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Common and Country-specific Fluctuations in Productivity, Investment, and the Current Account

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Abstract

Dynamic factor analysis and Kalman filtering are used to construct a measure of common economic activity for the G7 countries. Common movements are important in productivity, but account for a substantially smaller share of movements in investment, and virtually none of the variation in the current accounts. For all seven countries, country-specific investment fluctuations have a significant negative impact on the current account, while country-specific productivity movements have little effect. A multi-country dynamic general equilibrium model is analyzed which is consistent with our qualitative findings. The model overstates, however, the quantitative importance of investment fluctuations for movements in the current account.

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1. Introduction

The literature on the intertemporal approach to the current account investigates the proposition that a country's current account is determined by its intertemporal choices between savings, investment and consumption (for a survey of this literature, see Obstfeld and Rogoff (1994)). Empirical analysis of these relationships has been the subject of several studies. For example, Sachs (1981) found that investment booms tend to be associated with deteriorations of the current account balance for most developed countries. Tesar (1991), however, finds only weak evidence for such a relationship. Glick and Rogoff (1995) consider a model in which both global and country-specific technology shocks lead to investment fluctuations. Only country-specific investment movements are related to deteriorations in the current account. They present evidence that country-specific investment fluctuations are negatively related to the current account for the G7 countries (the U.S., U.K., France, Germany, Italy, Canada, and Japan).

The theoretical model studied by Glick and Rogoff (1995) is one of a small open economy, and so the distinction between country-specific and world-wide phenomena is explicit and distinct. For the empirical investigation, they use averages of investment and productivity across countries to represent their measures of world-wide aggregates. Since each of the G7 countries is large, however, the distinction between country-specific and world-wide fluctuations is actually somewhat blurred, and all fluctuations in a given country probably embody elements of both. In this paper we propose an alternative approach using dynamic factor analysis and Kalman filtering to study the relationships among total factor productivity (measured by the Solow residual), investment, and the current account for the G7 countries. In particular we estimate common and country-specific components in these three variables, and consider their fluctuations over time. The unobservable common component that we estimate is a measure of dynamic co-movement among the seven countries, and is an example of a "common feature" in the language of Engle and Kozicki (1993). We interpret this component as an overall measure of common economic activity for the G7 countries. We also estimate the effects of this component and the (also unobservable) country-specific components to both investment and productivity on the current account.

We find that the importance of the common component is greatest in total factor productivity, although it accounts for a statistically significant, but substantially smaller, share of investment fluctuations. With regard to country-specific fluctuations in investment, we find that a significant share are accounted for by country-specific productivity movements, but that an even greater share are due to other factors. With regard to the effects of fluctuations in productivity and investment on the current accounts, we find that country-specific investment fluctuations have a significant negative impact on the current account, while common movements have no significant effect. Also, country-specific productivity fluctuations have little effect on the current account. Quantitatively, the effects of productivity fluctuations on the current accounts are very small. In contrast, country-specific investment fluctuations in investment account for more than 15% of the variance of the ratio of the current account to output in all countries except Germany, and for more than a third of this variance for three of the seven countries.

We then compare our findings to the predictions of a multi-country model of international risk sharing where fluctuations are driven by both technology and government spending shocks. The economy we consider is a version of that studied by Baxter and Crucini (1993). In this model, *all* fluctuations are to some extent global regardless of whether they emanate from a shock that occurs in all countries or in only one. The evolution of the world-wide state, which contains all of the technology parameters, all of the national capital stocks, and all of the levels of government spending, determines a pattern of fluctuations in output which are to some extent global in character. These fluctuations generate a pattern of investment and intertemporal trade flows which are associated with fluctuations in the current account. Unlike Glick and Rogoff's model, this model does not provide an explicit decomposition of fluctuations in any endogenous variable into country-specific and global components. Therefore, in order to compare the predictions of the model to our empirical findings, we estimate the same dynamic factor decomposition applied to the G7 data with artificial data (generated by the model) on productivity shocks, investment, and the ratio of net exports to output.

We calibrate the exogenous technology shock process in the model to our estimates of the effects of the common component on Solow residuals, and the fiscal shock process to properties of government spending in the U.S.. We then consider the relationships between these shocks and fluctuations in investment and the current account. The model accurately reproduces the qualitative features of the G7 data along several dimensions. Quantitatively, however, investment fluctuations play a somewhat greater role in accounting for current account movements than in the G7 data. In the artificial economy, fluctuations in investment account for nearly 65% of the variance of the current accounts of all countries in our base case calibration, while in the data they account for more than 50% of the variance of the current account only for Italy.

We then consider whether either large adjustment costs or large fiscal shocks can substantially reduce the share of the variance of the current account arising from country-specific investment fluctuations in the model. We find that in principle either can. Very large adjustment costs are needed, however, and large adjustment costs cause the model to overstate the importance of common movements in investment. While large fiscal shocks are able to bring the artificial economy's quantitative predictions closer to our empirical findings, they must be substantially larger than is consistent with our calibration.

Overall, analysis of the artificial economy suggests that while the relationships among productivity shocks, investment, and the current account that are stressed in the model (and in the intertemporal approach to the current account in general) are present in G7 data, they are only part of the story. The largest shares of the variances of the G7 current accounts over the period studied are those not accounted for by either common or country-specific fluctuations in total factor productivity and investment. Fiscal shocks (or demand shocks more generally) might provide an explanation, but only if they are of sufficient magnitude.

The rest of the paper is organized as follows. Section 2 describes the dynamic factor model which is estimated using both actual and artificial data. Section 3 presents the empirical findings. Section 4 describes the artificial economy, and Section 5 presents the estimates of the dynamic factor model using artificial data. Section 6 concludes.

2. The Dynamic Factor Model

In this section we describe the dynamic factor model. As both the general framework and the methods used to estimate the model are standard the presentation of the technical aspects is brief; interested readers are referred to Stock and Watson (1991) and Harvey (1989) for a more complete description. Dynamic factor models have also been studied extensively in the macroeconometric literature (for example by Geweke (1977), Geweke and Singleton (1980), Sargent and Sims (1977), Watson (1994), and Watson and Engle (1983)). Gregory, Head, and Raynauld (1995) estimate a dynamic factor model to study world business cycles, but do not consider fluctuations in the current account. In that study a dynamic factor model is used to decompose aggregate output, consumption, and investment for each of the G7 countries into a single world-wide common factor, seven country specific factors, and factors specific to each series. The focus there is on the share of aggregate fluctuations in each of the countries accounted for by common and country-specific factors, and on identifying business cycle episodes in the individual countries that can be accounted for by the world business cycle.

Let Z_{jt} denote a measure of total factor productivity for country j at time t, where $j = 1, \ldots, 7$ indexes the G7 countries. Similarly, let I_{jt} and CA_{jt} denote measures of investment and the current account for country j, respectively. The dynamic factor decomposition can then be written,

$$\begin{aligned} Z_{jt} &= \alpha_j^Z \Gamma_t + \Phi_{jt}^Z \\ I_{jt} &= \alpha_j^I \Gamma_t + \beta_j \Phi_{jt}^Z + \Phi_{jt}^I \qquad\qquad j = 1, \ldots, 7. \qquad (2.1) \\ CA_{jt} &= \alpha_j^{CA} \Gamma_t + \gamma_j^Z \Phi_{jt}^Z + \gamma_j^I \Phi_{jt}^I + \Phi_{jt}^{CA} \end{aligned}$$

Here Γ_t is a world-wide factor common to all variables for all countries. We interpret this as a measure of overall economic activity that is common to the G7 countries. Total factor productivity in country j is decomposed into two components: One component is the product of the world-wide factor Γ_t and a time-invariant impact coefficient, α_j^Z; the other component, Φ_{jt}^Z, is specific to country j. Investment in country j is decomposed into three components: a world-wide component given by $\alpha_j^I \Gamma_t$, a component associated with the country-specific factor in total factor productivity, $\beta_j \Phi_{jt}^Z$, where β_j is a time invariant impact coefficient, and a component associated with country-specific fluctuations in investment that are not accounted for by country-specific productivity fluctuations,

Φ^I_{jt}. Finally, the current account for country j is decomposed into four components: a world-wide component, components due to both country-specific productivity fluctuations and country-specific investment fluctuations, and a residual component associated with fluctuations in neither productivity nor investment. All of the components are assumed to be orthogonal.

We assume that each of the unobservable factors follows a univariate first-order autoregressive process:

$$\begin{aligned} \Gamma_t &= \delta \Gamma_{t-1} + \varepsilon_t \\ \Phi^Z_{jt} &= \eta^Z_j \Phi^Z_{jt-1} + \varepsilon^Z_{jt} \\ \Phi^I_{jt} &= \eta^I_j \Phi^I_{jt-1} + \varepsilon^I_{jt} \\ \Phi^{CA}_{jt} &= \eta^{CA}_j \Phi^{CA}_{jt-1} + \varepsilon^{CA}_{jt} \end{aligned} \qquad j = 1, \ldots, 7. \tag{2.2}$$

In the language of dynamic factor models, (2.1) is a system of 21 measurement equations, and (2.2) comprises a system of 22 transition equations. Assume that the series for productivity, investment, and the current account are all stationary, that their means have been removed and their standard deviations normalized to one. To estimate the model, we assume that the errors in each of the transition equations are uncorrelated both contemporaneously and autoregressively, and normalize the variance of ε to one.

The structure chosen is a very specific one, and certainly others could be estimated. The use of this recursive structure is motivated by the intertemporal approach to the current account. We think of productivity fluctuations as driving fluctuations in investment, and these investment fluctuations in turn causing the current account to fluctuate. The common factor is suggested by the observation that productivity and investment are positively correlated across the G7 countries (see, for example Backus and Kehoe (1992) and Gregory, Head, and Raynauld (1995)). We expect that both productivity and investment will be influenced by common fluctuations in overall economic activity. The distinction between common and country-specific fluctuations is important for the dynamics of the trade balance in dynamic models (see Glick and Rogoff (1995) and the surveys by Backus, Kehoe, and Kydland (1995) and Baxter (1995)). If countries are symmetric, common fluctuations will not lead to intertemporal trade. Country-specific fluctuations, on the other hand, will be associated with changes in the trade balance and the current account.

The inclusion of the country-specific components of productivity in the investment equations is suggested by the interpretation of productivity fluctuations as a possible source of aggregate fluctuations. In the open economy real business cycle literature (see for example Backus, Kehoe, and Kydland (1992) and Baxter and Crucini (1993)), an increase in productivity in a given country, whether it is country-specific or common to all countries, will increase investment in that country. The component in investment related to neither the common factor nor the country-specific component of total factor productivity is intended to capture the effects of other factors that affect investment but are unrelated to productivity (*e.g.* fiscal shocks, taste shocks).

We allow the common factor and the country-specific components of investment and total factor productivity all to affect the current account. To the extent that fluctuations in productivity lead to aggregate fluctuations and intertemporal trade they will affect the current account. Also, to the extent that country-specific investment fluctuations embody international investment flows, they will constitute a potentially large component of the fluctuations in the current account. The component in the current account associated with neither country-specific productivity nor investment captures the effects of all other factors. For example, it has been recognized that fluctuations in government spending which may not be directly associated with either productivity or investment have substantial effects on the trade balance in intertemporal models (see Kollmann (1993) and Yi (1993)).

Two assumptions inherent in the particular dynamic factor model that we study bear further discussion. First, we restrict the unobservable factors to follow univariate first-order autoregressive processes. This assumption turns out not to have much effect, given the properties of the data that we consider. Second, the assumption of orthogonality among all of the unobservables rules out the possibility of bilateral correlations among the different factors. According to our model, all that matters for a given country is the world-wide factor and its own country-specific factors; no channel exists for, say, country-specific fluctuations in France to affect Canada. We think of this as a simplifying assumption that reduces the model to manageable size. Bilateral effects could, however, be built into the model, but the estimation would be substantially more time consuming and difficult computationally. We check the plausibility of this assumption by calculating the covariances of the estimated factors and return to this issue in our final remarks.

It is straightforward to cast this model in state-space/measurement equation form. The state-space equations give a representation on the evolution of Γ_t, Φ^Z_{jt}, Φ^I_{jt}, Φ^{CA}_{jt}, and their lags and the measurement equations link the observed variables to the elements of the state vector. Collect $(Z_{1t},\ldots,Z_{7t},I_{1t},\ldots,I_{7t},CA_{1t},\ldots,CA_{7t})$ into a (21×1) vector, y_t. The system given by (2.1) and (2.2) can then be written in the companion form:

$$\theta_t = T\theta_{t-1} + \lambda_t, \qquad y_t = V\theta_t, \tag{2.3}$$

with $\theta_t = (\Gamma_t, \Phi^I_{jt}, \Phi^I_{jt}, \Phi^{CA}_{jt})$, $\lambda_t = (\varepsilon_t, \varepsilon^Z_{jt}, \varepsilon^I_{jt}, \varepsilon^{CA}_{jt})'$, and with T and V the appropriately defined coefficient matrices. Denote the variance-covariance matrix of λ_t by Σ.

The Kalman filter consists of the prediction and updating equations. Let $\theta_{t|\tau}$ be the estimate of θ_t based upon information $(y_1,\ldots,y_\tau)$ and $P_{t|\tau} = E((\theta_{t|\tau}-\theta_t)(\theta_{t|\tau}-\theta_t)')$. The prediction equations are:

$$\theta_{t|t-1} = T\,\theta_{t-1|t-1} \tag{2.4}$$

and

$$P_{t|t-1} = T\,P_{t-1|t-1}T' + \Sigma. \tag{2.5}$$

The updating equations are:

$$\theta_{t|t} = \theta_{t|t-1} + P_{t|t-1}Z'F_t^{-1}\nu_t \tag{2.6}$$

and

$$P_{t|t} = P_{t|t-1} - P_{t|t-1}Z'F_t^{-1}\nu_t, \tag{2.7}$$

where $\nu_t = y_t - y_{t|t-1}$ and $F_t = E(\nu_t\nu_t') = ZP_{t|t-1}Z'$. Given initial estimates of T, Σ, Z and starting values $\theta_{0|0} = 0$ and $vec(P_{0|0}) = (I - T\otimes T)^{-1}vec(\Sigma)$ recursive calculation gives the prediction state vector $\theta_{t|t-1}$ and covariance $P_{t|t-1}$. The Gaussian log likelihood (excluding the constant) is:

$$L = \frac{-1}{2}\sum_{t=1}^{T}\nu_t'F_t^{-1}\nu_t - \frac{1}{2}\sum_{t=1}^{T} ln \det F_t. \tag{2.8}$$

The estimation problem, then, is to maximize (2.8) with respect to the 85 parameters and 22 unobservable factors. In estimating the models considered in this study, the EM algorithm was used first to provide good initial estimates for a Gauss-Newton scoring algorithm. All calculations were conducted on the IBM RS/6000 Model 355 Workstation. The program used is described in detail in Raynauld, Simonato, and Sigouin (1993). The code was written in GAUSS as implemented for a UNIX platform.

3. Empirical Findings

The dynamic factor model is estimated using data on total factor productivity measured by the Solow residual, real gross capital formation, and the ratio of the current account to nominal output for the G7 countries. The data are quarterly, seasonally adjusted, and covers the period 1973.1—1993.4. The data are from the *International Financial Statistics* of the IMF, the *Quarterly Labour Force Statistics* of the OECD, and Citibase. A detailed description of the series used is given in the data appendix. To render the data on total factor productivity and investment stationary, and to capture the corresponding high-frequency movements in the current account, these series are detrended using the Hodrick-Prescott filter with smoothing parameter 1600. Attention is therefore limited, in this paper, to fluctuations at what are normally considered business cycle frequencies.

The Solow residual is constructed as follows:

$$SR_j = \ln Y_j - LBS_j \ln H_j \qquad j = 1, \ldots, 7 \tag{3.1}$$

where Y_j is either real gross domestic product or gross national product, H_j is a measure of aggregate employment (for details country by country, see the appendix), and LBS_j is the share of labor compensation in national income. Our labor share measures are taken from Stockman and Tesar (1991); the values are U.S.: .66, U.K.: .68, France: .65, Germany: .64, Italy: .48, Canada: .63, and Japan: .54. In omitting the effects of capital movements, we follow Backus, Kehoe, and Kydland (1992) and Glick and Rogoff (1995). This is done because of the difficulty in obtaining comparable measures of the capital stock for all seven countries at quarterly frequencies. The omission of terms involving capital is unlikely to be severely restrictive as capital stock movements account for a relatively small share of fluctuation in the Solow residual at high frequencies.

Parameter estimates for equations (2.1) and (2.2) are contained in Table 1. Overall the estimates indicate the existence of a significant common factor in economic activity for the

G7 countries. Considering first total factor productivity, this common factor has a highly statistically significant positive impact on the Solow residual for all seven countries. This finding is consistent with those of Reynolds (1993), who found evidence of correlations in Solow residual movements in the G7 countries using vector autoregressions, and Gregory, Head, and Raynauld (1995) who estimated a statistically significant common component in G7 Solow residuals using a dynamic factor model. Backus and Kehoe (1992) and Baxter and Crucini (1993) also found evidence of positive co-movement in total factor productivity among developed countries. The country-specific components in total factor productivity are all positively autocorrelated.

Table 2 contains measures of the shares of the variance of each variable accounted for by fluctuations in the estimated unobservable factors. This measure is the estimated variance of the factor of interest, divided by the sum of the variances of the unobservable factors that make up the series under consideration. For example, the share of variance of the Solow residual in Country j accounted for by fluctuation in the country-specific component is given by

$$R_j^{\phi^Z} \equiv \frac{\frac{\hat{\sigma}^2_{\epsilon_j^Z}}{1-(\hat{\eta}_j^Z)^2}}{\frac{(\hat{\alpha}_j^Z)^2}{1-\hat{\delta}^2} + \frac{\hat{\sigma}^2_{\epsilon_j^Z}}{1-(\hat{\eta}_j^Z)^2}}, \tag{3.2}$$

where $\hat{\sigma}^2_{\epsilon_j^Z}$ is the estimated variance of the country-specific component in Country j's Solow residual. For investment and the current account, the denominator of the expression is modified accordingly as these series are decomposed into three and four unobservable factors respectively.

These measures can be used to gauge the quantitative importance of fluctuations in each of the unobservable factors. Considering the Solow residual, note that the importance of common fluctuations ranges widely, from 15% for the U.S. to around 60% for France and Japan. Overall, common fluctuations can be seen to be quantitatively important, accounting for over a third of the variance of the Solow residual in four countries. Still, country-specific fluctuations are important as well, and account for more than 50% of the variance of the Solow residual in five of the seven countries. Gregory, Head, and Raynauld (1995) obtained similar results with regard to the quantitative importance of common and country-specific fluctuations in total factor productivity. These findings are also in accordance with those of Costello (1993) who found that both country-specific and common fluctuations in Solow residuals were important in a sample of six European countries.

Considering the decomposition of investment fluctuations, we find that the effect of the common factor is statistically significant for all countries except the U.K.. The impact coefficients on the common component in the investment equations, however, are uniformly smaller than those for the Solow residuals. Quantitatively, the common factor accounts for little of the variance of investment in all countries. The share exceeds 5% only for Japan. Thus, while common fluctuations are quantitatively important for fluctuations in total factor productivity, they do not translate into quantitatively large common movements in investment. Country-specific factors account for over 85% of the variance of investment in all seven countries, and over 95% for all countries but Japan. Evidently, investment fluctuations are overwhelmingly country-specific.

In our decomposition, country-specific fluctuations in investment are themselves further decomposed into two components. One component may be thought of as country-specific investment fluctuations due to movements in the country-specific component of the Solow residual, while the other component measures fluctuations due to all other country-specific sources. We find that the impact of country-specific productivity fluctuations on investment is positive for all countries and statistically significant for all but the U.K.. For all countries the impact of the country-specific component in the Solow residual is substantially stronger than that of the common factor. Quantitatively, country-specific movements in the Solow residual account for more than 20% of the overall variance of investment for all countries except the U.K. and France, and account for more than a third of the variance in the U.S. and Germany. Still, in all cases that component of country-specific investment fluctuations *not* associated with country-specific productivity movements is substantially more important quantitatively. In all cases more than 60% of the overall variance of investment is accounted for by fluctuations in Φ_j^I. This component contains the effects of all variables other than the common component and country-specific total factor productivity that affect investment. This would include any country-specific shock that did not affect total factor productivity, for example, taste or domestic fiscal shocks.

Turning to fluctuations in the current account, note first that for all countries the effect of the common factor is statistically insignificant. This is consistent with the findings of Glick and Rogoff (1995) and can be interpreted as consistent with the intertemporal approach to the current account. The distinction between the effects of country-specific productivity and investment fluctuations on the current account is important. For all seven countries, the impact of the country-specific component of the Solow residual, Φ_j^Z, on the current account is statistically insignificant, although several of the point estimates are fairly large. The coefficient estimates do not, however, display a consistent pattern across countries (four are negative, three positive). In contrast, the estimated impact coefficients on Φ_j^I in the current account equations are negative for all countries, and are statistically significant for all but Germany. The finding of negative impacts of country-specific fluctuations in investment on the current account is consistent with those of Glick and Rogoff (1995) and Sachs (1981) who found deteriorations of the current account to be associated with increases in domestic investment.

The negative relationship between country-specific investment fluctuations and movements in the current account is also quantitatively substantial for all countries except Germany. For the other six countries, fluctuations in the country-specific component of investment account for at least 15% of the variance of the current account, and this share exceeds one-third for three countries. The quantitative effect of Φ_j^I (the component of country-specific investment fluctuations *not* associated with country-specific productivity fluctuations) exceeds that of Φ_j^Z (the country-specific productivity component) for all countries but Germany. Furthermore, the effect of the latter is uniformly small. Thus, while country-specific fluctuations in investment account for a substantial share of fluctuations in the current account, country-specific productivity fluctuations account for an insignificant share. In addition, the largest component of current account fluctuations is that associated with neither country-specific productivity nor investment.

In summary, we find that the effect of common movements in economic activity is quantitatively important for productivity fluctuations, but that they account for a much smaller share of movements in investment and virtually none of the fluctuations in the current accounts. Country-specific investment fluctuations have a negative impact on the current account as predicted by the intertemporal approach to the current account, and the effect of this relationship is quantitatively significant. Country-specific productivity fluctuations, however, account for only a very small share of the current account fluctuations.

4. An Artificial Economy

We now consider the relationships among total factor productivity, investment, and the current account in a multi-country artificial economy. It is not our intention to propose a model and test whether it is consistent with all of the empirical findings of the previous section. Rather, we are interested in using a model of intertemporal trade for the purposes of international risk sharing to provide an interpretation, both qualitative and quantitative, for our empirical findings. In particular, we are interested in the model's ability to account for common movements in investment, the effect of country-specific productivity shocks and investment fluctuations on the current account, and the share of current account fluctuations attributable to international investment flows.

The model that we consider is a multi-country version of that studied by Baxter and Crucini (1993). Since the environment and the methods used to compute the equilibrium are standard, the description of both will be brief. The properties of aggregate fluctuations in this environment are discussed in detail in the paper by Baxter and Crucini, and in the survey by Baxter (1995).

We consider an economy comprised of eight symmetric countries, each inhabited by a large number of identical agents. Thus we consider a representative agent in each country. We loosely interpret the eight countries in our model as the G7 countries plus the rest of the world. Each agent has preferences over consumption of a single homogeneous consumption good and leisure, given by,

$$\mathrm{E}_0 \sum_{t=0}^{\infty} R^t \frac{\left[C_{jt}^a (1 - H_{jt})^{1-a}\right]^{1-b}}{1-b} \qquad j = 1, \ldots, 8. \tag{4.1}$$

Here C_{jt} and H_{jt} denote consumption and the fraction of the time endowment devoted to working by the country j representative agent at time t, $R \in (0,1)$ is a discount factor, and $a \in (0,1)$ and $b > 0$ are parameters.

In each country the homogeneous good is produced by a competitive industry comprised of a large number of identical firms operating a stochastic, constant returns to scale technology. All countries have symmetric technologies, given by

$$Y_{jt} = Z_{jt} K_{jt}^{s} H_{jt}^{1-s} \qquad j = 1, \ldots, 8. \tag{4.2}$$

Here K_{jt} denotes country j capital, Z_{jt} is a stochastic productivity parameter, and s is a parameter governing capital's share in national income. The productivity parameter is the sum of two independent components,

$$Z_{jt} = m_t + m_{jt}. \qquad j = 1, \ldots, 8. \tag{4.3}$$

Here m_t is a common shock, and m_{jt} is specific to country j. Both shocks follow first order autoregressive processes in logarithms,

$$\begin{aligned} \ln m_t &= v \ln m_{t-1} + e_t^m \\ \ln m_{jt} &= v_j \ln m_{j,t-1} + e_{jt}^m \end{aligned} \tag{4.4}$$

where $\forall i \; v, v_j \in (0,1)$ and e^m, e_j^m are random disturbances that are independent across both countries and time.

Physical capital is accumulated by means of an intertemporal technology featuring adjustment costs,

$$K_{j,t+1} = (1-d)K_{jt} + \left[\frac{I_{jt}}{K_{jt}}\right]^p K_{jt} \qquad j = 1, \ldots, 8. \tag{4.5}$$

Here I_{jt} is investment in Country j at time t, $d \in (0,1)$ is the rate of depreciation, and $p \in (0,1)$ is a parameter governing the size of adjustment costs. Note that as p decreases, the quantity of investment required to augment the capital stock by a given proportion increases.

Finally, we assume that in each country there is a government that consumes a stochastic quantity, G_{jt} of the homogeneous good in each period. In all countries, G_{jt} follows a first order autoregressive process in logarithms,

$$\ln G_{jt} = (1-w)\ln \bar{G}_j + w \ln G_{j,t-1} + e_{jt}^g \qquad j = 1, \ldots, 8, \tag{4.6}$$

where $w \in (0,1)$, e^g_{jt} is a random disturbance which is independent across both countries and time, and $\bar{G}_j$ is the steady-state level of government spending in country j. We assume that government spending is financed solely by lump-sum taxation on domestic agents and that the governments all balance their budgets period-by-period.

The inclusion of stochastic government spending in the model is motivated by an empirical finding of the previous section. We found that large shares of the variances of the current accounts for all countries were attributable to country-specific factors *other* than fluctuations in productivity and investment. In order for there to be any possibility for the artificial economy to account for this empirical finding, it is necessary that the model have some other source of random fluctuations that does not affect total factor productivity. Government spending shocks are one possibility. There are other possibilities, for example taste shocks. We choose government spending shocks because it is relatively easy to measure the variance and persistence of government spending in the data and this is useful when we calibrate the model.

We assume that there are markets for a complete set of state-contingent claims, and consider the competitive equilibrium. Since the equilibrium allocation is Pareto efficient, it can be computed by solving a social planning problem. The social planner maximizes a weighted sum of the representative agents' utilities, (4.1) subject to (4.4), (4.5), (4.6), and the following world-wide feasibility constraint,

$$\sum_{j=1}^{8} C_{jt} + \sum_{j=1}^{8} I_{jt} \leq \sum_{j=1}^{8} Y_{jt} - \sum_{j=1}^{8} G_{jt}. \tag{4.7}$$

Since the planning problem does not have an analytic solution, we follow a standard procedure for computing a linear approximation. First we compute the deterministic steady-state. Then we linearize the first order conditions for the planning problem in a neighborhood of this steady-state and solve the resulting system of linear difference equations. Realizations of the economy's equilibrium stochastic process can then be computed by drawing sequences of the random disturbances, and computing the allocation using the linear decision rules.

In this economy, countries are "large" in the sense that their domestic consumption, output, and investment constitute significant parts of the corresponding world-wide aggregates. Thus, fluctuations in any one country will have an effect on world-wide fluctuations. Unfortunately, the economy does not provide an explicit decomposition for its endogenous variables into world-wide and country-specific components. In particular, the model does not give rise to the exact factor structure introduced in Section 2, except with regard to the specification of total factor productivity, which is exogenous and has been specified exactly as in the dynamic factor model. Nevertheless, we feel that this recursive factor structure is a useful way to summarize the relationships among common and country-specific fluctuations in the productivity, investment, and the current account. Our conjecture that this structure provides a fairly close approximation to the dynamics of the model is based on the intuition behind the effects of technology and government spending shocks in the model.

In this economy, agents trade intertemporally solely for the purpose of smoothing consumption over time, given that domestic income fluctuates due to exogenous technology and fiscal shocks. A common technology shock raises productivity world-wide, causing agents in all countries to work harder and accumulate capital in order to smooth the consumption increase over a long period of time. Since all countries are symmetric and the shock affects them all symmetrically, a common shock causes investment to rise in all countries, but does not result in international trade. In contrast, a country-specific shock leads to trade for two reasons. First, the country experiencing the shock will see its output rise, and would like to smooth the effect on its consumption. Thus it would tend to export, lending to the rest of the world so as to have a source of foreign income in later periods when its output is low. On the other hand, the country-specific technology shock results in a productivity differential between the country receiving the shock and the rest of the world. This generates a tendency to import, borrowing from the rest of the world and investing to take advantage of higher than average productivity. Thus, we expect country-specific fluctuations in total factor productivity to affect both investment and intertemporal trade, while common shocks will affect only the former. This is consistent with our specification of the dynamic factor model.

As for country-specific fluctuations in investment, the artificial economy also provides intuition for separating them into sub-components associated with domestic technology shocks and other factors. We may think of country-specific investment fluctuations as emanating from two types of sources. First, country-specific technology shocks translate directly into domestic investment fluctuations. Second, investment in a given country will also fluctuate because of movements in its capital stock and foreign technology shocks both of which affect its productivity relative to the rest of the world. The distinction between investment fluctuations associated with these two different factors may be useful for describing the dynamics of the current account. As noted above the effect of a country-specific technology shock on the current account may be ambiguous because of counteracting effects. Once the country-specific component of investment has been isolated, however, we would expect it to be negatively related to the current account. An increase in country-specific investment not associated with a domestic productivity shock can occur only if agents either consume a smaller share of domestic output or borrow from abroad. Given that agents want to smooth consumption and have access to complete markets, the latter will be the main channel for financing increased investment, and so the trade balance will deteriorate.

Finally, the component specific to the current accounts of the individual countries not associated with fluctuations in either total factor productivity or investment fluctuations can be traced primarily to the effect of fiscal shocks on consumption. A government spending shock, regardless of where it occurs, will reduce world-wide wealth and thus world-wide investment. This effect should be quantitatively small as the multiplier associated with fiscal shocks are typically small in neoclassical models (see, for example, Christiano and Eichenbaum (1992)). The consumption flows associated with agents' use of contingent claims to insure against fluctuations in domestic lump-sum taxes, however, may not be small. When government spending in an individual country rises due to a shock, it will smooth its consumption by borrowing from abroad.

We estimate the dynamic factor model, (2.1) and (2.2), using 500 periods of artificial data for seven of the eight countries. A single realization of the economy's equilibrium stochastic process for 1000 periods is computed. We discard the artificial data for Country 1, and the initial 500 periods of data for the remaining seven countries. The elimination of the initial 500 periods is intended to remove the effects of imposing the deterministic steady-state as initial condition. Our intention is to obtain parameters estimates that are 'close' to their population values, and 500 observations may be sufficient. Increasing the number of observations increases substantially the computational burden in estimating the dynamic factor model. Because we model all countries symmetrically, we can get some information on sampling variability by comparing our parameter estimates across countries. We find that our parameter estimates are in all cases very similar across countries, and thus conclude that 500 observations is sufficient for our purposes. We interpret the omitted country as the rest of the world, and seven remaining as relating to the G7. The possibility of a significant common component in the current accounts arises because we restrict attention to a subset of the countries in the world (as we did in the empirical analysis). This motivates the inclusion of the common factor in the current account equations.

Since with complete markets there are many asset structures that could support the social optimum as a competitive equilibrium, explicitly defining the current account is problematic. For this reason, we follow the literature in associating movements in net exports with fluctuations in the current account. We define net exports for country j as the difference between domestic output and the sum of domestic consumption, investment, and government spending. Given that our empirical analysis is restricted to studying relatively high frequency movements in the current account, the divergence between the empirical analysis and the consideration of the artificial economy should be minor, since in the short run empirical movements in the current account are likely to be dominated by movements in the trade balance (see Baxter (1995)). The artificial series that we use for estimation of the dynamic factor model are investment and the technology shock (or Solow residual), and the ratio of net exports to output. In the results presented, we do not apply the HP filter to these series. HP filtering, however, changes the parameter estimates but has little effect on the relationships we are studying. The main effect of filtering is to uniformly reduce the autocorrelation of all the unobservable factors.

In order to compute the equilibrium it is necessary to choose specific values for each of the economy's parameters. We choose parameters so as to achieve as close a correspondence between our artificial economy and those studied previously in the literature. In particular, following Backus, Kehoe, and Kydland (1992) we set $R = .99$, $a = .34$, $b = 2$, $s = .36$, and $d = .025$. Variations in any of these parameters has only minimal impact on the relationships among productivity shocks, investment, and the current account on which we focus here. For this reason we hold these constant across all experiments. In contrast, the adjustment cost parameter, p, does have a significant effect on some of our findings. Since we have no direct evidence on the size of adjustment costs, for our base case we follow Baxter and Crucini (1993) in setting this parameter so as to match the relative volatilities of investment and output. We choose a value of $p = .96$, so that the percent standard deviation of investment is three times that of output. We consider the effects of varying this parameter in two computational experiments.

In the parameterization of technology shocks, we set the persistence of both the common and country-specific components at .9 to reflect the fact that studies of international productivity fluctuations have found them to be very persistent. We choose the variances of the innovations to the two components so that the contemporaneous correlation of the actual technology parameters (*i.e.* the Z_j's) is equal to .4, as this turns out to produce results broadly consistent with the share of variance in Solow residuals accounted for by common shocks presented in Section 3. Finally, we set the steady-state share of government spending at 20%, and the persistence of government spending at .97, based on estimates using U.S. data in Devereux, Head, and Lapham (1995). We also consider the effects of increasing the size of the fiscal shocks in a computational experiment.

5. Dynamic Factor Analysis of Artificial Data

Tables 3 and 4 contain the parameter estimates and variance decompositions, respectively, for a series of artificial economies. Since all countries are symmetric, we report the averages across the seven countries for both the parameter estimates and the variance shares. The standard deviations of the estimates across countries are in parentheses. These provide some information on the sampling variability in our estimates.

Note that the effect of the common factor in the Solow residual in this case is a direct consequence of the calibration, rather than a finding. The exercise we are performing then is to set the decomposition between common and country-specific shocks, and then conditional on this we observe the extent to which the artificial economy replicates the qualitative and quantitative features of fluctuations in investment and the current account documented by the empirical analysis in Section 3. Considering the coefficients pertaining to the productivity equations in Table 3, and the variance decomposition of the Solow residual in Table 4, note that the dynamic factor model captures the true properties of the exogenous productivity process fairly well. The procedure produces estimates very close to the true properties of the data generating process with regard to both the share of the variance accounted for by the common factor and the autocorrelations of the two components. We take this as an indication that the differences between the dynamic factor model that we estimate and the true dynamic structure of the artificial economy are not too great.

Turning now to the investment and current account equations, we see that with respect to the parameter estimates, the artificial economy accounts for several of the qualitative features of the data. The effect of the common component on investment is positive, and the impact coefficients are uniformly smaller than those in the productivity equations. Also, a country-specific movement in total factor productivity has a positive impact on domestic investment. In the current account the influence of the common component is very small, as is that of country-specific productivity. A country-specific movement in investment not associated with domestic productivity, however, has a negative impact on the current account. Along all of these dimensions, the artificial economy replicates the qualitative properties of the data very well. Thus the empirical estimates of Section 3 may be taken as evidence in support of the dynamic relationships among Solow residuals, investment, and the current account that arise in a dynamic general equilibrium model of international risk sharing. In general, this may be interpreted as broad evidence in favor of the intertemporal approach to the current account.

Now consider the relationships among productivity, investment, and the current account in the artificial economy. Considering first the variance decomposition of investment (Table 4), roughly 8% of the variance of investment is associated with fluctuations in the common component, and the other two components each account for roughly half of the remainder. Relative to the empirical estimates, too much of the variance of investment in the artificial economy is accounted for by common fluctuations, and too little by the component not associated with country-specific technology shocks, Φ_j^I. There is a much larger component of investment fluctuations accounted for by factors other than country-specific technology shocks in the G7 data than in data generated by the artificial economy.

With regard to the variance decomposition of the current account, in the artificial economy both the common factor, and that associated with country-specific productivity fluctuations account for virtually none of the current account variance. Thus the model replicates the quantitative unimportance of both of these factors that was found in the data. In the artificial economy, however, fluctuations in the country-specific component of investment accounts for nearly 65% of the variance of the current account. Thus the model substantially overstates the share of current account fluctuations accounted for by this component. Whereas empirically the most important component of current account fluctuations is that associated with factors other than productivity and investment, in the artificial economy this component accounts for only about 35% on average.

Overall, our base case calibration fails to match the quantitative properties of our empirical estimates. We consider two modifications to the environment in an attempt to understand the source of the differences. First we investigate the effects of changing the size of adjustment costs. Recall that the adjustment cost parameter, p, was chosen so that the standard deviation of investment was three times that of output on average. In the two experiments that we conduct in Table 2 with different values of p, the relative volatilities of these series are of course changed. In the large adjustment cost case we set $p = .94$ and the relative standard deviation of investment is reduced to roughly two times that of output, and in the small adjustment cost case ($p = .98$) it is increased, to roughly five times that of output.

Consider first the case of large adjustment costs. The share of the current account variance accounted for by country-specific investment movements is reduced, but not by enough to be in line with our empirical estimates. The intuition behind this finding is straightforward. As adjustment costs are increased, the investment effect of technology shocks is reduced, as international capital flows are reduced. Thus, the relative importance of the consumption smoothing effect on trade balance movements is increased. This can be seen in Table 3, noting that $\hat{\gamma}^Z$ is now positive. In addition, with smaller international capital flows, the relative importance of fiscal shocks is increased, augmenting the importance of consumption smoothing for movements in the trade balance. Overall, this leads to a greater share of the variance of the current account being attributable to movements in Φ^{CA}. Presumably, if adjustment costs were to become large enough, this effect could be made to account for as large a share of current account fluctuations as desired, as high enough adjustment costs would shut down international capital flows altogether.

With higher adjustment costs, however, the variance decomposition of investment moves further away from that implied by our empirical estimates. The shares of investment fluctuations accounted for by both the common factor and the country-specific component of productivity are increased. Again the intuition is straightforward; while higher adjustment costs reduce investment fluctuations in general, their greatest effect is on the relatively large international flows that arise from international productivity differentials. Thus a larger share of the (smaller) variance of investment is now attributable to the common component, which arises from common technology shocks. The country-specific component of investment fluctuations *not* associated with country-specific productivity fluctuations is reduced in importance. Recall that this component captures the effects of capital stock movements (which are muted by larger adjustment costs) and foreign technology shocks (which are reduced in importance due to smaller international capital flows).

Given the effects of large adjustment costs, it is not surprising that *small* adjustment costs have the opposite effect; they improve the match between the artificial economy and the empirical estimates with regard to the variance decomposition of investment, but worsen the match with regard to current account fluctuations. Investment fluctuations and international capital flows are larger (note that in Table 3, $\hat{\gamma}^Z$ is now negative), and the importance of fiscal shocks is reduced. Under alternative settings for the adjustment cost parameter, p, the artificial economy's quantitative predictions can be made consistent with the empirical variance decomposition of *either* investment or the current account, but not with both simultaneously.

Next, consider the effects of large fiscal shocks. In this case, we increase the variance of e^g_{jt}, the innovation to the fiscal shock process, by a factor of five. This has little effect on the variance decomposition of investment and it neither improves nor worsens the match between model and data in this dimension. Large fiscal shocks do, however, bring the behaviour of the artificial economy's current accounts more into line with the empirical variance decomposition. Recall that fiscal shocks affect investment fluctuations only through a world-wide income effect, and so they do not provoke international capital flows. Moreover, given that fiscal shocks are not correlated across countries, they tend to average out, and thus the world-wide income effect is small. If it were large, then we would expect large fiscal shocks to increase the share of investment fluctuations accounted for by the common factor. They do not. Large fiscal shocks are, however, responsible for a large volume of intertemporal trade for consumption smoothing purposes. Since this is not associated with movements in either productivity or investment, by far the largest share of the variance of the current account is that associated with fluctuations in Φ^{CA}.

In summary, the analysis of the artificial economy suggests that it does provide an interpretation for many of the qualitative features of the relationships among productivity, investment, and the current account that we observe. Quantitatively, however, it understates the importance of the component of current account fluctuations not accounted for by investment flows or productivity shocks. While this can be remedied by increasing the size of adjustment costs, the required costs imply both too low a variance of investment fluctuations relative to that of output, and too large a share of investment fluctuations accounted for by common fluctuations. Large fiscal shocks can account for the variance decomposition of the current account, but they are required to be implausibly large.

6. Final Remarks

Our empirical findings show that for the G7 countries, common movements in economic activity are quantitatively important for productivity fluctuations, but that they account for a much smaller share of movements in investment and virtually none of the fluctuations in the current accounts. Country-specific investment fluctuations have a negative impact on the current account as predicted by the intertemporal approach to the current account, and the effect of this relationship is quantitatively significant. Country-specific productivity fluctuations, however, account for only a very small share of the current account fluctuations. The component which accounts for the largest share of the variance of the current account for each of the countries is that not associated with country-specific investment or productivity fluctuations. A multi-country dynamic general equilibrium model accounts for many of the qualitative features of the relationships among productivity, investment, and the current account. Quantitatively, however, the model tends to overstate the importance of country-specific investment fluctuations for movements in the current account.

One area for future empirical work is to permit the possibility of co-movements in aggregate activity among certain pairs or sub-groups of countries. In this study, we have assumed that all factors are orthogonal. This assumption is motivated mainly by the desire to estimate a tractable model. One way to evaluate the plausibility of this assumption is to consider the covariances among the estimated unobservable factors. Since there a large number of factors and covariances among them, we do not report them all here. One interesting feature of them, however, is that in many cases estimated country-specific investment, Φ^I, is positively correlated across countries. This may suggest that while the share of investment movements which are common to *all* of the G7 countries is small, the truly country-specific component for any given country is smaller than Φ^I, because of co-movements within certain sub-groups of countries. While in principle it is possible to enrich the dynamic factor model by adding bilateral factors, this is a rather time-consuming, computationally intensive exercise. A more fruitful approach would be to use the pattern of correlations generated by this model as a guide to identify certain groups of countries within the G7 for which a detailed study of co-movements would likely produce interesting results. Then only those additional factors that evidence suggests are crucial could be added to the dynamic factor model. We leave this for further research.

With regard to the analysis of the artificial economy, it is probably not surprising that a model of the type we consider cannot account for the importance of the component of current account fluctuations not accounted for by productivity or investment movement. In this type of model, the main source of aggregate fluctuations is productivity shocks, and the main channel for intertemporal trade is investment flows. Evidently, the only way to replicate the qualitative unimportance of productivity fluctuations *and* investment flows in current account movements in this type of model would be to consider cases of either very high adjustment costs or very weak country-specific technology shocks relative to fiscal shocks. High adjustment costs reduce the magnitude of international investment flows so that most of the movements in net exports is for consumption smoothing purposes. It is well known, however, that international capital flows are large. An explanation for current account fluctuations that relies on these flows being small does not seem very appealing.

The problem with large fiscal shocks (or some other disturbance not related to total factor productivity) is that it is not clear what these shocks are. In our computational experiments, we needed to set the variance of government spending at roughly five times that observed to bring the quantitative predictions of the artificial economy into line with those of the data. It is possible, however, that in a model with a larger role for demand shocks, fiscal shocks of plausible magnitude could play a substantially larger role. In addition, it is the relative magnitude of technology and fiscal shocks that accounts for the variance decomposition. Our calibration uses the variances of the simple Solow residual and of government spending. The Solow residual measurement relies on constant returns, perfect competition, and small variation in the capital input over the cycle. It has been shown that relaxing these assumptions can result in much smaller estimates of the variance of technology shocks. For example, Hornstein (1993) measures lower variance of technology shocks under specific assumptions about increasing returns and imperfect competition and in two papers, Burnside, Eichenbaum, and Rebelo (1993,1995) measure lower variances of technology shocks due to labour hoarding and variable capacity utilization. With smaller technology shocks, fiscal shocks of plausible magnitude could account for a substantially larger share of current account movements. We leave this also for further research.

Data Appendix

All data are quarterly, and cover the period 1973.1-1993.4. Aggregate investment is gross capital formation and is taken from the IMF *International Financial Statistics* (IFS). This data are in local currencies, at current prices. The data are deflated to 1990 prices using the implicit GDP (or GNP) deflator. The current account and trade balance are also taken from the IFS, where they are given in current U.S. dollars. These series are converted to local currency using the quarterly average of the daily spot exchange rate, taken from Citibase. These are then divided by nominal GDP (or GNP). Employment data used in construction of the Solow residuals are taken from the OECD *Quarterly Labour Force Statistics*. The real investment, Solow residual, current account/output, and trade balance/output series are seasonally adjusted by regressing on seasonal dummies. The IFS and Citibase codes for the series used are listed below.

Country	*Series*	*IFS or Citibase Code*
USA	Private Gross Capital Formation	I1110533
	Current Account	I1110376
	Trade Balance	I1110382
	Nominal GDP	I1110547
	1990 GDP	I1110551
	Civilian Employment	OECD
UK	Gross Capital Formation	I1120376
	Current Account	I1120251
	Trade Balance	I1120257
	Nominal GDP	I1120388
	1990 GDP	I1120390
	Monthly Ave. USD Exchange Rate	EXRUK
	Civilian Employment	OECD

France	Gross Capital Formation	I1320341
	Current Account	I1320253
	Trade Balance	I1320259
	Nominal GDP	I1320351
	1990 GDP	I1320354
	Monthly Ave. USD Exchange Rate	EXRFR
	Employment in Industry	OECD
Germany	Gross Capital Formation	I1340355
	Current Account	I1340261
	Trade Balance	I1340267
	Nominal GNP	I1340363
	1990 GNP	I1340365
	Monthly Ave. USD Exchange Rate	EXRGER
	Civilian Employment	OECD
Italy	Gross Capital Formation	I1360358
	Current Account	I1360257
	Trade Balance	I1360263
	Nominal GDP	I1360366
	1990 GDP	I1360368
	Monthly Ave. USD Exchange Rate	EXRITL
	Civilian Employment	OECD
Canada	Gross Capital Formation	I1560335
	Current Account	I1560234
	Trade Balance	I1560240
	Nominal GDP	I1560347
	1990 GDP	I1560351
	Monthly Ave. USD Exchange Rate	EXRCAN
	Civilian Employment	OECD

Japan	Gross Capital Formation	I1580352
	Current Account	I1580277
	Trade Balance	I1580283
	Nominal GNP	I1580364
	1990 GNP	I1580366
	Monthly Ave. USD Exchange Rate	EXRJAN
	Civilian Employment	OECD

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Table 1: Parameter Estimates

1973.1—1993.4

	Impact Coefficients						*Autoregressive Coefficients*			
	$\hat{\alpha}^Z$	$\hat{\alpha}^I$	$\hat{\beta}$	$\hat{\alpha}^{CA}$	$\hat{\gamma}^Z$	$\hat{\gamma}^I$	$\hat{\delta}$	$\hat{\eta}^Z$	$\hat{\eta}^I$	$\hat{\eta}^{CA}$
World							.475			
							(.116)			
U.S.	.328	.141	.380	-.010	-.263	-.505		.793	.901	.474
	(.065)	(.042)	(.066)	(.089)	(.142)	(.188)		(.071)	(.049)	(.096)
U.K.	.448	.036	.088	-.024	-.011	-.629		.697	.840	.151
	(.078)	(.056)	(.092)	(.091)	(.126)	(.099)		(.086)	(.057)	(.109)
France	.658	.157	.302	.055	.078	-.551		.539	.851	.293
	(.078)	(.054)	(.103)	(.098)	(.198)	(.133)		(.116)	(.057)	(.104)
Germany	.507	.151	.614	.021	-.275	-.175		.671	.761	.481
	(.074)	(.070)	(.109)	(.093)	(.159)	(.153)		(.087)	(.076)	(.096)
Italy	.631	.108	.536	.035	.140	-.876		.831	.874	.201
	(.068)	(.053)	(.137)	(.091)	(.185)	(.124)		(.070)	(.059)	(.117)
Canada	.445	.152	.319	-.073	-.120	-.417		.677	.885	.064
	(.079)	(.051)	(.074)	(.098)	(.128)	(.113)		(.084)	(.049)	(.109)
Japan	.745	.295	.394	.032	.290	-.802		.629	.865	.446
	(.086)	(.053)	(.084)	(.079)	(.149)	(.133)		(.113)	(.054)	(.100)

Notes: The model is:

$$Z_{jt} = \alpha_j^Z \Gamma_t + \Phi_{jt}^Z \qquad \Gamma_t = \delta \Gamma_{t-1} + \varepsilon_t$$

$$I_{jt} = \alpha_j^I \Gamma_t + \beta_j \Phi_{jt}^Z + \Phi_{jt}^I \qquad \Phi_{jt}^Z = \eta_j^Z \Phi_{jt-1}^Z + \varepsilon_{jt}^Z$$

$$CA_{jt} = \alpha_j^{CA} \Gamma_t + \gamma_j^Z \Phi_{jt}^Z + \gamma_j^I \Phi_{jt}^I + \Phi_{jt}^{CA} \qquad \Phi_{jt}^I = \eta_j^I \Phi_{jt-1}^I + \varepsilon_{jt}^I$$

$$\Phi_{jt}^{CA} = \eta_j^{CA} \Phi_{jt-1}^{CA} + \varepsilon_{jt}^{CA} \qquad j = 1, \ldots, 7.$$

Standard errors are in parentheses.

Table 2: Variance Decompositions

1973.1—1993.4

	Solow Residual		Investment			Current Account			
	$\alpha^Z \Gamma$	Φ^Z	$\alpha^I \Gamma$	$\beta\Phi^Z$	Φ^I	$\alpha^{CA} \Gamma$	$\gamma^Z \Phi^Z$	$\gamma^I \Phi^I$	Φ^{CA}
U.S.	.148	.852	.029	.344	.627	.000	.060	.153	.787
U.K.	.257	.743	.002	.068	.931	.001	.000	.375	.624
France	.606	.394	.035	.121	.844	.004	.002	.241	.752
Germany	.376	.624	.029	.334	.637	.001	.048	.023	.928
Italy	.477	.523	.014	.275	.711	.001	.010	.524	.465
Canada	.261	.739	.027	.210	.763	.007	.011	.150	.832
Japan	.596	.404	.126	.215	.659	.001	.047	.438	.514

Notes: Each entry is the share of the variance accounted for by the appropriate component of the variable for each country. For example, the share of the variance of the Solow residual accounted for by the country-specific component is given by:

$$\frac{\frac{\hat{\sigma}^2_{\epsilon^Z_j}}{\left(1-(\hat{\eta}^Z_j)^2\right)}}{\frac{(\hat{\alpha}^Z_j)^2}{\left(1-\hat{\delta}^2\right)} + \frac{\hat{\sigma}^2_{\epsilon^Z_j}}{\left(1-(\hat{\eta}^Z_j)^2\right)}}.$$

For investment and the current account, the denominator of the expression is modified accordingly as these series are decomposed into three and four unobservable factors respectively. Shares may not add to one because of rounding.

Table 3: Parameter Estimates

Artificial Economies, 500 periods

	Impact Coefficients						Autoregressive Coefficients			
	$\hat{\alpha}^Z$	$\hat{\alpha}^I$	$\hat{\beta}$	$\hat{\alpha}^{CA}$	$\hat{\gamma}^Z$	$\hat{\gamma}^I$	$\hat{\delta}$	$\hat{\eta}^Z$	$\hat{\eta}^I$	$\hat{\eta}^{CA}$
Base Case										
	.215	.153	1.937	.000	-.020	-.725	.948	.901	.988	.966
	(.019)	(.033)	(.115)	(.009)	(.043)	(.064)	(.014)	(.020)	(.003)	(.011)
Large Adjustment Costs										
	.215	.172	1.782	-.001	.147	-.712	.951	.902	.991	.966
	(.018)	(.030)	(.094)	(.009)	(.029)	(.066)	(.014)	(.021)	(.003)	(.011)
Small Adjustment Costs										
	.216	.122	2.194	.003	-.334	-.754	.945	.901	.982	.966
	(.019)	(.037)	(.150)	(.010)	(.078)	(.066)	(.015)	(.019)	(.003)	(.011)
Large Fiscal Shocks										
	.214	.150	1.925	.001	-.005	-.362	.945	.901	.988	.965
	(.018)	(.032)	(.117)	(.011)	(.051)	(.070)	(.015)	(.021)	(.003)	(.011)

Notes: See notes to Table 1. Reported estimates are averages across seven countries in the artificial economy. Numbers in parentheses are standard deviations of the coefficient estimates across the seven countries.

Table 4: Variance Decompositions

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	Solow Residual		*Investment*			*Net Exports/Output*			
	$\alpha^Z \Gamma$	Φ^Z	$\alpha^I \Gamma$	$\beta \Phi^Z$	Φ^I	$\alpha^{CA} \Gamma$	$\gamma^Z \Phi^Z$	$\gamma^I \Phi^I$	Φ^{CA}
Base Case									
	.407	.593	.081	.440	.479	.000	.001	.645	.354
	(.058)	(.058)	(.033)	(.062)	(.070)	(.001)	(.001)	(.129)	(.129)
Large Adjustment Costs									
	.417	.583	.122	.464	.414	.000	.016	.547	.437
	(.059)	(.059)	(.042)	(.073)	(.088)	(.001)	(.007)	(.154)	(.155)
Small Adjustment Costs									
	.396	.604	.041	.396	.563	.000	.046	.733	.221
	(.057)	(.057)	(.022)	(.042)	(.043)	(.001)	(.013)	(.086)	(.080)
Large Fiscal Shocks									
	.390	.610	.076	.445	.480	.001	.001	.188	.810
	(.059)	(.059)	(.030)	(.059)	(.067)	(.001)	(.001)	(.118)	(.119)

Notes: See notes to Table 2. Reported estimates are averages across seven countries in the artificial economy. Numbers in parentheses are standard deviations of the coefficient estimates across the seven countries.