test with $r = 0.04$, it is possible to reject the null hypothesis (32) at the 7.6 percent level of significance. For the Wald test with the same interest rate, it is possible to reject at the 3.8 percent level. The Wald test for $r = 0.04$ when the restrictions have been transformed according to (26) (and β set to zero), rejects the null at the 1.3 percent level of significance. When $r = 0.14$, the null is rejected at any conventional level of significance.

On the other hand, when testing the overidentifying restrictions implied by the ESH, the null hypothesis (33) and its equivalent transformation in (26) cannot be rejected at any conventional level of significance. Furthermore, the results for the ESH are robust with regard to the choice of level of interest rate. The table also shows estimates and standard errors of the excess sensitivity parameter, β, generated from the restricted models obtained when calculating the likelihood-ratio test statistics. For each interest rate, the estimated β is negative; it is -0.943 when $r = 0.04$, and -1.641 when $r = 0.14$. This suggests that Sweden's degree of international capital mobility is higher than the degree that is perfect according to the PIH. Statistically, when $r = 0.04$, the estimated β is weakly negative, since it is just 1.46 standard errors from zero. When $r = 0.14$, the estimated β is 1.71 standard errors from zero.

Figures 1 and 2 plot the predicted current account series under the PIH and ESH, respectively, along with the actual current account series; Table 4 shows the estimated standard deviation ratios of the series. Since the standard deviation ratio is a highly nonlinear function of the underlying VAR parameters, caution must be taken when making inference from it (Bekaert et al., 1997; Kilian, 1998). Accordingly, bootstrap simulations are used to construct 95 percent confidence intervals. The endpoints of each of these intervals are printed within brackets beneath the corresponding standard deviation ratio estimate in Table 4.[13]

[13]Each confidence interval is constructed by means of Kilian's (1998) "bootstrap-after-bootstrap" method. The method is basically divided into two parts. First, based on 1,000 artificial series of ΔZ_t and CA_t, estimation of and correction for bias in the original VAR parameters are made. Then, by use of these bias corrected estimates, another 2,000 artificial series of ΔZ_t and CA_t are produced. For each series of ΔZ_t and CA_t, the VAR parameters are estimated and again corrected for bias. Then, the ratio of standard deviations of the predicted and actual current account series is calculated. Repeating this procedure yields 2000 estimated standard deviation ratios. Finally, a 95 percent confidence interval is constructed from the 2.5th and 97.5th percentile interval endpoints of the resulting empirical distribution. For full details, see Kilian (1998).

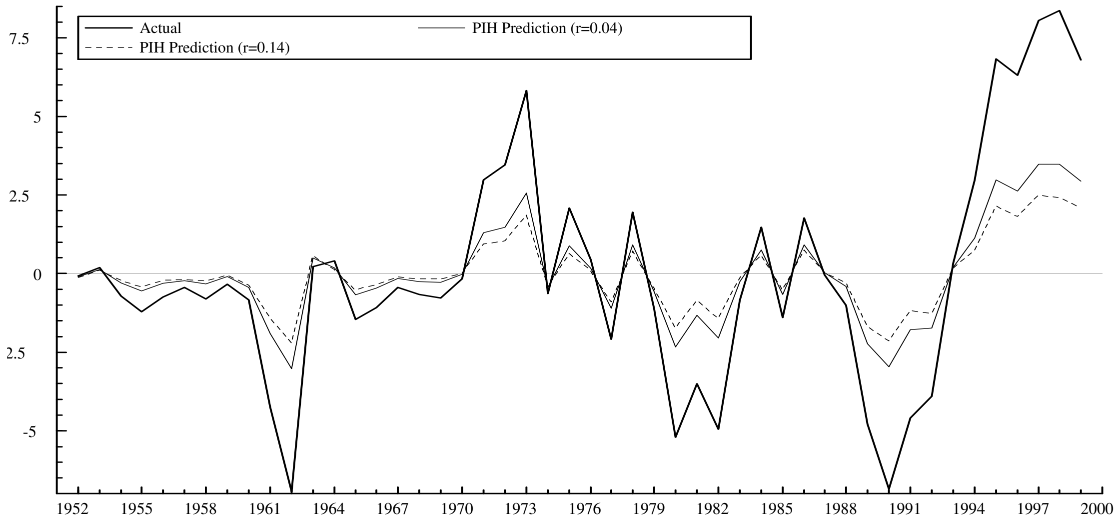

Fig. 1. *PIH predicted and actual current account series, 1952-99.*

Consider first the PIH. As Figure 1 shows, the predicted current account does a good job in capturing the shifts of the actual current account. However, the actual current account fluctuates more than its predicted counterpart. As discussed, this phenomenon is common when the PIH is applied to open economies. Table 4 shows that when $r = 0.04$, the estimated standard deviation ratio is 0.432. The right endpoint of the confidence interval is close to but just under unity, and it is therefore possible to reject the capital mobility hypothesis at the 5 percent level of significance. When $r = 0.14$, the estimated standard deviation ratio is 0.311, and the corresponding confidence interval suggests that the capital mobility hypothesis can be strongly rejected.

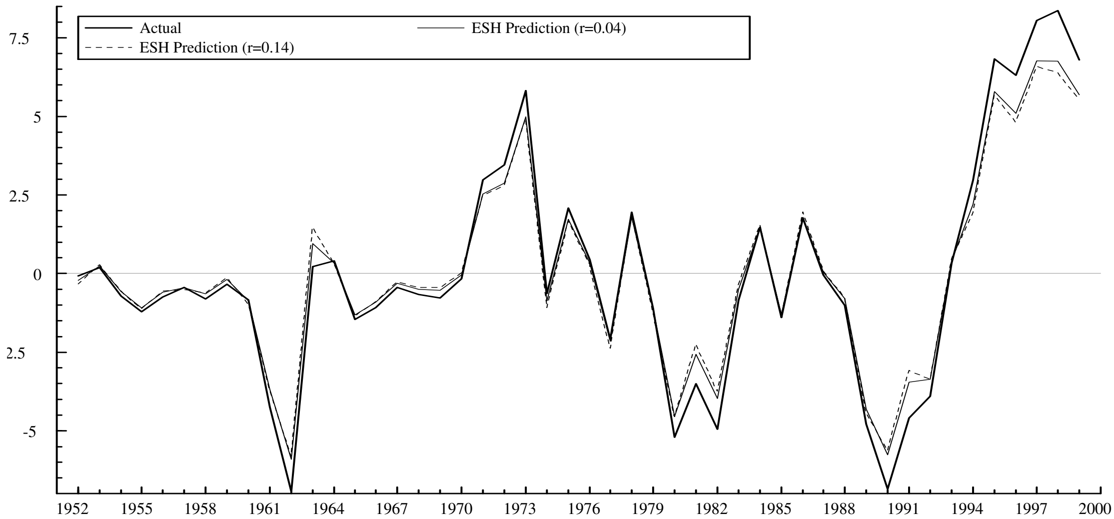

Fig. 2. *ESH predicted and actual current account series, 1952-99.*

Table 4

Estimated standard deviation ratios and confidence intervals

	PIH		ESH	
	4%	14%	4%	14%
$\sigma(\widehat{CA_t})/\sigma(CA_t)$	0.432	0.311	0.840	0.821
95% c.i.	[0.079 0.989]	[0.060 0.643]	[0.153 1.920]	[0.159 1.699]

In the case of the ESH, Figure 2 shows that, as suggested by the formal tests, the predicted and actual current account series are almost identical. The corresponding estimated standard deviation ratios shown in Table 4 also corroborate the failure to reject the ESH. For both interest rates, the ratios are above 0.8, and unity is easily contained in the corresponding confidence intervals. Hence, for each interest rate, the hypothesis that the ratio of standard deviations is equal to unity, cannot be rejected.

4. Concluding remarks

As emphasized by Flavin (1993), rather than the completely general alternative "any other behaviour other than that predicted by the PIH", the ESH is a *specific* alternative hypothesis to the PIH that, in the open economy setting, implies a mere rescalement of the current account, i.e., a mere rescalement of the degree of international borrowing and lending. Under the assumption of consumption smoothing behavior, the parameter that determines the size of the rescalement, i.e., the excess sensitivity parameter, is restricted to be less than unity. In order to solve the puzzle of an excessively volatile current account, the excess sensitivity parameter should be negative. Conversely, in order to solve the possible puzzle of a too smooth current account, the excess sensitivity parameter should be positive and less than unity.

Using the PIH framework, Ghosh (1995) argues that the puzzle of an excessively volatile current account is due to "too much" capital mobility. But, as he notes, since the PIH implicitly assumes that the degree of international capital mobility is fixed and, in an optimal consumption smoothing sense, perfect, such a conclusion must be interpreted with caution. In general, since several hypotheses are tested jointly, it is not possible to attribute model failure specifically to the assumption of perfect capital mobility. Thus, in the PIH framework, an excessively current account remains a puzzle. However, by showing that the behavioral consumption smoothing properties of the *ESH* framework can be reconciled with Ghosh's argument, a solution to the puzzle of an excessively volatile current account is offered. In contrast to the PIH, the ESH allows for *any* degree of international capital mobility that is consistent with consumption smoothing behavior. It turns out that if the ESH is true when the degree of capital mobility is higher than the degree that is perfect according to the PIH, the excess sensitivity parameter is negative. Hence, according to the ESH, an excessively volatile current account is not a puzzle, but rather what one would expect when the degree of capital mobility is relatively high. Conversely, if the ESH is true when capital mobility is relatively low, the estimated excess sensitivity parameter is positive and less than unity. The excess sensitivity parameter can be used to measure international capital mobility; it is inversely related to the degree of capital mobility and has an upper bound equal to unity.

Annual Swedish data for the period 1951-99 are used to compare the PIH with the ESH. The data illustrate what typically happens when testing the PIH on small open economies: Statistical evidence for the validity of the model is at best very weak, and the current account is excessively volatile. By contrast, when it is assumed that consumption is generated by the ESH, the model cannot be rejected and the actual and predicted current account series are almost identical. Accordingly, empirical estimates of the excess sensitivity parameter are negative, suggesting that Sweden's degree of international capital mobility is higher than the degree that is perfect according the PIH.[14]

Finally, there are some caveats to the analysis. As argued, the existence of excess sensitivity can be reconciled with the view that international capital mobility is not perfect. However, as Deaton (1991) points out, there could be other explanations for excess sensitivity as well, including durability and habit persistence. Thus, detecting excess sensitivity is one thing, attributing it fully to nonperfect capital flows is another, and this is a limitation one must recognize. Still, to the extent that the degree of international capital mobility *does* deviate from the degree that is perfect according the PIH, it should be captured by the excess sensitivity parameter. In this sense, the often observed volatility of international capital markets suggests that a nonperfect degree of capital mobility is a strong candidate for explaining excess sensitivity and the failure of the PIH in industrialized countries. At the same time, it should also be noted that there may also be other alternatives to the PIH that

[14]It is well-known that, on several occasions during the past decades, the Swedish krona has been subject to devaluation expectations, resulting in massive capital flows. As Ghosh (1995) points out, to the extent that such flows are not absorbed by reserves, they must be reflected in the change in the country's net foreign assets, i.e., in the current account. Thus, Ghosh's additional argument that an excessively volatile current account can be due to speculative flows rather than economic fundamentals, cannot be ruled out.

can improve the model fit.[15] Future research may shed more light on these issues.

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[15] Bergin and Sheffrin (2000) develop a model of the current account that allows for variable interest rates and exchange rates, and then use Campbell's (1987) method to evaluate and test it on Australia, Canada, and the United Kingdom (which all have excessively volatile current accounts). For these countries, the fit of the model is improved when compared to the benchmark PIH model used by previous studies. In another extension of the benchmark PIH model, Ghosh and Ostry (1997) show that precautionary saving motives can be an important determinant of current account surpluses.

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