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China's Imports: An Empirical Analysis Using Johansen's Cointegration Approach

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Abstract

In this paper, the behavior of China's imports during the period 1980-92 is studied. The estimation of cointegration and error correction mechanisms enables the separation of the long-run and short-run determinants of imports in China. The estimated cointegrating vector using Johansen's cointegration approach shows that, in the long run, China's imports are sensitive to changes in output, relative prices, and foreign exchange reserves. It also shows that the short-run output elasticity of imports is much greater than that in the long run, suggesting that import substitution may have been an important factor over the sample period. The forecasting ability of a conventional partial adjustment import function is then compared with that of the Johansen cointegration model; the Johansen model is shown to outperform the conventional one in forecasting accuracy.

JEL Classification Numbers

C22, C49, F14

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Table of Contents

Annexes

List of Tables

List of Charts

Summary

A very important component of China's economic transformation, which began in 1978, has been the process of "opening up" to the outside world. Consequently, the role of external trade in China's economy has grown dramatically in the last 15 years. The main feature of China's foreign trade policy during this period has been an emphasis on the promotion of exports to generate foreign exchange, coupled with a relatively restrictive and managed import regime, although the trade system has been progressively liberalized as part of the reform process. The focus of this paper is on the behavior of imports--which is specified as functions of real economic activity, relative prices, and foreign exchange reserves (the latter as a proxy for the use of quantitative import controls)--during the 1980-92 period. Specifically, the paper estimates the long-run and short-run determinants of China's imports by applying Johansen's generalization of the cointegration and error-correction approach to time series analysis.

The results show that imports depend positively on the level of foreign exchange reserves and negatively on relative prices, both in the short and long run. Also, the paper finds that long-run output elasticity of imports is considerably smaller than in the short run, suggesting that some import substitution has taken place over time. Parameter stability tests indicate that the estimated parameters of the short-run relationship are stable over the sample period. A comparison of the forecasting ability of the Johansen error-correction model with a conventional partial adjustment model shows that the former predicts the turning points with a greater degree of accuracy than does the latter.

I. Introduction 1/

Since the inception of the process of "opening up" to the outside world in the late 1970s, the role of external trade in China's economy has grown dramatically. 2/ The main feature of China's foreign trade over the past 15 years has been an emphasis on the promotion of exports to generate foreign exchange coupled with a relatively restrictive and managed import regime, although the trade system has been progressively liberalized as part of the reform process. Despite this, however, the average growth rates of exports and imports between 1980 and 1992 were broadly similar--export growth averaged 28 percent, while imports grew at an average of 23 percent. The share of total trade in China's GNP rose from 13 percent in 1980 to nearly 39 percent in 1992. China's share in total world trade also rose sharply, albeit from a small base.

The focus of the paper is on the behavior of China's imports. Three features are discernible when examining the development of China's imports during the period 1980-92. First, the share of food items witnessed a marked decline as did the share of primary products other than food. Correspondingly, the share of capital goods (machinery and transportation equipment) and intermediate goods rose steadily from 25 percent of total imports in 1980 to nearly 40 percent in 1992 (Chart 1). The share of consumer goods exhibited fluctuations, probably associated with the tightening and loosening of import controls, but remained under 5 percent throughout the period between 1980 and 1992.

Second, the role of the import plan has declined steadily through the reform period. In the early years of the reform process, the bulk of China's imports were undertaken in accordance with the trade plan, which was used to ensure adequate supplies of food, raw materials, and intermediate goods. Quantities imported were determined largely through a "gap-fill" exercise rather than on the basis of relative prices or quality. In the early 1980s, over 80 percent of food and intermediate goods were imported under the import plan. By 1991, only half of food imports and two thirds of intermediate goods imports were covered by the trade/import plan. 3/ However, notwithstanding the reduction in the role of the plan, China's import structure indicates significant management and control on the part of the authorities. Moreover, the exchange system has provided the authorities with another lever with which to control importers' access to foreign exchange and therefore, the composition of imports. In particular, the fact

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1/ This paper covers developments in China's reforms through late 1992. It does not, therefore, reflect the major initiatives to liberalize the exchange and trade regime that were implemented in late 1993 and 1994.

2/ For a more detailed discussion of China's reforms and the process of integration into the global economy, see Bell, Khor, and Kochhar (1993). For details on China's foreign trade regime and issues in foreign trade reform, see World Bank (1993).

3/ The mandatory import plan was abolished in early 1994 and replaced by a guidance plan.

that the share of consumer goods imports remained small indicates the use of administrative controls on imports and foreign exchange allocation.

Third, China's trade flows--especially its imports--have exhibited considerable volatility associated with periodic sharp fluctuations in economic activity and the concomitant intensification and relaxation of import controls (Chart 2). During the upswing of the cycles, imports would rise rapidly leading to a widening trade deficit and a deterioration in the balance of payments. The subsequent clamp down on credit, investment imports--often through administrative means--would lead a sharp decline in imports. 1/

The aim of this study is to estimate the long-run and short-run determinants of China's imports applying the principles behind the cointegration and error-correction approach to time series analysis. The rest of the paper is organized as follows. Section II outlines the issues involved in specifying and estimating an import function for China. Section III presents results of diagnostic tests of the data. In Section IV, the results of the estimation procedure using the Johansen procedure are discussed. Section V presents the results of a forecasting exercise in which in-sample forecasts are generated using two models--a simple, partial adjustment model of import behavior (referred to as a conventional model), and the Johansen model. Section VI contains a summary and conclusions.

II. Issues in the Specification and Estimation of an Import Function

1. Model specification

Traditionally, import demand models have specified imports as functions of relative prices and real activity variables such as GNP or industrial production. However, for many developing countries, foreign exchange constraints can be an important factor in the determination of imports. Government policy in the face of foreign exchange shortages can include changes in the exchange rate, and the imposition of tariffs or quantitative import restrictions that would affect both the relative price of imports and also, directly, the volume of imports. Thus, it has been argued that a variable such as foreign exchange reserves or foreign exchange earnings should be used as an additional explanatory variable in the import function (Hemphill (1974), Saracoglu and Zaidi (1986) and Moran (1989)).

Hemphill (1974) explicitly specifies a quadratic cost function defining the cost of adjustment of actual imports to the long-run desired level of imports to justify the use of a partial adjustment model. As for the specification of the import function, he argues that the theoretical

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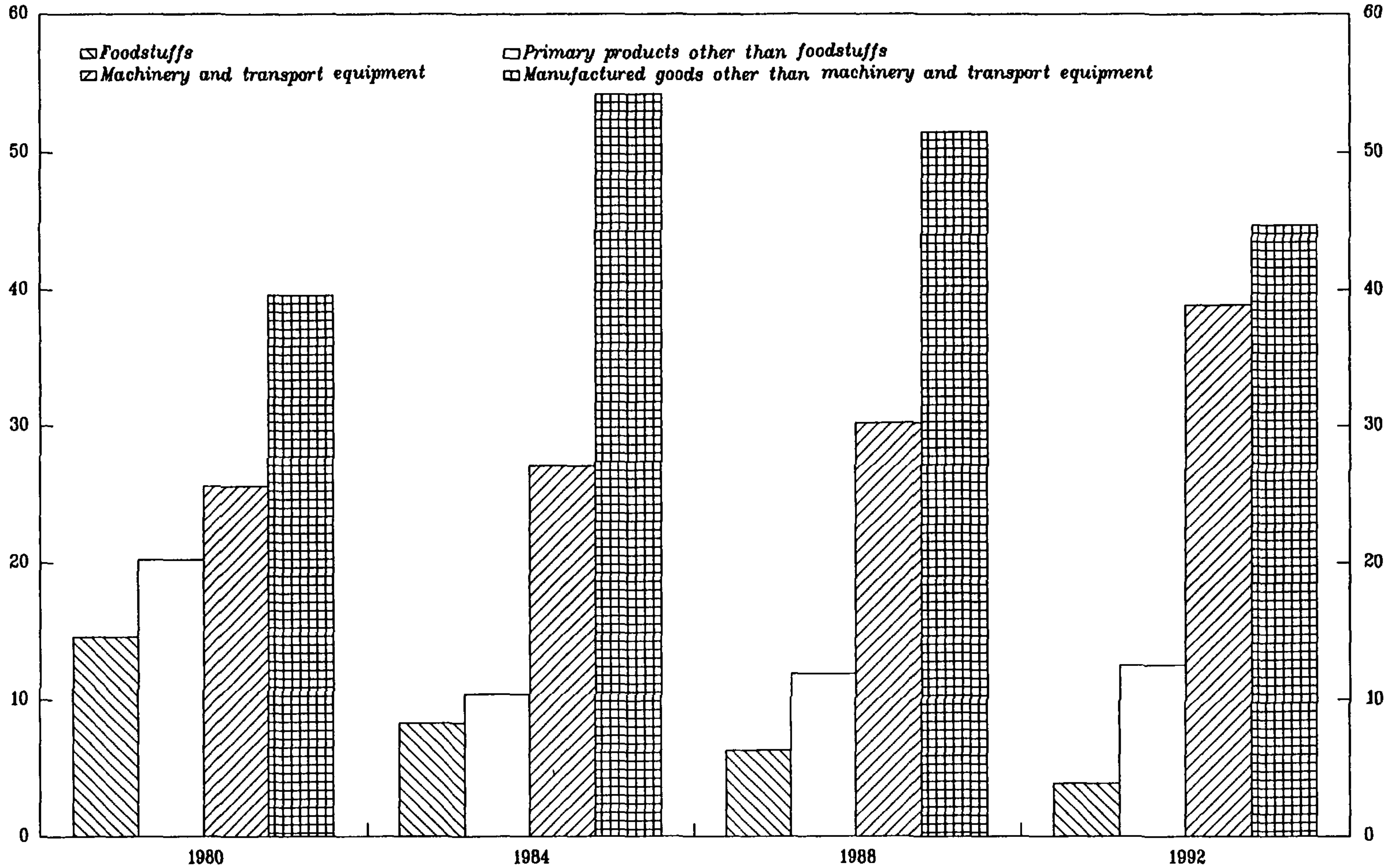
1/ For a fuller description of the macroeconomic cycles and their interaction with the reform process, see Khor (1991).

CHART 1

CHINA

COMMODITY COMPOSITION OF IMPORTS, 1980-92

(In percent of total)

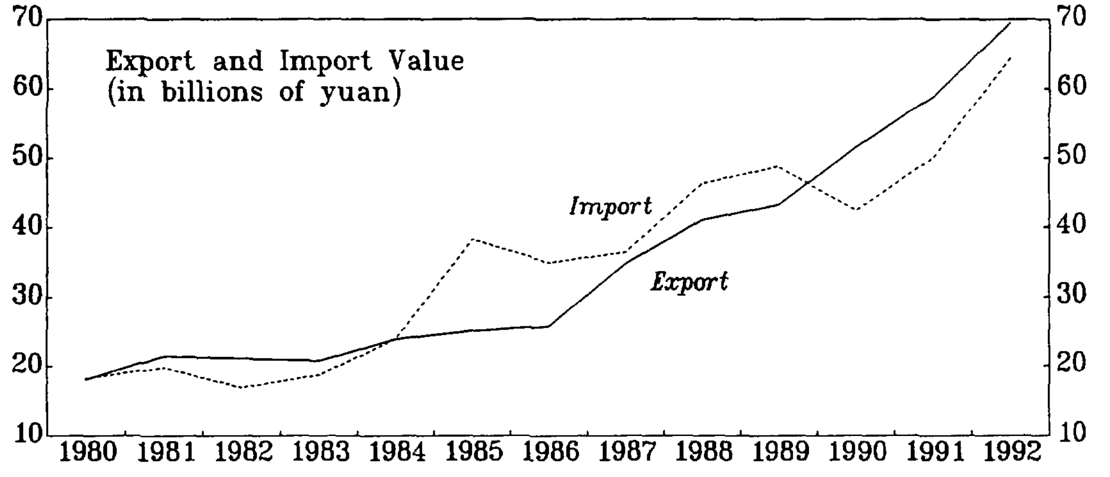


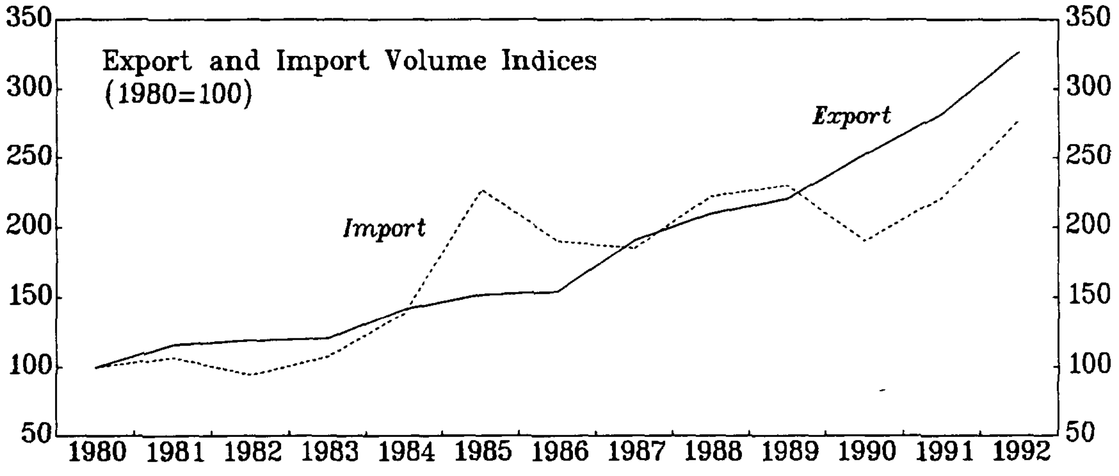
Source: Data provided by the Chinese authorities..

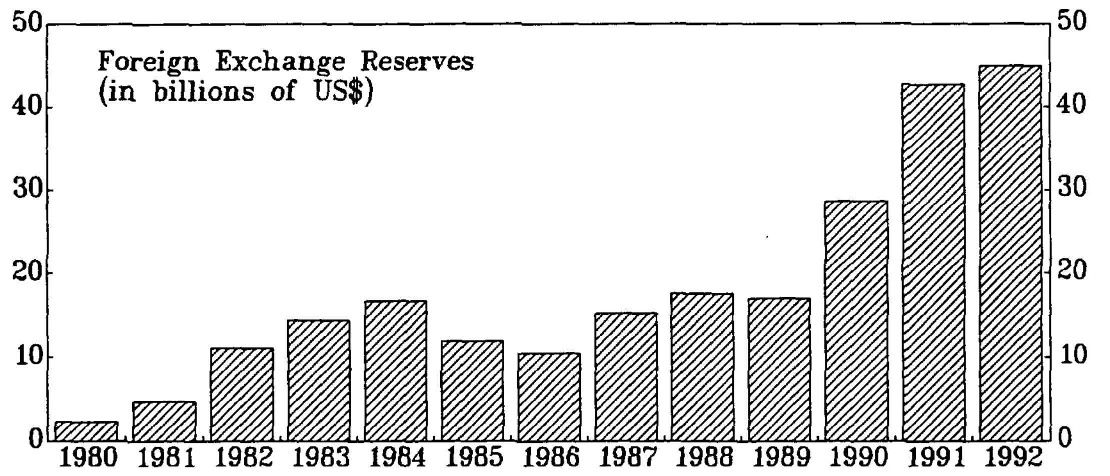
CHART 2

CHINA

EXPORTS, IMPORTS, AND FOREIGN EXCHANGE RESERVES, 1980-92







Sources: Data provided by the Chinese authorities; and staff estimates.

rationale for including foreign exchange reserves is that, in general, developing countries experience an almost persistent excess demand for foreign exchange. Thus changes in relative prices and activity affect imports only indirectly through changes in foreign exchange earnings. This is because, in the presence of import controls and rationing, part of the change in relative prices and activity is actually measured by the change in reserves. In the absence of such controls, changes in imports would be fully explained by changes in relative prices and changes in the level of economic activity. However, in the presence of quantitative restrictions, imports could change with no change in activity and relative prices, reflecting changes in the restrictiveness of import controls. In this case, the change in foreign exchange reserves could measure a large part of the true change in relative prices and/or activity. For this reason, Hemphill excludes relative prices and domestic activity variables as determinants of imports in developing countries.

Moran (1989) specifies an import model that includes both traditional activity and relative price variables, as well as indicators of import "capacity," such as foreign exchange reserves. The model used here follows Moran's generalization of Hemphill's model to allow for relative prices, real activity, and foreign exchange reserves to be included as explanatory variables in the determination of import volumes. The estimated function could thus be seen as the import decision rule of the authorities, rather than a "pure" import demand function, and take the following form:

$$\ln(M/P_m) = \alpha_0 + \alpha_1 \ln(Y) + \alpha_2 \ln(P_m/P) + \alpha_3 \ln(FX/P_m) + \epsilon_t$$

where M is the value of imports
P_m is the price of imports in domestic currency
Y is an index of real economic activity
P is the domestic price level
FX is the level of foreign exchange reserves

2. Estimation

For the purposes of estimation, conventionally, the import function is specified as a partial adjustment model. In this model, current imports are regressed on lagged imports, and other explanatory variables. The model is then estimated using ordinary least squares (OLS). However, as shown by several authors (Granger and Newbold (1974), Phillips (1986), and Stock and Watson (1988)), OLS estimators are not consistent in the presence of nonstationary economic time series. Thus, although OLS estimation results have high values for R^2 and significant t-statistics, inference based on the traditional test statistics may not be correct.

These findings suggest that nonstationarity of the time series should be tested for and stationarity induced before performing regression analysis. Econometricians (notably Box and Jenkins (1970) and Granger and Newbold (1974)) have suggested that the relevant time series should be made stationary by differencing, usually once or twice, and regressions should be run using these differenced time series. This method, however, suffers from the problem that information about the long-run relationship between the variables is lost, since in the long run, first differences of these variables are zero.

The development of the concept of cointegration suggested a way to improve this method. Granger (1981) first showed that there is a way to link integrated processes 1/ and the long-run, steady-state equilibrium. These methods have been further developed by Granger and Weiss (1983), and Engle and Granger (1987). Simply put, the idea behind the concept of cointegration is that even though level variables are individually I(1), that is, are dominated by the long-run components, special linear combinations of these I(1) variables can be I(0). In this case, the long-run components of these series cancel each other out to produce a stationary series, and such variables are then said to be cointegrated. The vector of the coefficients of the linear combination is called the cointegrating vector. When variables are cointegrated, it implies that there is some adjustment process that prevents the deviations from the long-run relationship from becoming larger and larger. This process is referred to as the error-correction mechanism.

Engle and Granger (1987) have shown that any set of cointegrated time series has an error-correction representation, which reflects the short-run adjustment mechanism. This is called the Granger representation theorem. The Engle-Granger two-step error-correction model provides a way to separate the long-run and short-run properties of the data. In the first step, a cointegrating regression is performed to obtain a cointegrating vector among the variables. This is done by regressing a traditional econometric model including variables and their lags, measured in levels, and estimating the equation by OLS. If the least squares estimation yields a stationary residual series, then a cointegrating relationship exists among these variables. Then, as noted above, according to the Granger representation theorem, there exists an error-correction representation. The estimation of the cointegration regression and the reformulation of the model in first differences produces a term representing the extent of the current "error" in achieving long-run equilibrium. As a result, the short-run adjustment mechanism is obtained in the second step.

With regard to estimating the cointegrating vector in the first step of the Engle-Granger model, Stock and Watson (1988) shows that when the variables are cointegrated, the OLS estimate of the cointegrating vector provides a "superconsistent" estimator of the true vector in the sense that the estimators converge to the true parameters at a much faster rate than in the case of standard econometric estimators. However, in a multivariate model, there may exist more than one cointegrating relationship. Johansen

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1/ Nelson and Plosser (1982) have shown that most economic time series are integrated of order 1, that is, their first differences are integrated of order zero, or stationary.

(1988) and Johansen and Juselius (1990) develop a maximum likelihood estimation procedure that has several advantages over the two-step regression procedure suggested by Engle and Granger (1987). The first step of the Engle-Granger procedure to estimate a cointegration relationship in a n-variate case does not clarify whether the estimated cointegrating vector is a unique one or whether it is simply a linear combination of the potential (n-1) cointegrating vectors. The Johansen technique fully captures the long-run relationships among the variables and provides the estimates of all possible cointegrating vectors that exist among these variables. Also, the number of the cointegrating vectors can be statistically tested.

III. Diagnostic Tests: Unit Roots and Granger Causality

Two types of diagnostic tests are conducted below. First, tests are conducted to detect nonstationarity and determine the order of integration of the variables included in the model. Second, Granger causality tests to examine the "causal" relationship between the variables. The data used are quarterly from 1981 to 1991; sources and definitions are provided in Annex I.

1. Unit root tests

Stationarity of a series is tested through unit root tests. Generally speaking, in a regression of the type $y_t = \alpha y_{t-1} + e_t$, unit root tests involve testing the null hypothesis that $\alpha=1$. A variety of tests have been developed to test for unit roots. Dickey and Fuller (1981) present a class of test statistics, known as Dickey-Fuller (DF) statistics and Augmented Dickey-Fuller (ADF) statistics to test whether a process has a unit root.

The test statistics and the corresponding p-values are reported in Table 1. 1/ The null hypotheses that the variables are I(1) cannot be rejected at the 1 percent significance level, and the null hypotheses that the first differences of the variables are I(1) are rejected. Thus, the processes of imports, foreign exchange reserves, industrial output, and relative prices are integrated of order 1. Chart 3 plots these variables.

1/ We utilize the critical values computed by MacKinnon (1991) for these tests. MacKinnon estimates response surface regressions permitting the calculation of more accurate critical values for any sample size.

Table 1. Unit Root Tests

Variables	(k,n) 1/	ADF(k,n)	p-value 2/
m	43,1	-2.065	0.59
r	43,1	-3.078	0.23
y	43,1	-2.612	0.39
p	43,1	-2.260	0.48
Δm	42,1	-6.774	0.00
Δr	42,1	-4.980	0.00
Δy	42,1	-8.256	0.00
Δp	42,1	-7.840	0.00

1/ k denotes the degree of freedom; n denotes the number of I(1) series to be tested.
2/ The p-values are the probabilities of accepting the null hypothesis.

2. Granger causality tests

Next, the causal relationship between imports, industrial output, foreign exchange reserves, and relative prices is examined. Granger (1969) introduced a concept of causality in which, broadly speaking, a variable y is said to be Granger caused by another variable x if current values of y can be predicted with better accuracy by using past values of x. It can be seen that Granger's concept of causality does not imply an "event-outcome" relationship, but rather is based on predictability. In other words, the finding that x Granger causes y implies that x has significant incremental predictive power in the evolution of y.

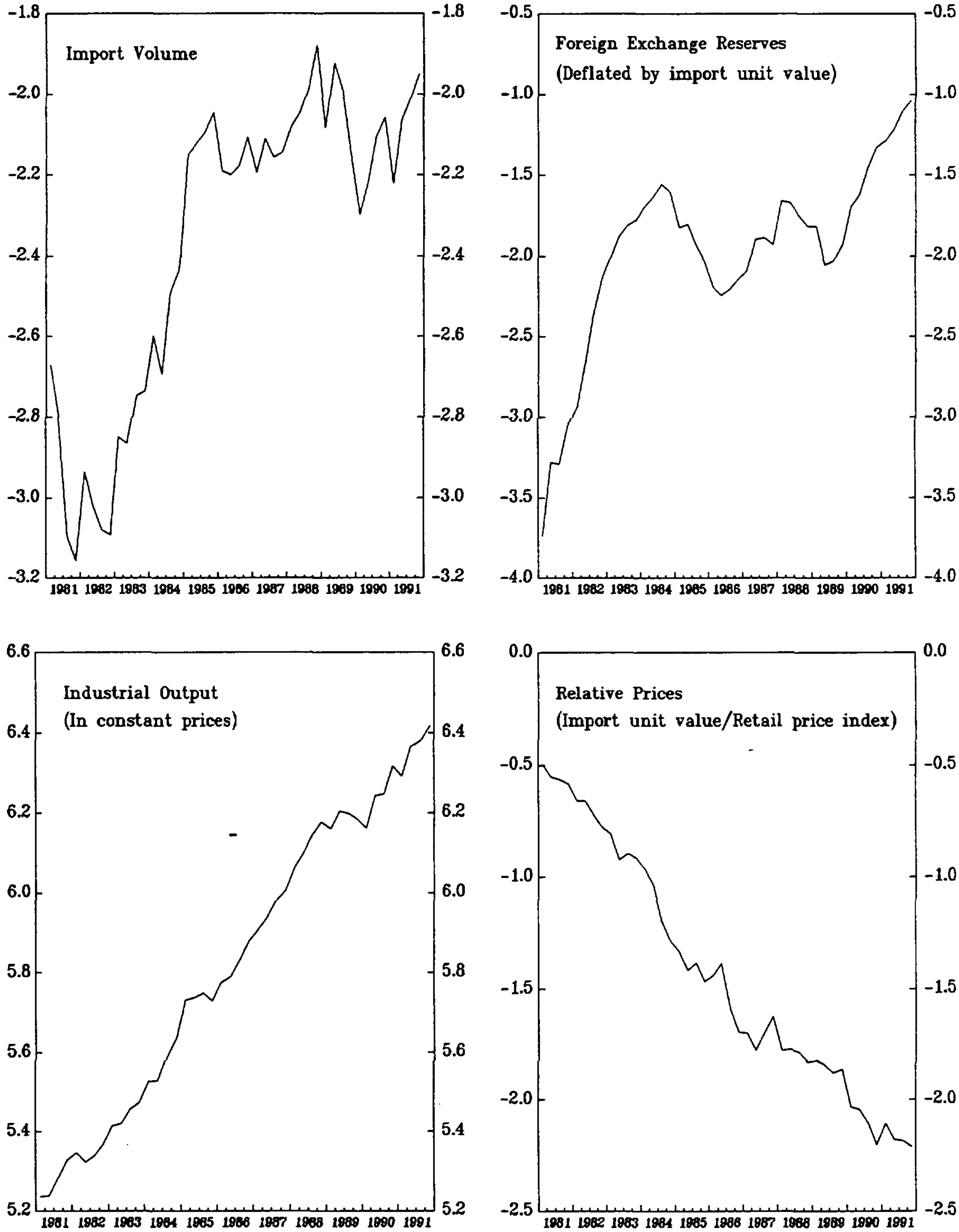
In order to test for the direction of Granger causality, the following model is used:

$$\Delta m_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i \Delta m_{t-i} + \sum_{i=1}^{n} \beta_i \Delta r_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta y_{t-i} + \sum_{i=1}^{n} \theta_i \Delta p_{t-i} + \epsilon_t$$

CHART 3

CHINA

INDEXES OF IMPORTS, INDUSTRIAL PRODUCTION, FOREIGN EXCHANGE RESERVES AND RELATIVE PRICES, 1981-91 1/



Sources: Data provided by the Chinese authorities; and staff estimates.

1/ All variables are in logarithms.

where m = volume of imports
r = foreign exchange reserves
p = the relative price of imports
y = industrial output

All variables are expressed in logarithms. The first null hypothesis is that the coefficients of lagged r are zeros, which implies that foreign exchange reserves do not Granger cause imports. The following steps are involved to test the null hypothesis: first, the current value of m is regressed on lags of y and p but not on r and the residual series is obtained; second, the residual series from the first step is regressed on the entire set of explanatory variables and the coefficient of determination R^2 is obtained; third, a Lagrange multiplier test in F distribution (LMF) is formulated. 1/ In the same manner, the causality between imports, industrial output, and relative prices is tested. The results are reported in Table 2.

Table 2. Granger Causality Tests

Null Hypothesis 1/	LMF(3,27)	p-value 2/
Δr does not → Δm	3.291	0.04
Δm does not → Δr	1.144	0.35
Δy does not → Δm	2.809	0.06
Δm does not → Δy	4.181	0.01
Δp does not → Δm	1.972	0.14
Δm does not → Δp	1.234	0.32

1/ x → y denotes that x Granger causes y.
2/ The p-values represent the probabilities of accepting the null hypothesis.

1/ The LMF statistic, defined as $LMF=(T-h)/k*R^2/(1-R^2)$ has an $F(k,T-h)$ distribution under the null hypothesis, where T is the sample size, h is the number of variables, and k is the number of restrictions. Kiviet (1986) shows that this test statistic has better statistical properties than the standard Lagrange multiplier test.

Examining first the implied relationship between imports and foreign exchange reserves, there is evidence that the current period change in imports is Granger caused by lagged values of the change in reserves. This finding would suggest that foreign exchange reserves can be seen as a trigger for the tightening or relaxation of import controls.

Next, the relationship between imports and industrial output is examined. The data suggest that there is a feedback relationship between these two variables. Given the high share of intermediate and capital goods in China's imports and the use of quantitative controls to restrict imports and influence their composition, it is not surprising to find such bidirectional "causality." After 1983, manufactured goods, including machinery and transportation equipment, and chemical and related products accounted for more than three fourths of total imports. This would explain the finding of causality from imports to industrial production.

Finally, as for the relationship between relative prices and imports, the data indicate only a weak causal relationship between these variables in both directions. While it is not surprising to find that China's imports do not Granger cause relative prices, the fact that relative prices fail to Granger cause imports can be explained by taking into account the relatively significant, albeit declining, role of the import plan. It is possible, however, that there is a statistically significant contemporaneous relationship between these variables.

IV. Cointegration Analysis Using Johansen's Approach

As noted above, there could exist several cointegrating vectors among multiple variables, and it is possible that the estimated cointegrating vector is simply a linear combination of these vectors. This consideration leads to pursuing Johansen's approach to obtain the long-run relationship among these variables.

A brief discussion of the approach is as follows. Consider an unrestricted 4 dimensional vector autoregression (VAR), which includes "k" lags:

$$Z_t = \delta + \theta_1 Z_{t-1} + \theta_2 Z_{t-2} + \ldots + \theta_k Z_{t-k} + v_t$$

where, $Z=[m\ r\ y\ p]'$, and $v_1,\ldots,v_4$ are i.i.d. $N(0,\Sigma)$.

From the unit root tests for each variable, it is clear that all the variables in Z_t are nonstationary and integrated of order 1; ΔZ_t's are therefore stationary. Rewriting the above model, the following error-correction form can be obtained:

where $$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma_i \, \Delta Z_{t-i} + \Pi Z_{t-k} + \epsilon_t$$

$$\Gamma_i = -I + \Theta_1 + \ldots + \Theta_i$$

$$\Pi = -(I - \Theta_1 - \ldots -\Theta_k)$$

In the long run, $\Delta Z_t=0$; thus the equation $\Pi Z=0$ incorporates the long-run relationship between the variables. Assume there are r cointegrating vectors among these variables, where $0 \leq r < 4$. In this case, Johansen shows that the matrix Π can be decomposed into two 4 by r matrices: $\Pi=\alpha\beta'$. The matrix β contains the parameters of the cointegrating vectors and the matrix α contains the weights with which the vectors enter the equations in the system. If the hypothesis about cointegration between the variables in the VAR is correct, then in the long run $\Pi Z_t = \alpha\beta' Z_t = 0$. Therefore, even though Z_t is not stationary, $\beta' Z_t$ is stationary. If the hypothesis concerning cointegration holds, the matrix $\beta' Z_t$ constitutes a set of r error-correction mechanisms separating out the long-run and short-run responses in the model.

1. Estimating the cointegration relationship

Johansen (1988) and Johansen and Juselius (1990) have shown how to calculate a maximum likelihood estimator for α and β in multivariate models. 1/ They also present two likelihood ratio tests of the hypothesis that there are at most r cointegrating relationships among these variables. One test is based on the maximal eigenvalue of the stochastic matrix π to test the null hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative of r+1 cointegrating vectors. The other test is based on the trace of the stochastic matrix and tests the null hypothesis against the alternative that there are at least r+1 cointegrating vectors. 2/

Here, the number of cointegrating vectors for imports, industrial output, foreign exchange reserves, and relative prices is tested. The test statistics are given in Table 3. From the results of both tests, it can be concluded that there are two cointegrating vectors among these variables.

1/ A brief discussion of the Johansen methodology can be found in Annex II. Some examples of studies using Johansen's approach are Coe and Moghadam (1993), Hall (1989), Johansen and Juselius (1990), and MacDonald and Taylor (1992).

2/ The first test is generally considered to be more powerful because the alternative is specified as an equality.

Table 3. Johansen Maximum Likelihood Tests 1/

1. Tests based on maximal eigenvalue of the stochastic matrix

HO	H1	Test Statistic	95% Critical Value	90% Critical Value
r=0	r=1	31.46	27.07	24.73
r≤1	r=2	27.87	20.97	18.60
r≤2	r=3	11.72	14.07	12.07
r≤3	r=4	0.80	3.76	2.69

2. Tests based on trace of the stochastic matrix

HO	H1	Test Statistic	95% Critical Value	90% Critical Value
r=0	r≥1	71.86	47.21	43.95
r≤1	r≥2	40.39	29.68	26.79
r≤2	r≥3	12.51	15.41	13.33
r≤3	r≥4	0.80	3.76	2.69

Note: r denotes the number of cointegrating vectors.

In Table 4, the estimates of eigenvalues $\mu_1,\ldots,\mu_4$, and the corresponding eigenvectors $v_1,\ldots,v_4$ and the weight matrix are given. Detailed definitions can be found in Annex II. Since there exist two cointegrating vectors, the ones with the two highest eigenvalues constitute the matrix β'.

1/ The critical values are from Table A1 in Johansen and Juselius (1990).

Table 4. Estimated Eigenvalues, Eigenvectors and Weight Matrix

Eigenvalues			
$\mu 1$	$\mu 2$	$\mu 3$	$\mu 4$
0.554	0.511	0.260	0.020

Eigenvectors			
$\upsilon 1$ ($\beta 1$)	$\upsilon 2$ ($\beta 2$)	$\upsilon 3$	$\upsilon 4$
3.0	-13.0	-10.1	6.6
5.1	-3.4	-0.1	-1.0
9.2	7.0	-22.5	-0.8
12.4	-3.8	-20.7	4.7

Weights			
$\omega 1$ ($\alpha 1$)	$\omega 2$ ($\alpha 2$)	$\omega 3$	$\omega 4$
0.050	-0.007	0.019	-0.001
-0.018	0.055	0.007	0.006
0.004	-0.009	0.006	0.000
-0.025	-0.014	0.001	-0.006

The results in Tables 3 and 4 suggest that there are two possible cointegrating vectors. The coefficients of one have the expected signs and the long run elasticities based on this vector are as follows:

Table 5. Estimated Long-Run Elasticities of Import Demand

	Industrial Output	Foreign Exchange Reserves	Relative Prices
Elasticity	0.538	0.261	-0.290

The long-run elasticity of imports with respect to industrial output is 0.5, while that with respect to relative prices is about -0.3. 1/ The reserve elasticity of imports is also estimated to be about 0.3 suggesting that, in the long run, imports depend positively on the value of foreign exchange reserves.

2. Short-run behavior of imports

A general-to-specific model selection technique is used to obtain the error-correction model. The unrestricted model is specified as:

$$\Delta m_t = \alpha_0 + \sum_{i=0}^{n} \beta_i \Delta r_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta p_{t-i} + \phi EC_{t-1} + \epsilon_t$$

where EC denotes the error-correction term based on the cointegration regression using Johansen's approach. A testing down procedure is used in which insignificant lags are dropped and the following parsimonious representation is obtained:

$$\Delta m_t = \alpha_0 + \alpha_1 \Delta r_t + \alpha_2 \Delta y_t + \alpha_3 \Delta p_t + \alpha_4 EC_{t-1} + \epsilon_t$$

The estimation results are reported in Table 6. The estimated parameters suggest that the short-run behavior of imports is dominated by developments in industrial production. In particular, the short-run elasticity of imports with respect to industrial production is considerably higher than its long-run value. One possible interpretation of these results is that, in the short run, in the absence of domestically available substitutes, an increase in economic activity tends to lead to a surge in imports, particularly of capital and intermediate goods. The lower long-run elasticities suggest that import substitution may be significant over longer periods of time. The results also suggest that a decrease in the level of reserves lagged one period leads to a decrease in current period imports, ceteris paribus. The significant negative relationship between changes in relative prices and import demand in the short run suggests that as reforms progressed, with enterprises being given increasing autonomy, the role of

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1/ Brender (1992) estimates import functions using quarterly, sectorally (ranging from 1.22 to 1.47) disaggregated data from 1981 to 1990 and finds higher income elasticities than in this paper and somewhat higher price elasticities (ranging between -0.36 and -0.6). He finds that, in a sample of commodities that excludes advanced technology machinery and electronic goods, imports depend positively on foreign reserves. Sekiguchi (1990) uses annual data from 1960 to 1986 and finds an income elasticity of imports of 0.87 while the price elasticity is not statistically significant from zero. However, since his sample spans the period before and after the inception in 1978 of market-oriented reforms and opening up to the outside world, a comparison between his results and this study is not possible.

the plan being progressively reduced, and imports being increasingly liberalized, agents' import demand has become more sensitive to price changes.

Table 6. Estimated Error-Correction Model

Variables	Estimated Coefficient	Standard Error	t-statistic	p-value
constant	-0.98	0.67	-1.47	0.15
Δr	-0.34	0.18	-1.89	0.07
Δy	1.77	0.76	2.34	0.03
Δp	-0.68	0.32	-2.17	0.04
EC(-1)	-0.15	0.11	-1.39	0.17

R-squared = .76, Adjusted R^2 = 0.71,
Durbin-Watson statistic = 2.09

3. Testing for short-run parameter stability

An examination of the behavior of import volumes shown in Chart 3 indicates that there may have been a behavioral change in 1986. Note that before 1986, import volumes exhibited a clear rising trend; from 1986, such a clear trend is no longer observed. 1/ To test whether there is indeed a change in the short-run responses of the import series around 1986, the model is re-estimated including a dummy variable that takes on a value of zero from 1981 to 1985 and of one between 1986 and 1991. The results show, however, that the dummy variable is not significant.

Next, Hansen's (1992) tests for parameter instability are conducted. Broadly speaking, Hansen's tests are Lagrange multiplier tests of the null hypothesis of constant parameters against the alternative hypothesis that the parameters follow a martingale process. 2/ The alternative hypothesis incorporates simple structural breaks of unknown timing. (A brief discussion of the tests is given in Annex III.) First, the stability of each parameter individually, and then the stability of all the parameters jointly, is tested. Table 7 contains the test results. These results show

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1/ It should be noted that the period 1989-91--the so-called rectification period--was one in which efforts were focused on macroeconomic stabilization, which led to a significant slowdown in import growth.

2/ A martingale process is a data generating mechanism that can be seen as a generalization of a random walk.

that the estimated parameters are both individually and jointly stable and suggest that there has not been a clearly discernible structural break during the estimation period.

Table 7. Hansen's Tests for Short-Run Parameter Instability 1/

	Constant	Δr	Δy	Δp	EC(-1)	σ^2	Joint
Statistic	0.099	0.038	0.180	0.040	0.100	0.272	0.847
Critical value (95 percent)	0.470	0.470	0.470	0.470	0.470	0.470	1.680

V. Comparing Forecasts

In this section, the forecasting ability of a conventional, partial adjustment and the Johansen approaches to estimating the import demand function are compared.

A conventional model for imports is specified as follows:

$$m_t = a_0 + a_1 t + a_2 m_{t-1} + a_3 r_t + a_4 y_t + a_5 p_t + \epsilon_t$$

The OLS estimation results are given in Table 8.

Table 8. Estimated Results for the Conventional Model

Variable	Estimated Coefficient	Standard Error	T-statistic	p-value
Constant	-8.61	2.63	-3.27	0.00
Time	-0.06	0.02	-3.48	0.00
m_{t-1}	0.57	0.12	4.96	0.00
r_t	0.13	0.05	2.60	0.02
y_t	1.43	0.52	2.74	0.01
p_t	-0.55	0.22	-2.50	0.02

R^2 = 0.96, Adjusted R^2 = 0.95,
Durbin-Watson statistic = 2.48

1/ The asymptotic critical values are from Hansen (1992), Table 1.

Using the two approaches described above, the models were estimated using data from 81:1 to 89:4 and then one-step ahead forecasts for the period 90:1 to 91:4 are generated. Chart 4 shows the actual and fitted values for imports and forecasts based on the conventional model, while Chart 5 shows the actual, fitted, and forecast values based on the Johansen model.

The forecast performance of these models is evaluated in two ways. First, we examine whether the models have the ability to detect the sharp increase in imports that occurred during the forecast period 91:1-91:4. Charts 4 and 5 show that the Johansen model predicts the turning points with relatively greater accuracy than the partial adjustment model. This is possibly because the error-correction mechanism prevents the forecasts from deviating too far from the underlying long-run relationship. Second, Table 9 reports several objective criteria that are used to evaluate the forecast performance. Examining the root-mean-squared error, the mean absolute error, and the mean error, it can be seen that the error-correction model far outperforms the conventional model.

Table 9. Comparison of Forecast Performance

	Conventional	Johansen
Root Mean Squared Error	0.117	0.089
Mean Absolute Error	0.104	0.079
Mean Error	-0.104	-0.045

VI. Summary and Conclusions

This paper has undertaken an examination of China's imports, which specified as being a function of real activity, relative prices and foreign exchange reserves as a proxy for the use of quantitative import controls. The diagnostic causality tests suggest that foreign exchange reserves do *Granger cause imports*. The model is estimated using the cointegration and error-correction methodology, first developed by Engle and Granger and later refined by Johansen. This methodology enables the separation of the underlying long-run and short-run relationships among the variables. Based on Johansen's approach and the likelihood ratio tests, it can be determined that there exists one cointegrating vector with the expected signs. The long-run output elasticity of imports is found to be considerably smaller than in the short run, implying that some import substitution has taken place over time in China. The results also show that imports depend positively on the level of foreign exchange reserves and negatively on relative prices, both in the short and long run. The dependence of imports on the level of foreign exchange reserves is consistent with the existence of import and exchange regimes which sometimes rely on administrative means to limit imports. The results also suggest that, over time, relative prices will play an increasingly important role as the import regime is further liberalized. Parameter stability tests indicate that the estimated parameters of the short-run relationship are stable over the sample period.

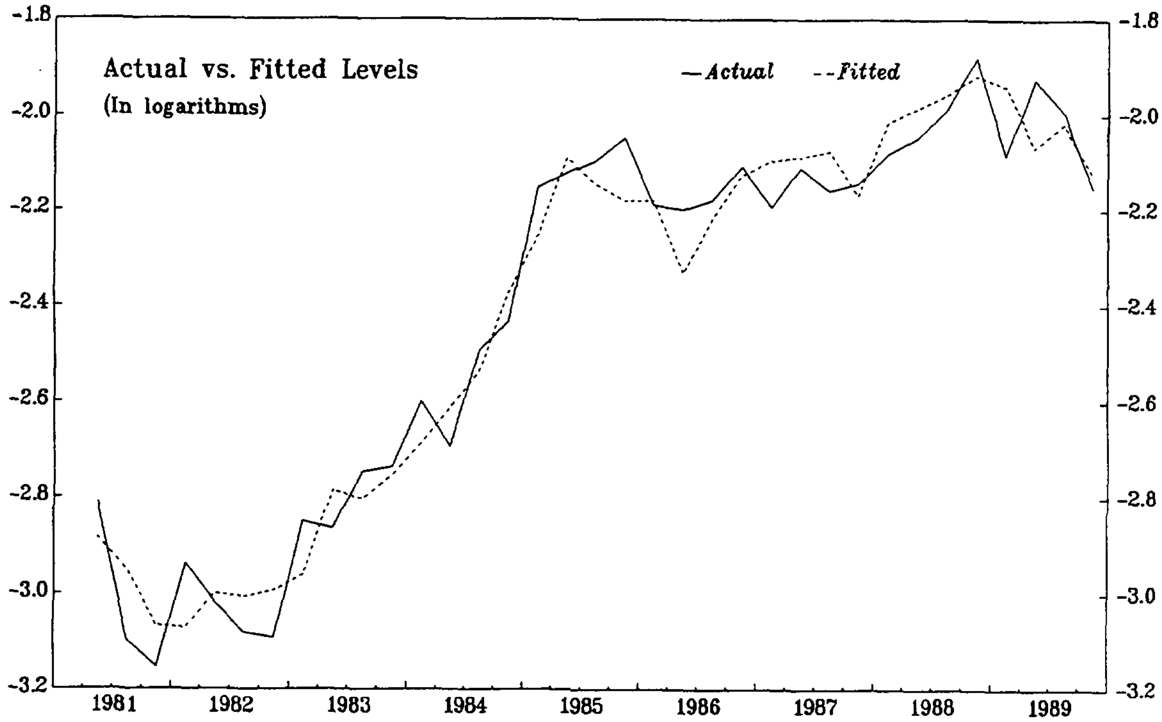
For the purposes of comparison, a conventional partial adjustment model of import demand is also estimated and the forecasting performance of the conventional and error-correction models is compared. Such a comparison shows that the error-correction model can predict turning points with a greater degree of accuracy than the conventional partial adjustment model.

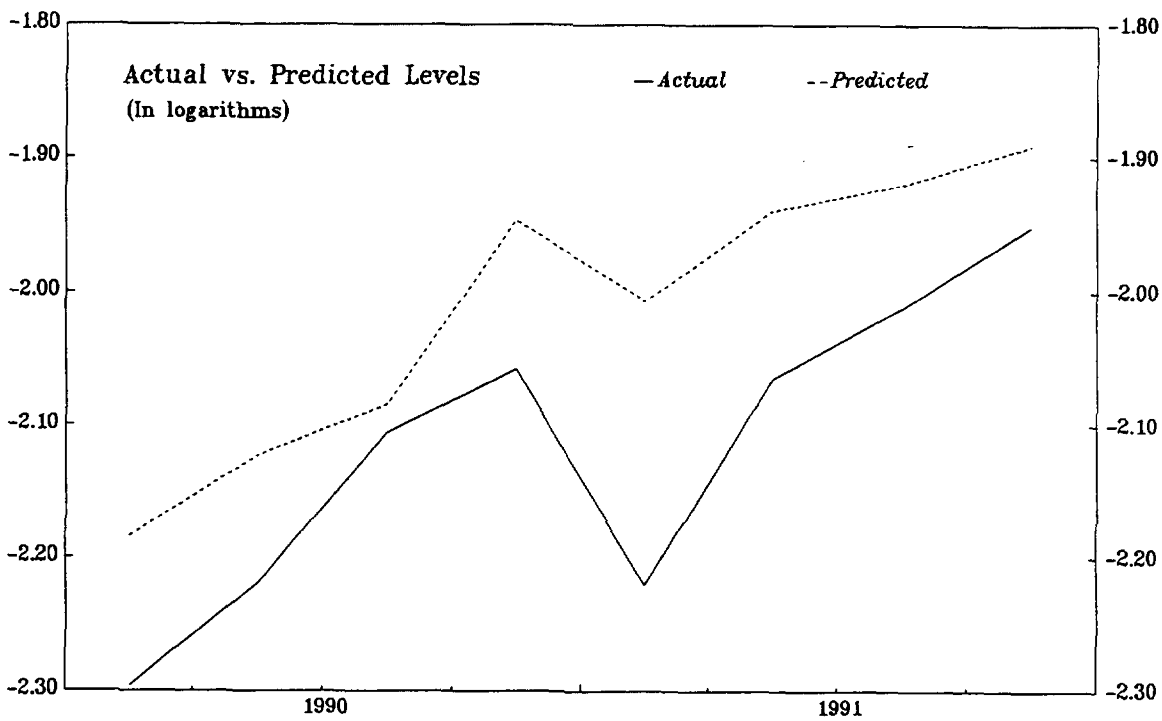
There are several ways in which the analysis could be extended. First, the official exchange rate could be replaced by the swap market exchange rate in the calculation of the relative price variable. However, as data on the swap market rate are only available from 1988, the size of the sample may be prohibitively small. Second, additional explanatory variables, such as changes in domestic credit, could be included in the import demand function to act as an alternative proxy for the use of direct controls on imports. Finally, it would be interesting to examine in greater detail the relationship between the restrictiveness of China's import regime and cyclical variability in macroeconomic activity. In particular, the presence or absence of import rationing for each observation in the sample could be determined by estimating the probability of a regime change using switching regression techniques.

CHART 4

CHINA

ACTUAL, FITTED AND PREDICTED IMPORTS, 1981-91
(Conventional model)



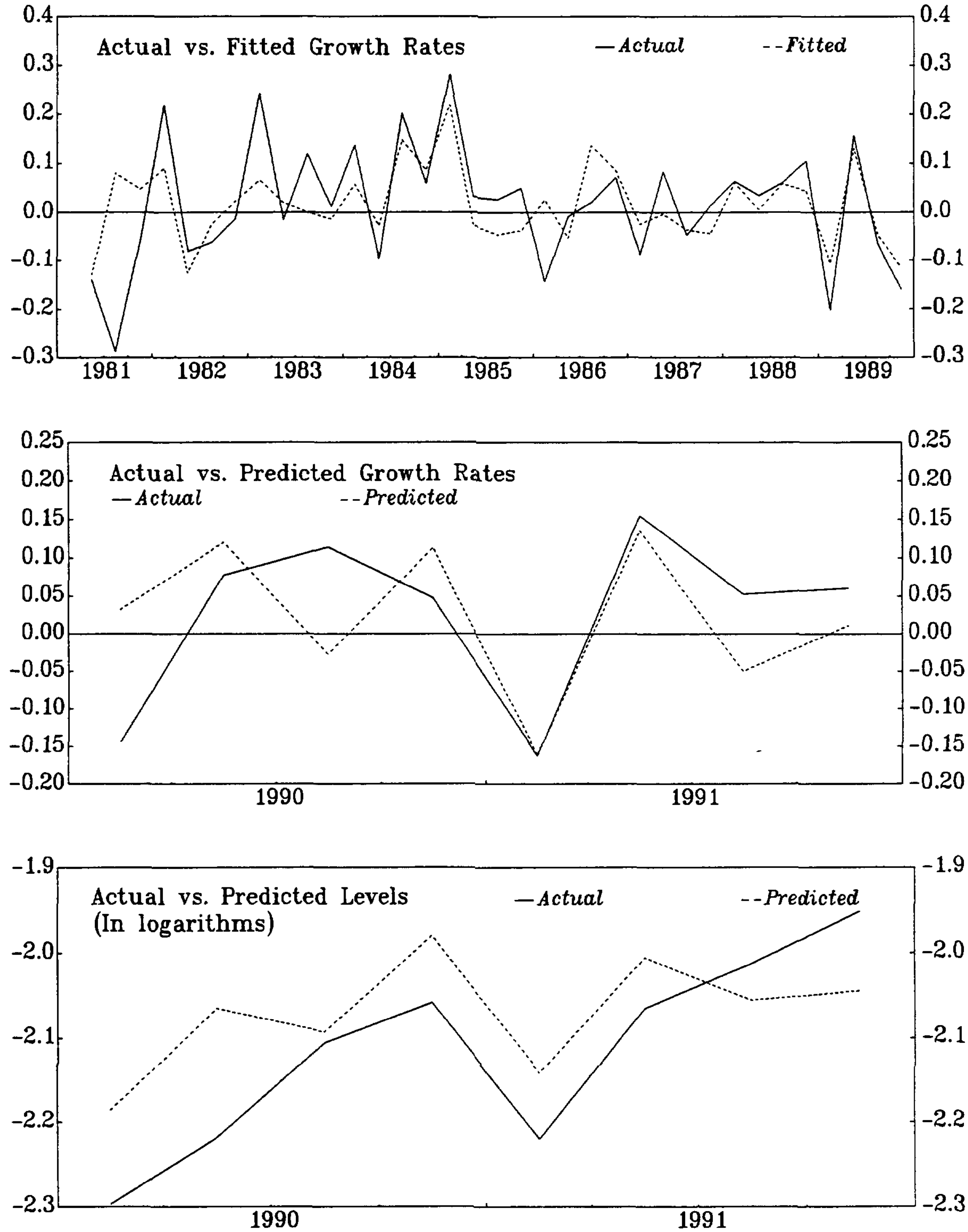


Sources: Data provided by the Chinese authorities; and staff estimates.

CHART 5

CHINA

ACTUAL, FITTED AND PREDICTED IMPORTS, 1981-91
(Johansen model)



Sources: Data provided by the Chinese authorities; and staff estimates.

Variables and Data Sources

The period studied here runs from the first quarter of 1981 to the fourth quarter of 1991.

M - total import value c.i.f. in yuan, quarterly data in International Financial Statistics (IFS), line 71.

P_m - unit value index of imports in U.S. dollars, quarterly data calculated by Brender (1992).

m - total import volume (M/P_m)

r - foreign exchange reserves in U.S. dollars, quarterly data in IFS, line 1d.d.

- exchange rate (yuan per U.S. dollar), IFS.

y - gross industrial output at constant 1990 prices, quarterly data from China Statistics Monthly.

p - overall retail price index, quarterly data from China Statistics Monthly.

Before estimation, all series were deseasonalized.

Summary of the Johansen Procedure

The main steps involved in estimating the error-correction model using the Johansen procedure are as follows:

1. Estimate the following equation by OLS

$$\Delta Z_t = \Gamma_{01}\Delta Z_{t-1} + \ldots + \Gamma_{0k-1}\Delta Z_{t-k+1} + \epsilon_{0t}$$

2. Estimate

$$Z_{t-k} = \Gamma_{11}\Delta Z_{t-1} + \ldots + \Gamma_{1k-1}\Delta Z_{t-k+1} + \epsilon_{1t}$$

3. Compute the product moment matrices of the residuals

$$S_{ij} = T^{-1}\sum_{t=1}^{T} \hat{\epsilon}_{it}\hat{\epsilon}'_{jt}; i,j=0,1.$$

4. Solve μ from the determinant

$$|\mu S_{11}-S_{10}S_{00}^{-1}S_{01}| = 0$$

The solution yields eigenvalues

$$\hat{\mu}_1 > \hat{\mu}_2 > \cdots > \hat{\mu}_n$$

and the associated matrix of eigenvectors

$$\hat{V} = [\hat{v}_1, \hat{v}_2, \cdots, \hat{v}_n]$$

The eigenvectors are normalized such that

$$\hat{V}' S_{11}\hat{V} = I.$$

If the cointegrating matrix β is of rank r < n, the first r eigenvectors are cointegrating vectors, given by the columns of matrix β.

5. Conduct the likelihood ratio test based on trace statistic of the null hypothesis $H_0(r)$: $\Pi=\alpha\cdot\beta'$, that is, there are at most r cointegration vectors. The test statistic is given by

$$LR_{trace} = -T\sum_{i=r+1}^{n} \ln(1-\hat{\mu}_i)$$

Also, the likelihood ratio statistic for testing the hypothesis that there are, at most, r cointegrating vectors against the alternative of r+1 cointegrating vectors, the maximum eigenvalue statistic, is given by

$$LR_{eigenvalue} = T \ln(1 - \mu_{r+1})$$

Johansen (1988) showed that LR is asymptotically distributed as a function of a Wiener process, and that the first r estimated eigenvectors $\hat{v}_1, \hat{v}_2, \ldots, \hat{v}_r$ are the maximum likelihood estimates of the columns of β, the cointegrating vectors. β can be interpreted as long-run parameters, after normalization.

Hansen's Tests for Parameter Instability

The standard linear regression model is given by:

$$y_t = \beta_1 x_{1t} + \ldots + \beta_m x_{mt} + e_t$$

This is estimated by least squares, yielding the estimates for β and σ^2 and the first order conditions:

$$0 = \sum_{t=1}^{n} x_{it}\hat{e}_t$$

$$0 = \sum_{t=1}^{n} (\hat{e}_t^2 - \hat{\sigma}^2)$$

where i=1,...,m.

Define

$$f_{it} = x_{it}\hat{e}_t$$

for i=1,...,m and

$$f_{it} = \hat{e}_t^2 - \hat{\sigma}^2$$

for i=m+1.

The first order conditions are equivalent to

$$0 = \sum_{t=1}^{n} f_{it}$$

for i=1,...,m+1.

Also define the cumulative first order conditions as

$$S_{it} = \sum_{j=1}^{t} f_{ij}$$

The individual stability test statistics are given by

$$L_i = \frac{1}{nV_i} \sum_{t=1}^{n} S_{it}^2$$

where

$$V_i = \sum_{t=1}^{n} f_{it}^2$$

For the joint stability test, define the vectors

$$f_t = (f_{1t}, \ldots, f_{m+1t})'$$
$$S_t = (S_{1t}, \ldots, S_{m+1t})'$$

The joint stability test statistic is given by

$$L_C = \frac{1}{n} \sum_{t=1}^{n} S_t' V^{-1} S_t$$

where

$$V = \sum_{t=1}^{n} f_t f_t'$$

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