EXCHANGE RATE VOLATILITY IMPACTS ON EXPORT VOLUME AND PRICE OF U.S. FOREST PRODUCTS

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Abstract

We estimated the relationship between exchange-rate volatility and export volume and prices with an Autoregressive Distributed Lag (ADL) model using monthly bilateral U.S. export data of eight forest products to nine countries. The exchange-rate volatility was measured as a GARCH (1, 1) process. The impact of exchange rate volatility on export volume and prices was measured by short-run and long-run multipliers. The exchange rate volatility tended to have a negative effect on the export volume and prices when the exchange rate volatility of the importing country was large within the study period. The effect was mainly positive when the volatility was small.

Keywords: GARCH, conditional variance, international trade, forest sector

Introduction

Exchange rate fluctuations bring uncertainty to international traders, thus they might influence the volume and prices of forest products. Many theoretical and empirical papers deal with the effects of increased exchange-rate volatility on international trade, but fail to reach a consensus (Bahmani-Oskooee and Hegerty 2007).

The earlier theoretical models generally assume that higher exchange-rate risk lowers the expected revenue from trade and that risk-averse international traders respond to exchange-rate risk by favoring the domestic market. Therefore, an increase in exchange rate volatility reduces the volume of international trade (Clark 1973).

Ethier (1973) showed that in the presence of well-developed forward markets, if firms have knowledge, their revenues depend on the future exchange rate. Thus by adjusting the forward contrast cover, the effect of the exchange rate volatility could be negligible.
Export can also be considered as an option held by firms (Franke 1991). The value of the real option to export can rise with volatility. Higher exchange rate volatility increases the potential gains from trade, therefore the trade volume increases.

Hooper and Kohlhagen (1978) suggests that the effect of exchange rate volatility on price depends on who bears the risk. The exchange rate risk has a positive effect on the price when the trading contract is invoiced in the importer’s currency so that it is the exporter who bears the exchange rate risk; and a negative effect when the contract is invoiced in the exporter’s currency so that it is the importer who bears the exchange rate risk.

Autoregressive conditional heteroskedastic (ARCH) models are useful to measure exchange rate volatility (Diebold and Nerlove 1989). Bollerslev (1986) extends the ARCH model to a multivariate generalized autoregressive conditional heteroskedastic (GARCH) model, which involves the lagged variance as well as lagged squared residuals.

There are few such studies on the effects of exchange rate risk within the forest sector. Yet, it is worth investigating trade by sectors because each sector reacts differently (Rapp and Reddy 2000). A greater understanding of this relationship for forest products could provide useful information for analysts and decision-makers.

Most studies within the forest sector have focused on the effect of the exchange rate level on trade. But, Sun and Zhang (2003) address the impact of exchange rate volatility on total U.S. exports of four forest commodities. They find that exchange rate volatility has a negative effect on U.S. exports in the long term, but short-term dynamics vary by commodity. They measure exchange rate volatility by the standard deviation of the growth rate of real effective exchange rate of the U.S. dollar.

The objective here was to test the effect of exchange rate volatility on export volume and prices of exports of many different forest products from the United States to several countries.

**Methods**

For each forest commodity and country, the following Autoregressive Distributed Lag (ADL) models were developed:

\[
\begin{align*}
\ln p_t &= a_0 + \sum_{i=0}^{n} d_{pi} \ln h_{t-i} + \sum_{i=1}^{a} a_{pi} \ln p_{t-i} + \varepsilon_{pt} \\
\ln x_t &= b_0 + \sum_{i=0}^{n} d_{xi} \ln h_{t-i} + \sum_{i=1}^{a} b_{xi} \ln x_{t-i} + \varepsilon_{xt}
\end{align*}
\]  

(1)  

(2)

where \(x_t\) is the U.S. export quantity of forest products during time period \(t\); \(p_t\) is the export price; \(h_t\) the time-varying conditional standard deviation of the exchange rate. The \(\varepsilon\)'s are white noise. \(n\) is up to 12 months.
Exchange rate volatility takes a form of GARCH(1,1) model (Kroner and Lastrapes 1993):

\[ \Delta \ln s_t = c + \sum_{i=1}^{m} \Delta \ln s_{t-i} + \varepsilon_{st} \]

\[ \varepsilon_{st} | \varepsilon_{st-1} \sim N(0, h_t^2) \]

\[ h_t^2 = \gamma_0 + \gamma_1 \varepsilon_{st-1}^2 + \gamma_2 h_{t-1}^2 \]  

where \( s_t \) is the foreign currency price of the U.S. dollar; \( \varepsilon_{st} \) is normally distributed with mean zero and a time dependent conditional variance; the \( \gamma \)'s and \( c \) are parameters to be estimated.

Equations 1 and 2 were estimated by Ordinary Least Squares (OLS). Equation 3 was estimated by Maximum likelihood. The number of lags in (1) and (2) was such that the residuals were white noise according to the Ljung-Box Q statistic. The Q test was also applied test for serial correlation in the mean and variance equation (3). Equation (3) was also tested for excess skewness and kurtosis.

Nominal, rather than real, exchange rates were used, but the results are not sensitive to this choice (Mark 1990). Valid inference using the GARCH model requires that the variables in the system be stationary (Greene 2003). If the series were found to have a unit root, they were made stationary by differencing.

The short-run, static, or impact multiplier of exchange rate volatility on, say, export volume shows the instantaneous effect of past and current changes in exchange rate volatility on volume. This short run multiplier is:

\[ SRM_x = \sum_{i=0}^{n} d_{xi} \]  

(4)

The short-run multiplier of the price equation was obtained in a similar fashion.

The full long-run impact of change in exchange rate volatility on exports, denoted by \( LRM_x \) was derived from equation 2:

\[ LRM_x = \frac{\sum_{i=0}^{n} d_{xi}}{1 - \sum_{i=1}^{n} b_{xi}} \]  

(5)

The standard error of the long-run multipliers was obtained from the variance-covariance matrix of the parameters.

**Data**

The export volume and export prices were for eight forest products at SITC-4 digit level, from January 1989 to November 2007, from the U.S. International Trade Commission (USITC) database. The importing countries were Canada, Mexico, Japan, Italy, Korea, Germany, the Netherlands, U.K. and Spain. Together, they account for 64% of total U.S. exports at 2007 export values in U.S. dollars. Among them, Canada, Mexico and Japan were the most important trade partners. The exchange rates were monthly averages of daily noon buying rates in New
York City, from the Federal Reserve Bank of St. Louis. For the European currencies that were replaced by the Euro in 2001, the Euro/U.S. dollar exchange rate was transformed to the original currency level with the conversion rates of 1999.

Results

All exchange rates series were nonstationary, and the first differences were stationary. For the exchange rate conditional standard deviation series, the ADF test results were mixed. The series with a unit root were differenced to achieve stationarity. Thus, all series in the estimation of equations 1 and 2 were stationary.

Table 1 shows the GARCH equation of the Canadian dollar exchange rate. In the mean equation, the exchange rate level is an AR (1) process. The conditional variance equation is an ARMA (1,1) process. Most of the GARCH estimations of other countries’ exchange rate volatility take a similar form. For all the countries, there are significant GARCH and/or ARCH effects in the conditional variance equation. For some countries, the exchange rate level equation takes an AR(p) process (p>1). The obtained skewness and kurtosis of the standardized residuals and the standardized squared residuals from the mean equation show that all the residuals are normally distributed.

Table 1. GARCH (1,1) model of the Canadian dollar exchange rate

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ln s_t = 0.22 \Delta \ln s_{t-1} + \varepsilon_{st}$</td>
<td>0.000002</td>
<td>(0.07)***</td>
<td>27.91</td>
<td>0.0000***</td>
</tr>
<tr>
<td>$Q(10) = 7.08$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$h_t = 0.00002 + 0.17 \varepsilon_{st-1}^2 + 0.74 h_{t-1}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skewness = -0.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Q(10) = 20.09$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kurtosis = 0.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***, **, *: significant at 1%, 5% and 10% significance level, respectively.

Figure 1 shows the graph of the Canadian dollar exchange rate volatility estimated from the GARCH model. The residuals from the mean equation of equation 3 are bounded by plus or minus the conditional standard deviation, $h_t$. These bands quantify the changing volatility of the exchange rate series residuals over time. After 2003, the conditional standard deviation bands are wide, indicating considerable volatility in the exchange rate regression error and thus considerable uncertainty about the resulting exchange rate forecasts. Therefore $h_t$ is an appropriate measurement of the exchange rate volatility.

The exchange rate volatility of Canada was the smallest. The largest volatility was observed for Mexico and Japan.

Table 2 shows the statistically significant short-run and long-run multipliers of the Canadian dollar exchange rate volatility on the volume and price of U.S. exports to Canada. The price multipliers are all positive, suggesting that exchange rate volatility increases prices, especially in the long-run. The effect of volatility on volume is strongest for uncoated paper and paperboard (641.2) in the long run. For a one percent permanent increase in the exchange rate volatility, the export volume of U.S. uncoated paper and paperboard exports to Canada increased by 2.13
percent in the long run. The negative effect on non-coniferous sawnwood was negative, but not economically significant.

Figure 1. Residuals from the exchange rate level equation and GARCH (1,1) bands

Table 2. Short run and long run multipliers of the exchange rate volatility on the volume and prices of U.S. exports to Canada, for selected commodities

<table>
<thead>
<tr>
<th>Products (SITC code)</th>
<th>Volume</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SRM</td>
<td>LRM</td>
</tr>
<tr>
<td>Coated paper, paperboard (641.7)</td>
<td>0.03*</td>
<td>0.02*</td>
</tr>
<tr>
<td>Coniferous wood in the rough (247.4)</td>
<td>1.35**</td>
<td></td>
</tr>
<tr>
<td>Non-coniferous sawnwood (248.4)</td>
<td>-0.07**</td>
<td>-0.03**</td>
</tr>
<tr>
<td>Uncoated paper and paperboard, for writing, printing (641.2)</td>
<td>0.14***</td>
<td>2.13***</td>
</tr>
</tbody>
</table>

For the other two largest importers of forest products from the United States, Mexico and Japan, the SRMs and LRM were mainly negative for both volume and prices. So were the results of Italy, South Korea, U.K. and Spain. Germany and the Netherlands were the two other countries besides Canada for which the multipliers were mainly positive, for both volume and prices.

**Summary and Conclusions**

The effects of the exchange rate volatility on the export volume and prices of U.S. forest products were studied with ADL models. The model was estimated with monthly export data of eight forest products exported to nine countries. The volatility of each country’s exchange rate was measured with a GARCH (1, 1) model. The effect of the exchange rate volatility on export volume and prices were measured with short-run and long-run multipliers.
In many cases, the coefficients of lagged exchange rate volatility were significant. This suggests that exchange rate volatility does affect trade, with some delay. The time lag could stretch up to six months.

Exchange rate volatility tended to have a negative effect on export volume and prices to a country if that country’s exchange rate had large volatility, such as for Mexico and South Korea. On the other hand, the exchange rate volatility tended to have a positive effect on export volume and prices to a country with relatively small exchange rate volatility, such as Canada, Germany and the Netherlands.

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Literature Cited