4

Shocks and Disturbances to the World Economy

It is a fact of life that the world economy is subject to continual disturbances or shocks. Some disturbances are large and noticeable, such as the sudden oil-price increases in 1973 and 1979 or the more recent oil-price rise after Iraq invaded Kuwait in August 1990. These oil-price shocks affected real economic growth and inflation in almost every country throughout the world. Although the 1990 oil-price shock ended quickly after the successful Allied military intervention in Kuwait, the shock probably helped bring the U.S. economy into recession; the first month of recession according to the National Bureau of Economic Research (NBER) was September 1990, one month after the Iraq invasion of Kuwait.

Of course not all disturbances are caused by oil shocks. In the fall of 1991, a different type of shock apparently hit the economy: a marked drop in consumer confidence. Whatever its source, it caused a decline in consumption demand and thereby slowed down the U.S. economy. Money-demand shocks, exchange-rate shocks, and international-portfolio shocks are other noticeable disturbances to the world economy. Numerous times, such shocks have altered the course of different economies.

Many shocks, however, go unnoticed. They may be small, or they may not be understood until well after they occur, if ever. Debate continues, for example, about whether shocks to the money supply, or to tariffs, or to financial intermediaries, or even to consumption demand were the source of the Great Depression of the 1930s.

If macroeconomic policy is to be effective, it must be designed to work well in a world where shocks and disturbances are everyday phenomena. A good policy rule will generally be effective in ironing out shocks and will not add more disturbances to the economy; a bad policy will tend to amplify shocks and may even add disturbances to the system.

In order to design policy systems that deal effectively with shocks, it is necessary to assess their past behavior and project their future behavior. Because shocks are by their nature unanticipated, however, no economic model can project particular paths for future shocks. For example, no reasonable model could make a prediction that there will be an oil-price increase of 50 percent in January 2012. It is only the general properties of these future shocks—for instance, their variances and their covariances—that we can hope to project. But even bits of information about these general properties can greatly improve the reliability of economic policy and should be taken into account when designing economic policy systems.

A physical-design analogy is useful if not taken too far. The design of a policy rule—say an international monetary system—can be compared with the design of an off-road vehicle. The design of such a vehicle—the suspension system, the center of gravity, the ground clearance, the gear ratio, and so on—will depend on the nature of the terrain. Similarly, the design of a macroeconomic policy—the degree of responsiveness of the instruments of policy—depends on the pattern of future economic shocks. A good macroeconomic policy design requires a forecast of the general properties of future shocks but not necessarily a forecast of when and where each individual shock will occur. Individual shocks will, by definition, be unanticipated. Analogously, the design of a good off-road vehicle requires an analysis of the typical terrain, not where each bump is placed on a given trail.

The purpose of this chapter is to try to measure and interpret systematically the shocks that hit the world economy during the 1970s and 1980s and to use this information to project future disturbances for policy-design analysis. I do this by using the model described in Chapter 3. I treat the "residuals" to the equations of that model as measures of the shocks that hit the real world. For example, the residuals in the durable-goods consumption equation in the United States are a measure of the shocks to durables-consumption demand during the sample period. Interpreting the consumption shock is more difficult. In principle it is a reflection of any variable not incorporated in the consumption equation as well as pure randomness. In order to assess the reliability of a policy-design analysis based on such shocks, however, it is essential to have some interpretation or intuitive understanding of the nature of the shocks. Otherwise, the analysis becomes a "black box" in which it is hard to place much confidence and that will have little practical appeal. Moreover, the analysis of the shocks can provide insights into the working of the world economy, which might have implications for this and other research programs.

Systematically studying the shocks is not an easy job for a model of this size. Even though, as I have argued, the ninety-eight individual equations of the model have straightforward theoretical interpretations, there are still ninety-eight different shocks to analyze. I will be working under the assumption that these shocks are serially uncorrelated, but that still leaves a 98 by 98 matrix with 4,851 distinct variances and contemporaneous covariances to describe and analyze.[1] Clearly some effort is required to find a good way to present simply such information, let alone to organize it in a manageable form for discussion.

I begin by describing how the shocks are computed and then go on to summarize the major properties of the variance-covariance matrix of the shocks. To do this I organize the ninety-eight shocks into three groups corresponding to the familiar framework of stylized macroeconomic models. The first group consists of twenty different *financial-market shocks,* which correspond to shocks to the demand for money, to the term structure of interest rates, and to the *ex ante* interest-rate parity relation for exchange rates. The second group consists of fifty different *goods-market shocks,* which correspond to different shocks to the components of consumption, the components of investment, exports, and imports. The third group consists of twenty-eight different *price shocks,* which correspond to shocks to wages, to the markup relations for product prices, export prices, and import prices.

For each of these groups I describe the volatility of the shocks and the correlation between the shocks. As detailed later, I find a significant amount of correlation between shocks in different sectors within the same country as well as significant correlation within some sectors across countries. The volatility of the shocks differs from country to country and from sector to sector.

One obvious point should be emphasized at the outset of this discussion. The correlations between the shocks are just that—correlations—not necessarily causal relations. It is useful to give interpretations to the correlations, and I do that in a number of cases. In some cases, however, the most satisfactory explanation is that there is a missing third factor explaining the behavior of more than one shock.

4.1 Defining and Computing the Shocks

The typical behavioral equation in the multicountry model features endogenous variables, predetermined variables, expectations of future variables, and an additive stochastic shock. It might help to look at Equation (1.28) of Chapter 1 that gave a general algebraic notation for the typical equation. For example, the durable-consumption equation in the United States presents personal consumption of durable goods on the left-hand side and the expectation of future income, the expectation of future inflation, the long-term interest rate, lagged durable consumption, and a stochastic shock on the right-hand side. In some equations—like the consumption equations—the stochastic shock is assumed to be serially uncorrelated. In other equations,

[1] As described in Chapter 3, some of the ninety-eight equations are modeled with $AR(1)$ disturbances. In these cases, the characteristics of the serially uncorrelated shock to the disturbances are estimated in this chapter.

the shock is serially correlated and usually modeled according to a first-order autoregressive process, with the shock to that autoregressive process assumed to be serially uncorrelated. It is this serially uncorrelated stochastic shock—whether directly to the equation or indirectly to the autoregressive error process in the equation—that is the subject of this chapter. These shocks are the *structural* residuals to the equations of the model. The task is to compute these residuals and estimate their properties.

Structural residuals for each equation can be computed for the period during which the model was estimated: the first quarter of 1972 through the last quarter of 1986. It would be a matter of simple arithmetic (again, it may help to check out Equation [1.28]) to compute the residuals if the expectation of future variables in each equation were known. In other words, the right-hand side variables could be subtracted from the left-hand side variables, just as the residuals are computed in a simple regression model. However, expectations of future variables are not known and must be computed at each date during the sample period. This can be accomplished by simulating the model dynamically into the future, conditional on data through each sample point. This generates forecasted values for each endogenous variable that can then be used in place of the expectations variable in each equation. In other words, at each of the sixty-eight points in the sample, one solves the model using the extended path method. This ensures that the expectations are rational forecasts in the sense that they are consistent with the model and are based only on information available at the time the forecast is made. Using this procedure, which is straightforward but computer intensive, the conditional forecasts can be computed for every equation in the model. How one treats exogenous variables—that is variables not modeled—is more ambiguous. There are only two exogenous variables in each country in this model—government purchases and the money supply. These were set to their actual values rather than extrapolated with auxiliary equations.

Note that these structural residuals are not the same as the residuals obtained from the instrumental variables-estimation procedure in Chapter 3. Those residuals—used to compute R^2—effectively assume that the forecast variables are equal to the actual future variables. Hence, those residuals include both the forecast errors in projecting the future and the structural equation errors. The procedure used here removes the forecast error from the residuals. Full-information maximum-likelihood (FIML) methods would require that the residuals be computed as in this chapter. FIML estimation has not been used, however, because it is not computationally feasible. This would require thousands of computations of the residuals for each of the sixty-eight sample points; only one computation for each of the sixty-eight sample points is done here.

Figure 4-1 illustrates the structural residual computations with examples from four of the ninety-eight stochastic equations of the model. The four time-series charts in Figure 4-1 each show the structural residual for each equation for the 1972:1 through 1986:4 period: (1) consumer durables in

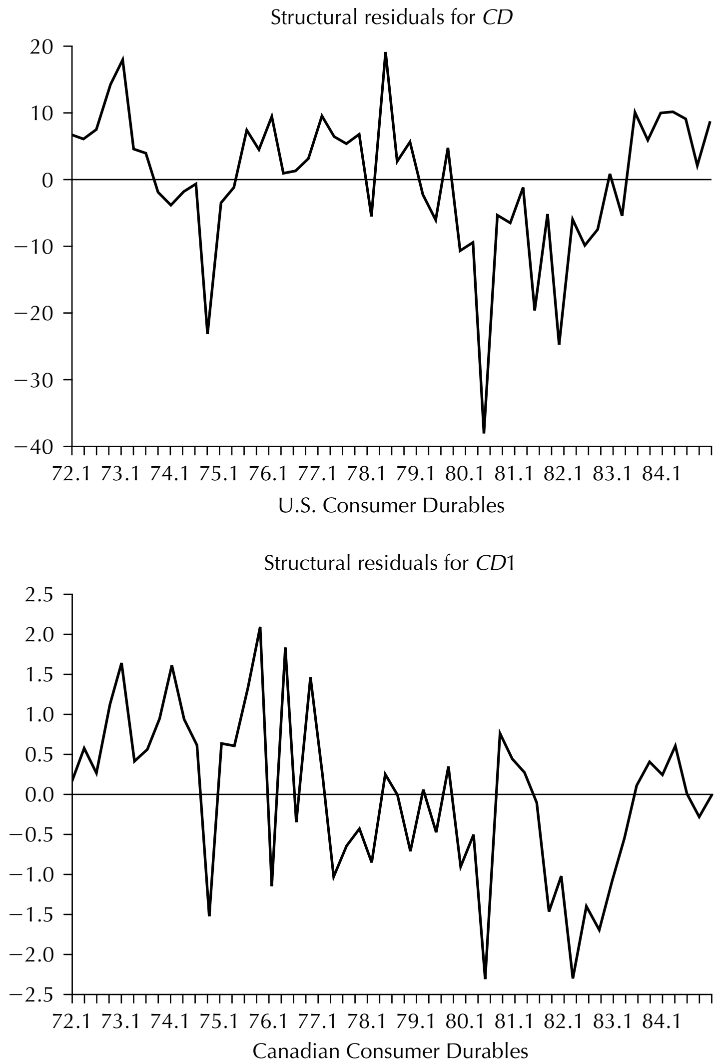


FIGURE 4-1 **Shocks to Consumer Demand and Import Prices (structural residuals from multicountry model).** The correlation coefficient between shocks to consumer durables in the United States and Canada is .51. The correlation coefficient between import price in the United States and Japan is .61. (See Table 4-1 and Table 4-2.)

the United States; (2) consumer durables in Canada; (3) import prices in the United States; and (4) import prices in Japan. As discussed below, there is a relatively high correlation between shocks to import prices in Japan and in the United States, and this correlation is visible in the time-series charts. The charts suggest this is largely due to a simultaneous occurrence of a large

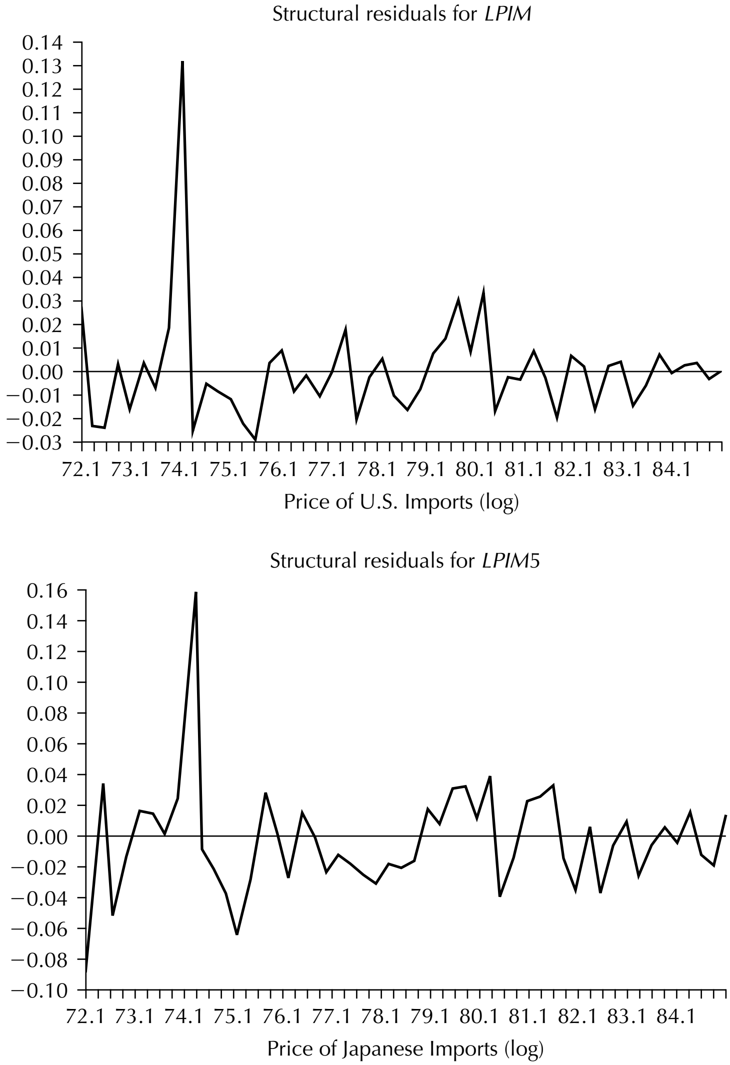


Figure 4-1 *(Continued)*

shock in 1974. This was apparently due to the increase in the price of oil following the war in the Middle East, and it gives an illustration of how price shocks show up in the multicountry model. The time-series charts also show a correlation between shocks to consumer durables in the United States and shocks to consumer durables in Canada. It is interesting to note that much of this correlation appears to be related to a simultaneous occurrence of a shock in 1980 when credit controls were instituted in the United States. The next section examines these and other correlations between the structural residuals more systematically.

4.2 Estimating the Variance-Covariance Matrix and Drawing New Shocks

Consistent estimates of the variance of each of the shocks and the covariance between the shocks in each pair of equations are obtained from the sample moments—the average of the sums of squares and cross-products—of the estimated residuals. Each of these estimates is perfectly well defined and consistent; as the sample size grows, the estimates converge to the true values.

It is straightforward to construct an estimated covariance matrix from these estimates of the variances and covariances, with the variances on the diagonal and the covariances on the off-diagonal. Call this 98 by 98 covariance matrix S. For stochastic simulation, I make the assumption that the 98-dimensional vector of structural residuals is normally distributed with mean vector 0 and covariance matrix S.

In order to determine how the endogenous variables of the multicountry model behave for different policy rules, it is necessary to stochastically simulate the model. For stochastic simulation, shocks from this normal distribution can be created by using a standard random-number generator. The resulting shocks will have the same distribution as the shocks to the equations during the sample period (under the normal and serially uncorrelated distribution assumption). Note that because the shocks are serially uncorrelated, the expectation of future shocks is zero in each equation (their unconditional mean). Of course, the shocks turn out not to be zero when the future periods of the simulation occur. No series of shocks drawn from this distribution will match the pattern during the sample period, but the statistical properties will be the same. Using the off-road vehicle analogy, the properties of the terrain are known, although a particular path is not.

A comparison of this approach with the simpler approach of Chapter 2 is useful. In Chapter 2 the model of the U.S. economy was linear and could be reduced to a linear VARMA. The structural shocks to this model were computed as part of the estimation procedure, and an estimate of the variance-covariance matrix of the shocks was obtained. That covariance matrix was 5 by 5. Given this covariance matrix, the statistical properties of the endogenous variables could be computed analytically *without* stochastic simulation; the variance-covariance matrix of the endogenous variables was a known function of the variance-covariance matrix of the shocks. The multicountry model is not linear, and therefore such a simple analytic computation is not feasible. Hence, we use stochastic simulation and a random-number generator to compute the statistical properties of the endogenous variables. Hence, although computationally different, the methods are conceptually the same.

One important technical issue in this computation procedure should be noted. Because the sample size (68) is less than the dimensions of the covariance matrix (98 by 98), the estimated covariance matrix is singular—that is, there is perfect contemporaneous correlation among some linear combinations of the estimated residuals. In other words, the normal distribution that is generated randomly is singular.

Using the Actual Shocks Again

Recall that in several experiments reported in Chapter 2, the actual residuals were used rather than the new residuals drawn from the estimated normal distribution. That same procedure is possible for the multicountry model, and the advantages and disadvantages are similar. An advantage is that nonnormalities—such as large outliers—can be taken into account if they are important during the sample period. A disadvantage is that there are only sixty-eight shocks to work with.

Dealing with Changes in the Stochastic Structure

One disadvantage of using estimated residuals (whether the actual estimates or randomly generated ones) for policy design is that it implicitly assumes that the properties of the disturbances in the future will be like those in the past, but this is a disadvantage for any empirical analysis based on actual data. This disadvantage can be dealt with by sensitivity analysis, changing the disturbances slightly and observing whether the results change. For example, one might suspect that the shocks to the exchange-rate equations (the "risk-premium terms") might be reduced significantly if exchange rates were fixed. To test whether the results are sensitive to such a change, the simulations could be conducted with and without the risk-premium shocks. This approach is followed in Chapter 6, which explores policy design.

4.3 Which Shocks Are Big and Which Are Correlated?

Table 4-1 shows the standard deviations of the errors to each equation (the square roots of the diagonal elements of the covariance matrix). The equations are usually labeled by the variable on the left-hand side of the equations. One exception is the shock to short-term interest rates that is computed from an inverted money-demand equation. For those equations that are not estimated in logs, I also report the ratio of the standard deviation of the shock to the mean of the right-hand side variable in order to control the large difference in the average size of the residuals. Hence, each standard deviation is stated in units roughly proportional to the average value of the variable on the left-hand side of the equation in question.

Table 4-2 shows the correlation matrix in several blocks (the elements below the main diagonal are grouped as shown on the first page of Table 4-2). In reading the correlation matrix, note that I have omitted the decimal point of each correlation and show only the first two digits to the right of the decimal. The first entry of 28 thus indicates that the correlation between the

TABLE 4-1 Standard Deviations of the Shocks to the Equations

*Variable Name**	*Standard Deviation of Shock*	*Variable Name*	*Standard Deviation of Shock*	*Variable Name*	*Standard Deviation of Shock*	*Standard Deviation/ Mean*
RS	0.041	*LX*	0.006	*CD*	10.38	0.042
*RS*1	0.036	*LX*1	0.069	*CN*	10.58	0.014
*RS*2	0.107	*LX*2	0.016	*CS*	5.46	0.006
*RS*3	0.032	*LX*3	0.010	*CD*1	1.00	0.040
*RS*4	0.040	*LX*4	0.057	*CN*1	0.68	0.009
*RS*5	0.033	*LX*5	0.054	*CS*1	0.49	0.006
*RS*6	0.026	*LX*6	0.022	*CD*2	3.75	0.058
*LE*1	0.037	*LP*	0.003	*CN*2	6.92	0.020
*LE*2	0.088	*LP*1	0.008	*CS*2	2.65	0.011
*LE*3	0.101	*LP*2	0.006	*C*3	10.35	0.013
*LE*4	0.076	*LP*3	0.007	*C*4	335.70	0.007
*LE*5	0.083	*LP*4	0.021	*CD*5	393.59	0.053
*LE*6	0.067	*LP*5	0.009	*CN*5	843.51	0.014
RL	0.020	*LP*6	0.010	*CS*5	872.27	0.014
*RL*1	0.018	*LPIM*	0.023	*CD*6	1.09	0.083
*RL*2	0.031	*LPIM*1	0.016	*CN*6	0.79	0.011
*RL*3	0.015	*LPIM*2	0.025	*CS*6	0.45	0.009
*RL*4	0.019	*LPIM*3	0.019	*INE*	9.07	0.041
*RL*5	0.022	*LPIM*4	0.025	*INS*	3.84	0.031
*RL*6	0.025	*LPIM*5	0.034	*IR*	17.58	0.119
LEX	0.029	*LPIM*6	0.020	*II*	17.22	0.971
*LEX*1	0.033	*LPEX*	0.009	*IF*1	1.75	0.026
*LEX*2	0.014	*LPEX*1	0.015	*II*1	2.95	1.305
*LEX*3	0.023	*LPEX*2	0.016	*IN*2	3.03	0.018
*LEX*4	0.033	*LPEX*3	0.007	*IR*2	1.07	0.018
*LEX*5	0.028	*LPEX*4	0.020	*II*2	6.80	0.553
*LEX*6	0.030	*LPEX*5	0.014	*IF*3	12.52	0.041
LIM	0.032	*LPEX*6	0.011	*II*3	12.94	1.847
*LIM*1	0.032			*IF*4	377.38	0.027
*LIM*2	0.024			*II*4	819.64	0.773
*LIM*3	0.022			*IN*5	897.65	0.026
*LIM*4	0.033			*IR*5	786.28	0.051
*LIM*5	0.028			*II*5	1462.42	0.812
*LIM*6	0.037			*IN*6	0.96	0.029
				*IR*6	0.43	0.049
				*II*6	2.04	3.623

*The definitions of the variable names are summarized in Box 3-1 (see p. 69).

shocks to the short-term interest-rate equation in Canada and the shocks to the short-term interest-rate equation in the United States is .28. The lower left-hand entry of −9 says that the correlation between shocks to inventory investment in the United Kingdom and the short-term interest-rate equation in the United States is −.09.

Financial-Sector Shocks

This group includes shocks to short-term interest rates (money-demand shocks), shocks to long-term interest rates (term-structure shocks), and shocks to exchange rates (*ex ante* interest-rate parity shocks).

The short-term interest-rate shocks have large standard deviations compared with the other equations. Recall that the short-term interest-rate equations were derived by first estimating a money-demand equation with the short-term interest rate on the right-hand side, and subsequently by inverting the equation to put the interest rate on the left-hand side. Hence, the shocks to short-term interest rates are directly related to velocity shocks that appear to be large in this model. Moreover, the estimated short-run interest-rate elasticity in the money-demand equations is very low. Hence, the inversion of the equation gives an even larger interest-rate variance—the inverse of a very low interest-rate elasticity multiplies the money-demand residual. Estimating the equation with the interest rate on the left-hand side might give a smaller variance. However, the size of these variances does not affect the policy analysis of later chapters. The policy rules we examine in this book do not rely on these equations, so that the large variance of the shocks does not affect the policy-design results. In other words, the monetary policy rules analyzed are interest-rate rules rather than money-supply rules. Since these interest-rate rules replace the money-demand equations in the simulations, the short-term interest-rate shocks do not enter the analysis.

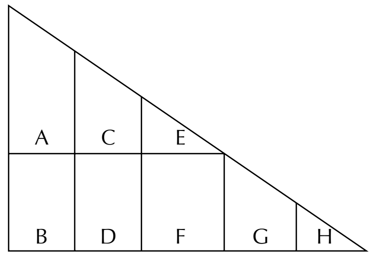
The long-term interest-rate equations have shocks with smaller variances than for the short-term interest rates. Recall that these are simply shocks to the term-structure equations. A positive shock will steepen the yield curve. The standard deviation of these shocks is generally around 2 or 3 percentage points and thus not insignificant. This represents deviations from the simple efficient model of the term structure and might be due to risk premia or other factors (including measurement error). Under the risk-premia interpretation, the risk premia are time varying and stochastic.

The shocks to the exchange-rate equations are important for the international policy analysis. These shocks are fairly large—with a standard deviation ranging from a relatively low 4 percent for the U.S. dollar/Canadian dollar exchange rate to around 10 percent for the U.S. dollar/deutsche mark exchange rate—but perhaps not surprisingly large given the behavior of exchange rates during the sample period. These standard deviations measure the size of the departure from *ex ante* interest-rate parity. They may be thought of as risk premia. If so, then the risk-premia shocks to *ex ante* interest-rate parity are generally larger than the risk-premia shocks to the

(continued on p. 130)

TABLE 4-2A Correlation Matrix of Errors to the Equations

	RS							LE						RL						
	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.
RS																				
Can.	28																			
Fra.	19	−6																		
Ger.	9	4	14																	
It.	14	6	30	−4																
Jap.	16	7	7	−0	2															
U.K.	12	−7	−4	20	25	−2														
LE																				
Can.	33	−24	−26	−38	−18	9	−14													
Fra.	−4	24	19	23	30	7	1	−60												
Ger.	−14	14	27	−6	23	11	−17	−47	79											
It.	−10	18	−29	2	−3	−2	−1	−10	39	41										
Jap.	−2	15	23	11	30	1	−9	−39	80	73	40									
U.K.	16	20	14	9	−1	0	3	−8	25	26	55	17								
RL																				
U.S.	4	−8	1	−2	7	−17	18	−3	−20	−40	−21	−14	−32							
Can.	11	−36	−30	1	−34	−9	3	40	−32	−37	23	−18	−2	42						
Fra.	24	19	28	14	16	−18	18	−25	34	1	−16	21	15	29	−13					
Ger.	3	3	−40	−32	−24	6	0	39	−32	−23	38	−21	2	29	51	−18				
It.	28	17	35	15	23	−12	16	−28	32	1	−1	21	13	44	11	73	−5			
Jap.	16	15	−26	9	5	−4	29	10	−11	−30	51	−2	14	39	38	2	53	21		
U.K.	−22	−12	−50	−20	−16	−5	−12	30	−34	−6	37	−9	−9	−8	26	−65	49	−61	33	
Consumption																				
U.S. *D*	9	11	−23	−11	27	−8	−5	21	1	−18	12	20	−27	32	20	5	29	14	39	14
N	11	−3	−19	−7	17	−1	6	22	−4	−19	35	16	−17	39	41	−3	45	14	64	18
S	25	18	−15	−7	12	8	−1	15	−2	−9	28	6	−4	32	31	−7	45	8	42	20
Can. *D*	7	12	−49	−7	−6	3	−18	44	−14	−22	19	4	−15	−13	14	−28	25	−29	29	35
N	−11	−5	−25	16	−18	−2	11	15	−10	−18	6	2	−15	1	6	−12	5	−22	12	23
S	2	10	7	1	7	12	−21	18	−15	−2	−6	−1	−13	−6	−1	−38	2	−33	3	11



Location of Parts of Correlation Matrix

		RS							LE						RL						
		U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.
Consumption (Continued)																					
Fra.	*D*	42	−12	−29	−12	−8	17	24	58	−50	−53	−6	−38	−14	29	53	−17	45	−7	46	29
	N	8	−12	−50	−13	−14	7	11	63	−53	−51	25	−31	−15	16	55	−39	62	−27	59	58
	S	3	−9	−38	−15	−14	9	−17	45	−43	−47	14	−17	−27	25	47	−29	55	−17	45	40
Ger.		25	8	−20	8	−9	10	23	18	15	−8	42	7	22	−8	23	−2	26	2	48	7
It.		24	−4	20	−10	25	10	36	8	7	−20	−27	−7	−12	8	−10	39	−28	39	5	−54
Jap.	*D*	−4	−8	−20	−9	7	24	10	5	17	4	40	10	10	−6	9	−13	24	8	40	4
	N	−9	18	−11	−12	5	8	6	−11	33	24	33	15	11	−8	−14	3	18	5	17	−9
	S	3	10	16	3	13	19	−28	−7	24	28	28	20	26	−16	−13	4	4	23	−7	−21
U.K.	*D*	24	−14	3	1	−8	24	−5	27	−19	−32	−9	−14	−23	31	30	13	25	14	32	−11
	N	19	−10	10	3	9	10	4	31	5	−8	15	15	3	10	17	25	14	21	33	−11
	S	33	6	13	0	−3	7	−1	27	−15	−27	6	−17	23	19	24	31	18	39	33	−22
Investment																					
U.S.	*NE*	4	−6	−12	−16	19	−9	−2	27	−9	−24	11	19	−17	14	10	6	13	11	37	16
	NS	15	10	9	−19	34	8	13	12	−2	−16	4	6	1	2	−20	6	−5	14	34	4
	R	17	2	−29	−10	19	−11	7	39	−24	−40	26	−1	−17	38	41	−7	49	9	69	34
	I	−29	−25	13	−16	−2	−29	16	4	−21	−15	−23	−3	−18	−4	−12	2	−11	−2	6	10
Can.	*F*	31	15	−19	19	7	6	−9	25	4	−10	19	6	22	−40	−5	−15	−8	−20	19	9
	I	−11	−14	−12	−20	−9	9	17	28	−44	−21	11	−35	0	−17	5	−28	35	−27	24	38
Fra.	*N*	25	12	−4	−4	19	13	8	14	2	−19	−2	−5	2	12	−3	12	−3	5	19	−11
	R	37	−8	−13	1	−21	1	12	56	−54	−54	−13	−38	−4	−5	21	−15	19	−15	33	16
	I	8	−22	5	−17	−9	−4	21	32	−17	−12	−15	−16	−2	15	20	4	−7	−1	−10	−14
Ger.	*F*	38	−1	−11	8	−14	20	5	41	−33	−52	−9	−37	8	9	26	8	17	7	36	−6
	I	−3	−12	−14	−6	−3	−1	11	19	−17	−14	−1	−19	−5	−35	−13	−19	−1	−24	5	−3
It.	*F*	30	−11	−8	−7	13	1	23	46	−32	−48	−20	−23	−19	4	10	−2	−5	−9	16	−14
	I	21	−28	−25	−5	−18	−5	−1	45	−38	−33	5	−24	−1	11	53	−39	18	−27	18	28
Jap.	*N*	1	3	−29	−9	−5	15	19	17	−11	−24	48	−7	22	3	27	−17	30	0	65	16
	R	−0	−7	7	34	19	3	16	−13	5	−18	20	2	7	21	11	9	3	15	45	6
	I	9	−12	−25	−1	−6	5	31	27	−25	−27	27	−20	25	−6	21	−16	22	−12	44	30
U.K.	*N*	−10	−32	0	−6	8	−6	1	22	−13	−19	−4	−0	−38	24	27	3	4	19	18	4
	R	3	−11	−0	4	7	−0	−4	20	0	−6	19	−7	−2	15	24	0	24	4	22	1
	I	−9	−2	−8	−25	21	−9	7	13	6	4	8	17	−23	−1	−8	−3	−1	−6	5	6

Table 4-2B Correlation Matrix of the Errors

	RS							LE						RL						
	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.
LEX																				
U.S.	−6	7	6	−14	25	3	13	10	−1	−3	16	−3	21	−23	−23	−2	−21	2	23	−4
Can.	13	−4	1	−2	−9	−16	0	17	−9	−26	−29	9	−22	3	−5	11	−9	−4	−4	−5
Fra.	17	−19	19	10	18	12	0	7	9	−1	−1	17	−17	19	5	−1	13	16	18	−2
Ger.	−0	−45	−7	−15	−16	8	12	35	−21	−20	−17	−4	−35	13	21	−11	16	−19	3	28
It.	−6	24	−6	−8	22	5	29	−16	15	9	8	7	2	5	−24	5	12	9	8	7
Jap.	2	−18	19	−20	5	−18	−8	26	−52	−32	−40	−37	−38	4	−14	−13	2	−14	−4	14
U.K.	−4	8	2	−10	9	33	−13	−10	30	25	8	12	8	−5	−14	−4	−8	−2	−18	−4
LIM																				
U.S.	−34	−8	2	−34	12	−10	−9	6	−27	−0	−7	−21	−5	−13	−24	−31	10	−31	−14	29
Can.	−3	−1	−7	1	4	4	−8	18	5	−1	3	14	−6	−49	−27	−12	−10	−23	1	7
Fra.	16	−9	4	−28	−0	1	11	47	−38	−31	−36	−35	−14	11	−9	−3	−2	−20	−6	5
Ger.	4	10	−2	26	−12	9	16	−21	21	−7	−6	−6	6	10	−15	14	1	20	2	−21
It.	11	−6	−8	−3	27	2	31	17	−4	−7	1	−2	−10	0	−1	−14	−6	−8	12	9
Jap.	−11	−23	11	−1	13	−3	34	9	−35	−35	−29	−29	−12	−3	−22	−10	−24	−4	8	−0
U.K.	−2	−8	9	−23	−6	13	−2	21	−38	−28	−25	−27	−33	10	1	−21	12	−0	4	7
LX																				
U.S.	5	15	−12	−16	−1	−18	11	14	−13	−15	26	0	6	11	11	3	31	2	33	19
Can.	11	−10	−6	6	−15	−31	5	35	−48	−47	−13	−54	7	19	20	13	11	9	10	−6
Fra.	12	−15	−18	−5	−38	−1	4	49	−54	−49	−23	−35	−22	10	42	−17	29	−11	3	13
Ger.	17	−7	−30	−14	−24	9	7	43	−21	−19	22	−6	19	−12	30	−16	23	−18	21	19
It.	11	9	38	9	−5	0	−6	−21	10	−5	−66	−5	−26	22	−21	37	−39	33	−53	−71
Jap.	−11	10	29	−6	3	13	−31	−27	25	49	−2	20	9	−34	−43	−10	−8	−13	−46	−8
U.K.	−21	−10	5	−7	−2	1	9	−15	−1	3	2	−15	1	−14	1	−1	20	−2	−14	−4

	RS U.S.	RS Can.	RS Fra.	RS Ger.	RS It.	RS Jap.	RS U.K.	LE Can.	LE Fra.	LE Ger.	LE It.	LE Jap.	LE U.K.	RL U.S.	RL Can.	RL Fra.	RL Ger.	RL It.	RL Jap.	RL U.K.
LP																				
U.S.	−48	−4	−31	12	1	−6	1	−10	2	−2	11	−1	−7	−34	−15	−25	−10	−27	−6	20
Can.	1	−20	−26	−12	−2	16	11	33	−23	−16	21	−11	1	−22	24	−40	20	−31	29	45
Fra.	8	−14	−7	3	−18	−5	10	19	1	−5	7	−6	16	−22	13	−3	−7	−4	−1	−14
Ger.	−7	−10	−6	−29	−11	−5	−13	20	−21	−21	2	−21	12	−11	10	−6	4	−8	−3	3
It.	−2	−20	−41	−10	−18	12	13	48	−36	−24	44	−15	16	−14	39	−51	48	−48	48	61
Jap.	−3	−19	−15	−24	1	−22	25	32	−36	−34	15	−19	5	12	31	−8	8	−4	45	23
U.K.	13	28	20	−11	−17	15	−53	4	11	19	14	1	36	−16	−13	2	3	17	−11	−24
LPIM																				
U.S.	19	−19	11	2	12	4	−1	22	−17	−14	−19	−19	7	−14	−8	−3	−21	−12	−14	4
Can.	5	10	−5	−13	−18	−15	−16	20	−21	0	10	−4	11	−31	−11	−27	5	−22	−1	31
Fra.	6	−18	−3	−8	8	27	8	21	10	14	7	13	−12	−35	−8	−26	−0	−26	1	18
Ger.	8	13	−5	−44	11	10	−5	5	7	18	7	13	−3	−10	−15	−4	3	−4	10	7
It.	2	−8	−6	0	28	13	19	8	−12	−8	−15	−5	−23	−25	−28	−9	−17	−11	−2	2
Jap.	30	4	14	8	20	17	4	11	9	8	−22	17	−17	−32	−31	−4	−32	−7	−14	−6
U.K.	7	−13	5	5	12	13	20	8	−3	3	−8	−3	−1	−31	−13	−10	−25	−15	−4	7
LPEX																				
U.S.	2	−11	15	14	26	6	2	2	28	30	3	32	1	−37	−12	−8	−29	−15	−22	−4
Can.	4	−6	8	−4	−5	−6	−13	2	3	14	9	3	18	−28	−11	−11	−21	−2	0	1
Fra.	16	2	18	−20	18	16	1	5	2	16	−32	17	−21	−23	−29	−9	−14	−15	−35	−1
Ger.	21	6	14	−17	26	21	10	12	−10	7	−21	−3	−16	−24	−34	−0	−25	−8	−14	2
It.	11	−24	16	−17	9	3	−9	8	−10	17	−11	−6	−21	−32	−19	−27	−18	−12	−26	5
Jap.	16	−5	23	−6	18	5	−2	23	−14	−14	−38	−5	−14	−33	−38	−5	−28	−18	−25	−7
U.K.	−18	−13	27	−12	15	6	−10	1	3	13	−22	1	−8	−17	−26	−5	−27	−10	−24	−16

TABLE 4-2C Correlation Matrix of the Errors

Consumption		U.S.			Can.			Fra.			Ger.	It.	Jap.			U.K.		
		D	*N*	*S*	*D*	*N*	*S*	*D*	*N*	*S*			*D*	*N*	*S*	*D*	*N*	*S*
U.S.	*N*	73																
	S	55	65															
Can.	*D*	51	40	32														
	N	17	15	16	46													
	S	11	18	24	33	8												
Fra.	*D*	20	33	28	24	7	−0											
	N	37	55	42	51	23	17	76										
	S	51	55	40	49	27	12	56	72									
Ger.		15	24	22	23	5	−11	24	33	12								
It.		12	12	−8	−0	−4	−7	16	−7	−6	17							
Jap.	*D*	19	34	12	12	−15	2	20	31	29	43	29						
	N	4	19	1	−5	−23	3	1	7	−4	27	6	37					
	S	−0	9	8	−9	−18	−14	−7	−2	−3	−5	−1	19	30				
U.K.	*D*	21	41	33	13	−2	12	33	29	28	43	33	28	1	12			
	N	36	45	30	22	2	−2	20	31	17	44	40	42	16	24	72		
	S	12	34	33	9	1	12	15	23	10	10	24	6	1	21	41	49	

Consumption

Investment		U.S. D	U.S. N	U.S. S	Can. D	Can. N	Can. S	Fra. D	Fra. N	Fra. S	Ger.	It.	Jap. D	Jap. N	Jap. S	U.K. D	U.K. N	U.K. S
U.S.	*NE*	72	64	44	49	24	−0	12	36	43	12	27	27	−15	−1	21	50	25
	NS	40	29	20	24	6	−11	3	9	21	17	39	20	−19	−4	16	30	20
	R	77	87	64	55	23	16	41	67	64	30	8	29	4	−11	38	46	33
	I	−1	1	−25	−3	−8	14	−5	7	−5	−3	22	8	8	−37	4	9	−9
Can.	*F*	17	6	2	59	20	25	−0	16	17	29	−2	11	−16	−10	−7	5	16
	I	−21	6	−10	−10	−10	−8	29	38	26	12	−0	29	−7	−5	21	6	−4
Fra.	*N*	17	14	6	12	−5	−1	34	15	20	7	38	14	−4	8	6	1	2
	R	−3	12	−0	38	26	7	58	54	46	19	14	16	−10	−9	24	26	27
	I	−13	−3	−19	−5	1	−16	29	7	−11	−1	28	−5	1	−3	2	14	−10
Ger.	*F*	17	21	12	33	7	10	48	34	35	23	37	34	−18	−14	48	41	37
	I	−4	20	−6	19	8	16	21	25	18	−0	20	17	44	8	−3	2	10
It.	*F*	34	39	14	38	11	4	44	35	45	15	48	14	−9	−18	25	30	14
	I	−8	17	19	30	17	24	49	46	33	21	−4	−4	−8	−13	24	2	9
Jap.	*N*	17	50	18	26	8	7	35	52	47	40	20	61	34	12	23	28	23
	R	10	32	6	−10	−21	2	9	18	3	22	8	34	12	6	12	13	8
	I	18	23	5	33	16	−8	30	38	20	33	15	23	−14	−24	3	18	22
U.K.	*N*	32	40	8	13	13	−4	15	26	23	−8	33	21	−11	8	30	41	18
	R	21	41	40	−3	−2	8	11	28	21	19	−0	23	6	12	26	25	29
	I	30	31	−1	12	3	−6	8	9	11	1	21	12	33	6	−13	10	−11

Consumption

Table 4-2D Correlation Matrix of the Errors

	U.S.			Can.			Fra.			Ger.	It.	Jap.			U.K.		
	D	*N*	*S*	*D*	*N*	*S*	*D*	*N*	*S*			*D*	*N*	*S*	*D*	*N*	*S*
LEX																	
U.S.	13	14	−9	27	13	9	2	10	−1	5	38	30	4	−5	−5	27	14
Can.	23	16	9	28	18	8	6	8	7	−5	19	−19	−8	−18	3	13	11
Fra.	37	43	36	16	27	15	12	12	26	−11	9	20	2	7	2	10	8
Ger.	14	4	−4	11	22	−13	30	24	20	15	10	9	−10	−37	3	13	−27
It.	21	2	9	−1	10	−11	−9	−5	−2	−10	0	20	3	−11	−36	−12	−17
Jap.	10	9	9	6	−5	22	1	10	10	−18	12	−21	−12	−25	14	4	11
U.K.	−1	−7	1	−15	−3	−8	−19	−24	−13	12	3	15	15	4	11	4	−15
LIM																	
U.S.	10	9	6	2	−16	17	−18	2	−5	−24	−9	−5	12	−4	−4	2	−3
Can.	11	11	−4	42	20	19	−9	10	10	9	16	12	−6	0	3	9	−5
Fra.	7	−8	−13	16	27	7	35	14	1	−10	30	−18	−8	−12	0	5	−7
Ger.	−0	−14	1	−13	21	−12	−6	−16	−15	26	11	5	32	−1	2	−7	3
It.	14	3	7	28	21	17	13	16	10	11	32	14	−7	−16	1	14	−3
Jap.	−3	5	−20	−1	12	−8	16	16	2	−14	25	2	−7	−10	−15	−8	4
U.K.	4	9	0	4	9	−0	16	15	18	−2	28	18	−1	3	29	24	−1
LX																	
U.S.	23	27	20	23	19	5	20	35	20	27	−4	12	22	−12	−0	18	14
Can.	5	17	−8	1	−11	−6	19	18	14	−7	1	−11	−17	−1	8	3	20
Fra.	3	6	−2	19	19	−2	53	47	44	6	4	−8	−2	−13	18	11	−3
Ger.	1	10	−0	19	6	−3	43	35	29	21	8	13	4	9	10	10	7
It.	−4	−26	−19	−30	−25	−5	−23	−51	−29	−30	25	−22	−8	2	5	−5	1
Jap.	−17	−34	−12	−17	−19	6	−33	−34	−24	−17	−23	−8	15	39	−25	−21	−24
U.K.	−17	−20	3	−30	−30	−19	−10	−11	−7	18	−4	4	22	13	9	−0	−14

Consumption

	U.S.			Can.			Fra.			Ger.	It.	Jap.			U.K.		
	D	*N*	*S*	*D*	*N*	*S*	*D*	*N*	*S*			*D*	*N*	*S*	*D*	*N*	*S*
LP																	
U.S.	5	−14	−22	19	2	−21	−9	15	9	14	−14	17	21	14	−22	−1	−36
Can.	−1	8	−1	39	27	−4	39	49	43	47	4	28	−8	−19	21	16	−2
Fra.	−24	−15	−16	−5	8	−17	20	5	0	22	9	10	22	22	5	9	−6
Ger.	−21	−12	−16	−3	−16	−4	9	12	−3	5	13	25	12	2	2	10	18
It.	8	36	16	39	31	16	50	68	57	30	−16	31	1	−10	16	14	3
Jap.	0	26	−2	14	19	13	35	45	19	20	22	21	−6	−31	9	10	17
U.K.	−31	−16	−21	−14	−25	7	−20	−23	−10	−14	−18	6	28	40	−12	−15	16
LPIM																	
U.S.	−5	−14	−13	12	24	−7	9	4	−3	−8	16	5	−49	−24	−10	4	3
Can.	6	6	−1	17	−3	10	5	20	9	−19	−21	3	4	−9	−42	−15	0
Fra.	5	4	0	25	19	8	13	20	16	24	19	30	−5	−24	2	15	−8
Ger.	−1	3	−5	18	1	−1	8	4	4	5	16	37	−10	−21	−5	5	−3
It.	0	0	−27	20	27	−9	11	10	14	−5	32	15	−22	−4	6	5	−17
Jap.	3	−16	−25	29	16	18	3	−4	−7	3	39	16	−29	−18	−2	12	−5
U.K.	−11	−13	−17	18	23	5	11	7	−3	−1	22	11	−45	−27	−6	−0	−4
LPEX																	
U.S.	−3	−3	−11	11	14	12	1	0	−4	5	19	15	7	12	7	31	−9
Can.	−18	−9	−4	16	−4	16	−3	4	−16	9	19	28	−12	1	11	24	12
Fra.	−8	−22	−8	4	4	6	3	−12	−6	−17	18	−8	−21	−7	−11	−7	−14
Ger.	−2	−12	−14	8	10	−0	7	−4	−8	−10	32	10	−35	−20	−3	5	−16
It.	−20	−15	−22	−2	7	−5	−7	−12	3	−16	13	5	−5	4	−9	−11	−20
Jap.	9	−27	−25	16	25	12	6	−2	8	−2	27	−0	−13	−11	−6	4	−11
U.K.	−14	−16	−37	3	8	21	−10	−10	−5	−22	19	7	−13	−4	−3	3	2

Consumption

Table 4-2E Correlation Matrix of the Errors

Investment		U.S. *NE*	U.S. *NS*	U.S. *R*	U.S. *I*	Can. *F*	Can. *I*	Fra. *N*	Fra. *R*	Fra. *I*	Ger. *F*	Ger. *I*	It. *F*	It. *I*	Jap. *N*	Jap. *R*	Jap. *I*	U.K. *N*	U.K. *R*	U.K. *I*
U.S.	*NS*	65																		
	R	72	45																	
	I	22	19	11																
Can.	*F*	24	35	24	−11															
	I	−0	20	13	31	−9														
Fra.	*N*	17	28	13	−18	6	−1													
	R	23	17	34	13	38	35	12												
	I	−1	−20	−7	1	−34	2	32	19											
Ger.	*F*	29	27	33	2	35	18	32	52	10										
	I	8	−1	10	28	9	22	11	32	10	7									
It.	*F*	44	43	44	5	27	16	43	48	30	46	45								
	I	−0	−18	23	−7	6	10	24	41	33	24	28	28							
Jap.	*N*	32	34	47	15	28	31	27	41	0	35	43	35	26						
	R	12	15	22	14	7	9	19	−8	−15	11	2	−1	−10	40					
	I	29	17	33	0	20	26	20	35	22	41	13	35	27	29	9				
U.K.	*N*	39	23	39	18	−7	1	5	11	10	23	5	15	3	14	18	−0			
	R	7	3	33	−18	−3	21	4	−3	−5	−2	5	12	4	13	31	1	14		
	I	32	4	20	8	−13	4	7	6	29	−14	21	20	−5	7	7	22	17	−0	

Table 4-2F Correlation Matrix of the Errors

	U.S.				Can.		Fra.			Ger.		It.		Jap.			U.K.		
	NE	*NS*	*R*	*I*	*F*	*I*	*N*	*R*	*I*	*F*	*I*	*F*	*I*	*N*	*R*	*I*	*N*	*R*	*I*
LEX																			
U.S.	42	48	25	29	27	20	23	32	25	32	23	36	−5	40	−5	41	10	−6	24
Can.	41	21	21	28	13	−31	22	17	3	15	26	26	13	−2	−5	2	31	−20	8
Fra.	30	16	38	−2	14	−17	−9	10	−20	14	3	7	−15	1	16	−8	41	23	9
Ger.	28	3	13	20	−14	−1	9	20	36	4	−4	19	12	−5	0	21	16	−12	16
It.	22	26	12	1	6	5	−9	−5	−9	−6	−19	−3	−48	2	−7	9	−15	−8	16
Jap.	28	24	20	41	−14	25	−1	16	3	3	29	25	14	−15	−9	4	11	7	9
U.K.	−12	10	−8	−13	−15	−11	17	−30	2	6	−30	−14	−17	−6	−1	−14	−0	−4	−7
LIM																			
U.S.	20	18	13	41	−24	23	−20	−14	−7	−4	20	−2	−3	−7	−8	7	9	−13	17
Can.	36	40	16	30	49	21	20	22	−20	22	41	27	1	22	−5	4	22	−7	1
Fra.	10	10	3	4	−13	3	42	33	65	26	10	31	22	−9	−19	26	13	−12	25
Ger.	−18	−4	−13	−4	−10	−30	10	−17	−15	−4	7	−17	−10	−4	8	−1	−17	2	−9
It.	27	21	15	4	17	2	25	18	25	19	11	28	38	16	−14	35	7	−5	16
Jap	22	33	8	43	5	34	2	31	7	9	38	37	−11	17	10	28	10	−2	20
U.K.	26	21	18	24	−27	21	2	33	27	26	−0	14	7	5	−10	1	36	−12	14
LX																			
U.S.	27	2	32	4	−3	−0	0	18	1	1	12	10	14	22	4	29	−1	−6	33
Can.	−4	2	14	0	7	27	0	29	17	25	1	25	10	3	1	20	8	16	−0
Fra.	5	−21	17	18	−15	21	−5	53	35	21	22	27	44	11	−21	17	9	−8	20
Ger.	3	−5	9	−14	12	28	27	35	22	35	14	24	38	28	−11	43	5	−12	30
It.	−19	−12	−33	−3	−21	−38	−11	−16	7	−7	−19	2	−34	−46	−22	−44	−4	−8	−9
Jap.	−30	−34	−45	−17	−21	−14	−16	−32	−3	−51	−0	−34	−30	−41	−29	−18	−38	−15	−3
U.K.	−16	−10	−25	5	−25	13	−13	−20	−17	−10	1	−19	−12	−4	3	−18	−13	−7	9

Investment

(Continued)

Table 4-2F *(Continued)*

	U.S.				Can.		Fra.			Ger.		It.		Jap.			U.K.		
	NE	*NS*	*R*	*I*	*F*	*I*	*N*	*R*	*I*	*F*	*I*	*F*	*I*	*N*	*R*	*I*	*N*	*R*	*I*
LP																			
U.S.	12	4	−4	18	16	6	−20	−0	−13	−13	24	−3	−9	17	9	−8	9	−23	11
Can.	9	16	25	11	28	44	2	47	−2	29	13	31	38	37	−5	50	−5	0	−1
Fra.	−13	−5	−13	−3	14	9	−6	36	27	10	17	10	13	19	−21	−16	−0	1	11
Ger.	5	−0	−5	13	1	7	13	20	5	23	6	−8	17	16	9	3	24	−5	15
It.	19	10	41	2	21	54	14	48	12	38	28	31	52	53	6	51	6	9	11
Jap.	23	14	35	45	10	38	11	41	23	26	19	21	37	50	26	34	22	17	21
U.K.	−30	−13	−25	−23	6	−4	7	−2	2	−0	13	−22	−2	13	4	−27	−14	10	−11
LPIM																			
U.S.	15	13	3	−7	25	3	17	21	23	29	−7	25	5	−14	−9	29	9	−0	−24
Can.	27	0	15	22	8	13	8	32	13	−2	33	13	12	10	−6	32	−9	−9	22
Fra.	21	18	11	12	21	17	16	16	10	10	27	32	13	12	−13	30	−2	3	−5
Ger.	16	20	6	3	17	14	17	13	4	17	5	13	−2	20	−6	13	9	−10	1
It.	11	23	3	10	15	34	15	18	−0	18	30	40	−0	10	−4	18	20	−16	−2
Jap.	16	21	−7	10	39	−6	20	18	1	23	5	26	−6	−11	−5	20	10	−26	−6
U.K.	8	16	−4	17	29	21	14	20	11	34	7	24	2	2	−13	33	14	−16	−23
LPEX																			
U.S.	14	2	−4	11	16	−2	−0	10	16	13	23	15	12	2	−15	−13	16	−19	5
Can.	14	6	−0	22	13	14	−1	22	16	15	8	7	18	8	−14	22	−10	3	−21
Fra.	7	8	−23	6	−4	−4	8	−7	5	−11	11	13	−4	−30	−24	−11	−13	−32	−6
Ger.	13	21	−5	11	4	26	23	9	22	17	4	29	−14	−10	−15	24	7	−14	1
It.	−7	4	−17	6	4	15	−5	13	5	−6	31	15	9	−3	−22	−5	19	−20	3
Jap.	16	19	−10	26	22	3	6	25	−1	17	16	25	−8	−17	−17	11	−8	−12	12
U.K.	−8	−5	−17	17	4	8	−6	7	14	11	5	9	−9	−13	−29	5	6	−13	−2

Investment

Table 4-2G Correlation Matrix of the Errors

	LEX							LIM							LX						
	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.
LEX																					
Can.	1																				
Fra.	−5	20																			
Ger.	−4	28	21																		
It.	34	−10	18	9																	
Jap.	10	25	3	25	−15																
U.K.	0	−9	6	3	−3	−19															
LIM																					
U.S.	20	15	−4	−8	11	51	18														
Can.	35	54	15	1	6	19	−11	14													
Fra.	30	21	5	42	−1	31	7	11	3												
Ger.	−14	20	9	8	6	−5	28	−9	−6	3											
It.	39	−13	17	30	17	−29	4	20	28	−0											
Jap.	48	14	12	5	26	36	−31	18	29	24	−0	16									
U.K.	20	7	17	31	−0	43	30	36	−5	34	−0	7	13								
LX																					
U.S.	20	20	−6	18	8	17	−16	13	−0	15	15	11	7	−3							
Can.	13	−22	−13	−19	8	17	−37	7	−7	24	−23	12	26	−14	6						
Fra.	−2	24	−7	26	−16	12	−21	2	−4	25	3	10	8	32	24	18					
Ger.	1	−3	−8	5	−28	−15	−8	−20	8	26	−17	7	3	−2	6	14	29				
It.	−19	14	6	−15	7	−5	4	−8	−19	1	14	−23	−0	2	−28	12	7	−34			
Jap.	−19	−19	−7	−1	12	−2	−1	8	−12	−5	6	−13	−16	−10	−7	−15	−19	−25	18		
U.K.	−26	−5	−27	−1	−4	14	11	27	−2	−23	19	−6	−13	12	13	−8	11	2	−4	9	

(Continued)

TABLE 4-2G *(Continued)*

	LEX							LIM							LX						
	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.
LP																					
U.S.	4	−1	−17	2	10	−8	−14	23	26	−17	−8	9	12	−0	3	1	4	−6	−17	5	33
Can.	21	−22	−12	21	−11	−1	2	−7	11	1	−18	24	15	16	4	−6	22	37	−54	−20	−2
Fra.	15	−8	−3	−2	6	−24	−10	−25	13	8	−4	8	12	14	−26	15	24	25	0	−9	14
Ger.	20	24	−10	6	−13	7	8	18	12	8	1	−1	2	29	26	−8	13	15	−7	−29	21
It.	16	−9	5	15	−17	1	3	11	16	17	−24	11	6	16	21	4	31	59	−69	−32	−6
Jap.	47	−6	−6	7	−7	10	−24	−1	4	18	−25	23	36	16	23	18	20	23	−42	−56	−23
U.K.	−2	−12	−1	−35	−23	−9	16	−10	0	−3	9	−32	−21	−2	−6	−0	−4	1	9	14	−8
LPIM																					
U.S.	32	7	16	32	14	10	4	−7	13	32	−12	18	16	7	−0	7	−12	−18	−5	6	−47
Can.	30	18	3	17	13	34	−14	32	13	18	−14	4	20	17	28	5	13	8	−24	17	−22
Fra.	19	11	13	49	3	8	10	−8	31	7	−1	24	−1	5	−1	−39	1	1	−28	14	−21
Ger.	26	−4	4	11	5	−5	−2	−14	11	5	−30	7	−4	4	13	−26	−19	9	−14	−9	−27
It.	18	−5	8	9	−11	14	−2	−4	30	14	−17	14	28	18	−6	−10	−1	13	−20	−6	−20
Jap.	22	22	12	29	6	5	−5	−19	33	18	−3	30	7	7	−2	−24	−9	−4	1	16	−40
U.K.	38	4	6	12	12	−5	−1	−7	37	13	−27	25	26	−5	−15	−2	−15	−1	−18	−1	−34
LPEX																					
U.S.	22	7	2	1	−6	−7	10	9	28	6	−18	24	−4	7	0	−23	−4	−3	−10	9	−4
Can.	50	−12	−14	1	−4	14	−11	1	8	1	−15	23	10	19	−0	−8	−7	−12	−13	17	−33
Fra.	−18	20	3	32	−4	21	−2	−0	8	11	−6	8	−5	16	−12	−51	−2	−4	7	36	−5
Ger.	37	−5	−2	25	18	24	4	−4	22	32	−27	27	28	16	−5	−4	−12	3	−10	12	−28
It.	2	−5	15	18	−21	37	8	5	15	12	−9	9	16	29	−2	−12	−1	6	−15	17	3
Jap.	24	20	12	27	8	23	−5	−0	25	37	17	26	30	19	4	−10	18	−1	9	20	−11
U.K.	31	−6	6	−5	6	−7	−1	11	15	16	−28	8	12	2	−10	2	−4	−15	17	26	−33

TABLE 4-2H Correlation Matrix of the Errors

	LP							LPIM							LPEX					
	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.	U.K.	U.S.	Can.	Fra.	Ger.	It.	Jap.
LP																				
U.S.																				
Can.	19																			
Fra.	21	13																		
Ger.	6	2	11																	
It.	9	62	14	8																
Jap.	−8	39	17	36	43															
U.K.	−16	−27	7	21	−8	−14														
LPIM																				
U.S.	−12	18	−18	8	5	11	−10													
Can.	5	2	−16	−13	21	16	13	22												
Fra.	4	48	−14	−15	29	2	−16	50	23											
Ger.	−8	27	−24	26	12	27	14	38	16	42										
It.	15	44	−17	−15	26	11	−14	41	−4	49	43									
Jap.	−6	23	−24	−6	−4	−2	−15	61	15	66	47	61								
U.K.	3	41	−9	−12	19	21	−29	70	11	61	41	56	66							
LPEX																				
U.S.	33	16	18	−5	16	−4	−13	27	7	35	8	30	39	41						
Can.	−13	23	2	10	2	28	0	44	35	37	32	15	42	39	26					
Fra.	−4	10	−23	−9	−6	−25	−11	32	9	56	40	49	64	32	31	16				
Ger.	−15	28	−23	−10	0	12	−16	61	16	50	55	67	66	68	19	35	50			
It.	−0	22	−7	−2	8	−6	14	27	17	35	33	59	39	29	27	16	41	50		
Jap.	5	23	5	3	−1	7	−13	37	13	40	6	39	58	33	25	19	44	38	25	
U.K.	3	17	−3	−6	3	6	2	46	−2	42	28	38	47	62	39	29	25	34	12	39

term structure. Because the estimated structural residuals turned out to be highly serially correlated, I assumed that they behave according to a first-order autoregressive process.[2]

Consider now the correlation between the shocks to the equations of the financial sector. A higher correlation is found among risk-premia shocks (for both exchange rates and long-term interest rates) in different countries than among shocks to money demand (short-term interest-rate shocks).[3] The highest correlation coefficient between short-term interest-rate shocks is only .3, and seventeen of twenty-one are less than .2 in absolute value. Although changes in regulations that affect money demand might be expected to be uncorrelated, it is surprising that technological changes affecting money demand worldwide do not create more correlation across countries.[4]

In comparison, shocks to the exchange-rate equations in the different countries are highly correlated. The correlation is positive between all pairs of exchange rates, except between the Canadian dollar and the other currencies. Recall that all the interest-rate parity equations are written relative to the U.S. dollar. Hence, with the exception of the Canadian dollar, there is a positive relationship between risk premia against the dollar. To the extent that this simply represents factors relating to the United States, this is not surprising—political developments in the United States or changes in the perception of the United States as a safe haven would explain these correlations quite well. The negative correlations with the U.S. dollar/Canadian dollar exchange rate raises the possibility that some of these same factors may have been applying to Canada and the United States at the same time.

Another set of high correlations is between term-premium shocks in the different countries, and more than twice as many correlations are positive as are negative. Perhaps this reflects worldwide shifts in uncertainty about future inflation that would tilt the yield curve simultaneously in different countries. However, note the two large negative correlations between term-premia shocks in the United Kingdom and France and between the United Kingdom and Italy. Examining the time series of these shocks indicates that the correlations are due to low-frequency movements with term premia being generally negative in France and Italy in the 1970s and generally positive in the United Kingdom in the same period with a reversal taking

[2]The autoregressive coefficient is not estimated separately for each equation. The coefficient is simply calibrated to .5 for all countries; this appeared to be a rough average. Although admittedly not as good as an econometric estimate for each country, the assumed .5 value is certainly better than 0. As the standard deviation reported in Table 4-1 refers to the serially uncorrelated shock to this autoregressive process, the standard deviation of the correlated risk-premium shock is slightly larger ($(1 - .5^2)^{-1} = 1.33$ times the standard deviation reported in Table 4-1).

[3]As we show below there is also a relatively high correlation among price shocks in the different countries and a relatively low correlation among goods-market shocks in different countries.

[4]Note, however, that some of the money-demand equations contain dummy shifts that may account for technological change.

place in the late 1970s and 1980s. A reduction in future inflation uncertainty in the United Kingdom in the late 1970s may have accompanied the change in governments, and perhaps similar factors were occurring in reverse in France and Italy. The term premium in the United States turned negative in the late 1970s and early 1980s, but this reversed in late 1982 and may have been due to business-cycle developments. In any case there is almost no correlation between the term premium in the United States and in the United Kingdom.

Goods-Market Shocks

Several important features of the variance-covariance matrix relate to the goods markets. Consider first the size of the shocks as measured by the standard deviations (see Table 4-1). The shocks to the more volatile components of spending are relatively large: shocks to durable-goods consumption are larger than shocks to nondurable consumption, which are in turn larger than shocks to services consumption (in percentage terms); shocks to inventory investment are larger than shocks to residential investment, which in turn are larger than shocks to business fixed investment. Shocks to exports and imports are of a magnitude between that of durables and nondurables consumption and of about the same size as that of business fixed investment.

Usually, the larger volatility of durable consumer goods compared to service and nondurables is attributed to their larger interest-rate sensitivity, but according to these results there are other factors at work, as the model explicitly accounts for the interest rate. For example, shifts in consumer confidence might affect big-ticket consumer durables items more than nondurables or services.

The size of the spending shocks in the different countries are surprisingly similar. The standard deviation of export shocks and import shocks hovers close to 3 percent in most countries. The standard deviation of consumer-services shocks rounds to exactly 1 percent in all countries for which we have measures of such shocks. In general, the difference between the size of the shocks to different categories of spending in a given country is larger than the difference between the size of spending shocks for a given category of spending in different countries.

Next, consider the correlation between spending shocks. Typically the correlation between components of spending in a given country is larger than the correlation found between components of spending in different countries. This is not surprising, and it offers us some measure of reassurance to see that the computational approach is generally on the right track. The correlation between the shocks to demand in different countries is by no means negligible, however, and cannot be ignored. Moreover, the vast majority of investment, consumption, export, and import shocks tend to be positively correlated between countries. Hence, there is little tendency for "*IS* curve" shocks to cancel out across countries.

Price Shocks

The data in Table 4-1 show that the shocks to wages tend to be larger than the shocks to aggregate prices (which are markup shocks). In fact, the size of the shocks to markups are surprisingly small in all countries. Note, however, that the aggregate-price shocks follow a first-order autoregressive process and that we are looking at the standard deviation of the shocks to the autoregressive process. Hence, the variability of the measured markup will show larger variation. Shocks to export prices and import prices are generally larger than the markup shocks; these are likely to be influenced by oil and other commodity price shocks.

The correlations between the export price and import price shocks are all positive (with one minor exception) and are frequently large. These positive correlations are most likely due to oil prices as suggested by Figure 4-1. The omission of oil-price equations is probably appropriate given that the stochastic simulations of the model are designed to capture oil shocks that are unpredictable. A regression equation for oil prices might include as explanatory functions items, such as war in the Middle East, that are similarly unpredictable.

On the other hand, there is very little correlation between wage shocks in the different countries, and correlation coefficients are almost as likely to be negative as positive. To the extent that price shocks originate in wages, they are unlikely to be a source of business-cycle correlation across countries. Also, little correlation appears in markup shocks across countries. I find it surprising that the correlation between wage shocks and both markup shocks and import-price shocks is frequently negative. Note the very large negative correlations between wage shocks and markup shocks in both Japan and Italy.

Correlation between Shocks in Different Groups

The most notable general correlations between shocks in the different groups appear to be between the financial-sector shocks and the price shocks. For example, the correlation matrix shows significant correlation coefficients between exchange-rate shocks and both price and wage shocks. One particular example is the large negative correlation ($-.54$) between shocks to the French exchange rate and the shock to French wages. Also relatively systematic negative correlations between term-structure premium shocks and almost all of the price shocks are evident. Finally, we find a relatively large negative correlation between all three financial-sector shocks and the three types of consumption in France.

4.4 Conclusion

This chapter focused on the structural residuals to the equations of the multicountry model and looked, in particular, at the variance-covariance matrix of the shocks. The variance-covariance matrix shows considerable differences in the size of shocks in the different sectors and different countries. Importantly, it also shows a high degree of correlation between shocks in different countries, especially financial shocks and price shocks. The variance-covariance matrix is far from being a diagonal matrix and even farther from being a scalar matrix. This suggests that theoretical shortcuts that assume that shocks are independent either across countries or across sectors are unlikely to yield satisfactory answers. An empirical policy analysis using the estimated variance-covariance matrix provided here appears necessary. This is the objective of Chapter 6. However, it is necessary to first look at the impact of changes in the instruments of fiscal and monetary policy in Chapter 5.

Reference Notes

That the average of the sum of squared estimated residuals and their cross-products gives consistent estimates of the covariance matrix of the shocks follows directly from the consistency proofs in Anderson (1971, Chapter 8). This requires that the estimators of the parameters of each equation of the multicountry model be consistent so that the estimates of the residuals are consistent. The consistency of the parameter estimates follows from Hansen (1982).

I am not aware of other research that has presented estimates of the covariance matrix for a multicountry model with rational expectations. Fair (1984) emphasizes the use of stochastic simulation for forecasting with nonlinear models and for model evaluation. Fair and Taylor (1983) describe how to compute the residuals by replacing the conditional expectations in each equation using the extended path method, although the aim there was primarily maximum-likelihood estimation, a task which has not yet been attempted in this large model.

The singularity of the covariance matrix prevents the use of the Cholesky decomposition algorithm (see Faddeeva, 1959, pp. 81–84) used by some random-number generators, but, as described in Appendix 2, it is still possible to draw random numbers from a singular normal distribution.