Exports and Growth of Forest Industries

Sijia Zhang¹ and Joseph Buongiorno, Department of Forest and Wildlife Ecology, University of Wisconsin, Madison.

Acknowledgements:

The research leading to this paper was supported in part by McIntire-Stennis grant 4979 and by the USDA Forest Service, Southern Forest Research Station. We thank Jeff Prestemon and Dave Wear for their support and collaboration.

¹ Research Associate, Department of Forest and Wildlife Ecology, University of Wisconsin-Madison. 1630 Linden Drive Room A141, Madison, WI 53706. sijia.zhang@wisc.edu, (608) 263-5574 (o).
Exports and Growth of Forest Industries

Abstract:

This paper investigates whether exports are the engine of production growth in forest industries in three countries. A bivariate autoregressive distributed lag model of production and exports was estimated with data of eleven forest industries from China, Finland, and the United States. Inferences were based on the short-run and long-run partial multipliers from exports to production by industry. The results show that in Finland, there was strong support for the exogenous growth hypothesis, while there was less support in the cases of China and the United States.

Key words: International trade, forest products, China, Finland, the United States.
**Introduction**

Different theories explain the relationship between exports and domestic production (Stern, 1989). According to the exogenous growth hypothesis, exports are the engine of domestic growth (Stern, 1989; Riezman et al, 1996). The exogenous growth hypothesis suggests that measures to directly stimulate exports, including more open trade, will accelerate domestic growth,

Export expansion generates foreign exchange earnings, investment capital and intermediate imports, which induce more production (Bhagwati, 1978; Krueger, 1978). By exporting more, an economy may increase productivity with better resource allocation and technological innovation, with development of indigenous entrepreneurship and exploitation of scale economies (Jung and Marshall, 1985). The exogenous growth hypothesis seemed initially to have been vindicated with the success of East Asia’s miracle economies, which achieved extraordinarily high growth between the early 1960s and mid-1990s, through export promotion (World Bank, 1993). However, after the Asian crisis in the late 1990s, doubts have been expressed for the effectiveness of export promotion to stimulate growth (Medina-Smith 2001; Felipe 2003).

Recent empirical studies have found mixed results for exogenous growth hypothesis. Riezman et al. (1996), Kwan et al. (1996), Islam (1998), Mamun and Nath (2005) found weak support for the export-led growth hypothesis, while Jin and Yu (1996), Yamada (1998), and van Rensburg and Naude (1999) find no relation between exports and domestic growth. As these studies use different methods, data, and country groups, a general conclusion is still elusive (Ahmad 2001).

Most of past studies used macroeconomic data on total exports and GDP. Studies at sector or industry level appear to be rare. Chao and Buongiorno (2002) use error correction models (ECM) to study the relation between exports and domestic production of the pulp and paper industries, with pooled time-series across countries. Here, we concentrate on production and export data from the United States, Finland and China, and examine all the forest industries, some of which, such as wood-based panels, have grown much more rapidly than others, such as sawnwood (Turner et al. 2006). Comparison of these three countries may shed light on the effect of the development stage of a country, and of the importance of exports relative to production, on the relationship between the two.

**Methods and data**

**Time series models**

The effect of exports on production was analyzed with time-series models. It is known that simple time-series non-structural models forecast as well as structural models (Diebold 1998). Zellner and Palm (1974) have shown that dynamic structural models are special cases of multivariate time-series processes. Nevertheless, a time-series approach to study the relation between production and exports, with both variables assumed to be endogenous does allow the determination of the dynamic net effect of exports on production, implicitly assuming the
adjustment of all other relevant variables. The results can therefore be interpreted as describing the path of change of production and exports in a general equilibrium framework.

Accordingly, the relation between a country’s exports, $X_t$, and production, $Y_t$, of a particular product was described with a bivariate time-series model based on a general autoregressive distributed lag (ADL) structure (Stock and Watson 2003, p. 446). Both $X_t$ and $Y_t$ are treated as being endogenous. As is standard practice, to facilitate the interpretation of the coefficients as elasticities, the logarithmic transforms, $\ln X_t$ and $\ln Y_t$, were used in the models:

\[ (1) \quad \ln X_t = \sum_{j=1}^{m} a_{1j} \ln X_{t-j} + \sum_{j=1}^{m} b_{1j} \ln Y_{t-j} + u_{1t} \]
\[ (2) \quad \ln Y_t = \sum_{j=1}^{m} a_{2j} \ln Y_{t-j} + \sum_{j=1}^{m} b_{2j} \ln X_{t-j} + u_{2t} \]

where $a_{1j}$, $a_{2j}$, $b_{1j}$, and $b_{2j}$ are coefficients to be determined empirically. $u_{1t}$ and $u_{2t}$ are the residuals, which may be cross-correlated, but not autocorrelated over time. In this general form, with the same predetermined variables on the right hand side of the equations, both equations can be consistently and separately estimated by Ordinary Least Square (OLS) (Judge et al., 1982: p.710).

However, in practice, several of the coefficients may be zero, and neglecting the correlation between $u_{1t}$ and $u_{2t}$ would lead to inefficient estimates. Judge et al. (1982, p. 711) suggest a way to still use OLS with a transformation that leads to:

\[ (3) \quad \ln Y_t = \sum_{j=0}^{m} a_{3j} \ln Y_{t-j} + \sum_{j=0}^{m} b_{3j} \ln X_{t-j} + u_{3t} \]

Judge show that equations (1) and (2) imply equation (3) with $a_{3j} = \lambda a_{1j} + a_{2j}$, $b_{3j} = \lambda b_{1j} + b_{2j}$. $j = 1, \ldots, m$, $a_{30} = -\lambda = \text{cov}(u_{1t}, u_{2t})/\text{var}(u_{1t})$. The residual $u_{3t}$ is uncorrelated with $u_{1t}$ and thus uncorrelated with $X_t$. OLS gives consistent and asymptotically efficient estimates of equation (3).

Equation (3) assumes that the data are drawn from a stationary distribution, so that the distribution of the data is independent of time (Stock and Watson 2003, p. 447). The stationarity of the exports and production series for each industry and country was tested with the Dickey-Fuller $t$ test with a time trend (Dickey and Fuller, 1979). When stationarity was rejected, equation (3) was estimated with data in first differences, as first differencing led to stationary series.

The optimal values of the lag length, $m$, in equation (3) were determined with Akaike’s Final Prediction Error (FPE) criterion (Hsiao, 1979). The best value of $m$ minimized the FPE, but lags were added until “dynamically complete” (Wooldridge 2006, p. 401) without serial correlation was obtained. The presence of serial correlation in the residuals $u_{3t}$ was tested with the Breusch (1978)–Godfrey (1978) Lagrange multiplier (LM) statistic for serial correlation.
Multiplier analysis

Various measures of the causal relationship between \( X_t \) and \( Y_t \) have been proposed in the literature, based on equations (1) to (3). Perhaps the most common are the “Granger-causality tests” (Granger, 1969, 1988). It simply states that a variable, say \( X_t \), “causes” \( Y_t \) if knowledge of \( X_t \) helps better predict future values of \( Y_t \). The measures of the relationship between production and exports used here follow the same general principles. They deal with the total effect of exports on production, whether exports precede production or occur in the same period. They take the form of short-run static multipliers, and long-run dynamic multipliers from exports to production.

Short-run static multipliers

The short-run, static, multiplier of exports on production shows the instantaneous effect of past and current changes in exports on production. In particular, \( b_{32} \) in equation (3) is the short-term impact of a change in exports in year \( t-2 \) on production in year \( t \). The total static impact of a change in exports in any year from \( t-m \) to \( t \) on production in year \( t \) is then the short-run multiplier (SRM):

\[
SRM_{x\rightarrow y} = \sum_{j=0}^{m} b_{3j}
\]

The variance of the short-run multiplier is \( h'V(\mathbf{b})h \) where \( h=(1,\ldots,1) \) is an \( m \times 1 \) vector, \( \mathbf{b}=(b_{31}, \ldots, b_{3m}) \) is the vector of parameters and \( V(\mathbf{b}) \) is their variance-covariance matrix (Goldberger 1991, p. 174).

A test of the significance of the short-run multipliers (4) is in effect a test of the Granger causality between exports and production, including the instantaneous causality defined in Granger (1969) and analyzed by Geweke (1984), and Harvey (1990, p. 305) among others.

Long-run dynamic multipliers

The long-run multipliers (LRM) measured the cumulative effect over time of a permanent change in exports on production, when production is kept unchanged initially (Hamilton, 1994). The full long-run impact of a unit change in exports on production, both lagged and instantaneous, denoted by \( LRM_{y\rightarrow x} \) was derived from the parameters of equation (3) (Banerjee et al., 1993, p. 54):

\[
LRM_{x\rightarrow y} = \sum_{j=0}^{m} b_{3j} \left/ \left( 1 - \sum_{j=0}^{m} a_{3j} \right) \right.
\]

The LRM gave information on the direction and magnitude of any long-term, persistent influences from one variable to another. The denominator of the LRM gave information on the
adjustment speed. The closer the sum of $a$ parameters was to unity, the slower the adjustment; the closer it was to zero, the faster the adjustment (Brorsen et al., 1985).

The variance of the long-run multipliers was obtained from the variance-covariance matrix of the parameters, $V(c)$, where $c=(b_{31},...,b_{3m}, a_{31},...,a_{3m})$ for equation (5), as:

$$V(LRM) = d'V(c)d$$

where $d$ is the vector of the partial derivatives of the LRM with respect to each parameter.

If $SRM_{x \rightarrow y}$ or $LRM_{x \rightarrow y}$ were statistically significant, we concluded that there was evidence supporting the exogenous growth hypothesis.

Data

All the data were obtained from the database of the Food and Agriculture Organization of the United Nations database (FAO 2007).

For the United States, the study used annual time series data from 1961 to 2004 of exports and production of eleven forest industries. The data for Finland were from 1961 to 2005, for the same eleven industries. For China, the data were from 1961 to 2005 for ten industries. Data of China included Taiwan and Hong Kong. The autoregressive-distributed lag models were estimated with the differenced series.

Results

Short-run and long-run multipliers

The second and third columns of Table 1 show the short-run and long-run multipliers from exports to production, derived from equation (4) and (5) with the parameters estimated from the autoregressive distributed lag model. Only the statistically significant results are reported.

For the United States, the SRMs and LRM$ _{x \rightarrow y}$ from exports to production were especially significant, statistically and economically for five industries out of eleven: industrial round wood, particleboard, fiberboard, recovered paper and other paper and paperboard. For Finland, all SRMs and LRM$ _{x \rightarrow y}$ were statistically significant at 1 percent level except for the recovered paper industry of which the result was statistically significant at 5 percent level. For China, the SRMs and LRM$ _{x \rightarrow y}$ from exports to production were statistically significant for five industries out of ten: plywood and veneer, particle board, fiberboard, newsprint, and printing and writing paper.

Over all industries and countries, the long-run multipliers tended to be smaller than the short-run multipliers, and the difference increased for larger multipliers.

Summary and Conclusion

The objective of this study was to test the exogenous (or export-led) growth hypothesis for forest industries. To this end eleven industries were analyzed, covering industrial round wood, sawn wood, panels, pulp, paper and paperboard, in the United States, Finland, and China.
The methods consisted of time-series analysis based on annual export and production data by country and industry, from 1961 to 2005. Autoregressive distributed lag models were formulated to predict production as a function of current and past exports, and past production. To ensure stationary series, the ADL models were formulated in terms of annual relative change. From the parameters of the ADL models, we derived short-run and long-run multipliers of exports to production, for each industry and country.

There was less support for the exogenous (export-led) growth hypothesis in China and the United States. In Finland, the multipliers were statistically significant for all but one industry. And the SRMs and LRMs of production response were a high percent of a permanent increase in exports, thus supporting the export-led growth hypothesis. Therefore, in Finland forest industries, export expansion stimulates domestic production.

Table 1. Short-run and long-run multipliers from exports, $x$ to production, $y$, by country and industry, and panel data results.

<table>
<thead>
<tr>
<th>Industry</th>
<th>SRM$_{1-3y}$</th>
<th>LRM$_{1-3y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Industrial roundwood</td>
<td>0.15(0.06)**</td>
<td>0.14(0.05)**</td>
</tr>
<tr>
<td>Particleboard</td>
<td>0.20(0.07)***</td>
<td>0.20(0.05)***</td>
</tr>
<tr>
<td>Fiberboard</td>
<td>0.30(0.13)**</td>
<td>0.36(0.13)***</td>
</tr>
<tr>
<td>Recovered paper</td>
<td>0.14(0.08)*</td>
<td>0.14(0.08)*</td>
</tr>
<tr>
<td>Other paper &amp; paperboard</td>
<td>0.12(0.07)*</td>
<td>0.12(0.06)**</td>
</tr>
<tr>
<td><strong>Finland</strong></td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Industrial roundwood</td>
<td>0.21(0.06)***</td>
<td>0.16(0.04)***</td>
</tr>
<tr>
<td>Sawnwood</td>
<td>1.14(0.12)***</td>
<td>0.82(0.06)***</td>
</tr>
<tr>
<td>Plywood &amp; veneer</td>
<td>1.09(0.10)***</td>
<td>0.87(0.04)***</td>
</tr>
<tr>
<td>Particleboard</td>
<td>1.15(0.23)***</td>
<td>0.72(0.06)***</td>
</tr>
<tr>
<td>Fiberboard</td>
<td>0.70(0.17)***</td>
<td>0.62(0.11)***</td>
</tr>
<tr>
<td>Chemical wood pulp</td>
<td>0.55(0.08)***</td>
<td>0.54(0.08)***</td>
</tr>
<tr>
<td>Recovered paper</td>
<td>0.12(0.05)**</td>
<td>0.11(0.04)**</td>
</tr>
<tr>
<td>Newsprint</td>
<td>1.79(0.26)***</td>
<td>0.93(0.04)***</td>
</tr>
<tr>
<td>Printing &amp; writing paper</td>
<td>1.09(0.15)***</td>
<td>0.90(0.05)***</td>
</tr>
<tr>
<td>Other paper &amp; paperboard</td>
<td>0.85(0.15)***</td>
<td>0.76(0.07)***</td>
</tr>
<tr>
<td><strong>China</strong></td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Plywood &amp; veneer</td>
<td>0.61(0.18)***</td>
<td>0.50(0.13)***</td>
</tr>
<tr>
<td>Particleboard</td>
<td>0.16(0.09)*</td>
<td>0.19(0.11)*</td>
</tr>
<tr>
<td>Fiberboard</td>
<td>0.25(0.12)**</td>
<td>0.30(0.13)**</td>
</tr>
<tr>
<td>Newsprint</td>
<td>0.17(0.08)**</td>
<td>0.26(0.14)**</td>
</tr>
<tr>
<td>Printing &amp; writing paper</td>
<td>0.24(0.10)**</td>
<td>0.22(0.09)**</td>
</tr>
</tbody>
</table>

***, **, *: significant at 1%, 5% and 10% level, respectively. Numbers in parentheses are standard errors.

**Literature cited**


