The U.S. and Taiwan Trade Balance Revisited: A Comparison of the Instrument Variable and the VAR Models

Bwo-Nung Huang, Soong-Nark Sohng, and Chin-Wei Yang*

The single factor that lies at the core of Taiwan's remarkable economic growth is sustained export growth. During the past twenty-five years, the balance of trade between the U.S. and Taiwan has its share of volatility. Taking variables from different theories, we employ the instrument variable and the VAR model to dissect the problem. It ought to be pointed out that the private sector interest rate instead of the official rate plays a key role in the model. The substantial investment in mainland China from Taiwan has distorted the trade balance picture. (*JEL* Classification: F32, F41)

I. Motivation of the Study

Taiwan, an island in Pacific Ocean with limited natural resources, has no choice but to adopt export-oriented economic policy to sustain her economic growth. The ratio of export to gross

*Professor, Department of Economics, National Chung Cheng University, Chia-Yi, 621, Taiwan, (Tel) +886-5-2720411, (Fax) +886-5-2720816, (E-mail) ecdbnh@ccunix.ccu.edu.tw; Professor, Department of Economics, Clarion University of Pennsylvania, Clarion, PA 16214-1232 USA, (Tel) +1-814-226-2632, (Fax) +1-814-226-1910, (E-mail) sohng@mail.clarion.edu; and Professor, Department of Economics, Clarion University of Pennsylvania, Clarion, PA 16214-1232 USA, (Tel) +1-814-226-2609, (E-mail) yang@mail.clarion.edu, respectively. Financial support from National Science Council of Taiwan (#NSC85-2415-H194-004) is gratefully acknowledged, as is typographical assistance of Ms. C. J. Lin. Usual caveats apply.
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TABLE 1
TAIWAN'S EXPORTS AND IMPORTS AS THE PERCENTAGE OF THE GNP

Year	Export/GNP	Import/GNP
1965	19.36%	22.36%
1970	30.37%	30.42%
1975	39.86%	43.15%
1980	52.61%	53.80%
1985	53.33%	39.75%
1990	46.54%	41.22%
1991	47.30%	42.37%
1992	43.48%	40.82%

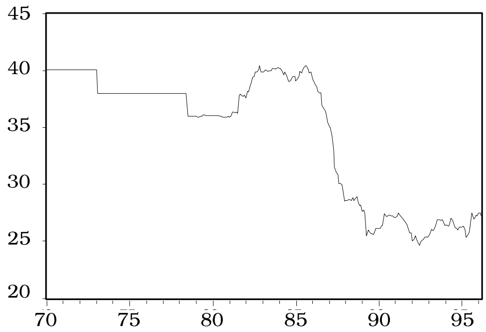
Source: NIAA data base at the Computer Center, Ministry of Education (Taiwan).

TABLE 2
VALUES OF EXPORT AND IMPORT (IN TRILLION TAIWAN DOLLARS) AND ITS SHARE(%) WITH RESPECT TO THE U.S. AND HONG KONG

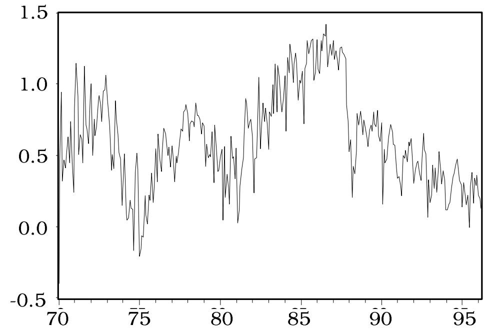
Year	Total Value of Export	Hong Kong (%)	The U.S. (%)	Total Value of Import	Hong Kong (%)	The U.S. (%)
1980	712	7.87	34.13	711	1.27	23.63
1982	864	7.06	39.47	736	1.63	24.18
1984	1204	6.89	48.84	870	1.72	22.99
1986	1507	7.30	47.71	917	1.53	22.46
1988	1731	9.19	38.71	1423	3.87	26.21
1990	1802	12.76	32.35	1471	2.65	23.05
1992	2047	18.95	28.92	1816	2.48	21.92
1994	2456	22.84	26.14	2261	1.81	21.14

Source: *Industries of Free China* (Executive Yuan of Taiwan)

national product (GNP) had increased from 20% in 1965 to 53.33% in 1985 before it decreased to 43.48% in 1992 (Table 1). Moreover, the U.S. has been the most important market for Taiwan's export; nearly as much as one half of the export went to the U.S. market at its peak. Since 1989 when the Taiwanese government approved investment in mainland China, the amount of export to Hong Kong



(a) Historical Trend of Taiwan-U.S. Exchange Rate



(b) Historical Trade Balances[1] between the U.S. and Taiwan

Note: 1) The relative trade balance graphed here is calculated based on $\log EX - \log IM$ in which *EX* and *IM* represent values of exports and imports of Taiwan.

Source: The ARE MOS data bank, computing center of Ministry of Education, Taiwan.

FIGURE 1

has skyrocketed. As direct trade is not allowed, Hong Kong serves as a transshipment center to facilitate the flow of capital and raw materials between Taiwan and mainland China. Consequently, the proportion of export to Hong Kong climbed to 22.84% in 1994, second only to the U.S. (Table 2). The proportion of import from the U.S. has been stabilized around 22% with a peak of 26.21% in 1988 (Table 2) when the Taiwan Dollar appreciated her value drastically. Having had a long-term favorable trade balance against the U.S., the Taiwan government was under pressure to appreciate her currency value from 40 (Taiwan dollars per U.S. dollar) to as much as 25 or a 37% appreciation (Figure 1 (a)). Would such appreciations of the Taiwan Dollar necessarily give license to a more balanced bilateral trade relation? An examination of Figure 1 (b) suggests the existence of a downward level shift in the mean value of trade balance. Could it be attributed to the currency appreciation or the huge emerging Chinese market or increasing amount of export to Hong Kong that serves as the transshipment center?

Although prior studies of this problem are modeled after standard economic theories in selection of variables, they do not consider the variables unique to Taiwan. In addition to the traditional regression analysis, we employ the time series models recently advanced to identify the key factors that explain the bilateral trade balance problem. The results of our study indicate that (1) interest rate of private sector more than that of government is a better predictor for trade balances, (2) the trade between the U.S. and Taiwan has dwindled since investment barriers on China was removed, (3) tariff rates could also be used as a microfoundation variable in explaining trade balances, and (4) the volatility of the exchange rate (New Taiwan Dollars per U.S. Dollar) plays an important role in determining trade balances with the correct sign on the estimated coefficients. The organization of the paper is as follows: The next section presents a comprehensive literature review; Section III includes data and models; Section IV discusses the empirical results; and Section V contains a conclusion.

II. Literature Review

Literature on balance of trade dates back to the elasticity approach known as the Marshall-Lerner condition: Depreciation can lead to an improved trade balance via price and quantity adjustment mechanism. At the other end of spectrum, Alexander (1952) proposed the income-expenditure approach in which income plays an important role in analyzing trade balance. Neither approach, however, takes values of currencies into consideration. According to the Walrasian Law, excess supply of the money market manifests itself in the excess demand of commodity and bond markets. That is, excess demand of the money market spells adverse trade balance. And these three approaches (or their combinations) dominate the empirical models in the choice of variables. For example, Rose and Yellen (1989) propose the following model:

$$TB_t = f(q_t, y_t, y_t^*), \tag{1}$$

where TB_t is the trade balance of time period t; $q_t = p_t^* e_t / p_t$ or real exchange rate in which p_t^* and p_t denote foreign and domestic prices respectively, and e_t is nominal exchange rate; y_t and y_t^* represent domestic and foreign real output respectively. Expanding on this formulation, Bahmani-Oskooee and Pourheydarian (1991) recast the model as

$$TB_t = f(q_t, y_t, y_t^*, m_t, m_t^*), \tag{2}$$

where m_t and m_t^* denote money supply of domestic and foreign economies respectively.

Great majority of studies before Rose and Yellen did not investigate stochastic properties of the time series variables. Examples abound: Miles (1979) regressed changes of trade balance on that of other macroeconomic variables while Bahmani-Oskooee (1985) applied regression technique on trade balance, output, exchange rate and money supply. Such a direct approach has lost its momentum since the seminal work by Nelson and Plosser (1982) in which they found the unit root property in most macroeconomic variables. A direct application of the regression model would very likely lead to the spurious correlation as pointed out by Granger and Newbold (1974). Without doubt, Rose and Yellen (1989) are among earlier pioneers who employ the concept of unit root and cointegration in analyzing the relationship among trade balances and macroeconomic variable. Prior works include the application of distributed lag model to the studies of the *J* curves (Bahmani-Oskooee 1985; Himarios 1985; Bahmani-Oskooee and Pourheydarian 1991). Other approaches circumscribe a wide variety of econometric techniques, i.e. seemingly unrelated estimates by Miles (1979) and instrument variable estimates by Felmingham (1988) and Rose and Yellen (1989). These reduced-form models suffer from the problem of the correlation due to errors in variables and disturbance terms, and the corresponding inconsistency could render the estimates quite unreliable.

Needless to say, the Granger causality technique is popularized in the trade balance literature as well. One of the most interesting studies is the so-called Feldstein Hypothesis: Would federal budget deficit Granger-cause the current account in the U. S.? Majority of such investigations point to the acceptance of the Feldstein Hypothesis. Darrat (1988) identifies feedback effects between the two variables under the floating exchange rate regime, but fails to locate any causality between the trade balances and other macroeconomic variables (e.g. money stock, inflation rate, and interest rate). In addition, Bachman (1992) finds that financial deficit Granger-causes trade balances, and Huang (1994) investigates the causality between trade balance and real output, money stock and exchange rate.

With the recent advances in the unit root and cointegration techniques, the focus of the research on trade balances has been shifted to the study of long-term equilibrium relationships among trade balance and other macroeconomic variables (e.g. Boucher 1991; Bahmani-Oskooee 1991 and 1992; Bahmani-Oskooee and Payesteh 1993; Arize 1994; Bahmani-Oskooee and Alse 1995). Boucher (1991) investigates the relationship among exchange rates, savings, and trade balances based on the identity of national income account identity:

$$X - M + V \equiv (T - G) + (S - I), \tag{3}$$

where X denotes export; M denotes import; V denotes net income of foreign investment; S denotes domestic private saving; I denotes domestic private investment; and G denotes government expenditure. Using the bivariate model, Boucher finds a significant cointegration between the net national saving and balance of trade. The absence of cointegration relation between the exchange rates and the balance of trade supports the Mundell-Mckinnon Hypothesis. In addition Boucher (1991) employs two sets of equilibrium conditions to explore the cointegration (multivariate) relations with respect to trade balance:

$$TB_t = \alpha + \beta q_t + \delta (y_t - y_t^*) + \theta (p_t - p_t^*) + e_t, \tag{4}$$

$$TB_t = \alpha + \sum_i \beta_i q_{t-i} + u_t, \tag{5}$$

where TB_t, q_t, y_t, y_t^*, p_t, p_t^* are trade balance, real exchange rate, domestic and foreign outputs, domestic and foreign prices respectively. Note the equation (5) describes the J curve phenomenon. Using quarterly data from the first quarter of 1974 to the second quarter of 1988, Boucher does not identity any cointegration relation.

Since the Autoregressive Conditional Heteroscedasticity (ARCH) model advocated by Engle (1982) and Bollerslev (1986), much attention has been focused on the speculative time series such as prices of financial assets or exchange rates. In particular, the volatility of exchange rates is found to exhibit the clustering phenomenon. As a result, the clumps of volatilities, not the exchange rates *per se*, play a critical role in trade balance. A plethora of papers have focused their analyses on the exchange rate volatility and its impacts on trade balance.[1] There seems to be a consensus that since the floating exchange system, the volatility of exchange rates has become more profound and profuse (Dornbusch 1989). The economic consequence of the increased risk in foreign exchange rate market manifests itself in the reallocation of resources from exporting sectors to non-exporting sectors, because greater volatility generally leads to decreased export activities as is supported by empirical studies (Edison and Melvin 1990). Majority of the research after 1990 resorts to the techniques of unit root, VAR, ARCH and ECM in order to analyze the impact of the volatility on trade balance (Koray and Lastrapes 1989; Asseery and Peel 1991; Savvides 1992). In particular, Savvides (1992) identifies unanticipated exchange rate volatility as the main cause of decreased real exports.

Another branch of study on trade balance and exchange rate changes is, to a considerable extent, based on microeconomic foundation. Among them are (i) overlapping generation models (Kareken and Wallace 1977; Fried 1980; Buiter 1981; Persson 1983; and Dornbusch 1989), (ii) intertemporal model (Sachs 1981; and Svensson and Razin 1983) and (iii) infinite-horizon overlapping generation model (Obstfeld 1982). As early as 1950, Harberger (1950), and Laursen and Metzler (1950), hypothesized that a deteriorating terms of trade would, in general, lead to a lower savings level which would in turn aggravate the current account. Viewed in this light, domestic savings play a pivotal role in the literature of trade balances. For example, several papers dealt with multiperiod investment behavior (e.g. Razin 1980; Marion and Svensson 1981; Sachs 1981; Bruno 1982; Svensson 1982; and

[1]Readers are referred to following papers: Hooper and Kohlhagen (1978); Abrams (1980); Akhtar and Hilton (1984); Gotur (1985); Kenen and Rodrik (1986); Thursby and Thursby (1987); Cushman (1983, 1988); De Grauwe (1988); and Bailey, Tavlas and Hlan (1987).

Helpman and Razin 1984). However, the dynamics of investment were not explicitly considered in these papers. In their overlapping generation model, Persson and Svensson (1985) discuss such dynamics: Temporary or permanent changes of the terms of trade and interest rates can exert different effects. Based on intertemporal models, Sen and Turnovsky (1989) as well as Gardner and Kimbrough (1989) explore the impact of different tariffs (anticipated or unanticipated, temporary or permanent) on the trade balances. The key parameters are found to be intertemporal substitution elasticities, budget deficit (surplus) and preference. In a different vein, Huang (1993) formulates the intertemporal model built upon a small open economy with incomplete capital market. Failing to consider interactive relations among real interest rate, terms of trade and trade balance, Huang does not provide a comprehensive model. Prior studies concentrate largely on trade balances for industrialized countries. Employing advanced time series techniques, the researchers adopt traditional macroeconomic variables to tackle the problem. In this study, we include both microeconomic and macroeconomic variables in the model to analyze the trade balance problem.

III. Model Formulation and Data Description

A. The Model

Variables selection of prior studies depends primarily on the choice of the models, i.e. the macroeconomics-based model (e.g. income, money supply) or intertemporal model (savings, investment, terms of trade). Yet in some cases, exchange rate volatility plays an important role. Our formulation as shown below is a hybrid of these models:

$$TB_t = f(\underset{-}{m},\ \underset{+}{m^*},\ \underset{+}{q},\ \underset{-}{r},\ \underset{+}{r^*},\ \underset{-}{y},\ \underset{+}{y^*},\ \underset{-}{Vq},\ \underset{-}{custx},\ X), \tag{6}$$

where TB_t = bilateral trade balance of time period t, and mathematically, $TB_t = \log EX - \log IM$ in which EX and IM are values of exports and imports;

m, m^* = domestic and foreign real money stock respectively;

$q = p_t^* e_t / p_t$ = real exchange rate;

p_t, p_t^* = domestic and foreign prices;

e = bilateral exchange rate (nominal);

y, y^* = domestic and foreign real income;

TABLE 3A

SOURCE OF DATA

Variable Name	Description	Source of Data
EX, IM	U.S.-Taiwan bilateral export and import values (in million Taiwan Dollars)	FSM Data Bank
$e_{\frac{TW}{US}}$	U.S.-Taiwan exchange rate (nominal)	IFS Data Bank
y, y^*	Industrial Production Index (line 66)	IFS Data Bank
m, m^*	currency+quasi-money (line 34 and line 35)	IFS Data Bank
r	Prime rate of First Bank (interest rate of private sector in Taipei)	FSM Data Bank
r^*	Interest rate of the U.S. money market	IFS Data Bank
custx	Tariff revenue	TAX Data Bank
IMP	Aggregate import	TRADE Data Bank
LBP	Labor productivity index (manufacturing sector, starting 1973:01)	WAGE Data Bank
MPIMAT	Price index of imported raw material (starting 1981:01)	PRICE Data Bank
EXTWHK	Value of export from Taiwan to Hong Kong	TRADE Data Bank
i, i^*, i_p	Domestic and foreign real interest rate (net of inflation) and private sector interest rate	Calculated Values
q	Real exchange rate	Calculated Values
EXTWUS	Value of export from Taiwan to U.S.	TRADE Data Bank
IMTWUS	Value of import from U.S. to Taiwan	TRADE Data Bank
TB	$\log EXTWUS - \log IMTWUS$	Calculated Values
Vq	Volatility of Taiwan Dollar/U.S. Dollar (real term)	Calculated Values
Vr	Volatility of the interest rate (private sector) of Taiwan	Calculated Values

custx=mean custom tariff=total tariff (monthly) / total import (monthly);[2]

X=other relevant variables such as dummy variables or seasonable dummies taken to explain the structural change; and

Vq=volatility of the exchange rate which is computed based on the definition by Koray and Lastrapes (1990) and Chowdhury (1993)

[2]Owing to the availability of custom duty data, we have to compute the general average rather than the weighted average custom duty.

TABLE 3B

CHRONOLOGICAL RECORDS OF MAJOR EVENTS

Time	Description of the Event
December, 1973 to 1974	The First Oil Crisis
October, 1979 to 1980	The Second Oil Crisis
August, 1978	Adoption of Floating Exchange Rate
October 19, 1987	DJIA Plummeted about 500 Points
November, 1987	Visitation of Relatives in Mainland China Approved
October 29, 1987	A Historically Low Yen/US Dollar Ratio of 137.55
August, 1986 and on	Bilateral Trade Negotiation Began
November, 1988	U.S. Negotiation Team Accuse Taiwan of Unfair Trade Practice
August 1990 to March 1991	The Gulf War
June, 1991	A Beginning of the Privatization of Taiwan Banks (15 Banks Were Allowed to Be Privately Owned)

Data Source: *Central Bank Quarterly* (Taiwan)

as shown below:

$$Vq = \left[\left(\frac{1}{m} \right) \sum_{i=1}^{m} (\log Q_{t+i-1} - \log Q_{t+i-2})^2 \right]^{\frac{1}{2}}. \tag{7}$$

Note that $m=12$ is the order of moving average, and Q_t is the growth rate of real exchange rate.[3] The signs beneath the variables of equation (6) are expected direction of response from the theories.[4]

B. Data and Sample Period

The sample period extends from January 1973 to March 1996, and the monthly data are obtained from AREMOS Data Bank, Ministry of Education, Taiwan.[5] Source of data, variable description and major events are reported in Table 3A and 3B to facilitate the model presentation.

[3]Other values of m are tried (e.g. $m=6$), but the results remain similar.

[4]Some signs may be ambiguous according to the empirical estimates.

[5]For time series plots of these variables, readers are referred to Huang (1996).

IV. Empirical Model and the Estimation Results of the U.S.-Taiwan Trade Balance

A. Unit Root Tests

Prior studies analyzing trade balances rely on, to a great extent, either single equation techniques or a joint-equation approach. While single equation techniques may render biased and/or inefficient estimate, the joint-equation approach, such as a VAR model does not have theoretical underpinnings and fails to take contemporaneous errors into consideration. In absence of a definitive advantage of either approach, we shall employ both models in hope of reaching a more reliable conclusion. As is well-known in the time series literature, the stationarity of model variables needs to be examined first. We adopt in this paper three different models: The augmented Dickey-Fuller (1979) or ADF, Phillips and Perron (1988) or PP, and Perron's Unit Root Test with structural change (1989). In their seminal paper, Dickey and Fuller (1979) formulated the following model:

$$\triangle y_t = (\rho - 1) y_{t-1} + \sum_{i=1}^{k-1} \theta_i \triangle y_{t-i} + a_t, \tag{8}$$

where a_t=residual that obeys white noise process with H_0: $\rho = 1$. Failure to reject the H_0 implies a unit root for y_t.

A similar model proposed by Phillips and Perron (1988), a nonparametric approach that adjusts for autocorrelation and heteroscedasticity, can be tested based on the following equation:

$$\tau_\mu = \hat{\tau}_\mu \left(\frac{S_a}{S_{Tn}} \right) - \frac{1}{2} (S_{Tn}^2 - S_a{}^2) \{S_{Tn}^2 T^2 (Y_{t-1} - Y_{-1})^2\}^{\frac{1}{2}}, \tag{9}$$

in which $S_{Tn}^2 = T^{-1} \sum_{t=2}^{T} a_t{}^2 + 2T^{-1} \sum_{j=1}^{n} w_{jn} \sum_{t=j+1}^{T} a_t a_{t-j}$, with $S_a{}^2$ being the sample variance or $S_a{}^2 = \sum_{t=2}^{T} \frac{a_t{}^2}{\mathrm{T}}$. Note that $w_{jn} = \left\{ 1 - \frac{j}{n+1} \right\}$ is the weight to assure the positivity of the S_{Tn}^2 .

It should be pointed out that Fuller's τ_μ table is needed for both ADF and PP tests with a drift term (Fuller 1976). In the absence of the drift term or in the presence of a trend, equations (8) and (9) are revised and compared with critical values of Fuller's τ_τ and τ values (Hamilton 1994). Moreover, the unit root test could lead to erroneous conclusions in the case of the mean shift caused by structural changes (Perron 1990; and Perron and Vogelsang 1992).

TABLE 4
RESULTS OF THE UNIT ROOT TESTS

Variable Name	ADF	PP	I(0) or I(1)	AO-ADF	I(0) or I(1)
EXTWHK	-3.1307	-10.0462*	?	-4.3457**	I(0)
LBP	-2.7430	-3.2195***	?	-3.6186	I(1)
TB	-2.4556	-5.2310*	?	-5.3504*	I(0)
MPIMAT	-1.7757	-1.8129	I(1)	-2.2765	I(1)
custx	-4.3212*	-11.1138*	I(0)		I(0)
q	-0.8838	-0.8448	I(1)	-2.9449	I(1)
m	-1.9117	-2.0758	I(1)	-2.7158	I(1)
m^*	-1.8828	-1.7927	I(1)	-2.7787	I(1)
i	-3.2199**	-8.7733*	I(0)		I(0)
i_p	-2.7286***	-6.8337*	?	-7.5038*	I(0)
i^*	-2.1439	-2.1093	I(1)	-3.4494	I(1)
Vq	-3.9429**	-3.8647**	I(0)		I(0)
Vr	-3.7932**	-12.8903*	I(0)		I(0)

Note: The critical values ($k=0$) from Table 1 of Perron and Vogelsang (1992) are -5.06, -4.42, -2.16, and -1.64 for 1%, 5%, 95% and 99% significance levels; ADF=Augmented Dickey-Fuller Unit Root Test; PP =Phillips and Perron Unit Root Test; AO-ADF=ADF test with AO-related structural changes. *=1% significance level, **=5% significance level, ***=10% significance level.

The level shift is considered a consequence of the existence of additive outliers (AO) and innovation outliers (IO) in the intervention analysis developed by Box and Tiao (1975), Chen and Tiao (1990), and Chen and Liu (1993). According to Perron and Vogelsang (1992), the unit root test in the case of the AO structural change is based on the following equations:

$$y_t = \mu + \delta DU_t + \hat{\varepsilon}_t \quad \text{for} \quad t=1, \cdots, T, \tag{10}$$

$$\hat{\varepsilon}_t = \sum_{i=0}^{k} w_i D(TB)_{t-i} + \rho \hat{\varepsilon}_{t-1} + \sum_{i=1}^{k} L_i \triangle \hat{\varepsilon}_{t-i} + e_t \quad \text{for } t=k+2, \cdots, T, \tag{11}$$

where $DU_t=1$, if $t>T_b$; $DU_t=0$ otherwise. The time when a major event took place is denoted by T_b; $D(TB)_t=1$ for $t=T_b+1$; $D(TB)_t=0$, otherwise. The null hypothesis is $\rho=1$. Similarly, the unit root model in the face of IO-related structural change can be formulated

TABLE 5

UNIT ROOT RESULTS OF THE FIRST-DIFFERENCED VARIABLES

Variable Name	ADF	PP
$\triangle LBP$	-10.54*	-39.88*
$\triangle MPIMAT$	-6.05*	-11.33*
$\triangle q$	-6.06*	-14.06*
$\triangle m$	-6.53*	-13.00*
$\triangle m^*$	-4.71*	-8.48*
$\triangle i^*$	-8.55*	-14.03*

Note: △=first difference
* denotes significant at 1%.

as:

$$y_t = \mu + \delta DU_t + \rho y_{t-1} + \sum_{i=1}^{k} C_i \triangle y_{t-i} + e_t. \tag{12}$$

The critical values of the two tests can be obtained from Tables 1 and 2 of Perron and Vogelsang (1992) for the hypothesis test.

An examination of Table 4 suggests readily that all the time series variables are found to be stationary except the import price of raw materials (*MPIMAT*), labor productivity of manufacturing sector of Taiwan (*LBP*), U.S.-Taiwan real exchange rate (*q*), real money supply of the U.S. (m^*), and Taiwan (*m*), and real interest rate of U.S. money market (i^*). Contrary to the result by Tsung and Hu (1996), the value of export to Hong Kong, interest of Taiwan (private sector), and U.S.-Taiwan trade balance are found to be stationary after taking AO-related or IO-related structural change into consideration. The discrepancy of the result indicates the erroneous conclusion that can be arrived at without considering the outliers in the unit root tests. Furthermore, we take the first-difference of all the variables in Table 4 with the property of I(1), and reapply the ADF and PP tests. The result of Table 5 immediately leads to the conclusion that they are indeed stationary after the first difference.

B. The Single Equation Model

Given that all the variables are stationary, a linear regression

TABLE 6
MODEL ESTIMATES

Instrument Variable Model

$$TB_t = 1.0418 - 0.0149\ i_{pt} + 0.1729\ TB_{t-1} + 0.2346\ TB_{t-2}$$
$$(6.1529)\quad (-2.6635)\qquad (2.5798)\qquad (4.0486)$$
$$-\ 4.2947\ Vq_t + 12.0567\ Vm2_t - 5.9254\ custx_t$$
$$(-2.2333)\qquad (4.5429)\qquad (-6.0269)$$
$$-\ 6.1361\ DSFINL - 0.2648\ DSMLD + \varepsilon_t$$
$$(-3.4651)\qquad (-5.4207)$$

$\overline{R}^2=0.8121$ $\quad D\text{-}W=2.0676$

Ljung-Box Q Statistics:

$Q(4)$ $\quad \chi^2_{(2)}=0.3915(.983)$ $\qquad Q(12)$ $\quad \chi^2_{(2)}=9.0753(.696)$

Note: Numbers in parentheses are t statistics; TB=U.S.-Taiwan trade balance (adjusted for seasonality); i_p=real interest rate of the private sector (Taipei); Vq_t=volatility of real exchange rate; $Vm2_t$=volatility of $m2$; $custx$=tariff revenue; $DSFINL$=the dummy variable for banding liberalization; $DSMLD$=the dummy variable for investment in mainland China.

model is amenable for the analysis. In addition, dummy variables are employed to capture the structural change as many major events occurred during the sample period. The instrument variable approach is deemed appropriate to avoid the inconsistency arising from the endogeneity of model variables. The result shown in Table 6 reveals that the single equation model explains about 79% of variation in the trade balance with all signs expected. The variables of domestic interest rate, tariff rate, volatility of M2, and volatility of real exchange rate are found to be significant.[6] In addition, two structural dummy variables are also found negatively significant: *DSFINL* and *DSMLD*. The privatization of banks in Taiwan (*DSFINL*) starting 1992 has liberalized the financial market which was under heavy-handed control by its government. As a result, the impact of volatility of the private sectors' interest rate in Taipei can better reflect the change in the U.S.-Taiwan balance of trade. Since the Taiwanese government legalized investment in mainland China

[6]We first estimate these coefficients based on equation (6) and find some are statistically insignificant. Table 6 includes the variables with significance level 10% or less. Due to pronounced seasonality, we deseasonalize the variables using X-11 model before estimation.

(*DSMLD*), there has been a significant structural change regarding the U.S.-Taiwan trade balance: Sizable amount of investment from export sectors in Taiwan has been shifted to China where manufacturing activities take place and finished products are then re-exported to the U.S. This substitution effect accounts for, to a great extent, decreasing trade surplus against the U.S.

We should point out that the interest rate of the private sector rather than the official rate plays a key role in the model.[7] Prior studies invariably employed official interest rates in explaining the variation in the U.S.-Taiwan trade balances, and results are ambiguous and weak.[8] As is well-known in the literature of international trade, the impact of changing interest rate on trade balance is two-fold. On the one hand, demand for domestic currency rises as the interest rate increases. The resulting appreciation of the domestic currency generally has a negative effect on trade balances. On the other hand, rising interest rates discourage current consumption of imports via the so-called intertemporal substitution effect. It would therefore improve the trade balance. The net result depends on the magnitudes of these two conflicting effects. The results by Tsung and Hu (1996) and Lee (1997) have verified that the intertemporal effect is insignificant in the two-tiered financial market. Consequently we expect a negative sign for the variable of domestic interest rate.

Similar to the findings in other studies the volatility of the exchange rate (Taiwan Dollar/U.S. Dollar) had a significant negative impact on the trade balance (5% significance level). As volatility of exchange rate increases, uncertainty would shift the resources away from exporting sectors. Often ignored in such models, the volatility of the domestic money supply (M2) plays an important role in this model: as well as (with the volatility) M2 increases, its impact on economy is positive and transmits itself to export sectors. The effect of a tariff (temporary or not) on trade balances has remained largely unsettled. In the short run, however, it is generally agreed that a tariff would deteriorate the balance of trade, as is witnessed in our analysis.

Without doubt, the financial variables, tariff and labor pro-

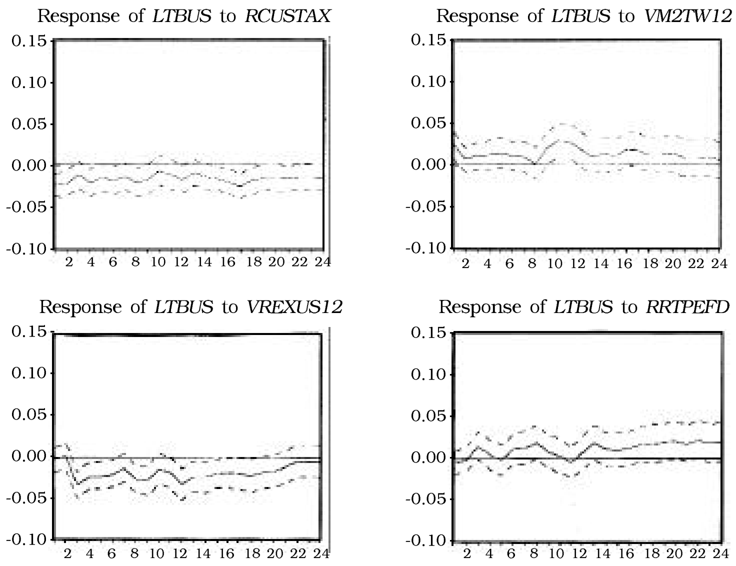
[7]The real interest rate i was found insignificant in the estimation.

[8]The role of private-sector interest rate was first mentioned by Hsu (1980), but was left unaddressed.

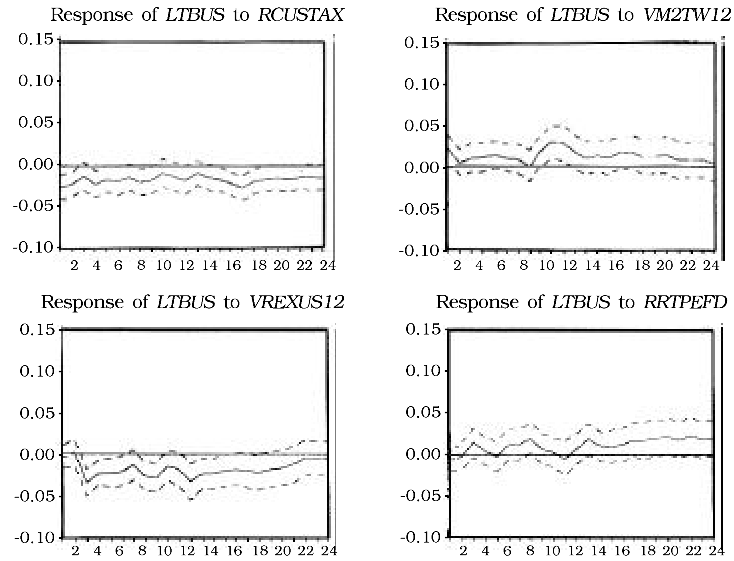
ductivity play key roles in the instrument variables model. However, it is the volatility of the exchange rate, not the exchange rate *per se*, that impacted the trade balance with a significance level of 5%. Perhaps, the most important factor in the analysis is the structural dummy variable: The overwhelming investment on mainland China has effectively masked the picture of the U.S.-Taiwan trade relations. In a nutshell, we have found that the appreciation of the New Taiwan Dollar should not be taken as the factor of decreasing the U.S.-Taiwan trade. The determining factors are (i) Taiwan's investment on mainland China, (ii) liberalization of financial institutions and (iii) instable financial policies during the period.

C. VAR Model

The vector autoregression (VAR) model known for its strength in incorporating various combinations of lagged endogenous variables, does not need an *a priori* theoretical foundation. While it is frequently applied in innovation analysis, the VAR model has its limitation: an *ad hoc* decomposition method due to some arbitrary order of variable appearance can give rise to different results. This limitation notwithstanding, VAR models being computationally efficient and theoretically simple are still widely accepted especially during the 1980's. In this section, we employ a five-variable VAR model with variables chosen from the single equation model. Note that all the five variables—tariff rate (*custx*), volatility of the domestic money supply M2 ($Vm2$), volatility of the real exchange rate (Vq), interest rate of private sector in Taipei (i_p), and the U.S.-Taiwan trade balance (*TB*) are found to be stationary; and hence are amenable to the analysis. With monthly data it is a good idea to include at least twelve lags in the regression. (Hamilton 1994, p. 583). This being the case, the estimated results based on VAR(12) model are employed to calculate impulse response functions (two standard deviations shock). In addition to the five variables, the structural dummies (*DSFINL* and *DSMLD*) are also included as exogenous variables. Shown in Figure 2 (a) are impulse response functions with two standard deviations of average tariff (*custx*), volatility of domestic money stock M2 ($Vm2$), volatility of the real exchange rate (Vq), interest rate of the private sector (i_p), and the U.S.-Taiwan trade balance (*TB*) respectively. Similarly, the impulse response functions are reported in Figure 2 (b) in the order of $Vm2$, Vq,



(a) Impulse Response Functions with Variable Order #1



(b) Impulse Response Functions with Variable Order #2

Note: order #1: $custx - Vm2 - Vq - i_p - TB$;
order #2: $Vm2 - Vq - custx - i_p - TB$.

FIGURE 2

custx, i_p and *TB*. A perusal of Figure 2 (a) and 2 (b) suggests that the order of the variable appearance does not make a noticeable difference. In general, innovation of tariff has some palpable (negative) effects in periods 1, 2, 4, 8, 17 on the U.S.-Taiwan trade balance; the volatility of money supply (M2) exerts its impact (positive) in period 1 and 10; the volatility of the real exchange rate has its negative impact (on the trade balance) felt in periods from 3, through 14 except period 7 and 10. These results are very much in agreement with the single equation estimates. The domestic interest rate, however, does not seem to have a noticeable impact on the trade balance. Barring this, the two models employed in this paper are nearly qualitatively identical.

V. Conclusion

For the past twenty years, Taiwan has witnessed a remarkable economic growth, and in no small part, can it be attributed to sustained export growth. We include in our model a combination of variables from different theories. In general, five key variables — tariff, real interest rate, volatility of the exchange rate, volatility of domestic money supply (M2) and lagged trade balance — explain more than 80% of the variation of the U.S.-Taiwan trade balances. It ought to be noticed that the real interest rate of private sector in Taipei, not the official rate, plays a key role in the model. No less important than these variables, the structural dummy variables are pivotal in the U.S.-Taiwan trade relations. The substantial investment in mainland China from Taiwan has decreased the size of favorable trade balance against the U.S. The "detour" via Hong Kong represents a structural break which is properly addressed in our paper. Consistent with the theory in international trade, a currency appreciation does not necessarily cause improvement in trade balances. Finally, it is interesting to find out that volatility of financial variables plays a major role in explaining U.S.-Taiwan trade balances.

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