AGRICULTURAL COMPETITIVENESS: MARKET FORCES AND POLICY CHOICE

PROCEEDINGS
OF THE
TWENTY-SECOND
INTERNATIONAL CONFERENCE
OF AGRICULTURAL ECONOMISTS

Held at Harare, Zimbabwe
22–29 August 1994

Edited by
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INTERNATIONAL ASSOCIATION OF
AGRICULTURAL ECONOMISTS
QUEEN ELIZABETH HOUSE
UNIVERSITY OF OXFORD

1995

Dartmouth

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Technological Progress and International Trade: The Case of the Less Developed ASEAN Countries

INTRODUCTION

Many trade economists believe that the introduction of technical change into an otherwise Heckscher–Ohlin (H-O) model could result in a more comprehensive explanation of trade flows. However, most of the investigations of this hypothesis have been based on the limiting assumption that technology is exogenously determined, and have narrowly focused on the manufacturing sector. In addition, most works on technology-based trade have dealt exclusively with the United States, which is a significant drawback in testing theories which seem to have originated with American observations in the first place (Deardoff, 1985).

This study aims to fill part of this gap by analysing the relationship between endogenous technology and international trade of the less developed countries of Southeast Asia. It tests the significance of a technology–trade relationship in both the agricultural and the agribased manufacturing sectors of their economies. Since Asia is considered to be the most dynamic region of the world in terms of economic growth and development, it is appropriate that this investigation be conducted on an area where 'newly industrializing economies' have originated and will continue to do so.

PREVIOUS RESEARCH ON TECHNOLOGY AND INTERNATIONAL TRADE

Posner (1961) suggested that innovating countries may export goods in which they may not even possess comparative advantage in terms of factor intensities and endowments. His model was adopted by Freeman (1963) who demonstrated that the location of production and exports is a function of technical progress. Posner's theory was formalized by Krugman (1979) who put it in the context of a Ricardian model with a continuum of goods, while Jones (1979) developed a neoclassical model which allows changes in technology to affect trade patterns. Although the latter treats technology as exogenous, Jones did not rule out the existence of mechanisms which may induce technological progress.

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One of the few economists who analysed agricultural trade of countries other than the United States was Arnade (1992), who developed an empirical model to test the relevance of factor endowments and exogenous technology in determining the agricultural trade patterns of Latin America. He concluded that both relative factor abundance and differences in technology explained Latin America's agricultural trading patterns.

ENDOGENIZATION OF TECHNOLOGY

The inducement mechanisms that drive technological changes can be divided into the two general categories of technology transfer and innovation. Technology transfer may result from purchases of capital goods, direct foreign investment, 'turnkey' projects or technical assistance and cooperation (Kakazu, 1989). Findlay (1973) established a strong positive association between foreign capital inflows into less developed countries (LDCs) and rates of foreign technology assimilation. Likewise, many consider foreign aid as a major avenue of technology transfer since most of the aid programmes are coupled with technical assistance and support from the donor countries.

Although most developing economies heavily depend upon technology transfer in improving their competitive position in the world market, it is widely recognized that indigenous technology must be developed as well, owing to the increasing costs associated with technology transfer and some possible adaption problems. This process of innovation requires an increasing share of research and development (R&D) expenditures (Kakazu, 1989; Jensen and Thursby, 1987; Gruber *et al.*, 1967).

Another possible driving force behind innovations is market power. Kamien and Schwartz (1982) presented the Schumpeterian position that innovation is a result of R&D races among large firms. While the controversy about the direction of causality between innovative efforts and market power remains unresolved, the Schumpeterian hypothesis provides strong support to those who believe that market power encourages innovation rather than innovation resulting in increased market power.

THE ENDOGENOUS TECHNOLOGY-BASED TRADE MODEL

This study follows the approach by Arnade who regressed relative exports of capital-intensive to labour-intensive agricultural crops on measures of relative factor supplies and relative technological indices. However, this investigation considers the possibility that technological change may be endogenous and tests the model, for the period 1970–90, in the case of the lesser developed countries who are members of the Association of Southeast Asian Nations (Indonesia, Malaysia, the Philippines and Thailand, referred to as ASEAN LDCs).

The general specification of the recursive system of equations is given by:

$$RTECH_{ct} = \alpha_0 + \alpha_1 FAID_{ct} + \alpha_2 DFI_{ct} + \alpha_3 RD_{ct} + \alpha_4 RELMP_{ct} + \varepsilon_1 \qquad (1)$$

$$RELEX_{ct} = \beta_0 + \beta_1 RFA_{ct} + \beta_2 RTECH_{ct} + \varepsilon_2 \quad (2)$$

where:

$RTECH_{ct}$ = index of relative technological progress between the capital-intensive and the labour-intensive industries;
$FAID_{ct}$ = foreign aid inflows;
DFI_{ct} = inflow of direct foreign investments;
RD_{ct} = research and development expenditures;
$RELMP_{ct}$ = relative market power between the capital-intensive and the labour-intensive industries in country *c* during time period *t*. The market power indicator used in the agricultural sector is the percentage of farms larger than three hectares, while the relative market power between the processed foods and textiles industries is represented by:

$$RELMP = \frac{market\ power\ (food)}{market\ power\ (textiles)}$$

where market power in the respective industries is measured as the reciprocal of the number of factories per 10 000 people in the country's population;
$RELEX_{ct}$ = relative exports of capital-intensive to labour-intensive products;
RFA_{ct} = relative factor abundance (that is, ratio of capital stocks to labour stocks);
c indexes country, and *t* indexes time period (year).

Since this study involves pooling cross-section and time-series observations, dummy variables were added to identify countries and years. The system of equations was fitted in both the agricultural and agribased manufacturing sectors of the ASEAN LDCs.

Capital- and labour-intensity of crops

Table 1 lists the agricultural capital to labour spending ratios of selected crops in the United States. This served as the basis for classifying each crop as either capital-intensive or labour-intensive. Input requirements of goods from the United States will be identical to other countries if technological differences between countries are Hicks-neutral. From Table 1, five crops were identified as agricultural capital-intensive: wheat, rice, corn, soybeans and cotton; two crops were considered labour-intensive: sugar and tobacco.

In the case of the agribased manufacturing sector, the capital-intensive category is represented by the food processing industry (SITC 20) while the labour-intensive category is represented by the textiles industry (SITC 22).

TABLE 1 *Capital to labour ratios of crops (1970–90 average)*

Crops	Ratio of agricultural capital to labour cost
Corn	4.99
Soybeans	4.84
Wheat	3.81
Rice	2.12
Cotton	1.71
Sugar Beet	1.12
Tobacco	0.57
Sugar Cane	0.55

Relative exports

The relative export index (*RELEX*) in agriculture was calculated as the ratio of the weighted value of capital-intensive crop exports to the weighted value of labour-intensive crop exports, using commodity prices as weights. The *RELEX* variable in manufactures was calculated as the ratio of the total export value of processed foods to the total export value of textiles.

Relative factor abundance

Agricultural capital is represented by the sum of undepreciated tractor equivalents and the three types of agricultural land (farmland, crop land and pasture), each weighted by their respective average prices. Labour stock on the other hand, was calculated by multiplying the agricultural labour force by the prevailing average agricultural wage rates of the respective countries. The relative factor abundance (*RFA*) variable was then calculated as the ratio of total agricultural capital stock to the total agricultural labour stock.

In the case of manufactures, *RFA* was calculated as the ratio of the total capital stock available in the combined processed foods and textiles industries to the total available manpower in those activities.

Relative technological change

Relative technological change (*RTECH*) was measured using the ratio of the agricultural capital-intensive industry's two-factor productivity index to the labour-intensive industry's two-factor productivity index. An industry's two-factor productivity index (TFPI) was calculated using Ball's formulation of the Tornqvist index (Ball, 1984). The Tornqvist index was also used in determining the two-factor productivity indices in the agribased manufacturing industry. However, the industries in the agribased manufacturing sector are each represented by a single commodity (processed foods for the capital-intensive industry and textiles for the labour-intensive industry).

EMPIRICAL RESULTS

Results of endogenizing technology are presented in Table 2. The specifications were tested for potential collinearity, autocorrelation and heteroskedasticity problems and were found to be free of each at the 10 per cent level.

TABLE 2 *Regression results of endogenizing technological progress*

	Agriculture	Agribased manufactures
	Parameter estimates	
Intercept	–1.16	0.88*
	(1.21)	(0.04)
Foreign aid (*FAID*)	–0.03	–0.07*
	(0.06)	(0.03)
Direct foreign investment (*DFI*)	–0.01	–0.03
	(0.02)	(0.02)
R&D expenditures (*RD*)	–0.19*	–0.04*
	(0.06)	(0.02)
Relative market power (*MP*)	0.04*	0.67*
	(0.02)	(0.13)
	$R^2 = 0.26$	$R^2 = 0.53$
	$n = 92$	$n = 52$
	$F = 4.19$	$F = 8.37$

Notes: Figures in parentheses are standard errors.
* = coefficient is significant at the 10 per cent level.

The agricultural sector

Results indicate that endogenization of technology holds true in the agricultural sector. A high R^2 of 0.26 (given that this is cross-sectional data analysis) and a high F statistic of 4.19 indicate that the model fits the data well. *RD* and *MP* were found to be significant at the 10 per cent level.

The negative sign of the *RD* coefficient indicates that, as R&D expenditures in agriculture increase, the labour-intensive industry experiences greater improvement relative to the capital-intensive industry. This finding implies that, assuming all other factors are held constant, technological improvement in the labour-intensive industry is more responsive to the infusion of research and development funds in agriculture. The positive sign of the *MP* coefficient indicates that, as the percentage of large farm owners increases, the productivity of the capital-intensive industry increases at a faster rate than the productivity of the labour-intensive industry.

The significance of the country dummy variables indicates structural differences between the countries included in the study that have not been accounted for by other independent variables. Differences in climate, natural resource endowment and culture, among others, may have accounted for these significant cross-country differences.

The impact of endogenous technology and relative factor endowments on international trade is reflected in Table 3. The model has a relatively high R^2 and a high F statistic, indicating that the model fits the data well. Results also indicate that both relative factor endowment and relative technological progress were non-significant at the 10 per cent level.[1] Despite the non-significance of the coefficients, analysis of the coefficient signs reveals that the ASEAN LDCs tend to export more of the agricultural crops where they have a technological advantage, a result which is consistent with prior expectations.

The agribased manufacturing sector[2]

As suggested by the high R^2 and F values, the model for manufactured goods appears to fit the data well (Table 2). Three of the regressors were found to be significant at the 10 per cent level: *FAID*, *RD* and *MP*. The significant negative coefficient of *FAID* indicates that, as the amount of foreign aid flowing into the ASEAN LDCs increases, the technological level of the food industry tends to lag behind that of textiles. This relationship indicates a strong possibility that the major portion of aid money that these countries receive is channelled into, or has spillover impacts on, the development of the textile industry.

The negative sign of the *RD* coefficient implies that, as the amount of R&D spending in the manufacturing sector increases, technological development in the food industry tends to lag behind that of textiles. This may also indicate a strong possibility that a more significant portion of R&D spending is channelled towards the textiles industry at the expense of the food processing industry. A more understandable result is suggested by the significant positive *MP* coefficient, which suggests that, as the market power in the food processing industry increases relative to that in the textiles industry, the former's technological level tends to surpass that of the latter. This relationship illustrates a case where market power or concentration is associated with a greater degree of technological advancement.

The negative coefficient of *DFI*, although not significant at the 10 per cent level, presents an interesting connotation. That is, as the volume of foreign direct investment inflows to the manufacturing sector increases, the relative technological progress in the food processing industry tends to diminish in comparison with textiles.

Results of regressing relative export against endogenous technological progress index and relative factor abundance are presented in Table 3. As the table shows, the model fits the data well with an R^2 of 0.43 and an F statistic of 5.98. However, only *RFA* was found to be significant at the 10 per cent level.

TABLE 3 *Regression results: the effects of relative factor endowments and relative endogenous technological change on trade patterns*

	Agriculture	Agribased manufactures
	Parameter estimates	
Intercept	2.98*	–10.98
	(0.26)	(11.07)
Relative factor endowments (*RFA*)	0.01	9197.13*
	(0.01)	(2987.79)
Relative technological progress (*RTECH*)	0.31	16.51
	(1.68)	(11.92)
	$R^2 = 0.77$	$R^2 = 0.43$
	$n = 22$	$n = 37$
	$F = 10.72$	$F = 5.98$

Notes: Figures in parentheses are standard errors.
* = coefficient is significant at the 10 per cent level.

The positive *RFA* coefficient in this case indicates that the Heckscher–Ohlin theory holds, as might have been expected. Although the *RTECH* coefficient is not significant at the 10 per cent level, it has a *p*-value of 0.176 which provides strong justification to consider discussing its impact on relative exports. A positive sign of the *RTECH* coefficient in this case indicates that international trade patterns are positively affected by technological progress. Thus results of this study provide strong support for the view that factor endowments and technological progress may simultaneously affect trade patterns.

DEVELOPMENTS IN THE ASIAN REGION

The development experience of Asia in the last decade is characterized by countries pursuing widely divergent strategies and policies resulting in diverse growth performance. The newly industrializing countries (NICs) which are poor in natural resources, namely Hong Kong, South Korea, Singapore and Taiwan, with their outward-looking export-oriented strategies, have recorded high growth rates. In contrast, the natural resource-rich countries of Indonesia, Malaysia the Philippines, and Thailand have had various experiences typical of lesser developed economies.

The finding that the *FAID* and *DFI* coefficients are both negative runs counter to expectations. However, recent developments in the Asian economy present some enlightening explanations for these relationships. For instance, currency appreciation, coupled with rising labour costs, has induced the NICs to transfer their industries, especially those that are labour-intensive, to the less developed Asian countries where wage rates are significantly lower. Thus, with the inflows of direct foreign investments mostly allocated in the labour-intensive industry, the relative technological progress of the capital-intensive to labour-intensive industries decreases in the less developed ASEAN countries.

In the same manner as the NICs increase their investment in the LDCs, the number of factories that are set up in the labour-intensive industry increases relative to that in the capital-intensive industry. This drives up the number of factories in the labour-intensive industry, creating a more competitive setting for them relative to the capital-intensive industry, and shows up as an increase in the relative market power of the latter industry against the former. This results in an increase in relative technological progress in the capital-intensive industry and may provide an explanation for the positive sign of *MP*.

This finding also provides support for the Schumpeterian hypothesis that market power provides an incentive to technological development. Such ramifications would be more credible, however, if the *RD* coefficient turned out to be positively signed, since that would have implied that innovation (as proxied by R&D expenditures) drives technological progress. Since larger firms tend to have a greater motivation to innovate, then a positive *RD* coefficient would have provided a stronger support for the Schumpeterian hypothesis. However, one should realize that the *RD* variable used in this study does not represent a ratio variable, and this limits our analytical capacity.

CONCLUSIONS

This paper has tested an alternative model that explains trade patterns based on the Heckscher–Ohlin model and endogenous technological influences. The basic feature of this model is the determination of variables which influence relative technological progress in the agricultural crop and agribased manufactured goods sectors of less developed economies in Southeast Asia.

Results suggest that both the agricultural and the agribased manufactured goods sectors experience endogenous technological development. More specifically, such development in ASEAN LDC agriculture is driven by innovations influenced by increased research and development expenditures and market power. Similarly, the agribased manufacturing sector exhibits endogenous technology-driven trade patterns between the capital-intensive industry (processed foods) and the labour-intensive industry (textiles). Such technological changes were found to be associated with both technology transfer mechanisms (such as, foreign aid) and innovations driven by R&D and market power.

It has become evident that both technology transfer and innovations play an important role in the development of the ASEAN LDCs technologies which, in turn, affect their trade patterns. Thus emphasis should be placed on formulating policies which encourage both innovations and the effective transfer of technology in the appropriate sectors. In the agricultural sector, for instance, large farms which have traditionally been linked to dynamic development and adoption of technological innovations were found to be directly related to relative technological progress between the agricultural capital-intensive industry and the labour-intensive industry. The basic premise is that large farmers have a greater margin for risk taking and greater access to capital which enable them to shift to new techniques sooner than the smaller farmers. This implies, therefore, that the channels for credit and modern inputs to small farms should be improved, thus displacing the misconception that a large farm structure is essential for the adoption of new techniques.

In the same manner, the finding that R&D expenditures in the agricultural sector of the ASEAN LDCs are negatively associated with technological progress (of the agricultural capital-intensive industry relative to the labour-intensive industry) indicates the need to increase R&D spending in order to achieve a higher level of technological progress in the appropriate industry. The significance of this implication is based on the assumption that the LDCs' agricultural sector is more labour-intensive than agricultural capital intensive.

NOTES

[1]One may suspect the existence of a multicollinearity problem between *RFA* and *RTECH* because of the evidently higher R^2 value and insignificant regressors. However, the low variance inflation factors of 3.01 and 1.26 for *RFA* and *RTECH* respectively, indicate that no such specification problem exists.

[2]Thailand was omitted in the analysis of the manufactured goods sector owing to lack of some data.

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