Inventory Levels Effect on Comparative Advantage in the Chemical Market Pulp Industry

James A. Eddy III
University of Oregon
Department of Economics
Spring, 2001

Abstract:

The competitive benefits of inventory management strategies, such as Just in Time (JIT) production, are routinely heralded. This paper attempts to analyze the effects of JIT production on comparative advantage in the international trade of pulp. Using ending inventories as a percent of total production, and the standard deviation of monthly inventory levels, as proxies for JIT, I find mixed results of their impact on international trade. A relatively large ending inventory, a compared to production, has a statistically significant negative impact on comparative advantage. However, the variation in monthly inventories does not appear to significantly impact comparative advantage. The apparent incongruence in my results should not detract from the importance of my findings, that inventory management techniques do affect comparative advantage.

Received by: Bruce Blonigen

Date: 6/4/01

Introduction:

Beginning in the mid-80's many Asian countries began using the "Just in Time" (JIT) production technique in many of their manufacturing facilities. One goal of JIT production is to minimize the capital resources invested in holding inventories. These inventories can include both inputs or finished goods, and possibly both. My analysis focuses on the benefits derived from reducing the level of finished good inventories. A second goal of JIT production is hold relatively small amounts of the factors of production in inventory. That is, schedule input deliveries so that they are moved from the truck directly to the production line. Using this method of JIT, the inventories in focus are in the beginning, rather than the end, of the production cycle. Either focus of JIT production has several key benefits. First, resources that are not tied up storing inventories can be invested elsewhere. Second, the risks of losses to inventory either through "shrinkage" (i.e. theft), aging or damage are diminished. Lastly, in order to utilize JIT production a reduction in defects must occur because without inventories a producer is unable to make returns without affecting production schedules. This increase in the product quality, if properly leveraged, is a competitive advantage. For instance in the pulp and paper industry the amount of "cull", the industry term for product that doesn't meet quality standards and must be re-pulped, has a huge impact on production costs.

Do these benefits increase one's comparative advantage, and, hence lead to increased net exports? The forest products industry within the United States has yet to broadly adopt JIT production techniques. Typically they produce as much as possible, regardless of sales, amassing large inventories when during economic downturns. This style of production is due, in part, by the perception that the immense capital investments made on equipment can be most efficiently recouped by spreading out the investment costs across the greatest amount of production, lowering the amount of fixed costs per unit. However, it appears as if this style of production focuses on the "sunk" costs of production, rather than the increase in variable costs due to storage and handling of excess inventories. However, it should be noted that in the pulp industry some inventory is necessary to maintain operations during scheduled maintenance. I would like to determine if the current practices of the forest products industry within the United States are placing them at a competitive disadvantage in the global marketplace.

Literature Review:

According to Little (1992), inventory management systems, an example being JIT, have an unambiguously positive effect on the U.S. economy. However, she notes the U.S. started using lean production, and other methods to reduce the inventory to sales ratio, in reaction to reductions in international competitiveness. This reduction was caused by the dollar's appreciation during the 1980's, as well as inventory management techniques being adopted in Asian countries, such as Japan. Furthermore, Little discusses the extent to which different industries in manufacturing have adopted JIT, noting that the paper and allied products industry is one of the industries with the least integration of inventory management plans. Also, she showed that the benefits of lean production have yet to outweigh the costs associated with learning a new production technique in many U.S. industries. This indicates that the U.S. pulp and paper industry may have lost some of the comparative advantage it possessed. Wolf (1997) explains one reason for trade specialization is the "technology gap". This theory indicates that the technology gaps between countries will be a major reason for trade flows and direction of flows. If true, it would reinforce my hypothesis that countries utilizing JIT production techniques have a comparative advantage over those who don't. Furthermore, Posner (1961) originally postulated that technology would induce trade flows during the time it takes for other countries to obtain or mimic the technology. Although not specifically defined as a technology in Wolf's paper I believe that different styles of production, including JIT, would have a similar impact. Lastly, Oman (1999) writes about the flexible "post-Taylorism" production techniques that have evolved and spurned greater regional and global competition. Taylorism was the style of scientific management that increased global productivity and pushed global competition higher between the 1950's and 1960's. Unfortunately, scientific management built serious rigidities into the production cycle, which Oman argues were a major cause of slowing production and stagflation of the 1970's. As this occurred capital began accelerating its flight to low-wage non-OECD countries, particularly in Asia. The acceleration of the flight of capital continued until the 1980's, when it began decelerating as OECD countries began to adopt more flexible production techniques. Oman also notes that the increases in production due to flexible production techniques found in OECD far exceed those used by Taylorist firms. This would indicate that countries in which JIT production is common (JIT being a form of flexible production) might have a comparative advantage over countries that use a more rigid style of production.

Theory:

Most empirical tests of trade patterns derive from the traditional H-O model, which doesn't account for technological differences. To demonstrate the traditional H-O model's, without an adjustment for technology, inefficiency in determining trade flows I ran the following regression.

Net Exports = f(Labor, Capital, Forest)

Net Exports = Total annual net exports of chemical wood pulp, all grades (SITC 2516-18), in thousands of U.S. dollars during 1997.

Labor = Total annual employment in manufacturing during, ISIC 34, during 1997 as published in the Yearbook of Labour Statistics (2000).

Capital = Was calculated using Gross Capital Formation as a percent of GDP, as published in the Financial Statistics Yearbook (2000), divided by GDP during 1997 in millions of U.S. dollars.

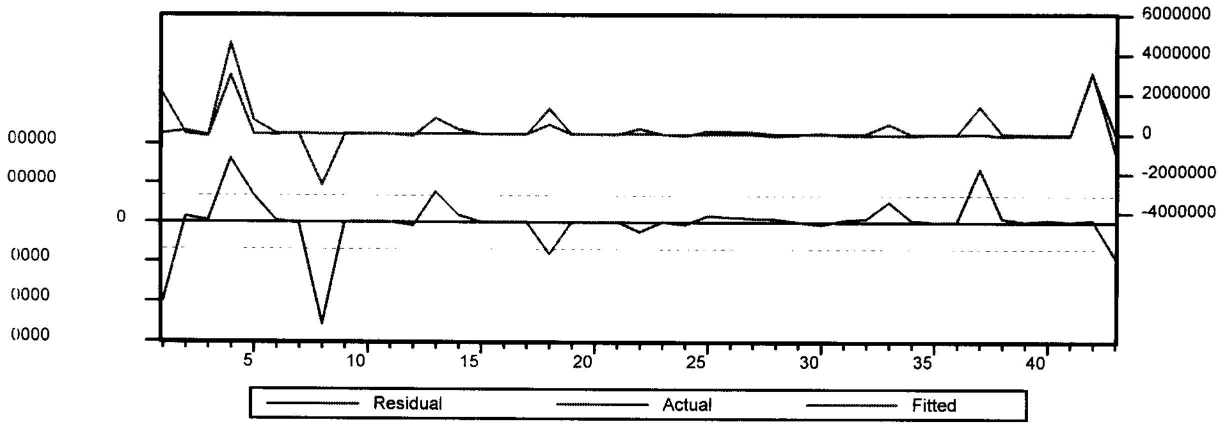
Forest = Total forested area in thousands of square kilometers in 1990[1] as published on the World Bank's website.

The results of traditional H-O model are as follows:

	Dependent Variable and Empirical Model
	Heckscher - Ohlin
Regressors	**Net Exports**
LABOR	-222961 (132399)
CAPITAL	252577.8* (108168.3)
FOREST	148538.1* (59622.24)
C	343188.5 (662027.3)
Adjusted R-squared	0.279502
F-statistic	5.043085
Sample Size	43

Although the F-statistic is significant at a 1% level of confidence the low adjusted r-squared indicates this model has little explanatory power. On the following page of is a graph of the residuals against the actual results. The graph also supports the conjecture that H-O model doesn't consistently predict trade patterns with great deal of accuracy.

[1] Due to data limitations I was unable to gather more recent data. However, assuming that the local timber industry practices reforestation, as in many parts of the world, the variation between the data used and current data should be immaterial.



Furthermore, others have also shown the inaccuracy of the traditional H-O model in predicting trade flows. Trefler (1995) demonstrates how the H-O model should be rejected for a model that allows for technological or other differences, other than factor endowments, between countries. He states that the high failure rate of the H-O model in predicting trade flows in the factor service industry is evidence of its shortcomings. He goes on to say that other economic models that perform equally poor are typically rejected and in search of a better model.

However, Leamer (1984) counters the argument that technology isn't included within the H-O model. He states that technological differences are, at least in part, accounted for within the various levels of factor endowments. For instance, if the labor endowment were disaggregated to identify various levels of education it would implicitly describe the level of productivities.

After concluding my literature review and the brief empirical survey, I believe that adjusting the standard H-O model to account for the use of JIT production is a theoretically sound modification. Using two variations of the H-O model I can effectively determine if accounting for inventory levels increases the explanatory power H-O model in determining comparative advantage. I will also be able to independently test the significance of the relative inventory levels on international trade. Below are descriptions of the relative variables under the H-O model of comparative advantage in the chemical pulp industry.

Y = f (I, K, L, F)

Y = Due to data limitations I was unable to gather import data, on a monthly basis, for chemical pulp. As such, I was unable to calculate net exports. I am satisfied that total exports, in 000's of tons, is a justifiable proxy for comparative advantage. However, I do recognize that the data limitations may cause specification problems within the H-O model.

I = A proxy variable for JIT production. I am using total month end inventories divided by total monthly production. I expect negative relationship between the amounts of inventory carried, as a percent of production, and a nation's comparative advantage and, hence, exports, because of the opportunity cost of holding large amounts of inventory.

K = The total value of gross capital formation, given in billions of U.S dollars. The H-O model assumes that the level factor endowments cause an increase in comparative advantage. As such, I predict a positive relationship between the level of gross capital flows and the percent of world exports.

L = Total employment, given in thousands, in the manufacturing industry. The H-O model assumes that the level factor endowments cause an increase in comparative advantage. As such, I predict a positive relationship between the number of people employed and the percent of world exports.

F = The total area of forest available for harvest. Because timber is the primary resource used in the production of pulp a large area of available timber means reduced production costs and an increased comparative advantage. The production costs would be reduced because a country with a large amount of timber (e.g. United States) will not have as high transportation costs as a country that imports logs to produce the pulp (e.g. Japan).

Data

I encountered great difficulty in collecting inventory data, which limited the countries I selected for my sample. The inventory, production, and export data was gathered from tables published by the Market Pulp Producers Association (MPPA). It can be assumed that the countries selected by the MPPA are "players" in the chemical pulp industry, thereby possessing a comparative advantage in relation to the rest of the world. This constraint on my sample may cause sample selection bias. The data used was report on a monthly basis from October 1995 – Oct 1998. The gross capital formation data was calculated from gross capital formation as a percent of GDP, gathered from the International Financial Statistics Yearbook (2000), multiplied by total GDP in U.S. dollars. The employment data was gathered from the Yearbook of Labour Statistics (2000). Both the gross capital formation data and employment statistics were reported on an annual basis. In order to utilize this information I evenly distributed the monthly portion of the annual change. The redundancy in the capital and labor statistics may cause my model to lose some descriptive power, over emphasizing the importance of capital and labor. To counter this effect I will run secondary regressions across the three years on an annual basis. In the secondary regression I will use the standard deviation of my JIT variable. This is consistent with my original hypothesis because countries using JIT production will have inventory management systems that will allow them to adjust to rapid changes in demand. This adaptability should correlate with smaller variations in monthly inventory levels.

Empirical Model

H-O Model – monthly basis

1) $Y = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(F) + \varepsilon$

2) $Y = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(F) - \beta_4(I) + \varepsilon$

Secondary Regressions –annual basis

3) $Y = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(F) + \varepsilon$

4) $Y = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(F) - \beta_4 \mathrm{StdDev}(I) + \varepsilon$

Empirical Results

	Dependent Variable and Empirical Model	
	Heckscher-Ohlin	
	Exports Chemical Pulp	
Regressors	Model 1	Model 2
LABOR	-11.10072* (5.090998)	-0.34056 (5.571997)
CAPITAL	-10.02065* (5.081976)	-15.4213* (5.062551)
FOREST	91.40753* (7.041779)	87.00781* (7.036944)
JIT		-27.16314* (7.216816)
C	-844.3852 (65.73784)	-807.75552 (65.71786)
Adjusted R-squared	0.534714	0.543386
F-statistic	168.552	130.6062
Sample Size	444	444

The following two-sided hypothesis tests were created under my assumptions for the theoretical model.

Labor: H_0: $\beta_1 = 0$; Ha: β_1 □ 0   Capital: H_0: $\beta_2 = 0$; Ha: β_2 □ 0
Forest: H_0: $\beta_3 = 0$; Ha: $\beta 3$ □ 0   JIT: H_0: $\beta_4 = 0$; Ha: β_4 □ 0

The critical value of t, for a two-sided test, with 95% probability and degrees of freedom of 440 is approximately 1.96. The results of my hypothesis tests for models one and two are as follows.

Model 1:
Labor: |t – labor| > t-critical; reject the null
Capital: |t- capital| > t- critical; reject the null
Forest: |t-forest| > t-critical; reject the null

Model 2:
Labor: |t – labor| < t-critical; can't reject the null
Capital: |t- capital| > t- critical; reject the null
Forest: |t-forest| > t-critical; reject the null
JIT: |t-JIT| > t-critical; reject the null

	Dependent Variable and Empirical Model	
	Heckscher - Ohlin	
	Exports Chemical Pulp	
Regressors	Model 3	Model 4
LABOR	-4.276472	4.523027
	(16.28015)	(15.30382)
CAPITAL	-10.09131	-20.08225
	(16.75018)	(16.05985)
FOREST	79.29799*	79.36734*
	-25.09803	(23.49827)
JIT		-182.8745
		-112.5024
C	-753.1818	-725.3366
	(227.0018)	(208.4998)
Adjusted R-squared	0.524718	0.556492
F-statistic	11.77	9.724311
Sample Size	36	36

The following are the results of the two-sided t-tests using my previous assumptions.

The critical value of t with 95% probability and 32 degrees of freedom is approximately 2.042.

Model 3:
Labor: |t-labor| < t-critical; can't reject null
Capital: |t-capital| < t-critical; can't reject null
Forest: |t-forest| > t-critical; reject null

Model 4:
Labor: |t-labor| < t-critical; can't reject null
Capital: |t-capital| < t-critical; can't reject null
Forest: |t-forest| > t-critical; reject null
JIT: |t-JIT| < t-critical, can't reject null

In model 2, I was able to reject the null regarding JIT production. This indicates that relatively high levels of inventory adversely affect comparative advantage. However, in model 4, which focused on monthly inventory variation, I was unable to reject the null regarding JIT. My results indicate that the relative levels of inventory are important in determining comparative advantage while the variation in inventories does not appear to significantly impact trade. The addition of JIT to my both series of equations improved my adjusted r-squared while decreasing the f-statistic. Furthermore, The significant increase in the f-stat and adjusted r-squared is also evidence of the traditional H-O inadequacy in prediction trade flows.

Conclusion

It appears that JIT, and other inventory management techniques, do affect an industry's comparative advantage in the global marketplace. The carrying costs associated with continually carrying a relatively high level of inventory could be a source of this advantage. Although, the smaller expected variations in monthly inventories associated with JIT production do not conclusively affect comparative advantage. This implies the benefits associated with JIT production stem from lower levels of inventory rather than decreased variation in inventory levels. As the more countries engage in free trade it is important for the U.S., and other countries, to fully understand how to maximize their comparative advantage. Under the H-O model countries can do nothing to change their relative advantage. It has been shown that various management techniques, such as JIT, affect trade patterns and that countries which readily pursue these tactics may be better able to improve their relative place in the global market place.

Works Cited

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Oman, Charles. "Technological Change, Globalization of Production and the Role of Multinationals" Growth and Competition in the New Global Economy (1999) 37-58

Trefler, Daniel. "The Case of the Missing Trade and other Mysteries" The American Economic Review (1995) Vol. 85 No. 5 1029-1046

Wolf, Edward N. " Productivity growth and shifting comparative advantage on industry level" Technology and International Trade (1997) 1-20

Dependent Variable: NEXPORTS
Method: Least Squares
Date: 05/22/01 Time: 18:02
Sample: 1 43
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(LABOR)	-222961.2	132399.0	-1.684009	0.1002
LOG(CAPITAL)	252577.8	108168.3	2.335044	0.0248
LOG(FOREST)	148538.1	59622.24	2.491321	0.0171
C	343188.5	662027.3	0.518390	0.6071

R-squared	0.279502	Mean dependent var	203197.8
Adjusted R-squared	0.224079	S.D. dependent var	981516.9
S.E. of regression	864582.4	Akaike info criterion	30.26629
Sum squared resid	2.92E+13	Schwarz criterion	30.43012
Log likelihood	-646.7252	F-statistic	5.043085
Durbin-Watson stat	1.680598	Prob(F-statistic)	0.004763

Appendix 2

Dependent Variable: EXPORTS
Method: Least Squares
Date: 05/22/01 Time: 18:14
Sample: 1 444
Included observations: 444
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(LABOR)	-11.10072	5.090998	-2.180460	0.0298
LOG(CAPITAL)	-10.02065	5.081976	-1.971803	0.0493
LOG(FOREST)	91.40753	7.041779	12.98074	0.0000
C	-844.3852	65.73784	-12.84474	0.0000

R-squared	0.534714	Mean dependent var	159.0068
Adjusted R-squared	0.531542	S.D. dependent var	181.1900
S.E. of regression	124.0136	Akaike info criterion	12.48763
Sum squared resid	6766929.	Schwarz criterion	12.52453
Log likelihood	-2768.254	F-statistic	168.5520
Durbin-Watson stat	0.135644	Prob(F-statistic)	0.000000

Dependent Variable: EXPORTS
Method: Least Squares
Date: 05/22/01 Time: 18:12
Sample: 1 444
Included observations: 444
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(LABOR)	-0.340559	5.571997	-0.061120	0.9513
LOG(CAPITAL)	-15.42129	5.062551	-3.046150	0.0025
LOG(FOREST)	87.00781	7.036944	12.36443	0.0000
JIT	-27.16314	7.216816	-3.763867	0.0002
C	-807.7552	65.71786	-12.29126	0.0000

R-squared	0.543386	Mean dependent var	159.0068
Adjusted R-squared	0.539226	S.D. dependent var	181.1900
S.E. of regression	122.9924	Akaike info criterion	12.47332
Sum squared resid	6640813.	Schwarz criterion	12.51944
Log likelihood	-2764.077	F-statistic	130.6062
Durbin-Watson stat	0.136808	Prob(F-statistic)	0.000000

Dependent Variable: EXPORTS
Method: Least Squares
Date: 05/23/01 Time: 20:08
Sample: 1 36
Included observations: 36
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(LABOR)	-4.276472	16.28015	-0.262680	0.7945
LOG(CAPITAL)	-10.09131	16.75018	-0.602460	0.5511
LOG(FOREST)	79.29799	25.09803	3.159531	0.0034
C	-753.1818	227.0018	-3.317955	0.0023

R-squared	0.524718	Mean dependent var	145.5237
Adjusted R-squared	0.480161	S.D. dependent var	160.6580
S.E. of regression	115.8342	Akaike info criterion	12.44664
Sum squared resid	429362.0	Schwarz criterion	12.62258
Log likelihood	-220.0394	F-statistic	11.77617
Durbin-Watson stat	1.300559	Prob(F-statistic)	0.000023

Dependent Variable: EXPORTS
Method: Least Squares
Date: 05/23/01 Time: 20:09
Sample: 1 36
Included observations: 36
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(LABOR)	4.523027	15.30832	0.295462	0.7696
LOG(CAPITAL)	-20.08225	16.05985	-1.250464	0.2205
LOG(FOREST)	79.36734	23.49827	3.377583	0.0020
JIT	-182.8745	112.5024	-1.625516	0.1142
C	-725.3366	208.4998	-3.478837	0.0015

R-squared	0.556492	Mean dependent var	145.5237
Adjusted R-squared	0.499265	S.D. dependent var	160.6580
S.E. of regression	113.6858	Akaike info criterion	12.43300
Sum squared resid	400658.4	Schwarz criterion	12.65293
Log likelihood	-218.7940	F-statistic	9.724311
Durbin-Watson stat	1.400597	Prob(F-statistic)	0.000032