

The J-curve effect and the US–Canada forest products trade

Jungho Baek*

Center for Agricultural Policy and Trade Studies, Department of Agribusiness and Applied Economics, North Dakota State University, USA

Received 1 February 2006; accepted 15 November 2006

Abstract

This paper examines the dynamic effect of the US–Canada exchange rate on bilateral trade of forest products between the two countries. Special attention is given to investigate the J-curve hypothesis: whether or not the trade balance for US forest products trade with Canada benefits from a decline in the value of the US dollar. We adopt the autoregressive distributed lag (ARDL) approach to cointegration to estimate quarterly bilateral trade data between the US and Canada from 1989 to 2005. We find little evidence of the J-curve phenomenon for US forest products trade with Canada.

© 2006 Elsevier GmbH. All rights reserved.

JEL classification: F140; L730

Keywords: Autoregressive distributed lag approach to cointegration; Exchange rate; Forest products trade balance; J-curve effect; Softwood lumber

Introduction

During the second half of the 1990s, the US forest products trade deficit and the increase in the value of the US dollar went hand in hand. For example, during the

*Tel.: +1 701 231 7451; fax: +1 701 231 7400.

E-mail address: jungho.baek@ndsu.edu.

1995–1999 period, the value of the US dollar increased by approximately 14%, 23%, and 28% against the Canadian dollar, the Japanese yen, and the euro, respectively. Accordingly, the US trade deficit in forest products increased from \$2.5 billion in 1995 to \$10.1 billion in 1999. After the US dollar peaked in value in 2002, the period of dollar decline started. For example, during the 2002–2004 period, the US dollar has declined by approximately 17%, 10%, and 20% against the Canadian dollar, the Japanese yen, and the euro, respectively. Despite the fall in the value of the US dollar, the US trade deficit in forest products has widened to almost \$18 billion in 2004, up 72% from 1999 (Fig. 1).

The conventional wisdom of the effect of exchange rate changes on the trade balance is called the J-curve effect. Assuming that the Marshall–Lerner (ML) condition – the sum of domestic and foreign price elasticities of demand (in absolute value) is greater than one – holds, it is possible that, after a depreciation, an initial deterioration in the trade balance occurs before an improvement is realized. The hypothesized response of the trade balance over time resembles a titled J in shape. The J-curve effect is attributed to a lagged adjustment of quantities to changes in relative prices (Magee, 1973; Junz and Rhomberg, 1973). For example, if there is a real depreciation of the domestic currency, then the increased competitiveness of prices for the domestic country leads to exporting more and importing less, thereby improving the trade balance, which is known as the volume effect. However, the depreciation of the domestic currency increases the unit value of import and results in a deterioration of trade balance, which is referred to as the value (price) effect. The value effect prevails in the short-run, while the volume effect dominates in the long-run, which causes the time path of the trade balance depicted by the J-curve phenomenon (Krugman and Obstfeld, 2001).

Many studies have been conducted to examine the J-curve effect in the international economics literature. The evidence that emerged from the literature is rather mixed. Some studies have confirmed the presence of the J-curve phenomenon (for example, Bahmani-Oskooee, 1985; Noland, 1989), while others

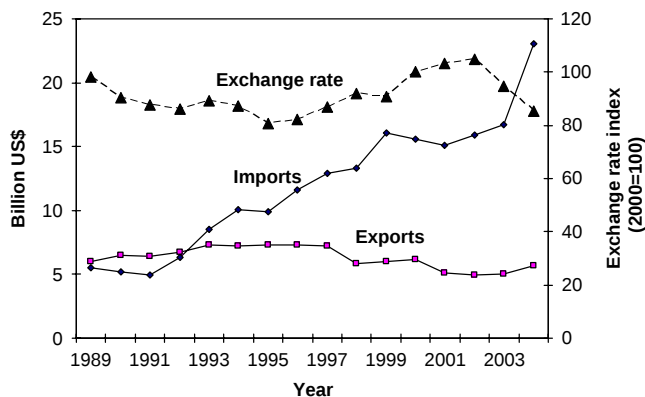


Fig. 1. US forest products trade and exchange rate.

have denied its existence (for example, [Rose and Yellen, 1989](#); [Rose, 1991](#)). These studies can be classified into two categories. With aggregate data, the first group uses a two-country (i.e., home and foreign) model to investigate the J-curve phenomenon (for example, [Guptar-Kapoor and Ramakrishnan, 1999](#)). By arguing that the results obtained by the first group may not be robust due to aggregation bias of data, the second group employs bilateral trade flows between a country and its main trading partners to analyze the J-curve effect (for example, [Bahmani-Oskooee and Brooks, 1999](#)).

In the literature on forest economics, on the other hand, most studies have mainly focused on the impacts of exchange rate changes on forest products trade volume and/or prices ([McCarl and Haynes, 1985](#); [Adams et al., 1986](#); [Buongiorno et al., 1998](#); [Buongiorno and Uusivuori, 1991](#); [Sarker, 1996](#); [Sun and Zhang, 2003](#); [Bolkesjø and Buongiorno, 2006](#)).¹ Relatively little attention has been paid to investigate the impact of exchange rate changes on the trade balance. To our knowledge, [Kaiser \(1984\)](#) is the only study that has investigated the effect of changes in exchange rate on the US forest product trade balance. Based on a descriptive method, he finds that the depreciation of the US dollar is the one of the most effective trade policies to increase US forest products exports and thus to stabilize the US trade balance.

The objective of this study is to examine the dynamic effects of exchange rate changes on the US trade balance in forest products. The empirical focus is on the characteristics of the short-run response (J-curve effect) and empirically determining whether or not the forest product trade balance benefits from a decline in the value of the US dollar. For this purpose, we use bilateral trade data of forest products between the US and Canada, and classify the US trade balance into five categories: softwood lumber, hardwood lumber, panel/plywood product, logs and chips, and other wood product. Canada consists of approximately 40% of US trade in forest products. Softwood lumber accounts for the largest share of the US–Canada bilateral trade, followed by panel/plywood, other wood product, hardwood lumber and logs and chips ([Table 1](#)). An autoregressive distributed lag (ARDL) approach to cointegration or an ARDL bound testing approach (referred to here as ARDL model) developed by [Pesaran et al. \(2001\)](#) is applied to these data. The ARDL model has certain econometric advantages in comparison to standard cointegration methods (e.g., [Engle and Granger, 1987](#); [Johansen, 1995](#)). First, the ARDL model is applicable irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$ or mutually cointegrated. In other words, this approach does not require the same order of integration among variables and pre-testing for unit roots. Second, the ARDL model takes sufficient numbers of lags

¹For example, [Adams et al. \(1986\)](#) use a structural econometric model (i.e., two-stage least squares) to analyze the role of exchange rate on the North American softwood lumber market. They conclude that an increase in exchange rate had played a key role in the expansion of Canadian share of the US market for the 1950–1983 period. More recently, [Bolkesjø and Buongiorno \(2006\)](#) adopt the vector autoregressive (VAR) model to examine the short- and the long-run impacts of exchange rate changes on US trade in forest products. They find that a change in the value of the US dollar significantly affects US forest products trade in both short- and long-run.

Table 1. US forest products trade, 2004

Commodities	Canada	Other
<i>Exports (million dollars)</i>		
Softwood lumber	110 (5.5)	326 (8.9)
Hardwood lumber	435 (21.6)	1024 (27.8)
Panel/plywood product	441 (21.9)	602 (16.4)
Logs and chips	446 (22.1)	1085 (29.5)
Other wood product	583 (28.9)	644 (17.5)
Total	2015 (100.0)	3681 (100.0)
<i>Imports (million dollars)</i>		
Softwood lumber	6689 (46.7)	1474 (16.9)
Hardwood lumber	301 (2.1)	335 (3.8)
Panel/plywood product	4286 (30.0)	2829 (32.4)
Logs and chips	182 (1.3)	37 (0.4)
Other wood product	2851 (19.9)	4062 (46.5)
Total	14,309 (100.0)	8737 (100.0)

Source: Foreign Agricultural Service (FAS Online).

Note: Numbers in parentheses are % shares of total exports and imports. Commodities are classified by the Bulk, Intermediate, and Consumer-Oriented (BICO) code. Softwood lumber includes treated lumber. Panel/plywood product includes hardboard, hardwood plywood, hardwood veneer, particleboard, softwood plywood, softwood veneer, and wafferboard and OSB. Other wood product is defines as builders carpentry, hardwood and softwood flooring/molding/siding, and railroad ties.

to capture the data generating process in a dynamic framework of a general-to-specific modeling. Third, an error-correction model (ECM) can be derived from the ARDL model through a simple linear transformation. The ECM captures the short-run dynamics while restricting the long-run equilibrium. The ARDL thus estimates the short- and long-run parameters of the model simultaneously. Finally, the ARDL model is more robust and performs better for small sample size than standard cointegration methods (Pesaran and Shin, 1999). The remaining sections present theoretical framework, empirical models and data, empirical results, and conclusions.

Theoretical framework

The traditional J-curve theory assumes that a country's exports are denominated in domestic currency and imports are in foreign currency (Magee, 1973). To derive the theoretical J-curve effect, the trade balance is defined as the difference between value of exports and value of imports as follows:

$$TB = P_x X - eP_x^* M, \quad (1)$$

where TB is the trade balance in domestic currency; P_x is the domestic export price in domestic currency; P_x^* is the foreign export price in foreign currency; $X(M)$ is the

quantity of exports (imports); and e is the exchange rate expressed as domestic currency per foreign currency.

To show the possible effect of exchange rate changes on trade balance, we then differentiate Eq. (1) with respect to exchange rate (e) and put the results in elasticity form as follows:

$$\frac{dTB}{de} = P_x X \left[\frac{(1 + \varepsilon)\eta^*}{(\varepsilon + \eta)} \right] - e P_x^* M \left[\frac{(1 - \eta)\varepsilon^*}{(\varepsilon^* + \eta)} \right], \quad (2)$$

where $\eta(\eta^*)$ denotes the absolute value of the domestic (foreign) price elasticity of demand; and $\varepsilon(\varepsilon^*)$ denotes the absolute value of the domestic (foreign) price elasticity of supply. Eq. (2) is known as the Bickerdike–Robinson–Metzler condition, or the elasticity approach. If trade is in balance ($TB = 0$) in an initial equilibrium, and both supply elasticities are infinite ($\varepsilon \rightarrow \infty$ and $\varepsilon^* \rightarrow \infty$), then Eq. (2) reduces to the well-known ML condition; a country's devaluation can improve a trade balance when the sum of domestic and foreign price elasticities of demand (in absolute value) exceeds one ($\eta + \eta^* > 1$).²

The elasticity approach identifies three different periods after a devaluation in which the adjustment process of the trade balance is affected by different factors: the currency-contract period, the pass-through period and the quantity-adjustment period (Magee, 1973). The current-contract period is defined as the short-period immediately after a devaluation in which the export and import contracts are specified before the change. For example, consider the case in which domestic export contracts are denominated in domestic currency and domestic import contracts denominated in foreign currency. In this case, a devaluation of domestic currency increases exchange rate (e) in Eq. (1) and immediately deteriorates trade balance in the currency-contract period before any price and volume changes. The pass-through period is defined as the period after a devaluation in which prices can change but quantities of exports and imports remain unchanged. This is also known as the value (price) effect. This effect depends on the scale of demand and supply elasticities of exports and imports. For example, consider the situation in which both domestic and foreign demand for imports are inelastic in the short-run. Under this circumstance, Eq. (2) can be reduced to as follows:

$$\frac{dTB}{de} = P_x X - e P_x^* M. \quad (3)$$

²The models dealing with the question of whether depreciation of the domestic currency would improve a country's trade balance can be classified into three categories: elasticity, absorption, and monetary approaches. In the elasticity approach, the effects of changes in exchange rate on the trade balance are determined by the demand and supply elasticities of exports and imports. In the absorption approach, on the other hand, the trade balance is determined by real national income and its absorption (consumption). Any improvement (decline) in the trade balance requires an increase (decrease) in domestic income over total domestic expenditures (Kruger, 1983). Finally, according to the monetary approach, the trade balance is essentially a monetary phenomenon. Money and asset markets determine the trade balance (i.e., capital account) through changes in supply and demand of the stock of money (Buluswar et al., 1996).

As a consequence of a devaluation, the import price measured in domestic currency (eP_x^*) increases but the demand stays the same, thereby resulting in an increase of value of imports, which is known as full pass-through. On the other hand, the export price in foreign currency decreases by the same proportion of the exchange rate variation (full pass-through) and the export price in domestic currency (P_x) remain unchanged. To combine both the currency-contract and the pass-through effects, therefore, the trade balance in domestic currency is expected to decrease following a J-curve pattern before any trade volume changes.

The quantity-adjustment period is defined as the period in which quantities start to adjust in response to changes in prices. This is also known as the volume effect. Under this circumstance, as both export and import elasticities increase, domestic volume of exports (imports) increases (decreases) in response to the price drop (increase) in foreign (domestic) currency. As a result, the trade balance eventually improves as long as the ML condition is satisfied. It should be noted that, although we adopt the elasticity approach for our analysis, we directly deal with the trade balance in the model, instead of analyzing the demand and supply elasticities separately.

Empirical models and data

Empirical models

To construct the ARDL model, we first derive a trade balance model of forest products by relying on the theoretical framework developed by [Rose and Yellen \(1989\)](#). For this purpose, the demand for imported forest commodities at home and in a foreign country is specified as follows:

$$M^d = M^d(P_m, Y) \quad \text{and} \quad M^{d*} = M^{d*}(P_m^*, Y^*), \quad (4)$$

where $M^d(M^{d*})$ is the import quantity of the home (foreign) country; $P_m(P_m^*)$ is the relative price of imported forest goods to domestically produced goods in the home (foreign) country; and $Y(Y^*)$ is the real income of the home (foreign) country. Similarly, the supply of exported forest commodities at home and in a foreign country is stated as follows:

$$X^s = X^s(P_x, Y^*) \quad \text{and} \quad X^{s*} = X^{s*}(P_x^*, Y), \quad (5)$$

where $X^s(X^{s*})$ is the export volume of the home (foreign) country; and $P_x(P_x^*)$ is the home (foreign) country's relative price of export goods.

The market equilibrium conditions for exports and imports are then:

$$M^d = X^{s*} \quad \text{and} \quad M^{d*} = X^s. \quad (6)$$

Assuming that the law of one price prevails in a perfectly competitive market, we can write $P = ER \times P^*$, where ER is the exchange rate between the domestic and the foreign currency. Given Eqs. (4)–(6), therefore, the trade balance (TB) defined as

the difference between value of exports and value of imports can be specified as follows:

$$TB = X^s(Y^*, ER) - M^d(Y, ER). \quad (7)$$

Finally, in its reduced form, Eq. (7) shows the following relationship:

$$TB = TB(Y, Y^*, ER). \quad (8)$$

To illustrate the ARDL modeling approach, we then express Eq. (8) in a log-linear form as follows:

$$\ln TB_{i,t} = \alpha + \beta_1 \ln Y_t^{US} + \beta_2 \ln Y_t^{CA} + \beta_3 \ln ER_t + \varepsilon_t, \quad (9)$$

where $TB_{i,t}$ is the US trade balance with Canada (expressed as trade deficit), i = softwood lumber, hardwood lumber, panel/plywood, logs and chips and other wood product; Y_t^{US} is the real US income; Y_t^{CA} is the real Canadian income; ER_t is the bilateral real exchange rate between the US and Canada; and ε_t is the error term. With regard to the signs of the coefficients in Eq. (9), it is expected that $\beta_1 > 0$ and $\beta_2 < 0$, since a rise in US (Canada) income leads to an increase in US imports (exports), thereby deteriorating (improving) the trade balance. As to the effect of exchange rate, it is expected that $\beta_3 > 0$, since the depreciation of the US dollar increases exports and decreases imports, thereby improving the trade balance.

The ARDL approach involves estimating the error correction version of the ARDL model for variables under estimation (Pesaran et al., 2001). From Eq. (9), the ARDL model of interest then can be written as follows:

$$\begin{aligned} \Delta \ln TB_{i,t} = & \alpha_0 + \sum_{i=1}^p \varepsilon_i \Delta \ln TB_{t-i} + \sum_{i=1}^p \phi_i \Delta \ln Y_{t-i}^{US} \\ & + \sum_{i=1}^p \varphi_i \Delta \ln Y_{t-i}^{CA} + \sum_{i=1}^p \gamma_i \Delta \ln ER_{t-i} \\ & + \lambda_1 \ln TB_{t-1} + \lambda_2 \ln Y_{t-1}^{US} + \lambda_3 \ln Y_{t-1}^{CA} \\ & + \lambda_4 \ln ER_{t-1} + u_t, \end{aligned} \quad (10)$$

where Δ is the difference operator; p is lag order; and u_t is assumed serially uncorrelated. Eq. (10) is called the error correction version related to the ARDL, since the terms with the summation signs ($\sum$) represent the short-run dynamics between the trade balance and its main determinants (i.e., J-curve effect) while the second part (terms with λ 's) corresponds to the long-run (cointegration) relationship. The null hypothesis in Eq. (10) is defined as $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$, indicating the non-existence of the long-run relationship.

Data

As noted in the introduction, the main purpose of this paper is to examine the short-run effects of exchange rate changes on the forest products trade between the US and Canada. For this purpose, using the Foreign Agricultural Service

(FAS Online) classified by the Bulk, Intermediate, and Consumer-Oriented (BICO) code, we identify the US trade balance in five categories: softwood lumber, hardwood lumber, panel/plywood, logs and chips, and other wood products. Quarterly data are collected for the period of 1989q1–2005q1.

The total values of exports and imports for forest commodities between the US and Canada are obtained from the FAS Online in the US Department of Agriculture (USDA). The US trade balance (TB_t) is then expressed as the ratio of imports to exports (trade deficit) for forest products with Canada.³ The US and Canadian real income (Y_t^{US} and Y_t^{CA}) are measured as real GDP index (2000 = 100) and are taken from the International Financial Statistics (IFS) published by the International Monetary Fund (IMF). The US–Canada real exchange rate (ER_t) is collected from the Economic Research Service (ERS) in the USDA. Since the exchange rate is expressed as Canadian dollars per the US dollar, a decline in exchange rate indicates a real depreciation of the US dollar. Finally, it should be noted that, since all variables are converted to natural logarithms, the estimated coefficients could be interpreted as elasticities.

Empirical results

The ARDL modeling procedure starts with determining the appropriate lag length (p) in Eq. (10). Note that, since Eq. (10) is based on the assumption that u_t is serially uncorrelated, it is important to balance between choosing p sufficiently large to mitigate the residual serial correlation problems and sufficiently small to avoid over-parameterized, particularly in view of the limited time-series data which are available (Pesaran et al., 2001, p. 308). For this purpose, we use the Akaike Information Criterion (AIC) and Lagrange multiplier (LM) statistics for testing the hypothesis of no serial correlation against orders 1 and 4, respectively (Table 2).⁴ For example, the AIC indicates that $p = 3$ is the most appropriate lag length for US–Canada trade in softwood lumber. The LM statistics also show that the null of no serial correlation cannot be rejected at $p = 3$. For panel/plywood product, on the other hand, the AIC suggests $p = 2$. However, the LM statistic shows that the null of serial correlation can be rejected at $p = 2$ and even $p = 1$, which provides the second highest AIC statistic. We then select $p = 4$, which gives the third highest AIC statistic as well as the acceptance of no serial correlation. Similarly, $p = 3$ is the most appropriate lag

³One of major reasons for using the ratio is that it is not sensitive to the units of measurement and can be interpreted as real trade balance. Second, the ratio can narrow the range of the variable to make it less susceptible to outlying or extreme observations (Wooldridge, 2000). Finally, the ratio can be transformed into a logarithmic form without being concerned about possible negative values.

⁴To ensure comparability of results of different choices of lag length, all regressions are computed over the same sample period, 1990q3–2005q1, with the first six observations reserved for the construction of lagged variables. In addition, it is found that lagged changes of the income variables in both countries are insignificant (either single or jointly) in all estimators. To avoid unnecessary over-parameterization, therefore, we re-estimate the regressions without these lagged variables, but including lagged changes of all other variables ($TB_{t,t-1}$, ER_t).

Table 2. A partial summary of statistics for selecting the lag order and F -statistic of US–Canada forest trade balance equation

Trade balance	Lag order	1 lag	2 lags	3 lags	4 lags	5 lags
Softwood lumber trade balance	AIC	−0.70	−0.69	−0.63	−0.89	−0.88
	$\chi^2_{SC}(1)$	6.63*	0.01	0.36	1.79	3.36
	$\chi^2_{SC}(4)$	13.34*	3.15	5.25	11.30*	19.78*
	F -statistic	4.52	3.64	4.45	2.98	2.66
Panel/plywood trade balance	AIC	−1.21	−1.20	−1.25	−1.23	−1.30
	$\chi^2_{SC}(1)$	4.16*	0.01	9.61*	2.64	3.63
	$\chi^2_{SC}(4)$	12.87*	16.13*	14.04*	6.04	6.38
	F -statistic	2.10	1.16	2.31	3.56	2.80

Note: *denotes significance at the 5% level. AIC represents Akaike Information Criterion for a given lag length. $\chi^2_{SC}(1)$ and $\chi^2_{SC}(4)$ are LM statistics for testing no serial correlation against orders 1 and 4. The F -statistic for 5% critical value bounds is (3.23, 4.35). The critical values are obtained from Table CI in Pesaran et al. (2001).

length for both hardwood lumber and other wood product, while $p = 2$ is selected for lags and chips.

Then, we conduct the bound test for the existence of a level relationship (cointegration) among variables. More specifically, unlike a standard vector autoregressive model, Eq. (10) includes the lagged level of variables. This linear combination of lagged variables replaces the lagged error-term in a standard ECM. It is thus necessary to decide whether we should retain the lagged level of variables in Eq. (10). If we do, the variables are said to be cointegrated. For this purpose, the null hypothesis of no cointegration ($\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$) in Eq. (10) is tested, irrespective of whether the regressors are purely $I(0)$, purely $I(1)$ or mutually cointegrated.⁵ This can be done by comparing the calculated F -statistic with two sets of asymptotic critical values tabulated by Pesaran et al. (2001) in which all the regressors are assumed to be purely $I(0)$ or purely $I(1)$.⁶ More specifically, if the computed F -statistic exceeds the upper critical value, the null hypothesis of no long-run relationship can be rejected regardless of whether the underlying order of integration of the variables are $I(0)$ or $I(1)$. Similarly, if the computed F -statistic falls below a lower critical value, the null hypothesis cannot be rejected, supporting lack of cointegration. With $p = 3$ for the US–Canada trade in softwood lumber, for

⁵To determine whether a deterministic linear trend is required, Eq. (10) is estimated with and without a linear trend. However, our findings are more conclusive when the F -test is applied to Eq. (10) without a linear trend.

⁶Pesaran et al. (2001) have tabulated two sets of critical values; the upper bound values assume all variables are purely $I(1)$ and the lower bound values assume that they are purely $I(0)$. This is called a bounds testing procedure, since the two sets of critical values provide bounds for all possibilities of the regressors into purely $I(0)$, purely $I(1)$ or mutually cointegrated.

example, the F -statistic is 4.45, which exceeds the upper level of the 5% critical bounds (Table 2).⁷ As such, this result supports the existence of the long-run relationship between the softwood lumber trade and its main determinants. In addition, with $p = 3$ for other wood products and $p = 2$ for logs and chips, the null hypothesis is conclusively rejected at the 5% significance level. Overall, the results support the existence of cointegrated trade balance equations when using $p = 3$ for softwood lumber and other wood products, and $p = 2$ for logs and chips trade between the US and Canada. On the other hand, the test results for panel/plywood and hardwood lumber are 3.56 ($p = 4$) and 3.61 ($p = 3$), respectively, which falls within the 5% bound. If the computed F -statistic falls between the two bounds, the inference is inconclusive. In these cases, the error-correction terms in the ARDL model are used to determine the existence of cointegrated trade balance equations. Hence, if a negative and significant lagged error-correction term is obtained, the variables are said to be cointegrated.

Next, we use the selected ARDL model to estimate the long-run coefficients and ECM. More specifically, the long-run model can be estimated from the reduced-form solution of Eq. (10), when the first-differenced variables jointly equal zero. The ECM is estimated by the ARDL approach to cointegration. For this purpose, the ARDL method first estimates $(p + 1)^k$ number of regressions to obtain lag length for each variable, where p is the number of lag to be chosen using the F -statistic and k is the number of variables in the equation. The AIC is then used to select the optimal lag structure for the ARDL specification. For the softwood lumber trade ($p = 3$), for example, the estimated orders of an ARDL(p, p_1, p_2, p_3) model in the four variables ($TB_t, Y_t^{US}, Y_t^{CA}, ER_t$) are selected by search across the $(3 + 1)^4 = 256$ ARDL models using the AIC, which results in the choice of an ARDL(3, 0, 0, 4) specification.⁸

The results of the long-run trade balance model show that the coefficients of exchange rate and income variables have the expected signs, and most of them are significant (Table 3). More specifically, the US trade balance has a positive long-run relationship with real exchange rates for the softwood lumber, panel/plywood,

⁷With different regressors ($k = 0, 1, \dots, 10$), Pesaran et al. (2001) provide five cases for asymptotic critical value bounds; (1) no intercept and no trend (case 1), (2) restricted intercept and no trend (case 2), (3) unrestricted intercept and no trend (case 3), (4) unrestricted intercept and restricted trend (case 4), and (5) unrestricted intercept and unrestricted trend (case 5) (pp. 300–301). In our case, with three regressor ($k = 3$) and unrestricted intercept and no trend (case 3), the 5% critical value bounds is (3.23, 4.35).

⁸It should be noted that, since the ARDL model is based on a single-equation approach, it may not be able to correct the potential endogeneity of the explanatory variables and thus yield inefficient estimates of the short- and long-run relationships (Pesaran and Shin, 1999). In our case, however, because the size of the forest sector is small relative to entire economy in the US and Canada, the exchange rate and income are expected to behavior exogenously in the forest sector. As such, this economic relationship justifies the use of a single-equation approach to estimate Eq. (10). In addition, the results of the ARDL model could be contingent on the value movement (i.e., clustering of the values) that may be presented in the data (Doornik and Hendry, 2001). More specifically, if there is volatility clustering due to price and price contracts over certain period of our sample, the generalized autoregressive conditional-heteroskedastic (GARCH)-type model could be more appropriate than the ARDL model. In our case, however, the use of quarterly data rather than daily or monthly data should somewhat mitigate the concern of volatility clustering and strengthen the credibility of our ARDL approach.

Table 3. Estimated long-run coefficients of US-Canada forest trade balance equation

Trade balance (TB _{<i>t</i>})	Exchange rate (ER _{<i>t</i>})	US income (Y _{<i>t</i>} ^{US})	Canadian income (Y _{<i>t</i>} ^{CA})	Constant
Softwood lumber trade balance	1.50 (4.55)*	8.90 (5.01)*	−7.56 (−4.45)*	−2.79 (−2.30)*
Panel/plywood trade balance	0.24 (2.06)*	7.23 (4.86)*	−4.52 (−3.18)*	−10.63 (−10.5)*
Hardwood lumber trade balance	0.99 (6.46)*	6.15 (7.42)*	−4.77 (−6.02)*	−7.18 (−12.7)*
Logs and chips trade balance	0.51 (1.05)	3.13 (1.20)	−1.91 (−0.77)	−6.77 (−3.79)*
Other wood product trade balance	0.45 (2.27)*	0.68 (0.46)	−3.59 (−2.52)*	−12.09 (−11.9)*

Note: *denotes significance at the 5% level. Parentheses are *t*-statistics.

hardwood lumber and other wood product trade with Canada. This implies that the depreciation of the US dollar indeed improves the trade balance in the long-run. In addition, the US trade balance has a positive long-run relationship with real domestic income and a negative relationship with real Canadian income for the softwood lumber, panel/plywood and hardwood lumber trade. This suggests that a rise in real US (Canadian) income leads to an increase in domestic (Canadian) demand for Canadian imports (domestic exports), thereby worsening (improving) the trade deficit. However, it is found that exchange rate and income variables have little effect on the US logs and chips trade with Canada in the long-run.

Finally, the ECM is estimated by the ARDL approach to capture the short-run dynamic effects of the depreciation on the trade balance or the J-curve effect (Table 4). The sign of the coefficient of the exchange rate determines the existence of the J-curve effect. That is, an initially negative sign followed by a positive one on the lag coefficients would be consistent with the J-curve phenomenon. The results show that all the coefficients of the current and lagged exchange rate (except for ΔER_{t-2} of panel/plywood and ΔER_t of hardwood lumber) are mostly positive and statistically insignificant at the 5% level. As such, the findings indicate that there is no J-curve effect for the US forest products trade with Canada.⁹ The results also show that income variables are found to be highly significant for all cases (except for the logs and chips trade), indicating that the real income is an important determinant of the

⁹It should be noted that the Softwood Lumber Agreement (SLA; 1996q2–2001q1) and other US market shocks such as the federal harvest reductions in the Pacific Northwest (PNW; 1991q1–1993q4) and the Asian financial crisis (1997q3–1998q4) may result in changes in the supply of Canadian softwood lumber exports to the US. To capture such effects, the dummy variables are used in the trade balance model of softwood lumber. It is found that the federal harvest reductions in the PNW led to a significant deterioration of the trade balance, while the SLA and the Asian financial crisis did not have any significant impacts on the softwood lumber trade with Canada.

Table 4. Estimated short-run coefficients of exchange rate and error-correction term based on autoregressive distributed lag (ARDL) model

Trade balance	ΔER_t	ΔER_{t-1}	ΔER_{t-2}	ΔER_{t-3}	ΔER_{t-4}	EC_{t-1}
Softwood lumber trade balance	0.64 (0.77)	1.16 (1.32)	-0.38 (-0.44)	1.28 (1.40)		-0.37 (-2.66)*
Panel/plywood trade balance	0.99 (1.60)	-0.21 (-0.30)	-1.67 (-2.48)*	0.88 (1.24)	0.63 (0.86)	-0.45 (-3.70)*
Hardwood lumber trade balance	1.02 (2.02)*	0.09 (0.18)	0.23 (0.44)	0.28 (0.52)		-0.52 (-3.16)*
Logs and chips trade balance	0.37 (0.25)	0.16 (0.11)	0.73 (0.47)			-0.75 (-4.13)*
Other wood product trade balance	-0.02 (-0.03)	-0.24 (-0.27)	0.59 (0.63)	0.23 (0.24)		-0.76 (-3.58)*

Note: ER_t is the US-Canada exchange rate. EC_{t-1} refers to the error-correction term. Δ indicates the first difference of a variable. *denotes significance at 5% level. Parentheses are t -statistics.

US forest products trade with Canada in the short-run. Notice that all the error-correction terms in five cases are negative and statistically significant at the 5% level, confirming the existence of the long-run relationship between variables. The findings further justify the ARDL modeling of the US–Canada trade in panel/plywood and hardwood lumber in which the results of the *F*-statistics are inconclusive.

Concluding remarks

This paper examines the hypothesis of the J-curve for the US–Canada trade in five forest commodities – softwood lumber, hardwood lumber, panel/plywood product, logs and chips, and other wood product. For this purpose, the ARDL approach to cointegration is used to estimate quarterly bilateral trade data from 1989 to 2005. We find little evidence of the J-curve phenomenon for the US–Canada trade in five forest products. This implies that, in the short-run, a change in the value of the US dollar is not a significant factor influencing the US trade in forest products. This finding substantiates the results of Buongiorno et al. (1998), Buongiorno and Uusivouri (1991) and Sarker (1996). For example, Buongiorno and Uusivouri (1991) show that a real depreciation of the US dollar may not be effective in increasing exports of forest products in the short-run. However, this finding contrasts with Bolkesjø and Buongiorno (2006) who find the substantial short-run effect of exchange rate on US forest products trade. This finding further suggests that the increasing forest products trade deficit and the decline in the value of the US dollar during the 2002–2004 cannot be explained by the J-curve effect. On the other hand, it is found that the exchange rate plays a pivotal role in determining the long-run behavior of the US trade balance with Canada in forest products. This result substantiates the results of Kaiser (1984), Adams et al. (1986), Sarker (1996) and Bolkesjø and Buongiorno (2006).

References

- Adams, D.M., McCarl, B.A., Homayounfarrokhi, L.H., 1986. The role of exchange rates in Canadian-US lumber trade. *Forest Science* 32 (4), 973–988.
- Bahmani-Oskooee, M., 1985. Devaluation and the J-curve: some evidence from LDCs. *Review of Economics and Statistics* 67, 500–504.
- Bahmani-Oskooee, M., Brooks, T.J., 1999. Bilateral J-curve between US and her trading partners. *Weltwirtschaftliches Archiv* 135 (1), 156–165.
- Bolkesjø, T.F., Buongiorno, J., 2006. Short- and long-run exchange rate effects on forest product trade: evidence from panel data. *Journal of Forest Economics* 11, 205–221.
- Buluswar, M.D., Thompson, H., Upadhyaya, K.P., 1996. Devaluation and the trade balance in India: stationarity and cointegration. *Applied Economics* 28, 429–432.
- Buongiorno, J., Uusivouri, J., 1991. Pass-through of exchange rates on prices of forest product exports from the United States to Europe and Japan. *Forest Science* 37 (3), 931–948.
- Buongiorno, J., Chavas, J.P., Uusivouri, J., 1998. Exchange rates, Canadian lumber imports and US prices: a time series analysis. *Canadian Journal of Forest Research* 18, 1587–1594.
- Doornik, J., Hendry, D., 2001. *Empirical Econometric Modeling* (PcGive 10). Timberlake Consultants Ltd., London.

- Engle, R.F., Granger, C.W.J., 1987. Cointegration and error correction representation: estimation and testing. *Econometrica* 55, 251–276.
- Guptar-Kapoor, A., Ramakrishnan, U., 1999. Is there a J-curve: a new estimation for Japan. *International Economic Journal* 13 (4), 71–79.
- Johansen, S., 1995. *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press, Oxford.
- Junz, H.B., Rhomberg, R.R., 1973. Price competitiveness in export trade among industrial countries. *American Economic Review* 63, 412–418.
- Kaiser, H.F., 1984. Floating exchange rates and the US forest products trade balance. *Forest Product Journal* 34, 55–58.
- Kruger, A.D., 1983. *Exchange Rate Determination*. Cambridge University Press, Cambridge.
- Krugman, P.R., Obstfeld, M., 2001. *International Economics: Theory and Policy*. Addison-Wesley, New York.
- Magee, S.P., 1973. Currency contracts, pass-through, and the J-curve. *Brookings Papers of Economic Activity* 1, 303–323.
- McCarl, B.A., Haynes, R.W., 1985. Exchange rates influence softwood lumber trade. *Journal of Forestry* 83 (1), 368–370.
- Noland, M., 1989. Japanese trade elasticities and the J-curve. *Review of Economics and Statistics* 71, 175–179.
- Pesaran, M.H., Shin, Y., 1999. An autoregressive distributed lag modeling approach to cointegration analysis. In: Strom, S. (Ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Cambridge University Press, Cambridge, UK (Chapter 11).
- Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics* 16, 289–326.
- Rose, A.K., 1991. The role of exchange rate in a popular model of international trade: does the Marshall–Lerner condition hold? *Journal of International Economics* 30, 301–316.
- Rose, A.K., Yellen, J.L., 1989. Is there a J-curve? *Journal of Monetary Economics* 24, 53–68.
- Sarker, R., 1996. Canadian softwood lumber export to the United States: a co-integrated and error corrected system. *Journal of Forest Economics* 2, 205–231.
- Sun, C., Zhang, D., 2003. The effects of exchange rate volatility on US forest commodities exports. *Forest Science* 49 (5), 807–814.
- Wooldridge, J.M., 2000. *Introductory Econometrics: A Modern Approach*. South-Western College Publishing, Mason, OH.