Economics Bulletin

Volume 30, Issue 1

Investigating time series properties of a dynamic system for Japan's import demand

Takamitsu Kurita
Faculty of Economics, Fukuoka University

Abstract

This note aims to investigate time series properties of a dynamic system for Japan's aggregate import demand. A multivariate cointegration analysis of Japanese data reveals a stable economic linkage interpretable as a long-run import demand function. A vector equilibrium correction system is then estimated, which exhibits short-run and long-run interdependent relationships between aggregate import demand and the ratio of import price to domestic price level.

I would like to thank the editor and anonymous referee for helpful comments.
Citation: Takamitsu Kurita, (2010) "Investigating time series properties of a dynamic system for Japan's import demand", *Economics Bulletin*, Vol. 30 no.1 pp. 450-460.
Submitted: Dec 08 2009. **Published:** February 03, 2010.

1 Introduction

The objective of this note is to investigate time series properties of a small dynamic system for Japan's aggregate import demand. Japan's recent time series data are thoroughly analysed using cointegrated vector autoregressive (VAR) methodology. Quantitative findings revealed in this note will be informative for the development of Japan's trade and exchange rate policy in the future. The introductory section briefly reviews the related literature and then describes the significant aspects of the present note.

Macroeconomic time series data often exhibit non-stationary behaviour, thus they need to be seen as processes integrated of order 1 (denoted as $I(1)$ henceforth) rather than stationary processes. An $I(1)$ cointegrated VAR system is developed by Johansen (1988, 1996) in order to investigate various time series properties of non-stationary data. An econometric analysis using the cointegrated VAR system enables us to explore long-run economic relationships embedded in the data. See Juselius (2006) and Kurita (2007), *inter alia*, for empirical research using the cointegrated VAR methodology. In addition to non-stationarity and cointegration, the concept of weak exogeneity, which is introduced by Engle, Hendry and Richard (1983), has also played an important role in time series analysis. Weak exogeneity allows us to model a partial or conditional system alone, instead of a full system, in order to make statistical inference on parameters of interest with no loss of information. See Johansen (1996, Ch.8) for weak exogeneity in the cointegrated VAR system.

Empirical studies of Japan's import demand have been of interest in applied macroeconomics; see Hamori and Matsubayashi (2001), Tang (2003, 2006) and references therein. The existing studies convey useful information on various aspects of aggregate import demand in Japan. Since accumulated research evidence is of much use for economists and policy makers, this note aims to provide additional updated information on Japan's import demand based on the analysis of recent quarterly time series data. There are several important issues to be addressed. For instance, for the purpose of general-to-specific econometric modelling (see Campos, Ericsson and Hendry, 2005), it is necessary to inspect whether there is any weakly exogenous variable in the system for import demand. It is also important, from the viewpoint of trade and exchange rate policy, to investigate short-run and long-run interdependent relationships between import demand and the ratio of import price to domestic price level. This note, studying recent quarterly time series data from Japan, addresses these issues. Time series properties revealed in this note will amount to quantitative information useful for Japan's economic policy in the future.

The organization of this note is as follows. Section 2 reviews a cointegrated VAR model and weak exogeneity. Section 3 performs a cointegrated VAR analysis of Japan's data, then arriving at a parsimonious dynamic system. Section 4 provides concluding remarks. All the empirical analysis and graphics in this note use *CATS in RATS* (Dennis, Hansen, Johansen and Juselius, 2005) and *PcGive* (Doornik and Hendry, 2007a,b).

2 Review of Cointegrated VAR Analysis

In this section, we review a likelihood-based analysis of a cointegrated VAR model based on Johansen (1988, 1996). A brief review is also made of a conditional cointegrated VAR model and weak exogeneity. Let us introduce a p-dimensional $I(1)$ cointegrated VAR(k)

model for X_t as follows:

$$\Delta X_t = \alpha (\beta', \gamma) \begin{pmatrix} X_{t-1} \\ t \end{pmatrix} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t, \quad \text{for} \quad t = 1, ..., T, \tag{1}$$

where a sequence of innovations ε_t has independent and identical normal $N(0, \Omega)$ distributions conditional on $X_{-k+1}, ..., X_0$, and $\alpha, \beta \in \mathbf{R}^{p \times r}$ for $r < p$, $\gamma \in \mathbf{R}^{r \times 1}$, $\mu \in \mathbf{R}^{p \times 1}$ and $\Gamma_i \in \mathbf{R}^{p \times p}$. Let $\beta^{*\prime} = (\beta', \gamma')$ and $X^*_{t-1} = \left(X'_{t-1}, t\right)'$ for future reference. Johansen (1996) demonstrates details of likelihood-based inference for these parameters. In equation (1) α is referred to as adjustment vectors, while β^* is called cointegrating vectors. The index r is called cointegrating rank. Since this note is interested in modelling aggregate import demand in Japan, the following variables are chosen for X_t:

$$X_t = (im_t, rp_t, y_t), \tag{2}$$

where im_t and y_t denote the logs of Japan's real import and GDP, respectively. The variable rp_t denotes the log of relative prices defined as $rp_t = p^{im}_t - p^y_t$, where p^{im}_t is the log of Japan's import demand deflator while p^y_t is the log of Japan's domestic price level, represented by GDP deflator in Japan. The variable y_t is expected to play the role of income effect on import demand, whereas it is anticipated that rp_t will capture relative price effect, or substitution effect, on aggregate import. The choice of such variables as in (2) appears to be standard in the literature on aggregate import demand; see Tang (2003), *inter alia*. In the model above, deterministic trend t is expected to be an approximation to a set of unspecified factors influencing the long-run behaviour of im_t, such as wealth effects on aggregate import demand.

The cointegrating rank is, however, usually unknown to investigators; the rank needs to be estimated from the data. Whether the cointegrating rank is zero or unity ($r = 0$ or $r = 1$), or greater than unity ($r = 2$ or $r = p = 3$), is a very important empirical question to be answered. A log-likelihood ratio ($\log LR$) test statistic for the choice of r can be constructed from the VAR model, and its asymptotic quantiles are provided by Johansen (1996, Ch.15). A small-sample correction for the $\log LR$ test statistic is also investigated by Johansen (2002). Determining the cointegrating rank in (1) allows us to test various restrictions on α and β^*. Cointegrating relationships, embodied by $\beta^{*\prime} X^*_{t-1}$, are interpreted as a set of long-run economic combinations, acting as equilibrium correction mechanisms in (1). It is therefore important to check if estimates for β^* can be subject to economic interpretations.

Suppose that there is a single cointegrating relation or $r = 1$ in the VAR system; a cointegrating relation for (2), interpretable as the long-run import demand function, would be

$$\beta^{*\prime} X^*_{t-1} = im_{t-1} - \delta y_{t-1} + \zeta rp_{t-1} - \theta t, \tag{3}$$

where δ, ζ and θ denote positive long-run coefficients. The expression (3) corresponds to a long-run relationship between aggregate import demand and the other variables, consistent with income and substitution effects as discussed above; solving (3) for import demand, one finds that import demand tends to positively synchronise with aggregate income and to negatively synchronise with relative prices. It is also necessary to check if $\delta = 1$ or not, in order to ascertain the validity of a hypothesis of unit income elasticity.

Whether such a relationship as (3) with $\delta = 1$ can be estimated from the data is also a critical empirical question in the cointegrated VAR analysis.

When considering a plausible interdependent relationship between import demand and its price, it seems natural to treat both im_t and rp_t as endogenous variables in the system above. In contrast, y_t is expected to play the role of an explanatory variable, *i.e.* representing an income effect on im_t. In other words, it is implicitly anticipated that y_t is an exogenous variable in the system for X_t. The concept of exogeneity may vary according to contexts, but exogeneity in the cointegrated VAR system can be clearly defined by restricting our attention to parameters of interest, as demonstrated by Engle *et al.* (1983) and Johansen (1996, Ch.8). For this purpose, let the process be decomposed as $X_t = (W_t', y_t)'$ for $W_t = (im_t, rp_t)'$. The set of parameters and the error terms are also expressed as

$$\alpha = \begin{pmatrix} \alpha_w \\ \alpha_y \end{pmatrix}, \Gamma_i = \begin{pmatrix} \Gamma_{w,i} \\ \Gamma_{y,i} \end{pmatrix}, \mu = \begin{pmatrix} \mu_w \\ \mu_y \end{pmatrix}, \varepsilon_t = \begin{pmatrix} \varepsilon_{w,t} \\ \varepsilon_{y,t} \end{pmatrix},\ \Omega = \begin{pmatrix} \Omega_{ww} & \Omega_{wy} \\ \Omega_{yw} & \Omega_{yy} \end{pmatrix}.$$

Equation (1) can then be decomposed into a model for W_t conditional on y_t and a marginal model for y_t. As shown by Johansen (1996, Ch.8), if the condition $\alpha_y = 0$ is fulfilled, these models are then given by

$$\Delta W_t = \omega \Delta y_t + \alpha_w \beta^{*\prime} X^*_{t-1} + \sum_{i=1}^{k-1} \widetilde{\Gamma}_{w,i} \Delta X_{t-i} + \widetilde{\mu}_w + \widetilde{\varepsilon}_{w,t}, \tag{4}$$

$$\Delta y_t = \sum_{i=1}^{k-1} \Gamma_{y,i} \Delta X_{t-i} + \mu_y + \varepsilon_{y,t}, \tag{5}$$

where

$$\omega = \Omega_{wy}\Omega_{yy}^{-1},\ \widetilde{\Gamma}_{w,i} = \Gamma_{w,i} - \omega\Gamma_{y,i},\ \widetilde{\mu}_w = \mu_w - \omega\mu_y,\ \widetilde{\varepsilon}_{w,t} = \varepsilon_{w,t} - \omega\varepsilon_{y,t},$$

and $\widetilde{\varepsilon}_{w,t}$ is a mean-zero conditional error process independent of $\varepsilon_{y,t}$ and its variance is given by $\Omega_{ww} - \Omega_{wy}\Omega_{yy}^{-1}\Omega_{yw}$. In the case where $\alpha_y = 0$ holds such that the marginal model for y_t does not contain any equilibrium correction mechanisms as in (5), the variable y_t is said to be weakly exogenous for all the parameters appearing in (4). Under the weak exogeneity condition or $\alpha_y = 0$, the parameters in (4) can be estimated solely from (4) with no loss of information, hence enabling us to disregard (5) and reducing the modelling efforts required. Thus, whether $\alpha_y = 0$ or not is also an important empirical question to be answered. All of these issues introduced in this section are addressed in the rest of this note.

3 Econometric Analysis of Japan's Aggregate Data

This section conducts a rigorous cointegrated VAR analysis of Japan's quarterly time series data. The sample period for estimation runs from the second quarter in 1993 to the second quarter of 2008. The starting point of this period is chosen based on the fact that Japan's bubble economy collapsed in the early 1990s, leading to long-lasting stagnation (see Yoshikawa, 2002, *inter alia*). Thus the early 1990s is considered to be a break point in Japan's macroeconomic data. See the Appendix for an overview of the data and their details.

This section consists of three sub-sections. Section 3.1 addresses the issue of choosing the cointegrating rank, and Section 3.2 then reveals an theory-consistent cointegrating relation. Finally, Section 3.3 achieves a parsimonious dynamic system for Japan's aggregate import demand.

3.1 Choosing the Cointegrating Rank

This sub-section, after checking the validity of an unrestricted VAR model fitted to the data, determines the cointegrating rank. The unrestricted VAR model is a statistical representation, so that the estimated coefficients are not necessarily subject to economic interpretations. Identifying cointegrating relations and conducting the model reduction, one can pursue such interpretations. The unrestricted VAR model provides a basis for a likelihood-based analysis of cointegration. Hence its residual need to satisfy the condition of normality and temporal independence, as in line with ε_t in (1). The lag-length of the VAR model is set to be three, or VAR(3), based on F-tests for the model reduction.

	im_t	rp_t	y_t
Autocorr.[F_{ar}(4,46)]	0.56[0.69]	1.15[0.34]	1.35[0.27]
ARCH [F_{arch}(4,42)]	0.09[0.99]	0.42[0.80]	0.87[0.49]
Hetero.[F_{het}(20,29)]	0.59[0.89]	0.91[0.58]	0.44[0.97]
Normality [$\chi^2_{nd}(2)$]	1.42[0.49]	1.19[0.55]	0.50[0.77]

Note. The figures in the square brackets are p-values.

Table 1: Diagnostic Tests for the Unrestricted VAR Model

Table 1 provides a battery of residual diagnostic tests for the unrestricted VAR model. Most of the test results are given in the form $F_j(k, T-l)$, which denotes an approximate F-test against the alternative hypothesis j: kth-order serial correlation (F_{ar}: see Godfrey, 1978, Nielsen, 2006), kth-order ARCH (F_{arch}: see Engle, 1982), heteroscedasticity (F_{het}: see White, 1980). A chi-square test for normality (χ^2_{nd}: see Doornik and Hansen, 1994) is also provided. The diagnostic test statistics are all insignificant at the 5% level, indicating that the residuals fulfill the condition of independent Gaussian distribution and thus the VAR model is a satisfactory representation of the data. The VAR model can therefore be subject to a subsequent likelihood-based analysis for cointegration.

It is also necessary, in addition to the diagnostic tests above, to check if each variable in the VAR system is seen as an $I(1)$ variable for the purpose of conducting an interpretable cointegration analysis. Table 2 presents a battery of augmented Dickey-Fuller (ADF) tests for a unit root in each variable in the VAR model. Two sorts of ADF tests are examined, that is, a test with constant (denoted as *ADF* in the table) and a test with constant and linear trend (denoted as *ADF-Trend* in the table). The lag order of autoregressive terms in each test is determined by the Akaike information criteria (AIC). Each variable is subject to these unit root tests in level and in difference; the former test results are provided in the first panel of Table 2, while those in the latter cases are given in the second panel of the table. According to Table 2, the null hypothesis of a unit root is not rejected in level, whereas the same null hypothesis is rejected with respect to each variable

	im_t	rp_t	y_t
ADF	$-1.68(2)$	$2.00\,(0)$	$0.41\,(0)$
ADF-Trend	$-3.09\,(2)$	$-0.70\,(0)$	$-1.65\,(0)$

	Δim_t	Δrp_t	Δy_t
ADF	$-3.48\,(1)^{*}$	$-6.31\,(0)^{**}$	$-6.88\,(0)^{**}$
ADF-Trend	$-3.55\,(1)^{*}$	$-7.18\,(0)^{**}$	$-6.92\,(0)^{**}$

Note. The figures in the parentheses are lag orders selected by the AIC.
* and ** indicate significance at the 5% and 1% levels, respectively.

Table 2: Unit Root Tests for Each Variable in the VAR System

in difference. These results suggest that each variable in the VAR model is considered as an $I(1)$ series, therefore fitted for a cointegrated VAR analysis in pursuit of long-run economic relationships.

We are now in a position to determine the underlying cointegrating rank. Table 3 displays $\log LR$ test statistics for cointegrating rank, in addition to the modulus of the six largest roots of a companion matrix for the model.

	$r = 0$	$r \leq 1$	$r \leq 2$
$-2\log Q\,(\mathsf{H}\,(r)\,\vert\mathsf{H}\,(p))$	54.03[0.00]**	20.02[0.22]	4.73[0.64]
$-2\log Q^{BC}\,(\mathsf{H}\,(r)\,\vert\mathsf{H}\,(p))$	48.28[0.01]*	14.85[0.59]	3.75[0.78]

mod (unrestricted)	0.96	0.81	0.81	0.53	0.53	0.46
mod ($r = 1$)	1.00	1.00	0.84	0.70	0.59	0.59

Note. The figures in the square brackets are p-values.

Table 3: Determination of the Cointegration Rank

Standard $\log LR$ test statistics for the cointegrating rank, according to Johansen (1996, Ch.6), are denoted as $-2\log Q\,(\mathsf{H}\,(r)\,|\mathsf{H}\,(p))$ and presented in the first panel of the table. Based on Johansen (2002), Bartlett-corrected $\log LR$ test statistics, *i.e.* $\log LR$ test statistics adjusted for the small sample size, are also given in the same panel, denoted as $-2\log Q^{BC}\,(\mathsf{H}\,(r)\,|\mathsf{H}\,(p))$. Both of the $\log LR$ tests reject the null hypothesis of $r = 0$ but do not reject the remaining hypotheses at the 5% level, thus supporting $r = 1$. The second panel presents two types of modulus (denoted *mod*) of the six largest eigenvalues of the companion matrix, unrestricted and restricted with $r = 1$. These are the reciprocal values of the roots of a characteristic polynomial based on the VAR model (see Johansen, 1996, Ch.4). No eigenvalue over 1.0 implies that the model does not include any explosive root, while, in the restricted case, all the eigenvalues apart from the first two values seem to be distinct from a unit root. These results are all in support of the validity of $I(1)$ cointegration analysis with $r = 1$. Thus $r = 1$ is chosen, which is consistent with the argument above based on equation (3). The $I(1)$ cointegration analysis with the restriction of $r = 1$ is continued in the rest of this note.

3.2 Identifying the Long-Run Relationship

This sub-section pursues a long-run economic relationship subject to economic interpretations. Determining the cointegrating rank, or $r = 1$, allows us to test restrictions on α and β^*. According to (3), the cointegrating vector is normalised for im_t and a homogeneity restriction is imposed on the coefficient for y_t, *i.e.* $\delta = 1$ in (3), corresponding to unit income elasticity. Furthermore, a zero restriction is jointly imposed on the adjustment coefficient for y_t, in order to check if y_t is judged to be weakly exogenous for a set of parameters of interest. If judged to be so, it could justify modelling im_t and rp_t conditional on y_t, hence reducing the modelling efforts required, as demonstrated in Section 2. The restricted estimates for α and β^* are reported, together with the corresponding $\log LR$ test statistic, in Table 4. According to the table, the joint null hypotheses are not rejected at the 5% level.

	im_t	rp_t	y_t	t	$\log LR$
$\widehat{\alpha}'$	-0.11 (0.04)	0.27 (0.05)	0 $(-)$		$2.49[0.29]$
$\widehat{\beta}^{*\prime}$	1 $(-)$	0.35 (0.12)	-1 $(-)$	-0.0055 (0.0008)	

Note. The figure in the square bracket is a p-value according to $\chi^2(2)$, while the figures in the parentheses are standard errors.

Table 4: Restricted Estimates of the Adjustment and Cointegrating Vectors

Hence, one finds that the interpretable long-run relationship, or the equilibrium correction mechanism in the VAR system, is given by

$$ecm_{t-1} = im_{t-1} - y_{t-1} + 0.35rp_{t-1} - 0.0055t. \tag{6}$$

This is in accord with (3), thus it is possible to consider (6) as an empirical expression of the underlying long-run aggregate import demand function in Japan. In addition, according to Table 4, y_t is judged to be weakly exogenous for the parameters of interest, thereby allowing us to model im_t and rp_t given y_t. The restricted cointegrating relationship, (6), acts as the equilibrium correction mechanism in the parsimonious model pursued in the next sub-section.

3.3 A Reduced Vector Equilibrium Correction System

Finally, this sub-section achieves a parsimonious dynamic system for Japan's aggregate import and price ratio, conditional on aggregate income, a weakly exogenous variable in the system. First, all the data are mapped to $I(0)$ series by differencing and using the restricted cointegrating relationship. A bivariate equilibrium correction system for Δim_t and Δrp_t is estimated conditional on Δy_t. Insignificant regressors are deleted from the system step by step, leading to a reduced dynamic system for Δim_t and Δrp_t, as given in (7) below.

According to (7), none of the diagnostic tests is significant at the 5% level, indicating that the reduced system is a satisfactory representation of the data. The statistic $\widehat{\sigma}$ denotes the standard error of the regression. Figure 1(a)(c) display the actual and fitted values, and Figure 1(b)(d) present the scaled residuals of the system. The graphs indicate no clear evidence for model mis-specification. The test results reported in (7), together with the graphic analysis, allow us to reach the conclusion that the parsimonious model is a data-congruent representation.

$$
\begin{aligned}
\widehat{\Delta im_t} \;=\; & -\underset{(0.02)}{0.11}\; ecm_{t-1} + \underset{(0.28)}{1.09}\; \Delta y_t + \underset{(0.29)}{1.14}\; \Delta y_{t-1} \\
& + \underset{(0.1)}{0.2}\; \Delta im_{t-2} - \underset{(0.07)}{0.3}\;, \\
& \widehat{\sigma} = 0.016,\; F_{ar}(4{,}48) = 1.59[0.19],\; \chi^2_{nd}(2) = 1.96[0.38], \\
& F_{arch}(4{,}48) = 0.69[0.60],\; F_{het}(16{,}39) = 0.63[0.84], \\
\widehat{\Delta rp_t} \;=\; & \underset{(0.05)}{0.27}\; ecm_{t-1} + \underset{(0.37)}{0.84}\; \Delta y_t - \underset{(0.13)}{0.29}\; \Delta rp_{t-1} \\
& - \underset{(0.13)}{0.36}\; \Delta rp_{t-2} + \underset{(0.13)}{0.52}\; \Delta im_{t-2} + \underset{(0.14)}{0.75}\;, \\
& \widehat{\sigma} = 0.021,\; F_{ar}(4{,}48) = 1.16[0.34],\; \chi^2_{nd}(2) = 1.44[0.49], \\
& F_{arch}(4{,}48) = 0.47[0.76],\; F_{het}(16{,}39) = 0.83[0.65].
\end{aligned}
\tag{7}
$$

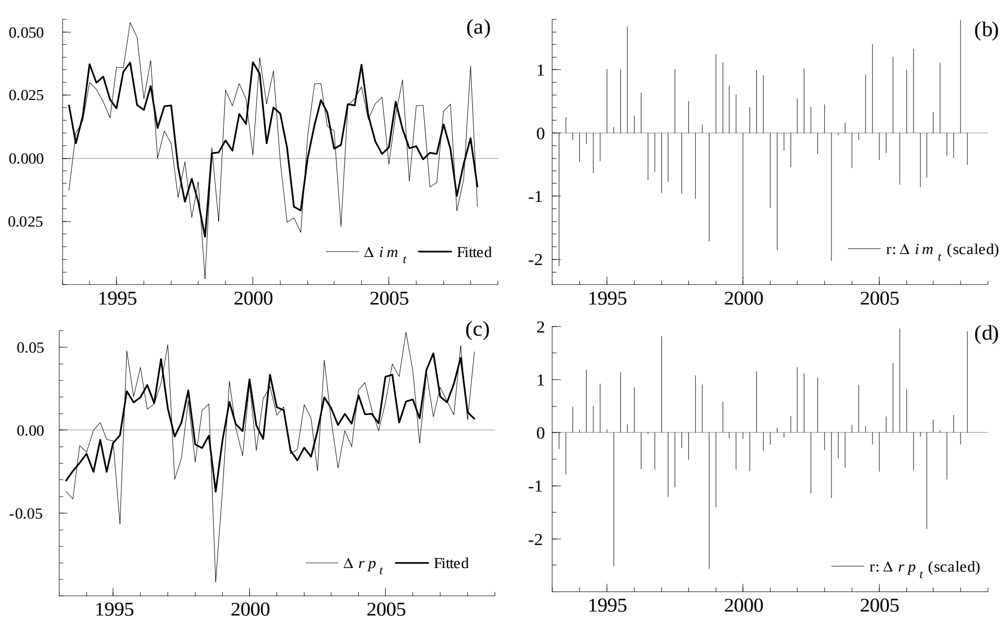


Figure 1: Actual and Fitted Values, and Scaled Residuals

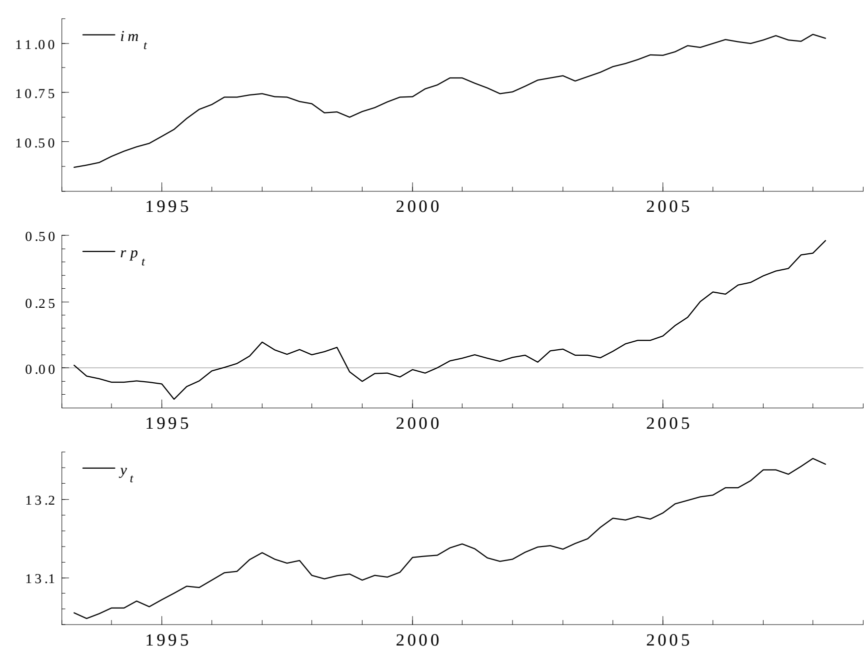
According to the equation for Δim_t in the system (7), both Δy_t and Δy_{t-1} play a significant role in the short-run dynamics of the equation, indicating that aggregate income is an important factor in the determination of aggregate import demand. In contrast, there is no short-run dynamic terms associated with the past values of Δrp_t, suggesting that the price ratio is relevant solely in the long-run import demand relation. Turning to the equation for Δrp_t, one finds that Δy_t is significant as in line with the Δim_t equation. The term Δim_{t-2} is significant with positive sign, possibly indicating a short-run impact from a demand increase on the relative price. This may be seen as statistical evidence for the presence of a short-run dynamic relationship between Japan's aggregate import demand and price ratio. Finally, as expected from the results in Section 3.2, ecm_{t-1} is highly significant in both equations, playing a key role in the parsimonious dynamic system for Δim_t and Δrp_t.

4 Concluding Remarks

This note investigates time series properties of a dynamic system for Japan's aggregate import demand. Japan's recent time series data are rigorously analysed based on cointegrated VAR methodology. A cointegrated VAR analysis has revealed a stable economic linkage, which is seen as an empirical representation of the underlying long-run import demand function. It is also found that aggregate income is weakly exogenous for a set of parameters of interest, therefore allowing us to estimate a conditional system centering on aggregate import demand. Finally, a bivariate vector equilibrium correction system is estimated conditional on aggregate income, exhibiting short-run and long-run interdependent relationships between import demand and the ratio of import price to domestic price level. These quantitative findings convey useful information for the development of Japan's trade and exchange rate policy in the future.

Appendix: Data Overview and Details

(Data Overview)



(Data Definitions)
im_t = the log of real import demand in Japan,
rp_t = the log of implicit deflator for Japan's import demand
- the log of implicit deflator for Japan's GDP,
y_t = the log of real GDP in Japan.

(Sources and Notes)
System of National Accounts, the webpage of Economic and Social Research Institute, Japan.
The data for im_t and y_t are seasonally adjusted. The implicit deflators for rp_t are constructed from the division of the nominal series by the corresponding real series.

References

[1] Campos J, N.R. Ericsson, and D.F. Hendry (2005) *General to Specific Modelling*, Edward Elgar.

[2] Dennis, J.G., H. Hansen, S. Johansen and K. Juselius (2005) *CATS in RATS*, version 2, Estima.

[3] Doornik, J.A. and H. Hansen (1994) "A practical test for univariate and multivariate normality" Discussion paper. Nuffield College, University of Oxford.

[4] Doornik, J.A. and D.F. Hendry (2007a) *Empirical Econometric Modelling - PcGive*^{TM} 12: Volume 1, Timberlake Consultants Ltd.

[5] Doornik, J.A. and D.F. Hendry (2007b) *Modelling Dynamic Systems - PcGive*^{TM} 12: Volume 2, Timberlake Consultants Ltd.

[6] Engle, R.F. (1982) "Autoregressive conditional heteroscedasticity, with estimates of the variance of United Kingdom inflation" *Econometrica* **50**, 987-1007.

[7] Engle, R.F., D.F. Hendry and J.F. Richard (1983) "Exogeneity" *Econometrica* **51**, 277-304.

[8] Godfrey, L.G. (1978) "Testing for higher order serial correlation in regression equations when the regressors include lagged dependent variables" *Econometrica* **46**, 1303-1313.

[9] Hamori, S. and Y. Matsubayashi (2001) "An empirical analysis on the stability of Japan's aggregate import demand function" *Japan and the World Economy* **13**, 135-144.

[10] Johansen, S. (1988) "Statistical analysis of cointegration vectors" *Journal of Economic Dynamics and Control* **12**, 231-254.

[11] Johansen, S. (1996) *Likelihood-Based Inference in Cointegrated Vector Auto-Regressive Models*, 2nd printing. Oxford University Press.

[12] Johansen, S. (2002) "A small sample correction of the test for cointegrating rank in the vector autoregressive model" *Econometrica* **70**, 1929-1961.

[13] Juselius, K. (2006) *The Cointegrated VAR Model*. Oxford University Press.

[14] Kurita, T. (2007) "A dynamic econometric system for the real yen-dollar rate" *Empirical Economics* **33**, 115-149.

[15] Nielsen, B. (2006) "Order determination in general vector autoregressions" *Time Series and Related Topics: In Memory of Ching-Zong Wei*, IMS Lecture Notes and Monograph Series **52**, 93-112. H-C. Ho, C-K. Ing, T.L. Lai. (Eds.).

[16] Tang, T.C. (2003) "Japanese aggregate import demand function: reassesement from 'bounds' testing approach" *Japan and the World Economy* **15**, 419-436.

[17] Tang, T.C. (2006) "Cointegration analysis of Japan's aggregate import demand function: does data frequency matter?" *Labuan Bulletin of International Business and Finance* **4**, 19-43.

[18] White, H. (1980) "A heteroskedastic-consistent covariance matrix estimator and a direct test for heteroskedasticity" *Econometrica* **48**, 817-838.

[19] Yoshikawa, H. (2002) *Japan's Lost Decade*, the International House of Japan.