ELSEVIER Journal of Monetary Economics 35 (1995) 159–192

JOURNAL OF Monetary ECONOMICS

Global versus country-specific productivity shocks and the current account

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(Received August 1993; final version received July 1994)

Abstract

This paper develops an analytically tractable empirical model of investment and the current account, and applies it to data from the G-7 countries. The distinction between global and country-specific shocks turns out to be quite important for explaining current account behavior; overall the model performs surprisingly well. One apparent puzzle, however, is that the current account responds by much less than investment to country-specific shocks, despite the near unit root behavior of these shocks. We show theoretically that this apparent anomaly can be explained if the shocks have very slow mean reversion.

Key words: Current account; Productivity; Investment

JEL classification: F32; F41

1. Introduction

This paper develops an empirical model of the current account to explore the remarkably consistent correlation between investment and the current account

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We are grateful to Shaghil Ahmed, David Backus, Marianne Baxter, Maurice Obstfeld, and Assaf Razin for comments on earlier drafts and to Robert Marquez for research assistance. Part of the research for this paper was performed while Rogoff was a visiting scholar at the Federal Reserve Bank of San Francisco. The views presented in this paper are those of the authors alone and do not necessarily reflect those of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System. Rogoff has benefited from the support of the National Science Foundation and the German Marshall Fund of the United States.

0304-3932/95/$09.50
SSDI 0304393294011819

deficit, in differences, across major industrialized countries over the post-war period. Though the correlation is negative as the theory predicts, the main puzzle is why, with open capital markets, it is not larger. On average, a rise in investment tends to increase the current account deficit by only one third as much.

Our framework is in the tradition of Sachs (1981), Obstfeld (1986), and Frenkel and Razin (1987) who theoretically analyze the intertemporal effects of government spending and productivity shocks. The main departure here, aside from developing and implementing a highly tractable, empirical formulation, is the distinction between global and country-specific shocks. Global productivity shocks affect investment but should not have a significant effect on current accounts; we find this to be consistently the case in our structural regressions. The importance of global shocks, which account for roughly 50 percent of the variance of total productivity, appears to be an important explanation of why the current account–investment correlation is not closer to one. But it is not the entire story.

Even after controlling for global shocks, an interesting puzzle remains. A fundamental implication of the intertemporal model is that a permanent country-specific productivity shock will induce a rise in the current account deficit in *excess* of the corresponding rise in investment. Because it takes time for the capital stock to adjust, permanent income rises by more than current income; this implies that domestic savings should fall.

Empirically, country-specific productivity shifts indeed tend to be very long-lasting. Using conventional unit root tests, the random walk hypothesis cannot be rejected for any country in our sample. But despite the near random walk behavior of country-specific productivity shocks, we find that empirically their effect on investment tends to be two to three times *larger* than on the current account. In other words, if one assumes random walk productivity, the data decisively reject a fundamental cross-equation restriction implied by the intertemporal model. Controlling for government consumption shocks does not reverse this result. Allowing for slight mean reversion in country-specific productivity – convergence – can, however, provide a resolution.

With adjustment costs, both the current account *and* investment depend on the present discounted value of future country-specific productivity shocks. Using closed-form solutions, we are able to show analytically that the current account response is more sensitive to the degree of persistence of the shocks. Quantitatively, with a real interest rate of 3 percent, the relative current account response falls by three-fourths when the first-order autocorrelation coefficient for (country-specific) productivity drops from 1.00 to 0.97, near the mean of our point estimates (a similar sensitivity to persistence arises in the consumption volatility literature; see Deaton, 1992).

Section 2 develops the model and Section 3 contains the empirical results for the random walk productivity case for the Group of Seven (G-7) major industrialized countries. In Section 4 we relax the random walk restriction, re-estimate the model, and demonstrate why the relative response of the current account depends very nonlinearly on persistence. In Section 5 we show that the model fits well the stylized facts on the correlations between changes in investment and the current account.

2. A one-good, small-country model with adjustment costs to investment

In this section we develop a structural model in which investment and the current account depend on exogenous shocks to productivity. The basic building blocks – a model of investment with adjustment costs and the random walk model of consumption – are quite familiar so our discussion of individuals' and firms' maximization problems will be quite brief. We will show that by using a linear-quadratic approach one can obtain extremely tractable estimating equations for investment and the current account. Initially, we will focus on the effects of country-specific productivity shocks; global shocks and government spending shocks will be incorporated later.

2.1. Capital markets

The representative agent in each country can borrow freely in world capital markets at the riskless (gross) world real interest rate r, which is denominated in terms of the single consumption good. If all shocks are country-specific (i.e., uncorrelated with global shocks), then for a small country r may be treated as exogenous. Only riskless bonds are traded internationally, so that agents cannot diversify away country-specific shocks.[1]

2.2. Aggregate supply

The representative agent supplies labor inelastically so that net aggregate output Y is given by

$$Y_t = A_t^c K_t^\alpha \left[1 - \frac{g}{2}\left(\frac{I_t^2}{K_t}\right) \right]. \tag{1}$$

[1] Thus our model follows the classic intertemporal approach in which country-specific productivity shocks cannot be diversified, rather than the complete markets open-economy real business cycle (RBC) approach. For RBC models, see Stockman and Tesar (1994), Backus, Kehoe, and Kydland (1992), and Mendoza (1991). Baxter and Crucini (1992) find that the two approaches yield similar results for cross-country consumption correlations unless the degree of persistence of productivity shocks is very high.

where K_t is the capital stock at time t, A_t^c is the time-t country-specific productivity shock, and

$$I_t = K_{t+1} - K_t \tag{2}$$

is investment. (Introducing depreciation slightly complicates the empirical specification below, but does not appear to significantly affect our results.) The I^2/K term in Eq. (1) captures adjustment costs in changing the capital stock.

The representative firm chooses the path of $\{I_t\}$ to maximize the present discounted value of future profits discounted at the world interest rate.[2] The solution to this problem is well-known (see, for example, Abel and Blanchard, 1986; Meese, 1980; Shapiro, 1986). Taking a linear approximation to the first-order conditions yields[3]

$$Y_t \cong \alpha_I I_t + \alpha_K K_t + \alpha_A A_t^c, \tag{3}$$

$$I_t \cong \beta_1 I_{t-1} + \eta \sum_{s=1}^{\infty} \lambda^s (\mathrm{E}_t A_{t-s}^c - \mathrm{E}_{t-1} A_{t+s-1}^c), \tag{4}$$

where in Eq. (3) $\alpha_I < 0$ (due to costs of adjustment), and $\alpha_K, \alpha_A > 0$. In Eq. (4), $0 < \beta_1 < 1$, $0 < \eta$, and $0 < \lambda < 1$; E_t denotes expectations based on time t information. The first term captures the effects on current investment of lagged productivity shocks, and the second term captures the impact of revisions in expectations about the future path of productivity.

2.3. Consumption

The representative agent chooses his path of consumption $\{C_t\}$ to maximize

$$\mathrm{E}_t \sum_{s=0}^{\infty} \beta^s U(C_{t+s}), \qquad U = C - \frac{h}{2}C^2, \tag{5}$$

subject to the intertemporal budget constraint

$$F_{t+1} = rF_t + y_t - C_t, \tag{6}$$

where $y \equiv Y - I$ is net (of investment) income and F_t denotes foreign assets entering period t. For simplicity, we assume $\beta = 1/r$. The quadratic specification

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[2] Our empirical specification implicitly assumes that the covariance of the marginal utility of consumption and investment is constant over time, since country-specific shocks to productivity cannot be diversified.

[3] Implicitly we assume that the productivity shocks are homoskedastic and that the variance terms that would appear in the second-order approximation are constant. Abel and Blanchard (1986) show that for reasonable parameter values a first-order approximation yields virtually the same empirical predictions as the more precise, but much more complicated, second-order approximation.

of utility in (5) is, of course, the same as in Hall's (1978) random walk model of consumption. The solution to the maximization problem embodied in (5) and (6) yields[4]

$$C_t = \frac{r-1}{r}\left(F_t + \mathrm{E}_t \sum_{s=0}^{\infty} y_{t+s}/r^s\right) = + \frac{r-1}{r} F_t \bar{y}_t. \tag{7}$$

As in Hall (1978), the *ex post* rate of change of consumption depends only on unanticipated movements in permanent net income:

$$\Delta C_t = (\mathrm{E}_t - \mathrm{E}_{t-1})\frac{r-1}{r}\left(\mathrm{E}_t \sum_{s=0}^{\infty} y_{t+s}/r^s\right) = \bar{y}_t - \mathrm{E}_{t-1}\bar{y}_t, \tag{8}$$

where $\Delta C_t \equiv C_t - C_{t-1}$.

2.4. Exogenous country-specific productivity shocks

It will be assumed that country-specific productivity shocks follow a first-order autoregressive process:

$$A_t^c = \rho A_{t-1}^c + \varepsilon_t, \qquad 0 \leq \rho \leq 1, \tag{9}$$

Extending the analysis to higher-order ARMA processes is straightforward.

2.5. Deriving the reduced-form estimating equations for the current account and investment when $\rho = 1$

We are now prepared to solve (1)–(9) to derive estimating equations for investment and the current account. For expositional purposes, it is convenient to initially focus attention on the case where $\rho = 1$. Aside from the advantage of analytical tractability, the random walk productivity assumption appears to provide a good empirical approximation for all the G-7 countries in our sample (see Table 2 in Section 3.2 below). Later, in Section 4, we will consider whether any of our empirical results may be sensitive to this restriction. Combining Eqs. (4) and (9) (with $\rho = 1$) yields simply

$$I_t = \overset{(+)}{\beta_1} I_{t-1} + \overset{(+)}{\beta_2} \Delta A_t^c, \tag{10}$$

[4] In deriving (7) it is assumed r is nonstochastic. Otherwise second-order terms would appear in our linearizations. In the empirical work below, we implicitly assume that the variance of productivity shocks is constant over time so that the second-order terms may be treated as constants.

where $\beta_2 \equiv \eta[\lambda/(1-\lambda)] > 0$. Since the empirical regularity we seek to explain involves changes in investment and the current account, we will subtract I_{t-1} from both sides of Eq. (10) to obtain[5]

$$\Delta I_t = \overset{(-)}{(\beta_1 - 1)} I_{t-1} + \overset{(+)}{\beta_2} \Delta A_t^c. \tag{11}$$

We now proceed to obtain a similar reduced-form expression for ΔCA as a function of ΔA^c and lagged endogenous variables. Differencing the accounting identity for the current account, one obtains

$$\Delta CA_t = (r-1)\Delta F_t + \Delta Y_t - \Delta I_t - \Delta C_t. \tag{12}$$

Note that $\Delta F_t = CA_{t-1}$ and that ΔI_t is given by (11). ΔY_t is easily obtained by substituting Eq. (2) into the first difference of Eq. (3), and then using (11) to solve out for ΔI_t:

$$\Delta Y_t = \overset{(+)}{[\alpha_I(\beta_1 - 1) + \alpha_K]} I_{t-1} + \overset{(+)}{(\alpha_I \beta_2 + \alpha_A)} \Delta A_t^c. \tag{13}$$

Substituting out for ΔC in Eq. (12) involves slightly more work. We begin with Eq. (8) which gives ΔC as a function of innovations to permanent (net) income. Using Eqs. (11) and (13) to substitute out for ΔI and ΔY, and Eq. (9) (with $\rho = 1$), one obtains (see Appendix 1)

$$\Delta C_t = \overset{(+)}{\left\{ \frac{\beta_2[(\alpha_I - 1)(r-1) + \alpha_K]}{r - \beta_1} + \alpha_A \right\}} \Delta A_t^c. \tag{14}$$

Since $r - \beta_1, \alpha_A > 0$, the coefficient on ΔA^c on the RHS of (14) is necessarily positive provided that $(\alpha_I - 1) + \alpha_k/(r-1) > 0$; this corresponds to the condition that the adjustment costs to marginal investment do not exceed the present discounted value of the corresponding output gain, which follows from convexity. Since $\alpha_I < 0$, it follows that $\partial \Delta C / \partial \Delta A^c > \partial \Delta Y / \partial \Delta A^c > 0$ – by comparing Eqs. (13) and (14).

The intuition behind the result that the coefficient on the country-specific productivity shock ΔA^c is greater in Eq. (14) for consumption than in Eq. (13) for output is simple but important. A permanent productivity shock has a greater effect on ΔC than on ΔY because a permanent rise in A^c induces investment and leads to a higher future capital stock, thereby causing permanent *net* income $\bar{y}_t$ to rise by more than current *gross* income Y_t. Note that if the country were to

[5] Note that our procedure for transforming Eq. (10) for I into Eq. (11) for ΔI would have no effect on any error term in (10). We address the error specification of our estimating equations more systematically in Section 2.8 below.

hold investment constant in response to the shock, then $\bar{y}$ and Y would rise by exactly the same amount. However, since it becomes profitable to raise investment after a positive productivity shock, $\bar{y}$ and hence C must rise by more than Y.

Combining Eqs. (11)–(14) yields the estimating equation for the current account:

$$\Delta CA_t = \overset{(+)}{\gamma_1 I_{t-1}} + \overset{(-)}{\gamma_2 \Delta A_t^c} + \overset{(+)}{(r-1) CA_{t-1}}, \tag{15}$$

where

$$\gamma_1 \equiv (\beta_1 - 1)(\alpha_I - 1) + \alpha_K > 0,$$

$$\gamma_2 \equiv \beta_2[(\alpha_I - 1)(1 - \beta_1) - \alpha_K]/(r - \beta_1) < 0.$$

For exactly the same reasons that the coefficient on ΔA^c is greater in the consumption equation than in the income equation, one can show that the coefficient on ΔA^c in the current account Eq. (15) is greater in absolute value than the corresponding coefficient in the investment Eq. (11); that is $|\partial \Delta CA / \partial \Delta A^c| > \partial \Delta I / \partial \Delta A^c > 0$.[6] A permanent rise in productivity not only worsens the current account due to higher investment, but also, as we have already discussed, because it causes consumption to rise by more than gross output.[7]

Of course, this result can be traced to the random walk productivity shock assumption. If $\rho = 0$ – so that the country-specific productivity shock is temporary – then current income would rise by more than permanent income. Since there would be no investment response to a purely temporary shock, the current account would necessarily move into *surplus*. As we shall see, a random walk provides a good empirical approximation for the productivity shocks, so we will postpone discussion of the $\rho < 1$ case until Section 4. Instead, we first introduce global productivity shocks and (global and country-specific) government spending shocks.

[6] To show that $|\gamma_2| > \beta_2$, note that $[(\alpha_I - 1)(1 - \beta_1) - \alpha_K]/(r - \beta_1) < -1$ iff $[(\alpha_I - 1)(\beta_1 - 1) - \alpha_K] > r - \beta_1$ iff $(\alpha_I - 1)(r - 1) + (\alpha_I - 1)(\beta_1 - r) + \alpha_K > r - \beta_1$ iff $(\alpha_I - 1)(r - 1) + \alpha_K > (r - \beta_1)\alpha_1$. This final condition holds provided $(\alpha_I - 1)(r - 1) + \alpha_K > 0$, which is again the condition that the present discounted value of higher output from investment exceeds the adjustment cost.

[7] Note also that the coefficient (γ_1) on I_{t-1} in ΔCA equation (15) is positive and larger in absolute value than the corresponding coefficient in the ΔI equation $(1 - \beta_1)$. (Recall that $\alpha_I < 0$ and $0 < \beta_1 < 1$.) A positive level of I_{t-1} causes the current account to improve both because I_t tends to revert to equilibrium and also because lagged investment raises current output. The change in consumption ΔC_t is, of course, unaffected by any variables dated $t - 1$ or earlier, including lagged investment.

2.6. Global productivity shocks

Suppose that in addition to the country-specific component A^c, the productivity shock contains a global component (common to all countries) A^w, so that Eq. (1) is replaced by

$$Y_t^c = (A_t^w \cdot A_t^c) K_t^\alpha \left[1 - \frac{g}{2}\left(\frac{I_t^2}{K_t}\right)\right], \tag{16}$$

for country c. If all countries have identical preferences, technology, and initial capital stocks, then the change in a country's current account depends on its country-specific shock A^c, but not on the global shock A^w since the latter impacts on all countries equally. (This assumes zero initial net foreign asset positions, which is a reasonable empirical approximation for the G-7 countries over the sample period.)

A^w does, of course, affect investment, but by less than an idiosyncratic shock of the same duration, since A^w affects world interest rates. Eq. (11) is then replaced by

$$\Delta I_t = (\beta_1 - 1) I_{t-1} + \beta_2 \Delta A_t^c + \beta_3 \Delta A_t^w, \tag{17}$$

where, if both A^w and A^c follow random walks ($\rho = 1$), $0 < \beta_3 < \beta_2$ due to the interest rate effect of the global shock.[8] If, however, the global shock is permanent and the country-specific shock is sufficiently transitory, then, of course, β_3 may be greater than β_2.

2.7. Government spending shocks

Introducing country-specific government (consumption) spending shocks is similarly straightforward. We assume that government spending is purely dissipative (or equivalently, that utility is separable in private and public consumption), and is financed by exogenous lump-sum taxes. In this case, country-specific government spending shocks G^c should have no effect on I, though *transitory* global government spending shocks G^w can have an impact through the real interest rate. The reverse is true for the current account. Global shocks should not impact on the current account but country-specific government spending shocks may if they are temporary. (A permanent rise in G^c will be fully offset by a permanent fall in C.) Note that government spending shocks constitute pure aggregate demand shocks in our formulation.

[8] Since β_3 arises out of the standard closed-economy model, we do not present an explicit derivation here; see Abel and Blanchard (1986) or Blanchard and Fischer (1989) for further discussion.

Defining permanent country-specific government spending as $\bar{G}_t^c \equiv [(r-1)/r] \times \mathrm{E}_t \sum_{s=0}^{\infty} G_{t+s}^c / r^s$, the current account equation, Eq. (15), becomes

$$\Delta CA_t = \gamma_1 I_{t-1} + \gamma_2 \Delta A_t^c + (\bar{G}_t^c - \mathrm{E}_{t-1} \bar{G}_t^c - \Delta G_t^c) + (r-1) CA_{-1}. \tag{18}$$

A temporary rise in country-specific government spending G^c leads to a deterioration in the current account since permanent after-tax income and therefore consumption declines by less than the rise in G^c (except for the global/local distinction, our approach to introducing government spending is similar to Ahmed, 1986).

Suppose, for example, that G^c is governed by the IMA(0, 1, 1) process:

$$G_t^c = G_{t-1}^c + \varepsilon_{Gt}^c - \theta^c \varepsilon_{Gt-1}^c. \tag{19}$$

Then one can show that in Eq. (18), the term $\bar{G}_t^c - \mathrm{E}_{t-1} \bar{G}_t^c - \Delta G_t^c$ equals $\theta^c(\varepsilon_{Gt-1}^c - \varepsilon_{Gt}^c / r)$.

2.8. *Error specification*

As a final preparation for empirical estimation, we introduce additive error terms μ_{It}, μ_{Yt}, and μ_{Ct} to the investment, output, and consumption equations – (4), (3), and (7). The μs are assumed independent of each other (although this assumption is not necessary for identification of the key parameters of interest). The error terms in Eqs. (11) and (13) for ΔI and ΔY become μ_{It} and $\alpha_I \mu_{It} + \Delta \mu_{Yt}$, respectively. The error term for the ΔC equation, Eq. (14), becomes

$$\left(\frac{(\alpha_I - 1)(r-1) + \alpha_K}{r - \beta_1}\right) \mu_{It} + \frac{r-1}{r} \mu_{Yt} + \Delta \mu_{Ct}, \tag{20}$$

and the error term in the ΔCA equation, Eq. (15), becomes

$$\frac{(\alpha_I - 1)(1 - \beta_1) + \alpha_K}{r - \beta_1} \mu_{It} + \Delta \mu_{Yt} - \left(\frac{r-1}{r}\right) \mu_{Yt} - \Delta \mu_{Ct}. \tag{21}$$

With this error specification, we see that I_{t-1} may be treated as a predetermined variable in the regression for ΔCA_t, but CA_{t-1} is endogenous.

3. Empirical results

Before turning to our estimates of structural equations for the current account and investment, it is helpful to first explore some simple correlations between these two variables. There is, in fact, a substantial literature starting from Sachs (1981) that attempts to use nonstructural current account/investment equations to draw inferences on international capital mobility.

Using long-term averages of cross-country data, Sachs (1981, 1983) argues that for OECD countries there is indeed a high negative correlation between these two variables (Sachs divides both by output), casting doubt on Feldstein and Horioka's (1980) conclusion that capital markets are relatively insular.[9] Subsequent writers, however, including Penati and Dooley (1984), Tesar (1991), and others, find that Sachs' correlations are quite sensitive to a couple of outliers; the general conclusion of this literature is that any correlation is tenuous at best.

3.1. Reduced-form regressions for ΔCA on ΔI

Is it indeed the case that the empirical correlation between investment and current accounts is so weak? One might argue that the type of decade-average data that is the focus of the post-Sachs literature looks at too long a horizon to capture the kind of dynamic effects emphasized by the model used here. In Table 1 below, which uses annual time series data instead of cross-country data (and where variables are expressed in levels rather than as ratios to output), we see that the *change* in the current account exhibits a strong and consistent negative correlation with the *change* in investment.[10] For the G-7 industrialized countries in the top half of the table, regressing ΔCA on ΔI for the years 1961–90 yields coefficients ranging from -0.16 to -0.55, averaging -0.36; all the coefficients are significant at better than 5 percent. The negative correlation between ΔCA and ΔI generally remains intact across the subperiods 1961–74 and 1975–1990, rising slightly in the second half of the sample. Unreported regressions for the remaining sixteen OECD countries over the full period

[9] Sachs argues that the observed nonstructural correlations may be caused by productivity shocks; the structural equations presented here support his conjecture. Of course, a strong negative correlation between current accounts and investment only provides evidence on the degree of capital mobility if one is willing to make some very strong identifying assumptions. It is not enough to assume that the only driving variable is productivity shocks; it is necessary that they be permanent and not transitory, country-specific and not global. Even if the productivity shocks are permanent, country-specific government spending shocks (and more generally demand shocks) reduce the correlation by effecting the current account without affecting investment. Shocks to nontraded goods productivity, on the other hand, may affect investment without having a significant impact on the current account; see Tesar (1993).

[10] The construction of all variables is described in Appendix 2; GDP or GNP deflators are used to construct real variables. There is also evidence of negative correlation in the levels regressions, though it is less robust across time and countries. Baxter and Crucini (1993) report finding negative correlations in the levels regressions, but do not give significance levels. Roubini (1990) finds evidence of a significant negative correlation when one includes budget deficits in the nonstructural current-account investment level regressions.

Table 1
Time-series regressions of current account on investment, $\Delta CA_t = a + b\Delta I_t$

Country	Sample period	b	R^2	D.W.
U.S.	1961–90	– 0.16 (0.07)**	0.18	1.44
Japan	1961–90	– 0.32 (0.07)**	0.40	1.27
Germany	1961–90	– 0.29 (0.11)**	0.21	1.94
France	1968–90	– 0.37 (0.11)**	0.34	1.82
Italy	1961–90	– 0.55 (0.08)**	0.61	1.95
U.K.	1961–90	– 0.53 (0.09)**	0.53	2.08
Canada	1961–90	– 0.31 (0.08)**	0.37	2.06
U.S.	1961–74	0.04 (0.10)	0.01	2.67
Japan	1961–74	– 0.21 (0.11)*	0.24	0.89
Germany	1961–74	– 0.35 (0.09)**	0.58	2.22
France	1968–74	0.10 (0.51)	0.01	1.74
Italy	1961–74	– 0.50 (0.16)**	0.44	2.54
U.K.	1961–74	– 0.37 (0.20)*	0.22	1.39
Canada	1961–74	– 0.40 (0.11)**	0.52	3.04
U.S.	1975–90	– 0.20 (0.09)**	0.27	1.18
Japan	1975–90	– 0.37 (0.10)**	0.49	1.54
Germany	1975–90	– 0.23 (0.19)	0.10	1.60
France	1975–90	– 0.42 (0.12)**	0.47	1.42
Italy	1975–90	– 0.59 (0.10)**	0.71	1.19
U.K.	1975–90	– 0.60 (0.10)**	0.72	1.81
Canada	1975–90	– 0.30 (0.10)**	0.38	1.88

The dependent variable is the absolute change in the real current account and the independent variable is the absolute change in real gross investment. Constant terms are not reported. Figures in parentheses are standard errors. Significance levels at 5 and 10 percent are indicated by ** and *, respectively.

1961–90 yield negative coefficients in all cases. In all but three cases, the coefficients are highly significant.[11]

Overall, the time series regressions on differences yield a remarkably consistent relationship between changes in current accounts and investment. The regression coefficient is well below one, but is impossible to draw any inferences on the validity of the intertemporal model without a more detailed investigation of the sources of the shocks.

[11] See Glick and Rogoff (1992). The point estimates for the smaller countries tend to be slightly larger on average than for the larger G-7 countries. The negative coefficients are significant for Austria, Denmark, Finland, Greece, Iceland, Ireland, Norway, Portugal, Spain, Sweden, Switzerland, Australia, and New Zealand. They are not significant at the 5 percent level for Belgium, the Netherlands, and Turkey.

3.2. Construction and time series properties of A^c and A^w

We consider two approaches to constructing Solow residuals, one that attempts to control for fluctuations in the capital stock and one that controls only for changes in labor. The labor-only measure is based on data published by the Bureau of Labor Statistics (BLS) on output and employment hours in manufacturing for major industrialized countries, 1960–90 (see Appendix 2). Following Backus, Kehoe, and Kydland (1992), we form productivity measures as the residuals from Cobb–Douglas production functions:

$$\ln Y - \pi \ln L,$$

where π, the share of labor in manufacturing output, is based on data from the OECD intersectoral data base.[12] With the BLS data, one cannot control for changes in the capital stock, K, except to the limited extent of including trend terms in the regressions.

Our alternative measure of Solow residuals does attempt to control for capital inputs by using the OECD international sectoral data base (see Appendix 2), though our data only covers the years 1970–85. Backus, Kehoe, and Kydland argue that adjusting for capital inputs should not produce radically different results since, if one extrapolates from United States data, short-term movements in capital are small relative to short-term movements in labor. As Fig. 1 illustrates, the U.S. case is not entirely representative, though the two productivity measures are highly correlated for all the countries in our sample. [Baxter and Crucini (1992) and Reynolds (1993) discuss the significance of adjusting for capital inputs in more detail.] In any event, we will later show that results based on OECD total factor productivity residuals over the shorter time period are very similar to the results obtained with the BLS-based residuals over the full sample. For this reason, and because dynamic issues are so central to our analysis, our main results below will be based on the longer BLS data set. One might also argue that the problems in constructing comparable capital stock measures in cross-country data are so severe (see Griliches, 1988) that attempts to adjust for capital inputs are not that reliable, anyway.

A further limitation of our data set is that it only covers manufacturing. We note, however, that much more accurate cross-country data are available for manufacturing than for services, particularly over the earlier part of our sample. Productivity in services is notoriously difficult to measure, and international

[12] See Meyer-zu-Schlochtern (1988) and Englander and Mittelstädt (1988). The estimates for π used are labor share in the traded goods sector: United States, 0.66; Japan, 0.54; Germany, 0.64; France, 0.65; Italy, 0.48; U.K., 0.68; Canada, 0.63; and are taken from Stockman and Tesar (1994).

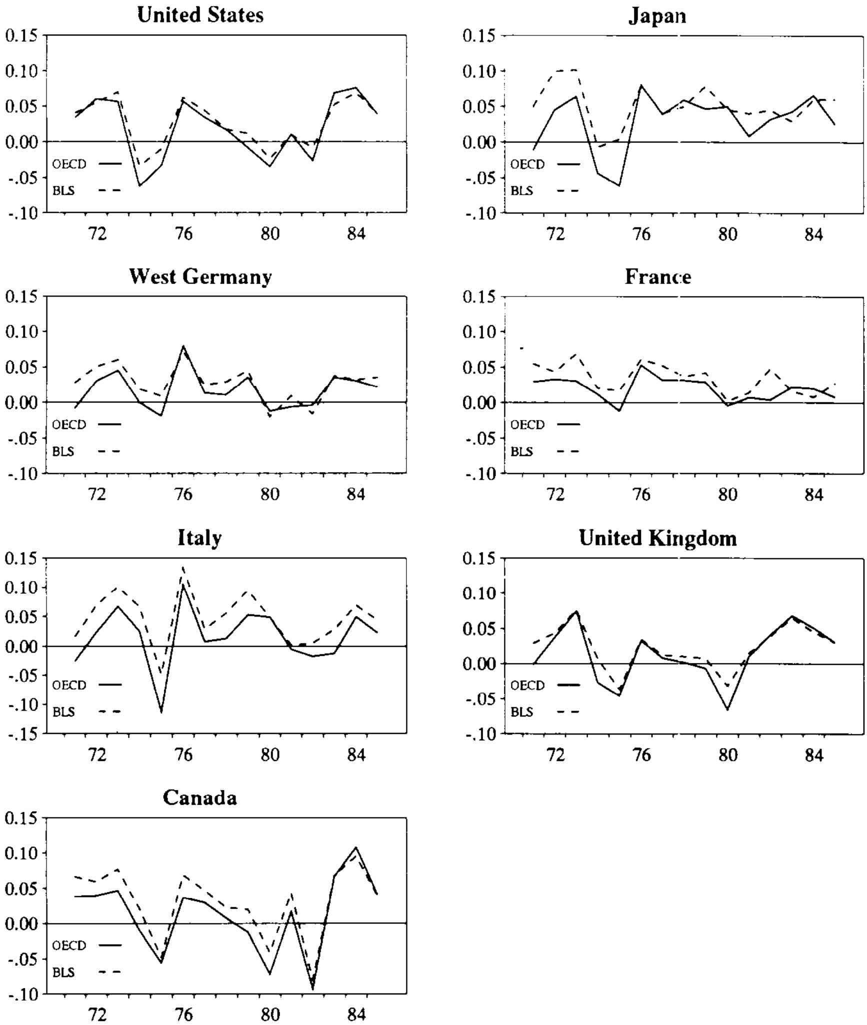

Fig. 1. Total factor productivity in manufacturing constructed from BLS and OECD data (log changes).

comparisons are further complicated by the high variability in the relative price of nontraded goods across countries.

Our global productivity measure is formed by taking a GNP-weighted average of the seven individual-country measures,[13] and the country-specific

[13]The weights were constructed from each country's share of total GDP in 1975, where local currency GDP figures were converted to dollars by the average dollar exchange rate for the year.

Table 2
Country-specific and global productivity unit root tests, 1961–90

Country	$DF\ t_\tau$	$ADF\ t_\tau$	ρ
U.S.	− 0.40	− 0.78	0.93 (0.026)
Japan	− 1.14	− 0.87	0.94 (0.020)
Germany	− 1.09	− 1.64	0.98 (0.078)
France	− 0.52	− 0.86	0.91 (0.048)
Italy	− 1.76	− 1.58	0.95 (0.042)
U.K.	− 1.29	− 1.51	0.89 (0.031)
Canada	− 2.43	− 1.76	1.01 (0.082)
Global	− 2.06	− 2.37	0.97 (0.012)

The dependent variable is the percent change in country-specific or global productivity. $DF\ t_\tau$ is the t-statistic on b_1 in the regression $\Delta A_t = b_0 + b_1 A_{t-1} + b_2 T$. $ADF\ t_\tau$ is the t-statistic on b_1 in the augmented regression $\Delta A_t = b_0 + b_1 A_{t-1} + b_2 T + b_3 \Delta A_{t-1}$. Critical values for t_τ (with 25 observations) are − 3.60 at 5 percent and − 3.24 at 10 percent. ρ is the coefficient on A_{t-1} in the regression $A_t = \alpha + \rho A_{t-1}$, with the standard error in parentheses.

component is then formed as the deviation from the global average.[14] Table 2 presents Dickey–Fuller unit root tests (with a constant and trend) for our productivity measures for the eight countries in the sample, and for the world average. In none of the cases is one able to reject the unit root hypothesis at standard significance levels.[15] The third column of the table presents estimates for a first-order autoregressive process. As one can see, the point estimates of ρ are all quite close to one.

[14] We also considered a more elaborate approach to decomposing A into A^c and A^w. We regressed A for each country on a GNP-weighted average of A (A^f) for the other six countries, treating the residual as the country-specific component. We found in all cases that one could not reject the hypothesis that both A and A^f have unit roots, and that they are not cointegrated. The more elaborate procedure gives very similar results in our current account and investment equations.

[15] In addition to the Dickey–Fuller test, we also employed the Phillips–Perron test with similar results. Another approach, based on Levin and Lin (1992), tests the joint hypothesis that there is a unit root in all of the country-specific productivity series. The ΔA^w regression in this method allows for different coefficients across countries on all variables (intercept and trend terms) except A^c_{t-1}. With this test, one still cannot in fact reject (at the 5 percent level) the joint hypothesis that $\rho = 1$ for all the countries. (Because the seven country-specific productivity series are linearly dependent by construction, it was necessary to drop one of the countries from the joint test.) Finally, we tested the unit root hypothesis against the alternative of a deterministic trend with a break, based on the procedure proposed by Christiano (1992), which does not impose priors on the point in time where the break occurs. One cannot reject the hypothesis of a unit root in favor of a trend break for any of the countries at the 10 percent level of significance. For a version of the test corresponding to an augmented Dickey–Fuller regression, one can reject the unit root null at the 5 percent level for Italy and 7 percent for the U.K. (These results included the Netherlands in the construction of ΔA^w.)

The estimates in Table 2 suggest that our earlier assumption that country-specific shocks follow a random walk is at least plausible. Note that by imposing that $\rho = 1$, we can avoid the issue of how uncertainty over ρ affects standard errors in the current account and investment equations. In Section 4, however, we tackle the more general serial correlation case and are thus able to test the robustness of our results.[16]

It must be emphasized that the exogeneity of productivity shocks is central to structural interpretation of the results below. Though often imposed in modern empirical macroeconomics (e.g., in the real business cycle literature), the assumption that the economy is operating along its equilibrium production function is admittedly extreme. Evans (1992), for example, has shown that Solow residuals are Granger-caused by other variables such as government spending. To the extent there is a large endogenous component to productivity, it would obviously affect the interpretation of our results.

3.3. *Structural estimates of the ΔCA and ΔI equations*

We are now prepared to estimate the central structural equations of our model, Eqs. (15) and (17) for ΔCA and ΔI. Table 3 presents individual country results under the assumption $\rho = 1$.[17]

For ΔI, the coefficients on ΔA^c and ΔA^w are all of the correct sign and are significant at the 5 percent level in almost 80 percent of the cases. The Ljung–Box Q-statistic does indicate serial correlation for Germany and the U.K.[18] The fact that the coefficients on ΔA^w are typically larger than for ΔA^c in the investment equation might be attributable to the residual positive serial correlation in the first difference of the world productivity shocks. Otherwise, of

[16] There does appear to be some residual correlation in a couple of the series even after taking first differences, especially in ΔA^w. Estimating a first-order MA process in ΔA^w yields a point estimate of 0.52 (positive serial correlation), with a standard error of 0.16. There also appears to be some positive serial correlation in ΔA^c for France, Germany, and the U.K., though less than for ΔA^w. (These results included the Netherlands in the construction of ΔA^w.)

[17] The results are not sensitive to the inclusion of time trends in the ΔCA regressions, but we excluded them on *a priori* grounds. The ΔI results are only marginally worse without trends, though the results for the U.S. are actually markedly better. To facilitate the cross-country comparison of the coefficients on productivity (and trend) terms, for each country these variables were multiplied by the mean of local real GDP or GNP over the sample period. This gives the reported coefficients on ΔA^c and ΔA^w the interpretation of the change in the left-hand-side variable *as a percent of mean GNP* in response to a 1 percent increase in productivity.

[18] The heteroskedasticity and autocorrelation-consistent standard errors in Table 3 are obtained using the ROBUSTERRORS option to the LINREG command in RATS, with DAMP = 1 and $L = 2$. This provides Newey–West estimates of the covariance matrix corrected for heteroskedasticity and for serial correlation in the form of a moving average of order 2.

course, this would be a puzzle. The coefficients on the lagged investment level, I_{t-1}, are generally not significant. We note that if investment is nonstationary (say, due to a stochastic trend), the standard errors on the coefficient of I_{t-1} will not be meaningful. However, according to the theorem discussed in Stock and Watson (1988), the nonstationarity of I_{t-1} will not affect the standard errors on the other, stationary, variables in our regressions.

Table 3 also presents results for the ΔCA equation. To deal with possible simultaneity of CA_{t-1} in (15), we constrain its coefficient to equal its theoretically-predicted value $r-1$.[19] Given the near random walk behavior of the country-specific productivity shocks, one would expect the estimated coefficients on ΔA^c to be negative, as indeed they are in all cases. Except for France and Germany, the coefficients are all significant at the 10 percent level or better. As we discuss in Appendix 2, French current account data is available on a consistent basis only since 1967 so the French results are based on a much smaller sample. The model also predicts that world productivity shocks, ΔA^w, should have no effect on current accounts since they affect all countries equally. This hypothesis cannot be rejected for any country except the United Kingdom, but even for the U.K. the country-specific shock has a much larger effect. It should be noted that the seven countries included in our proxy for world productivity shocks, while constituting a significant share of world output, provide somewhat less than complete world coverage. Thus, one might not expect the coefficient on ΔA^w to literally be zero. It should, however, be much smaller than the coefficient on ΔA^c.

Table 4 reports results for the full pooled time-series cross-section data set with and without country-specific time trends.[20] As in the individual country regressions, the coefficients in the ΔI equations are of the correct sign, and all are highly significant. ΔA^c is negative in the pooled ΔCA regressions, and is also highly significant. The point estimates for the world shock ΔA^w remain small in the pooled ΔCA equations and, as the model predicts, are insignificantly different from zero.

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[19] As our proxy for r, we use the real world interest rate series constructed by Barro and Sala-i-Martin (1990). Fluctuations in $(r-1)CA_{t-1}$ are quite small relative to fluctuations in ΔCA_t.

[20] The pooled results are estimated using the SUR command in RATS, a GLS system procedure, with equality restrictions imposed across equations, excluding the constants and time trends. To adjust for cross-country heteroskedasticity and to allow the pooling of data in different currency units, we scaled all variables in each equation in the system by the standard error of the corresponding OLS country regressions. In addition, as in the individual-country OLS regressions, variables without units, such as productivity changes and trend terms, were multiplied by the mean of local real GNP or GDP over the sample period. We used the SUR option ITER which begins with estimates of cross-country covariances based on the residuals from individual country OLS regressions and recomputes the covariances and system equation estimates iteratively. We set a maximum of 25 iterations, but all results converged before reaching this limit.

Table 3

Individual-country time-series regressions, 1961–90, $\Delta Z_t = b_0 + b_1 \Delta A_t^c + b_2 \Delta A_t^w + b_3 I_{t-1} + b_4 T$

Country	ΔZ	b_1	b_2	b_3	$b_4 \times 10^2$	R^2	Q-msl
U.S.	ΔI	0.20 (0.11)*	0.40 (0.07)**	– 0.22 (0.18)	0.11 (0.09)	0.53	0.88
	ΔCA	– 0.14 (0.08)*	0.01 (0.07)	0.04 (0.04)		0.13	0.25
Japan	ΔI	0.43 (0.06)**	0.58 (0.11)**	0.10 (0.08)	0.06 (0.10)	0.68	0.87
	ΔCA	– 0.14 (0.04)**	0.06 (0.07)	0.04 (0.02)*		0.19	0.40
Germany	ΔI	0.47 (0.10)**	0.52 (0.12)**	0.15 (0.07)**	0.13 (0.04)**	0.55	0.00
	ΔCA	0.20 (0.13)	0.00 (0.07)	0.02 (0.07)		0.11	0.16
France	ΔI	0.46 (0.12)**	0.43 (0.15)**	– 0.14 (0.08)*	0.15 (0.05)**	0.36	0.53
	ΔCA[a]	– 0.07 (0.13)	0.03 (0.13)	0.02 (0.06)		0.03	0.16
Italy	ΔI	0.60 (0.13)**	0.26 (0.19)	– 0.18 (0.14)	0.16 (0.07)**	0.66	0.17
	ΔCA	– 0.30 (0.12)**	– 0.10 (0.14)	0.03 (0.04)		0.24	0.49
U.K.	ΔI	0.50 (0.11)**	0.65 (0.07)**	0.05 (0.08)	0.01 (0.04)	0.76	0.00
	ΔCA	0.46 (0.09)**	– 0.20 (0.08)**	0.00 (0.05)		0.49	0.64
Canada	ΔI	0.41 (0.18)**	0.17 (0.15)	0.12 (0.16)	0.13 (0.14)	0.44	0.17
	ΔCA	– 0.24 (0.08)**	0.07 (0.10)	– 0.04 (0.02)		0.30	0.68

The dependent variable is the absolute change in real gross investment or current account. The independent variables are the percent change in country-specific productivity, percent change in global productivity, and a time trend, all multiplied by the mean of real GDP or GNP, and the lagged level of real gross investment. Constant terms not reported. Standard errors from Newey–West heteroskedastic and autocorrelation consistent estimates of covariance matrix are in parentheses. Significance levels at 5 and 10 percent are indicated by ** and *, respectively. Q-msl is the marginal significance level of the Box–Ljung Q-statistic for serial correlation.

[a] 1968–90.

Table 4
Pooled time-series regressions, 1961–90, $\Delta Z_t = b_0 + b_1 \Delta A_t^c + b_2 \Delta A_t^w + b_3 I_{t-1} + b_4 T$

ΔZ	b_1	b_2	b_3
With country-specific time trends			
ΔI	0.35 (0.03)**	0.53 (0.06)**	− 0.10 (0.04)**
ΔCA	− 0.17 (0.03)**	0.01 (0.02)	0.04 (0.03)
Without time trends ($b_4 = 0$)			
ΔI	0.36 (0.03)**	0.56 (0.05)**	0.08 (0.02)**
ΔCA	− 0.16 (0.02)**	− 0.01 (0.02)	− 0.01 (0.01)*

Pooled regressions are estimated by generalized least squares with equality restrictions imposed across the country equations, excluding the constant and trend terms, and with each equation scaled by the standard error of the corresponding OLS regression. Dependent and independent variables are the same as described in the note to Table 3. Constants and country-specific time trends are not reported. France is excluded from the ΔCA regressions. Figures in parentheses are standard errors. Significance levels at 5 and 10 percent are indicated by ** and *, respectively.

The main puzzle in Table 3 and 4 lies in the relative magnitudes of the coefficients on ΔA^c in the ΔI and ΔCA equations. Both in Table 4 and in the individual country results in Table 3 the coefficient on ΔA^c is *smaller* in absolute value in the current account regressions than in the ΔI regressions. For the pooled results, it is less than half as large. Given the evidence in Table 2 that productivity shocks (nearly) follow random walks, one might expect the current account response to be *larger* than the investment response, since consumption should move by more than output; we return to this issue in Section 4 below. Similarly, the coefficient on I_{t-1} in the ΔCA equation in Table 4, though of the correct sign, is smaller rather than larger (in absolute value) than the corresponding coefficient in the ΔI equation.

Our empirical analysis thus far has focused entirely on supply shocks: In the next section we attempt to control for changes in government spending, which constitutes one form of demand shock.

3.4. *Temporary government spending shocks*

Recall that in theory permanent country-specific government consumption spending shocks have no effect on investment, whereas global government spending shocks have no effect on current accounts. G^c shocks can affect ΔCA and G^w shocks can affect ΔI, but in each case only if they are temporary. (It would be interesting to extend the analysis to incorporate government investment, but we do not attempt this here.)

To estimate temporary shocks to government spending, we estimate the ARIMA(0, 1, 1) process given in Eq. (19) above, again forming G^w as a weighted

Table 5
Pooled time-series regressions with government consumption, 1961–90

b_1	b_2	b_3	b_5
$\Delta I_t = b_0 + b_1\Delta A_t^c + b_2\Delta A_t^w + b_3 I_{t-1} + b_4 T + b_5(\bar{G}_t^w - \mathrm{E}_{t-1}\bar{G}_t^w)$			
0.35 (0.03)**	0.51 (0.06)**	− 0.10 (0.04)**	− 0.51 (0.47)
$\Delta CA_t = b_0 + b_1\Delta A_t^c + b_2\Delta A_t^w + b_3 I_{t-1} + b_4 T + b_5(\bar{G}_t^c - \mathrm{E}_{t-1}\bar{G}_t^c - \Delta\bar{G}_t^c)$			
− 0.17 (0.03)**	0.01 (0.02)	0.04 (0.03)	− 0.40 (0.34)

Estimation procedure and variables are the same as described in the note to Table 4 with addition of the unanticipated change in permanent global real government consumption in the investment regression, and the difference between the unanticipated permanent change and actual change in country-specific real government consumption in the current account regression. France is excluded from ΔCA regressions. Figures in parentheses are standard errors. Significance levels at 5 and 10 percent are indicated by ** and *, respectively.

average of individual-country Gs, normalized by GNP.[21] Given our assumption that ΔG follows an MA(1) process, $(\bar{G}_t^c - \mathrm{E}_{t-1}\bar{G}_t^c - \Delta G_t^c)$ is then given by the formula below Eq. (19), $\theta^c(\varepsilon_{Gt-1}^c - \varepsilon_{Gt}^c/r)$. $\bar{G}_t^w - \mathrm{E}_{t-1}\bar{G}_t^w$, the temporary component of changes in G^w, is given by $(r - \theta^w)\varepsilon_{Gt}^w/r$. The pooled time-series cross-section results are presented in Table 5, where G is measured by real government consumption (see Appendix 2); the θs are allowed to vary across countries.[22] The coefficients on ΔA^c, ΔA^w, I_{t-1} remain exactly as before, and the G shocks do not enter significantly. Individual country regressions (not reported) are also largely unaffected by the inclusion of G shocks.[23] The fact that government spending appears to have relatively little impact may be due to the difficulty of extracting the temporary component of changes in G. In any event, the main conclusion here is that our findings on productivity shocks are largely unaffected by controlling for government consumption shocks.

3.5. Alternative empirical measures of productivity

In addition to our BLS-based Solow residual estimates, we tried two alternative measures of productivity. The first was straight output/worker hour,

[21] To form G^w, we normalized each country's G by the country's average level of GNP in the period, and then formed a world index using 1975 nominal dollar GNP weights.

[22] We measured the r in the G shock formulas by the mean over the period of the world real interest rate constructed by Barro and Sala-i-Martin (1990).

[23] To check the robustness of these results, we also entered ΔG^c and ΔG^w in raw form into the ΔCA and ΔI equations, respectively, but they remain insignificant. We also tried controlling for world interest rates directly in the ΔCA and ΔI equations using the Barro and Sala-i-Martin (1990) measure of world real interest rates; again the productivity coefficients were little affected.

Table 6
Pooled time-series regressions using OECD total factor productivity data, 1971–85 subsample, $\Delta Z_t = b_0 + b_1 \Delta A_t^c + b_2 \Delta A_t^w + b_3 I_{t-1} + b_4 T$

ΔZ	b_1	b_2	b_3
With country-specific time trends			
ΔI	0.36 (0.03)**	0.43 (0.06)**	− 0.06 (0.07)
ΔCA	− 0.27 (0.02)**	0.05 (0.02)**	0.05 (0.03)
Without time trends ($b_4 = 0$)			
ΔI	0.39 (0.03)**	0.44 (0.06)**	− 0.02 (0.05)
ΔCA	− 0.28 (0.02)**	0.03 (0.01)	− 0.01 (0.01)

Estimation procedure and variables are the same as described in note to Table 4. France is excluded from ΔCA regressions. Figures in parentheses are standard errors. Significance levels at 5 and 10 percent are indicated by ** and *, respectively.

without attempting to adjust for decreasing returns to labor inputs. The results are qualitatively extremely similar to those presented above, both for the time series of productivity and for Tables 3 and 4.

Next, we used data on total factor productivity in manufacturing from the OECD international sectoral data base, available for the years 1970–1985. These estimates attempt to account for changes in capital. Table 6 presents pooled results corresponding to those in Table 4 for the BLS-based Solow residual estimates. The results are quite similar to those in Table 4.[24] The coefficient on ΔA^w is actually significant in the ΔCA regression with a time trend, but it is much smaller in magnitude than the coefficient on the country-specific shock, ΔA^c. As mentioned above, one possible rationale why ΔA^w might enter significantly with a very small coefficient is that the seven large industrialized countries here do not quite constitute 100 percent of world GNP, even among countries with relatively open capital markets. The individual-country results are also qualitatively similar, with only slightly fewer coefficients significant at the 5 percent level, due in part to the shorter sample.

Note that the coefficients on ΔA^c in the ΔCA and ΔI equations are actually much closer in magnitude in Table 6 than in Table 4, though they are tightly

[24] We also estimated the regressions in Table 6 using business sector total factor productivity, despite the misgivings expressed above. For the ΔI equation with a time trend we obtained estimates of 1.08 for b_1 and 0.64 for b_2 with marginal significance levels of 0.00 in both cases. For the ΔCA equation without a time trend, we obtained estimates of − 0.08 for b_1 and − 0.04 for b_2 with marginal significance levels of 0.04 and 0.44, respectively. It is not surprising that β_2 is larger relative to γ_2 when productivity is measured using the overall business sector rather than manufacturing; nontraded goods constitute a much smaller share of manufacturing. (These regressions included the Netherlands in the construction of ΔA^w and in the pooled country estimates.)

Table 7
Pooled time-series regressions, 1975–90 subsample, $\Delta Z_t = b_0 + b_1 \Delta A_t^c + b_2 \Delta A_t^w + b_3 I_{t-1} + b_4 T$

ΔZ	b_1	b_2	b_3
With country-specific time trends			
ΔI	0.34 (0.04)**	0.66 (0.06)**	– 0.05 (0.05)
ΔCA	– 0.30 (0.02)**	0.02 (0.02)	0.02 (0.03)
Without time trends ($b_4 = 0$)			
ΔI	0.32 (0.03)**	0.62 (0.06)**	0.00 (0.04)
ΔCA	– 0.26 (0.03)**	– 0.01 (0.02)	– 0.02 (0.02)

Estimation procedure and variables are the same as described in note to Table 4. France is excluded from ΔCA regressions. Figures in parentheses are standard errors. Significance levels at 5 and 10 percent are indicated by ** and *, respectively.

estimated and remain smaller in the ΔCA equations. As a final check, we present in Table 7 pooled estimates using the BLS-based Solow residuals for the post-oil-shock period. Overall, the results are similar to the OECD-based results for the recent period in Table 6.

4. Mean-reverting country-specific productivity shocks ($\rho < 1$)

In this section, we explore the sensitivity of our results to the assumption that country-specific productivity shocks follow a random walk. While in Section 3.2 we could not reject the $\rho = 1$ hypothesis for any country using standard unit root tests, it is well known that these tests generally lack power against the alternative of a ρ slightly less than one; the available time series are simply too short to give reliable estimates for the low frequencies. Moreover even if country-specific productivity shocks contain a random walk component, it seems quite likely that they would contain a significant mean-reverting component as well. If one cannot separate the two components empirically, then the estimated consumption response will be a weighted average response.[25]

In Section 4.1 below, we ask whether relaxing the $\rho = 1$ restriction would reverse our conclusion that empirically *unanticipated* productivity shocks have a greater impact on investment than on the current account; it turns out that the estimated responses change very little. Nevertheless, as we argue in Section 4.2, allowing for ρ slightly less than one can dramatically impact our cross-equation

[25] That is, if one thought of productivity shocks as being the sum of a permanent component and a temporary component, consumers would still expect to see some mean reversion, on average (see Quah, 1990).

restriction. We show analytically that the current account response to productivity shocks is likely to be hypersensitive to small changes in their persistence.

4.1. Deriving estimating equations for innovations in investment and the current account

Deriving the impact effect of shocks on investment is again straightforward. Subtract $t-1$ expectations from both sides of Eq. (4) and evaluate the resulting expression to obtain (Appendix 1 contains the formal derivations for this section):

$$\tilde{I}_t = \overset{(+)}{\beta'_2}\varepsilon_t, \tag{22}$$

where $\sim$ denotes the revision of expectations operator $\mathrm{E}_t - \mathrm{E}_{t-1}$, $\tilde{I}_t$ is the innovation to investment, $\beta'_2 \equiv \eta\rho/(1-\lambda\rho)$, and $\varepsilon_t = \tilde{A}^c_t = A^c_t - \rho A^c_{t-1}$ is the country-specific productivity shock [see Eq. (9)]. Note that $\partial\beta'_2/\partial\rho < 0$ for $0 < \rho < 1$; when $\rho = 0$, then $\beta'_2 = 0$. If the shock is entirely transitory, there is no investment response.

As before, the corresponding equation for the unanticipated change in the current account $\tilde{CA} = \tilde{Y} - \tilde{I} - \tilde{C}$ (note $\tilde{F}_{-1} = 0$) must be constructed from its component parts. (Note that net foreign assets F_t are predetermined.) $\tilde{I}$ is given by Eq. (22); $\tilde{Y}$ can be derived using Eqs. (3) and (22),

$$\tilde{Y}_t = (\alpha_I\beta'_2 + \alpha_A)\varepsilon_t, \tag{23}$$

where we have used the fact that $\tilde{K}_t = 0$. Finally, the effect of ε on permanent income – and therefore on $\tilde{C}(=\Delta C)$ – is given by (see Appendix 1)[26]

$$\tilde{C}_t = \overset{(+)}{\delta'_2}\varepsilon_t, \tag{24}$$

where

$$\delta'_2 \equiv \frac{r-1}{r-\rho}\left[\beta'_2\frac{(\alpha_I-1)(r-1)+\alpha_K}{r-\beta_1} + \alpha_A\right] > 0.$$

Combining Eqs. (22)–(24) yields

$$\tilde{CA}_t \equiv \gamma'_2\varepsilon_t, \tag{25}$$

where

$$\begin{aligned}\gamma'_2 &\equiv (\alpha_I - 1)\beta'_2 + \alpha_A - \delta'_2\\ &= \alpha_A\frac{1-\rho}{r-\rho} + \beta'_2(\alpha_I - 1) - \frac{r-1}{r-\rho}\beta'_2\frac{(\alpha_I-1)(r-1)+\alpha_K}{r-\beta_1}.\end{aligned}$$

[26] Note that when $\rho = 0$, Eqs. (23) and (24) imply $\tilde{C} = ((r-1)/(r-\rho))\,\alpha_A\varepsilon < \alpha_A\varepsilon = \tilde{Y}$. As we have already discussed, the current account moves into surplus in response to a purely transitory shock.

It is easy to see that $\partial\gamma'_2/\partial\rho > 0$ (for $0 < \rho < 1$); that is, the lower the serial correlation in the productivity disturbance, the smaller the increase in the current account deficit. For ρ small enough, γ'_2 must eventually become positive.

Of course, Eqs. (22) and (25) cannot be estimated directly since $\tilde{I}$ and $\widetilde{CA}$ are not directly observable. Noting that $\Delta I_t = \tilde{I}_t + \mathrm{E}_{t-1}I_t - I_{t-1}$, one can use Eq. (4) to transform Eq. (22) into

$$\Delta I_t = \beta'_2\varepsilon_t + (\beta_1 - 1)I_{t-1} + \beta'_2(\rho - 1)A^c_{t-1} \quad \text{or}$$

$$\Delta I_t = (\beta_1 - 1)I_{t-1} + \beta'_2\Delta A^c_t, \tag{26}$$

which is exactly the same as Eq. (11) which we have already estimated, except that β_2 is replaced by β'_2! [With a higher-order autoregressive process, more lags of A^c would enter into Eq. (26).] Thus we do not have to alter our investment equation at all to generalize the empirical analysis to the $\rho < 1$ case.

The current account equation, however, must be modified slightly. Noting that $\Delta CA_t = \widetilde{CA}_t + \mathrm{E}_{t-1}CA_t - CA_{t-1}$ and adding $\mathrm{E}_{t-1}(Y - I - C)_t - (Y - I - C)_{t-1} + (r - 1)\,(F_{t-1} - F_{t-2})$ to both sides of Eq. (25) yields (after some manipulation; see Appendix 1):

$$\Delta CA_t = \gamma_1 I_{t-1} + \gamma'_2 A^c_t + \gamma A^c_{t-1} + (r - 1)CA_{t-1}, \tag{27}$$

where $\gamma_1 \equiv (\beta_1 - 1)(\alpha_I - 1) + \alpha_K$, γ'_2 is the same as in Eq. (25), and $\gamma \equiv -\gamma'_2 + (\rho - 1)\delta'_2$, where δ'_2 is the coefficient on ε_t in the $\tilde{C}$ equation, Eq. (24). Intuitively, the reason why A^c_t has the same coefficient in Eq. (27) as does ε_t in Eq. (25) is that anticipated productivity depends on A^c_{t-1}. Therefore, once the direct and indirect effects of A^c_{t-1} are controlled for, A^c_t affects the current account only through its unanticipated component.

The system of equations for empirical estimation in the $\rho < 1$ case is thus given by Eqs. (26), (27), and (9) (the AR process for country-specific productivity). The extension to global shocks is immediate; global shocks enter exactly as before into the investment equation and, as before, they do not enter into the current account equation. Note that the system of estimating equations is just identified.[27]

[27] The form in which we have written the current account and investment equation does not require any cross-equation restrictions for identification. One could write the current account equation in terms of ΔA^c_t and $\varepsilon_t (= A^c_t - \rho A^c_{t-1})$ instead of in terms of A^c_t and A^c_{t-1} as we have done. In this case one would have to impose the constraint that the coefficient on A^c_{t-1} is ρ times the coefficient on A^c_t to obtain identification. This equivalent approach (which yields identical estimates) is the conventional one. Note that there would be an overidentifying cross-equation restriction if the consumption equation, Eq. (24), were estimated jointly with (26), (27), and (9).

Table 8 presents joint estimates of Eq. (26) and Eq. (27) for each country (with global shocks included).[28] The investment results are, of course, identical to those in Table 3 since the modified investment equation, Eq. (26), is isomorphic to the earlier Eq. (11). Note that our estimates of γ_2' (the coefficient on country-specific productivity in the ΔCA equation) are virtually identical to the estimates of γ_2 in Table 3 for the random walk case. (For the U.K., γ_2' is now marginally larger in absolute value than β_2', but in all other cases β_2' is larger.)

Table 8 also presents chi-square tests of the restriction $\beta_2' = |\gamma_2'|$; β_2' is significantly larger for all cases except the U.K. and the U.S. Thus, it appears that our empirical result that country-specific productivity shocks do not have a larger effect on the current account than on investment remains intact when one relaxes the $\rho = 1$ assumption.

4.2. *The sensitivity of $|\gamma_2'|/\beta_2'$ to ρ*

At first glance, it would seem that given the highly linear nature of the model, our estimated values of ρ (which average 0.94 in Table 2) are simply too close to one to explain why, empirically, γ_2' appears to be less than half as large (on average) as β_2'. It is well-known from the consumption literature, however, that the response of variables which depend on present discounted calculations (as is the case here for both the current account *and* investment) can depend in a very nonlinear fashion on the persistence of the exogenous variables.

The fundamental intuition is most easily seen by abstracting from investment and assuming that net output y is exogenous. In this case, Eq. (24) for the innovation in consumption ($\tilde{C} = \Delta C$) reduces to

$$\tilde{C}_t = \frac{r-1}{r-\rho}\alpha_A \varepsilon_t . \tag{28}$$

If the gross real interest rate r is a number like 1.03, then when ρ falls from 1 to 0.97, the consumption response *halves* – the denominator in Eq. (28) goes from 0.03 to 0.06. At $\rho = 0.91$, the consumption response is one-fourth as large.[29] Endogenizing investment amplifies this difference (since the response of investment declines as ρ falls). Because the consumption response to an income shock drops sharply as ρ falls, the current response is likely to be similarly muted.

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[28] These joint estimates were obtained with the RATS SUR command. To adjust for cross-equation heteroskedasticity, each equation was scaled by the standard error of the corresponding OLS regression.

[29] For discussion of income persistence and its implications for consumption volatility, see Deaton (1992). Mankiw and Shapiro (1985) also stress the importance of stationarity in tests of the permanent income hypothesis.

Table 8
Individual-country time-series regressions, 1961–90, $\Delta I_t = b_0 + b_1 \Delta A_t^c + b_2 \Delta A_t^w + b_3 I_{t-1} + b_4 T$ and $\Delta CA_t = b_0 + b_1 A_t^c + b_2 \Delta A_t^w + b_3 I_{t-1} + b_5 A_{t-1}^c$

Country	ΔZ	b_1	b_2	b_3	$b_4 \times 10^2$	b_5	R^2	χ^2
U.S.	ΔI	0.22 (0.17)	0.41 (0.11)**	−0.17 (0.18)	0.08 (0.09)		0.53	0.88 (0.35)
	ΔCA	0.06 (0.07)	−0.01 (0.05)	0.13 (0.05)**		0.11 (0.07)*	0.32	
Japan	ΔI	0.43 (0.07)**	0.55 (0.12)**	0.05 (0.06)	0.12 (0.07)		0.67	30.73 (0.00)**
	ΔCA	−0.13 (0.05)**	−0.07 (0.09)	−0.07 (0.05)		0.15 (0.05)**	0.25	
Germany	ΔI	0.47 (0.13)**	0.52 (0.12)**	−0.15 (0.11)	0.13 (0.04)**		0.55	5.79 (0.02)**
	ΔCA	−0.20 (0.12)*	0.00 (0.11)	0.01 (0.08)		0.20 (0.12)*	0.11	
France[a]	ΔI	0.40 (0.18)**	0.39 (0.19)**	0.15 (0.15)	0.11 (0.05)**		0.34	3.31 (0.07)*
	ΔCA	0.11 (0.15)	0.00 (0.15)	0.03 (0.11)		0.08 (0.14)	0.00	
Italy	ΔI	0.60 (0.09)**	0.28 (0.16)*	−0.16 (0.10)	0.15 (0.07)**		0.66	20.74 (0.00)**
	ΔCA	−0.30 (0.10)**	−0.05 (0.16)	0.09 (0.11)		0.24 (0.11)**	0.27	
U.K.	ΔI	0.49 (0.10)**	0.64 (0.08)**	0.05 (0.08)	0.01 (0.03)		0.76	0.01 (0.93)
	ΔCA	−0.50 (0.10)**	−0.19 (0.09)**	−0.03 (0.06)		0.48 (0.09)**	0.50	
Canada	ΔI	0.43 (0.13)**	0.18 (0.16)	−0.08 (0.14)	0.10 (0.11)		0.44	4.24 (0.04)**
	ΔCA	−0.21 (0.08)**	0.10 (0.09)	0.00 (0.05)		0.26 (0.07)**	0.28	

The dependent and independent variables are the same as described in the note to Table 3 with the difference that the current and lagged levels, rather than percent change, of country-specific productivity are entered in the current account equation. For each country, the two equations are estimated jointly by generalized least squares with each equation scaled by the standard error of the corresponding OLS regression. Figures in parentheses are standard errors. Significance levels at 5 and 10 percent are indicated by ** and *, respectively. χ^2 denotes chi-square statistic for the restriction that the coefficient on ΔA^c in the ΔI equation equals minus the coefficient on A^c in the ΔCA equation, with the marginal significance level in parentheses.

[a] 1968–90.

Table 9
Relative response of investment and the current account to productivity shocks as a function of ρ, $\tilde{I}_t = \beta'_2 \varepsilon_t$, $\widetilde{CA}_t = \tilde{\gamma}_2 \varepsilon_t$, $\beta'_2 \equiv \eta\lambda\rho/(1-\lambda\rho)$, $\gamma'_2 \equiv \alpha_A((1-\rho)/(r-\rho)) + \beta'_2(\alpha_I - 1) - ((r-1)/(r-\rho)) \times \beta'_2(((\alpha_I - 1)(r-1) + \alpha_K)/(r - \beta_1))$

ρ	β'_2	γ'_2	$\lvert\gamma'_2\rvert/\beta_2$
1.00	0.35	– 0.97	2.76
0.99	0.35	– 0.60	1.72
0.98	0.34	– 0.35	1.04
0.97	0.32	– 0.21	0.64
0.96	0.31	– 0.04	0.13
0.95	0.30	0.05	0.18

Parameter values:

$\alpha_I = -0.39$, $\alpha_K = 0.22$, $\alpha_A = 1.00$, $\lambda = 0.72$, $\beta_1 = 0.90$, $\eta = 0.14$, $r = 1.03$

The table reports the calculated effects of a given productivity innovation ε_t on the unanticipated levels of investment and the current account for varying degrees of productivity shock persistence as measured by ρ. The calculations are based on Shapiro (1986) values for α_I, α_K, α_A, and λ. Since Shapiro's estimates were based on quarterly rates, annualized values were obtained by multiplying his value of α_K by 4 and by taking the fourth power of his estimate of λ. η was calibrated by equating the formula for β'_2 to 0.35, the point estimate from the pooled regression in Table 4, and assuming $\rho = 1$ and $\lambda = 0.72$. β_1 is taken from the pooled investment regression with country-specific time trends in Table 4.

Consumption is not the whole story since the investment response to a productivity account shock is also muted by a fall in ρ. Therefore, the preceding logic is not enough to show that

$$\partial(|\gamma'_2|/\beta'_2)/\partial\rho < 0. \tag{29}$$

We prove in Appendix 1, however, that (29) indeed holds and that $|\gamma'_2|/\beta'_2$ is monotonically decreasing in ρ for $\gamma'_2 < 0$, $0 < \rho < 1$.

Can slow convergence explain the apparent anomaly in Tables 3 and 8? In Table 9, we calculate implied values of β'_2 and γ'_2 using estimates for the production function parameters in Eqs. (3) and (4) based on Shapiro (1986). (The parameters are listed in the table.) The table gives the value of $|\gamma'_2|/\beta'_2$ corresponding to different values of ρ. For $\rho = 0.97$, the implied values of $\beta'_2 = 0.32$ and $\gamma'_2 = -0.21$ are very close to our pooled empirical estimates in Table 4. Thus the distinction between random walk and near random walk productivity may be central to explaining the small response of the current account.

5. Applying the model to explain the reduced form ΔCA–ΔI correlations

Earlier in Table 1 we saw that there is a rather striking empirical regularity between changes in the current account and changes in investment. For the G-7 countries, the coefficient ΔI in the ΔCA regressions averaged around one-third (in absolute value). In this section we do some crude calculations to see if our simple intertemporal model based on productivity shocks is consistent with this regularity. For simplicity, it is helpful to focus on the random walk case ($\rho = 1$), and to further assume that $\beta_1 = 1$ (our point estimate in the pooled data in Table 4 was 0.90) and $\beta_2 = \beta_3$ (i.e., that global and country-specific shocks affect investment equally). One then can easily solve for the slope coefficient in the regression of ΔCA on ΔI:[30]

$$b = \frac{\gamma_2}{\beta_2}\left(\frac{\sigma^2_{\Delta A^c}}{\sigma^2_{\Delta A^c} + \sigma^2_{\Delta A^w}}\right). \tag{30}$$

To implement (30), note that the pooled results in Table 4 provide an estimate of γ_2/β_2 roughly equal to -0.48. The ratio $\sigma^2_{\Delta A^c}/(\sigma^2_{\Delta A^c} + \sigma^2_{\Delta A^w})$ is 0.49 in our sample when averaged over the seven countries.[31] Combining these two parameters, one obtains an estimate of $b = -0.24$. Thus, taking into account the fact that global shocks are roughly as important as local shocks – and only investment responds to global shocks – supplies half the explanation why the nonstructural coefficients in Table 1 are closer to $-1/3$ than to -1. The other half of the explanation lies in the estimate of $|\gamma_2|/\beta_2$, which instead of being greater than one is closer to 1/2. As we have argued, this estimate is quite plausible provided country-specific productivity shocks are not literally a random walk, so that there is some degree of long-run convergence.

6. Conclusions

Earlier attempts at empirical implementation of the intertemporal model of the current account have been limited to simulation or vector autoregression methods.[32] The present paper introduces a tractable approach to structural estimation.[33] The ability to derive closed-form solutions helps clarify some

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[30] We have also assumed that ΔA^c is uncorrelated with ΔA^w, which holds exactly for a small country.

[31] The ratio $\sigma^2_{\Delta A^c}/(\sigma^2_{\Delta A^c} + \sigma^2_{\Delta A^w})$ is as follows for the countries in our sample: U.S., 0.32; Canada, 0.56; Japan, 0.70; France, 0.42; Germany, 0.37; Italy, 0.63; U.K., 0.41.

[32] Some examples of simulation studies include the open-economy real business cycles analyses of Backus, Kehoe, and Kydland (1992), Baxter and Crucini (1992), Mendoza (1991), Stockman and Tesar (1994), and Tesar (1993). Ahmed, Ickes, Wang, and Yoo (1993) apply a variant of the Blanchard–Quah vector-autoregression methodology. It should be noted that in a world of complete goods and capital markets the current account and investment would move one for one in response to country-specific productivity shocks, regardless of their duration.

[33] An important exception is Ahmed (1986), who focuses on the effects of permanent versus transitory government spending shocks. Ahmed's model, however, does not incorporate investment or productivity shocks.

interesting issues that may easily be obscured in simulation analysis or vector autoregression estimation. With the source of results less of a block box this class of models potentially becomes more useful for policy analysis.

Overall, our empirical model performs fairly well in explaining the stable correlation between investment and the current account, in differences, over the period 1961–1990. Investment consistently responds positively and significantly to both country-specific and global productivity shocks. The current account responds negatively and generally significantly to country-specific shocks; as the model predicts, there is little or no response to global shocks. The fact that investment responds by more than the current account to country-specific shocks would be a puzzle, if country-specific productivity shocks literally followed a random walk. But with even a small degree of mean reversion, the results can be fully explained. (Global shocks also tend to follow a near random walk, but since the current account impact is zero regardless, they do not present a similar puzzle.) Thus our empirical results may be construed as providing evidence that there is a significant convergent component to productivity across G-7 countries.

There are other possible explanations of the stylized fact we have established. Allowing for nontraded goods can reduce the relative response of the current account.[34] Even with perfectly integrated international capital markets, moral hazard problems at the microeconomic level can force home residents to self-finance a larger portion of domestic investment than they would under perfect information (see Gertler and Rogoff, 1990). It would be interesting to explore these issues in future research; hopefully the tractable empirical model presented here will provide a useful benchmark against which these alternatives may be compared.

Appendix 1: Derivations

A.1. Derivation of Eqs. (14) and (24) for ΔC

From Eq. (8),

$$\Delta C_t = \bar{y}_t - \mathrm{E}_{t-1}\bar{y}_t, \quad \text{where} \quad \bar{y}_t \equiv \left(\frac{r-1}{r}\right)\mathrm{E}_t \sum_{s=0}^{\infty} y_{t+s}/r^s.$$

Denoting the revision of expectations operator $\mathrm{E}_t - \mathrm{E}_{t-1}$ by $\sim$, Eq. (3) implies that $r/(r-1)\Delta C$ equals

$$\sum_{s=0}^{\infty} \tilde{y}_{t+s}/r^s \equiv \sum_{s=0}^{\infty} (\tilde{Y}_{t+s} - \tilde{I}_{t+s})/r^s$$

$$= \sum_{s=0}^{\infty} [(\alpha_I - 1)\tilde{I}_{t+s} + \alpha_A \tilde{A}_{t+s} + \alpha_K \tilde{K}_{t+s}]/r^s. \tag{A.1}$$

[34] Stockman and Tesar (1994) introduce nontraded goods into an open-economy real business cycle model; see also Baxter and Crucini (1992) and Tesar (1993).

(In this appendix, we omit c superscripts on the A shocks for notational convenience.)

When $\rho = 1$, note that by Eqs. (9) and (10)

$$\tilde{A}_{t+s} = \Delta A_t, \qquad \forall s, \tag{A.2}$$

and

$$\tilde{I}_{t+s} = \beta_2 \beta_1^s \Delta A_t, \quad \forall s. \tag{A.3}$$

By Eqs. (2), (A.2), and (A.3),

$$\tilde{K}_{t+s} = \sum_{i=0}^{s} \tilde{I}_{t+i-1} = (\beta_2/\beta_1)\Delta A_t \left[\left(\sum_{i=0}^{s} \beta_1^i \right) - 1 \right]. \tag{A.4}$$

Eqs. (A.2)–(A.4) imply

$$\sum_{s=0}^{\infty} \tilde{A}_{t+s}/r^s = \frac{r}{r-1} \Delta A_t, \tag{A.5}$$

$$\sum_{s=0}^{\infty} \tilde{I}_{t+s}/r^s = \beta_2 \left(\frac{r}{r-\beta_1} \right) \Delta A_t, \tag{A.6}$$

$$\sum_{s=0}^{\infty} \tilde{K}_{t+s}/r^s = \sum_{s=0}^{\infty} \sum_{i=0}^{s} \tilde{I}_{t+i-1}/r^s = \beta_2 \left(\frac{r}{r-\beta_1} \right) \left(\frac{1}{r-1} \right) \Delta A_t. \tag{A.7}$$

Substituting (A.5)–(A.7) into (A.1) gives the reduced-form expression (14) for ΔC_t.

When $\rho < 1$, Eqs. (4) and (9) imply

$$I_t = \beta_1 I_{t-1} + \eta \sum_{i=1}^{\infty} (\lambda\rho)^i \Delta A_t = \beta_1 I_{t-1} + \beta_2' \Delta A_t, \tag{A.8}$$

where $\beta_2' \equiv \eta\lambda\rho/(1-\lambda\rho)$. Derivation of Eq. (22) for $\tilde{I}_t$ and (26) for ΔI_t is immediate.

It follows from (9) and (A.8) that

$$\tilde{A}_{t+s} = \rho^s \tilde{A}_t, \qquad \forall s, \tag{A.9}$$

and

$$\tilde{I}_{t+s} = \beta_2' \sum_{j=0}^{s} \beta_1^j \Delta A_{t+s-j}, \quad \forall s, \tag{A.10}$$

where again by (9)

$$\Delta \tilde{A}_{t+s} = \begin{cases} \varepsilon_t & \text{for} \quad s = 0, \\ \rho^{s-1}(\rho - 1)\varepsilon_t & \text{for} \quad s > 1. \end{cases} \tag{A.11}$$

By Eqs. (2), (A.10), and (A.11),

$$\tilde{K}_{t+s} = \sum_{i=0}^{s} \tilde{I}_{t+1-i} = \beta_2' \sum_{i=0}^{s} \sum_{j=0}^{i} \beta_1^j \Delta\tilde{A}_{t+i-1-j}. \tag{A.12}$$

Eqs. (A.9)–(A.12) imply

$$\sum_{s=0}^{\infty} \tilde{A}_{t+s}/r^s = \sum_{s=0}^{\infty} \rho^s \varepsilon_t/r^s = \frac{r}{r-\rho}\varepsilon_t, \tag{A.13}$$

$$\begin{aligned}\sum_{s=0}^{\infty} \tilde{I}_{t+s}/r^s &= \beta_2' \sum_{s=0}^{\infty} \sum_{j=0}^{s} \beta_1^j \Delta\tilde{A}_{t+s-j}/r^s \\ &= \beta_2' \left[\frac{r}{r-\beta_1}\right]\left[1+\frac{\rho-1}{r-\rho}\right]\varepsilon_t,\end{aligned} \tag{A.14}$$

$$\begin{aligned}\sum_{s=0}^{\infty} \tilde{K}_{t-s}/r^s &= \beta_2' \sum_{s=0}^{\infty} \sum_{i=0}^{s} \sum_{j=0}^{i} \beta_1^j \Delta\tilde{A}_{t+i-1-j}/r^s \\ &= \beta_2' \left[\frac{r}{r-\beta_1}\right]\left[\frac{1}{r-1}\right]\left[1+\frac{\rho-1}{r-\rho}\right]\varepsilon_t.\end{aligned} \tag{A.15}$$

Substituting (A.13)–(A.15) into (A.1) gives the reduced-form expression (24) for $\Delta C_t = \tilde{C}$.

A.2. Derivation of Eq. (27) for ΔCA

To derive expression (27) for ΔCA note that

$$\begin{aligned}\Delta CA &= \tilde{CA}_t + \mathrm{E}_{t-1} CA_t - CA_{t-1} \\ &= \tilde{CA}_t + \mathrm{E}_{t-1}(Y_t - I_t - C_t) - Y_{t-1} - I_{t-1} \\ &\quad - C_{t-1} + (r-1)CA_{t-1}.\end{aligned} \tag{A.16}$$

From (25),

$$\tilde{CA}_t = \gamma_2' \varepsilon_t. \tag{A.17}$$

From (A.8) and (9),

$$\mathrm{E}_{t-1} I_t - I_{t-1} = \beta_1 I_{t-1} + \beta_2'(\rho-1)A_{t-1} - I_{t-1}. \tag{A.18}$$

Using Eqs. (3) and (A.18),

$$\begin{aligned} \mathrm{E}_{t-1}Y_t - Y_{t-1} &= \mathrm{E}_{t-1}[\alpha_I I_t + \alpha_A A_t + \alpha_K K_t] \\ &\quad - (\alpha_I I_{t-1} + \alpha_A A_{t-1} + \alpha_K K_{t-1}] \\ &= \alpha_I(\mathrm{E}_{t-1}I_t - I_{t-1}) + \alpha_A(\mathrm{E}_{t-1}A_t - A_{t-1}) \\ &\quad + \alpha_K(\mathrm{E}_{t-1}K_t - K_{t-1}) \\ &= (\alpha_I\beta'_2 + \alpha_A)(\rho - 1)A_{t-1} + [\alpha_I(\beta_1 - 1) + \alpha_K]I_{t-1}, \end{aligned} \tag{A.19}$$

where we have used the fact that $\mathrm{E}_{t-1}A_t - A_{t-1} = (\rho - 1)A_{t-1}$ and $\mathrm{E}_{t-1}K_t - K_{t-1} = I_{t-1}$. Since $\mathrm{E}_{t-1}C_t - C_{t-1} = 0$, substitution of (A.17)–(A.19) in (A.16) yields Eq. (27).

A.3. Proof that $\partial(|\gamma'_2|/\beta'_2)/\partial\rho > 0$

To evaluate $\partial(|\gamma'_2|/\beta'_2)/\partial\rho$, we first evaluate $\partial\beta'_2/\partial\rho$ and $\partial|\gamma'_2|/\partial\rho$. From the definitions of β'_2 and γ'_2,

$$\frac{\partial\beta'_2}{\partial\rho} = \frac{\eta\lambda}{(1-\rho\lambda)^2} > 0, \tag{A.20}$$

$$\begin{aligned} \frac{\partial|\gamma'_2|}{\partial\rho} &= -\alpha_A\frac{1-r}{(r-\rho)^2} - \frac{\partial\beta'_2}{\partial\rho}\left[\alpha_I - 1 - \frac{\phi(r-1)}{(r-\rho)(r-\beta_1)}\right] \\ &\quad + \frac{\beta'_2\phi(r-1)}{(r-\rho)^2(r-\beta_1)} > 0, \end{aligned} \tag{A.21}$$

since $\phi \equiv (\alpha_I - 1)(r-1) + \alpha_K > 0$. [In (A.21), we evaluate in the region $\gamma'_2 < 0$.]

Differentiating $|\gamma'_2|/\beta'_2$ with respect to ρ gives

$$\frac{\partial|\gamma'_2|/\beta'_2}{\partial\rho} = \frac{1}{(\beta'_2)^2}\left[\beta'_2\frac{\partial|\gamma'_2|}{\partial\rho} - |\gamma'_2|\frac{\partial\beta'_2}{\partial\rho}\right]. \tag{A.22}$$

Substituting for $|\gamma'_2|$ with (25) and for $\partial|\gamma'_2|/\partial\rho$ with (A.21) yields

$$\frac{\partial|\gamma'_2|/\beta'_2}{\partial\rho} = \frac{1}{(\beta'_2)^2}\left[\beta'_2\frac{\alpha_A(r-1)}{(r-\rho)^2} + \frac{\beta'_2\phi(r-1)}{(r-\beta_1)(r-\rho)^2} + \alpha_A\frac{(1-\rho)}{r-\rho}\frac{\partial\beta'_2}{\partial\rho}\right] > 0.$$

Appendix 2: Data

Annual data for the years 1960–1990 for the current accounts of the balance of payments were obtained from International Financial Statistics (IFS), line 77a.d. Because the current accounts were expressed in dollars, they were converted to local currencies using the average market exchange rates for the year (rf). Data on France's current account is available only from 1967, because of the absence of data on the transactions between metropolitan France and countries in the franc area in prior years.

Annual data on nominal investment, output, consumption, and government spending were obtained from the national accounts section of the IFS for each country. Investment was defined as the sum of gross fixed capital formation (line 93e) and changes in (inventory) stocks (line 93i). For the United States the investment total included government gross fixed capital formation (line 93 gf). Government spending was defined as government consumption (line 91f, or 91ff less 93gf in the case of the U.S.). Output was defined as GDP (line 99b) or when not available by GNP (line 99a).

All nominal aggregates were converted into real terms by the GDP or, where necessary, by the GNP deflator. The deflator was calculated as the ratio of real GDP (line 99b.r or 99b.p) or GNP (99a.r) to the corresponding nominal output aggregate.

To construct productivity, we used Bureau of Labor Statistics figures on manufacturing output and employment hours, as reported in 'International Comparisons of Manufacturing Productivity and Unit Labor Costs, 1990', Table 2 (BLS, U.S. Department of Labor, 91-406). We formed our basic measure of total factor productivity as the Solow residuals from Cobb–Douglas production functions, as described in the text, using the BLS data on manufacturing output and hours and the labor share figures of Stockman and Tesar (1994), and treating capital as following a constant trend.

An alternative measure of total factor productivity in manufacturing for the years 1970–1985 controlling for capital inputs was constructed using data on output, employment, and the capital stock from the OECD international sectoral data base and the Stockman and Tesar labor share figures.

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