Document généré le 9 mai 2024 06:50

Journal of Comparative International Management

Technological Achievement, High Technology Exports and Growth

Azmat Gani

Volume 12, numéro 2, august 2009

URI : https://id.erudit.org/iderudit/jcim12_2art02

Aller au sommaire du numéro

Éditeur(s)

ISSN

1481-0468 (imprimé)
1718-0864 (numérique)

Découvrir la revue

Citer cet article

Gani, A. (2009). Technological Achievement, High Technology Exports and Growth. *Journal of Comparative International Management*, *12*(2), 31–47.

Résumé de l'article

The relationship between high technology exports and per capita economic growth in countries with higher levels of technological achievement is examined. Three groups of countries classified as technological leaders, potential leaders and dynamic adopters are chosen for empirical analysis on the basis of the technological achievement index. The regression results reveal that high technology exports exert a statistically significant positive effect on growth of the technological leader category of countries and a positive but statistically insignificant effect on thepotential leader category of countries. The main policy implication is that low-income countries with lower levels of technological achievement and growth may need to focus on new product development with high technological content so as to be competitive in the global trading environment as well as to enhance their growth and development.

All rights reserved © Management Futures, 2009

Ce document est protégé par la loi sur le droit d’auteur. L’utilisation des services d’Érudit (y compris la reproduction) est assujettie à sa politique d’utilisation que vous pouvez consulter en ligne.

https://apropos.erudit.org/fr/usagers/politique-dutilisation/

Cet article est diffusé et préservé par Érudit.

Érudit est un consortium interuniversitaire sans but lucratif composé de l’Université de Montréal, l’Université Laval et l’Université du Québec à Montréal. Il a pour mission la promotion et la valorisation de la recherche.

https://www.erudit.org/fr/

Journal of Comparative International Management
2009, Vol. 12, No.2, 31-47
©2009 Management Futures
Printed in Canada

Technological Achievement, High Technology Exports and Growth

by
Azmat Gani
The University of the South Pacific, Suva, Fiji Islands

The relationship between high technology exports and per capita economic growth in countries with higher levels of technological achievement is examined. Three groups of countries classified as technological leaders, potential leaders and dynamic adopters are chosen for empirical analysis on the basis of the technological achievement index. The regression results reveal that high technology exports exert a statistically significant positive effect on growth of the technological leader category of countries and a positive but statistically insignificant effect on thepotential leader category of countries. The main policy implication is that low-income countries with lower levels of technological achievement and growth may need to focus on new product development with high technological content so as to be competitive in the global trading environment as well as to enhance their growth and development.

1. Introduction

Technological diffusion and advancements as experienced largely by several high-income countries seem to be the overriding cause of their trade patterns in technology specific products. The rise in technological capabilities is due to technological creation, improvements and advances that have taken place in a range of countries on several fronts. Given the importance of technology, its role in influencing nations economic well being and the global economic growth process has been addressed elsewhere (United Nations Development Program (UNDP), 2001; Chan and Yang, 2005; Fu, 2005; and Kim and Park, 2006).

The ongoing strong emphasis and investments in research and development (R&D), largely in production sectors, has led to the creation of high technology products, leading to high technology exports (Liu and Lin, 2005). High technology exports are products with high research and development intensity such as computers, pharmaceuticals, scientific instruments, electrical machinery, consumer electronics, software, transportation electronics and military and civil aerospace products. Information technology (IT) goods such as electronic data processing equipment, software, electronic components and telecommunications equipment are also part of the high technology products.

It is noted that high-tech manufacturing has been the fastest growing area of world trade and now accounts for over one fifth of total trade (see for example, UNDP, 2001, p.31). Such high-tech exports are likely to have a significant effect on the economic well-being of exporting countries (Liu and Lin, 2005). In addition, Sen (2002) has emphasised that "the importance of global contact and interaction applies to economic relations among others and that there is much evidence that global economy has brought prosperity to many different areas of the globe and in overcoming pervasive poverty, both modern technology and economic interrelations have been influential." Similar sentiments are also expressed by Stiglitz (2002).

This paper examines whether or not high technology exports have been a determining factor in per capita economic growth in countries with higher levels of technological achievement. Cross country annual data for 45 countries for 1996-2004 are used in reduced form equations for empirical analysis. Separate equations are estimated for the full sample of 45 countries, the leaders, potential leaders and dynamic adopters of technology, using the cross sectionally hetroskedastic and timewise autoregressive procedure. In addition, a fixed effects procedure correcting for AR(1) errors are also utilised. These three procedures are repeated with the full sample countries as well as the three categories of countries based on their technological achievement.

The next section describes global patterns in high technology exports. Section Three presents the analytical framework followed by a discussion of sample countries and data in Section Four. Section Five presents the empirical results. Conclusions and policy implications follow.

2. Global Technological Achievement and the Shift Towards High Technology Exports

A major factor contributing to technological advancement across several nations is investment in R&D and human capital formation. For example, in the new growth framework, it has been suggested that a country's productivity depends on its own investment in R&D as well as spillovers from R&D by other countries (Grossman and Helpman, 1991 and Barro and Salai-i-Martin, 1995). Thus, R&D activities have contributed to technological improvements and product development in several areas: communication, transportation networks, information technology; computers and peripherals; industrial manufactures; pharmaceuticals; and military and civil aerospace technology.

The level of technological achievement of a country had first been put into perspective by Rodriguez and Wilson (2000) through the Index of Technological Progress (ITP), using five components—personal computers, Internet hosts, fax machines, mobile phones and televisions, for 110 countries. Their ITP showed high-income economies as leaders in technological progress and poor countries as laggards.

In a similar vein, UNDP (2001, Table A2.1, p. 48-51) also introduced a measure of technological achievement, the technology achievement index (TAI) for 72 countries. The TAI is a composite index composed of (a) technology creation, (b) diffusion of recent innovation, (c) diffusion of old innovation, and (d) human skills. According to the TAI, there are 18 countries that are leaders in technological achievement, 19 countries as potential leaders, 26 countries as dynamic adopters and 9 countries as marginalized.

Building on similar attempts as that of UNDP (2001), Archibugi and Coco (2004) devised a new indicator of technological capabilities for developed and developing countries. These authors cite a wider number of variables associated with technological change, with their measures including three main components: the creation of technology, technological infrastructures and the development of human skills.

While measures of technological capacity are now well established as indicated above, technological improvements have led to the development of industries that manufacture products of high technological content. This has contributed to the growth of high technology exporters. On the basis of the Heckscher-Ohlin trade theory, nations' economic structures are likely to change, therefore, changing factor endowments such as technological improvement would result in shifts in the structure of trade. For example, Das (1998) notes that "the product composition of exports would shift from a predominance of natural resource intensive exports to unskilled labour intensive exports, further to physical and human capital-intensive exports, and then on to technology and knowledge-intensive exports."

The expansion of high technology exports has given a quick push and an expansion to growth in world trade. For example, technological advancements have created new finished products, consumer and industrial goods as well as new product market sectors. At the same time, improved communications technology, continued improvements in efficiency of international transport and lower levels of trade barriers have also facilitated the rapid increase in global trade (The World Bank, 2000, p. 30). For example, Wolf (2003) notes that as the technologies of travel, transportation and communications have improved, so inevitably have returns to these activities, also noting that with the internet, the cost of global communication is now close to zero. Falling costs of global communication is also facilitating increased global trade.

Exports of high technology products are giving a quick boost to the export incomes of several countries with high technological capability. While export contributions to national growth and productivity is obvious, imports of high technology goods can raise output directly as inputs into the production process. For example, Connolly (2003) provides empirical evidence that high technology goods imports from developed countries not only positively affects domestic innovation, but also leads to increased GDP growth as higher quality capital goods are used in domestic production. In addition, Coe, Helpman and Hoffmaister (1997) have noted that access to imported inputs facilitates the diffusion of knowledge, which contributes to productivity while Wacziarg (2001) notes that import competition increases not only the exit but also the entry of domestic firms, spurring innovation.

The liberalization of trade has also contributed to the increased internationalization of the world economies and expansion of the global business environment (Edwards, 1993; International Monetary Fund, 2001 and Dreher, 2006). Combined with the ease of flow of goods and services across several nations within the world communities, this has also resulted in changing production structures of several nations (Mehta and Parikh, 2005).

The developments in global exports are directly related to the changes in sectoral production among several nations. Increases in global exports have largely been concentrated between two sectoral outputs: exports of manufactures and exports of services. For example, trade in manufactures accounts for over 75 per cent of international trade (The World Bank, 2000). There is a rapidly growing share of IT goods in the world trade, which has risen from some 7.5 percent in 1990 to 11 percent in 1999, reflecting both growing demand for new technology and the high price-to-weight ratio of IT goods, which contributes to their greater tradability (International Monetary Fund, 2001).

Although the degree of dependence on high technology exports varies considerably across the globe, the relative importance of high technology exports has increased in almost all individual cases for all of the countries selected in this study (Table 1). Among the technological leader category, Singapore leads in high technology exports while in the potential leader category; Malaysia outpaced all other countries (Table 1). Among the dynamic adopters, Thailand is ranked at the top in terms of high technology exports (Table 1).

Table 1: High Technology Exports as a Percent of Manufactured Exports

Country	1995	2000	2004
Leaders			
Australia	15.7	15.2	13.6
Austria	8.6	13.0	12.1
Canada	15.1	18.6	13.6
Finland	14.7	27.3	20.9
France	18.7	23.8	19.1
Germany	12.9	18.0	17.2
Ireland	45.8	47.5	33.8
Israel	15.8	25.1	18.8
Japan	26.1	28.3	23.7
Korea, Rep.	25.9	34.8	32.8
Netherlands	23.8	35.4	29.1
New Zealand	11.6	14.8	13.7
Norway	14.0	17.1	18.3
Singapore	53.9	62.6	58.9

Sweden	16.1	22.1	17.2
United Kingdom	27.3	30.0	24.1
United States	32.8	35.3	32.3
Potential Leaders			
Argentina	3.5	9.0	7.6
Chile	3.3	3.4	4.8
Costa Rica	6.1	51.6	36.8
Croatia	5.9	8.5	13.0
Cyprus	13.4	6.4	22.1
Czech Republic	5.0	8.1	12.9
Greece	5.7	13.3	11.4
Hong Kong, China	16.4	23.6	32.0
Hungary	6.8	26.4	28.9
Italy	8.0	9.2	7.7
Malaysia	46.1	59.5	55.4
Mexico	15.1	22.4	21.2
Poland	2.7	3.3	3.2
Portugal	5.4	6.4	8.7
Romania	2.3	5.5	3.4
Slovak Republic	3.8	4.1	5.2
Slovenia	3.4	4.7	5.5
Spain	7.1	7.6	7.0
Dynamic Adopters			
Bolivia	14.0	40.0	9.2
China	10.0	18.6	29.8
Colombia	7.0	7.7	5.6
Ecuador	6.0	5.6	7.3
El Savador	8.0	6.0	4.1
India	4.0	5.0	4.9
Indonesia	7.0	16.2	16.1
Panama	1.0	0.1	2.1
Thailand	24.0	33.3	30.2
Tunisia	2.0	3.4	4.9

Source: The World Bank (2006).

3. The Analytical Framework

The estimation framework adopted here complements the more macroeconomic oriented discussion on economic growth (Mankiw, Romer and Weil, 1992; Fischer, 1993; Barro and Sala-i-Martin, 1995; Yao, 2006; Awokuse, 2006; and Tang, 2006). An important aspect of the empirical framework is that key issues relating to high technology exports and growth are unfolded.

Growth in output is presumed to be primarily a function of the growth of factor supplies as well as several other variables affecting the efficiency of resource allocation and factor productivity. The variables tested are predominantly the main conventional variables as used in many cross-country studies. These are: (a) the growth rate of population to account for the growth in the productive labour force; (b) the ratio of gross domestic investment to GDP to account for the growth in the stock of physical capital; (c) the starting level of income per capita to probe if it actually correlates with per capita growth over the entire period (convergence hypothesis); (d) the number of researchers involved in research and development per million people as a proxy for human capital; and the rate of inflation. Jones (1998) and Temple (1999) provide a comprehensive review of these conventional variables while Rogers (2003) provides an in depth survey on economic growth that focuses on a wide range of models and empirical results.

Exports have been regarded as an engine for growth. Past studies examining export growth and growth in income have suggested that they were significantly positively correlated. There are numerous studies examining the possible link between exports and economic growth (Balassa, 1978; Edwards, 1993; Fosu, 1996; Awokuse, 2006; Tang, 2006; and Yao, 2006). On the other hand, Sharer (1999) points out that in recent years, no country with an inward focused policy has proved successful in attaining or sustaining a high internal growth rate of GDP. High technology exports as a share of manufactured exports is the prime variable, added to test whether it has any impact on per capita growth. It is expected that a high technology exports coefficient would show with a statistically significant positive sign, in the estimation phase of the structural equation.

The estimation framework consists of the following generic forms:

$$g_{ir}^{ALL} = l_{it}\gamma + htx_{it}\pi + \upsilon_{it} \quad (1)$$

$$g_{ir}^{L} = l_{it}\gamma + htx_{it}\pi + \upsilon_{it} \quad (2)$$

$$g_{ir}^{PL} = l_{it}\gamma + htx_{it}\pi + \upsilon_{it} \quad (3)$$

$$g_{ir}^{DA} = l_{it}\gamma + htx_{it}\pi + \upsilon_{it} \quad (4)$$

where g is growth rate of gross domestic product per capita. The generic form includes two types of regressors, l and htx. l represents the standard variables, commonly known to influence per capita growth and htx, in contrast, is high technology exports. The standard variables in equations (1) to (4) are the growth rate of population (grp); the ratio of gross domestic investment to GDP (inv); the real per capita GDP (PPP) at the start of the period (pcgdp); the GDP deflator inflation (ifn); the human capital, measured by number of researchers per million people (hc); and htx is high technology exports as a share of manufactured exports. *ALL* is a sample of 45 countries (leaders, potential leaders and dynamic adopters); *L* is the leader's category (17 countries), *PL* is the potential leader's category (18 countries) and *DA* is the dynamic adopter's category (10 countries). The subscripts i and t are countries and time period respectively.

The error term in the above equation is υ_{it} with the assumption that $\upsilon_{it} \approx iid(0, \sigma^2)$.

While equations (1) to (4) can be estimated with ordinary least squares, the result is likely to be biased if the error terms are correlated within each time series unit and are heteroscadastic across each cross sectional unit, given that the data utilised here is cross-sectional. Combining these assumptions means estimating a cross-sectionally heteroscdastic and time-wise autoregressive model. Hence, the initial estimation procedure begins with the estimation of a cross-sectionally heteroskedastic and time-wise autoregressive model.

4. Same Countries and Data

The selection of countries for empirical analysis is based on the Technological Achievement Index (TAI) developed by the UNDP (2001). The TAI is numbered 0.0 to 1.0, indicating the level of innovation in a society, with 0 being low and 1.0 being high. The TAI is a composite index composed of (a) technology creation, (b) diffusion of recent innovation, (c) diffusion of old innovation, and (d) human skills. Based on the TAI, the UNDP (2001) classifies countries into four categories: *leaders* (TAI of 0.50 and above); *potential leaders* (TAI between 0.35 and 0.49); *dynamic adopters* (TAI between 0.20 and 0.34); and *marginalized* (TAI below 0.20). In this analysis, the countries are chosen from leaders, potential leaders and dynamic adopter categories.

The sample of countries selected for the *leader* category include Finland, United States of America, Sweden, Japan, Republic of Korea, the Netherlands, United Kingdom, Canada, Australia, Singapore, Germany, Norway, Ireland, New Zealand, Austria, France, and Israel.

The sample of countries selected for the *potential leader* category include Spain, Italy, Czech Republic, Hungary, Slovenia, Hong Kong, Slovakia, Greece, Portugal, Poland, Malaysia, Croatia, Mexico, Cyprus, Argentina, Romania, Costa Rica, and Chile.

The sample of countries selected for the *dynamic adopter* category include Bolivia, China, Colombia, Ecuador, El Salvador, India, Indonesia, Panama, Thailand and Tunisia.

The sample period covers the years 1996-2004. The data source for all variables is the *World Bank's World Development Indicators CD-ROM 2006* (The World Bank, 2006). Tables 2 and 5 in Section 5 present the results of the contribution of high technology to growth of real GDP per capita.

5. Estimation Procedure, Results and Discussion

Equation (1) includes 45 countries and 9 time periods; equation (2) includes 17 countries and 9 time periods; equation (3) includes 18 countries and 9 time periods; and equation (4) includes 10 countries and 9 time periods. A cross-sectionally heteroskadastic and time-wise autoregressive model is estimated first. This procedure of estimation is also equivalent to the generalised least squares (GLS) estimation (Kmenta, 1986). The results of this estimation procedure are recorded in the in the second column of Tables 2 to 5.

The GLS equivalent estimation does not take into account country-specific factors. While the sample of countries share somewhat similar economic structures, the extent of the development of their export sector differs from one country to another. To take into account country-specific differences, a fixed effects estimation procedure including country-specific dummy variables is adopted. In total there are 45 dummies for equation 1, 17 for equation 2, 18 for equation 3, and 9 for equation 4. The no-constant option is adopted in the estimation procedure so as to avoid the commonly known dummy variable trap. Tables 2 to 5 do not report results of these country effect dummy variables due to space constraints.

The initial estimation results suggested autocorrelated errors within the cross-sections in the fixed effects estimation procedure. Given the nature of data, the possibility of AR (1) errors are likely and so a third procedure is adopted: the fixed effects estimation procedure corrected for AR (1) errors. The results of this third procedure of estimation (AR(1) errors) is reported in the fourth column of Tables 2 to 5 and is considered to be most robust of the three estimation procedures adopted here.

Turning to the central focus of this paper, namely the impact of high technology exports *(htx)*, the robustly positive and statistically significant coefficients in the full sample (Table 2) and leader category (Table 3), and the positive but statistically insignificant coefficients in the potential leader category (Table 4) are obtained. The results, particularly of the leader category, confirm the strong and positive impact of high technology exports on per capita growth. This suggests that, insofar as the expansion of the technological base of the export oriented industries entails a greater overall productivity and a more efficient resource allocation within the economy, such effects are favorably and strongly contributing to the growth in per capita income in the leader economies category of countries. In the potential leader category of countries, the coefficient of high-technology exports has the expected positive sign but is statistically insignificant across the three estimation methods adopted. The results of this category are not surprising given that the sample countries in this category have low levels of technological achievement and a limited range of high-technology export products compared to the technological leader category of countries.

Table 2: Regression Results – All Countries

Variable	GLS	Fixed Effects	Fixed Effects Corrected for AR(1) Errors
constant	1.667 (3.808)*	...	...
grp	-1.061 (18.420)*	-0.984 (9.069)*	-0.989 (8.868)*
inv	0.133 (7.996)*	0.107 (4.204)*	0.088 (3.649)*
pcgdp	-0.0001 (6.056)*	-0.0001 (5.884)*	-0.0002 (6.092)*
ifn	-0.063 (5.608)*	-0.088 (6.823)*	-0.086 (7.349)*
hc	0.0007 (0.909)	0.0002 (1.770)***	0.0002 (2.068)**
htx	0.037 (4.979)*	0.025 (1.902)**	0.033 (2.642)*
N	405	405	405
R-square	0.54	0.47	0.53
DW	1.75	2.19	...
Von Neumann	1.76	2.19	...
LM (Hetroskedasticity)	...	273.64	...
B-P	...	1182.9	...

t- statistics are in parentheses.

*, ** and *** indicates statistically significant at the 1, 5 and 10 % levels respectively.

Table 3: Regression Results – Leaders Category

Variable	GLS	Fixed Effects	Fixed Effects Corrected for AR(1) Errors
constant	4.636 (4.694)*	...	...
grp	-1.078 (17.610)*	-0.930 (7.257)*	-.0934 (7.152)
inv	-0.006 (0.353)	-0.037 (1.403)	-0.043 (1.625)***
pcgdp	-0.0002 (5.202)*	-0.0002 (3.411)*	-0.0002 (3.408)
ifn	0.215 (3.577)*	0.838 (1.116)	0.077 (1.032)
hc	0.0004 (0.419)	-0.0006 (0.464)	-0.0007 (0.599)
htx	0.087 (7.898)*	0.075 (5.268)*	0.077 (5.427)*
N	153	153	153
R-square	0.71	0.63	0.65
DW	1.77	2.10	...
Von Neumann	1.78	2.12	...
LM (Hetroskedasticity)	...	87.76	...
B-P	....	149.16	...

t- statistics are in parentheses.

* and *** indicates statistically significant at the 1 and 10 % level respectively.

Table 4: Regression Results – Potential Leaders Category

Variable	GLS	Fixed Effects	Fixed Effects Corrected for AR(1) Errors
constant	2.099 (2.087)*	...	...
grp	-0.803 (4.858)*	-1.108 (4.727)*	-0.965 (4.786)*
inv	0.115 (3.439)*	0.064 (1.322)	0.045 (0.885)
pcgdp	-0.0002 (4.451)*	-0.0001 (2.083)**	-0.0001 (2.835)*
ifn	-0.069 (4.180)*	-0.078 (7.060)*	-0.081 (7.473)*
hc	0.0004 (1.237)	0.0007 (1.098)	0.0009 (1.530)
htx	0.019 (1.236)	0.032 (1.539)	0.029 (1.411)
N	162	162	162
R-square	0.39	0.38	0.56
DW	1.86	2.48	...
Von Neumann	1.88	2.50	...
LM (Hetroskedasticity)	...	63.63	...
B-P	...	245.3	...

t- statistics are in parentheses.

* and *** indicates statistically significant at the 1 and 5 % level respectively.

Table 5: Regression Results – Dynamic Adopters Category

Variable	GLS	Fixed Effects	Fixed Effects Corrected for AR(1) Errors
constant	1.053 (0.413)	...	...
grp	-1-198 (1.365)	0.690 (0.532)	0.908 (0.676)
inv	0.267 (4.945)*	0.321 (4.327)*	0.323 (4.542)*
pcgdp	-0.0004 (2.772)*	-0.0004 (2.188)**	-0.0004 (2.512)**
ifn	-0.114 (3.871)*	-0.144 (3.840)*	-0.146 (4.086)*
hc	-0.0003 (0.249)	0.002 (1.132)	0.002 (1.273)
htx	-0.033 (1.520)	-0.022 (0.608)	-0.0001 (0.003)
N	90	90	90
R-square	0.63	0.59	0.63
DW	1.65	2.25	...
Von Neumann	1.66	2.27	...
LM (Hetroskedasticity)	...	66.58	...
B-P	...	55.60	...

t- statistics are in parentheses.

* and ** indicates statistically significant at the 1 and 5 % level respectively.

The results show that the growth of population, *grp*, has a negative and statistically significant effect in all but the dynamic adopter's category. This might be viewed as counter intuitive at first, as population growth is often hypothesized to have a negative impact on per capita growth (Kelley, 1988). But the empirical evidence on this relationship has been less than robust at best, if not altogether inconclusive. The correlation between population growth and per capita growth generally varies by the level of economic development (in terms of both the direction and the size of the correlations with the correlation likely to be negative in relatively poor countries and positive in relatively wealthy countries. The result of this variable is also consistent with some past empirical studies controlling for population growth while testing growth equations, for example, Miller (1996) and Burney (1996).

As expected, the coefficient investment *(inv)* is positive and statistically significant in the all countries category (Table 2), the dynamic adopter category (Table 5) and positive but statistically insignificant in the potential leader's category (Table 4). The results obtained for these categories of countries indicate that physical capital accumulation is indeed an important factor for per capita growth.

The results of variable *pcgdp* provide evidence in favour of the convergence hypothesis in the all countries category (Table 2), leaders and potential leader's categories and dynamic adopter categories (Tables 3 to 5). The estimated coefficient of *pcgdp* is statistically significant across all specifications in all cases. This expected effect shown by *pcgdp* is also consistent with some of the previous growth studies and confirms the pattern noted by many others.

As for human capital *(hc)*, the coefficient is positive and significant in all countries (Table 1), and positive but insignificant in the potential leaders and dynamic adopter categories (Tables 4 and 5). In general, the modeling of the relationship between human capital and economic growth has produced very mixed results. Engelbrecht (2003) provides a good review of the empirical literature pertaining to this issue. Existing empirical work shows both positive and negative effects of human capital measures.

Tables 2 to 5 also show that the inflation rate variable, *ifn*, is negative and statistically significant in the all countries (Table 2), potential leaders and dynamic adopter's categories across all the specifications tested. The results here for this variable are also consistent with this and with other cross-country studies (Alexander, 1997). This suggests that high inflation rates are potentially disruptive to per capita growth in these economies.

5. Conclusion and Policy Implications

Using methodologies common in the literature, this paper examines whether or not high technology exports have recently been a determinant in per capita economic growth in countries with higher levels of technological achievement. The analysis used data from a sample of countries based on the technological achievement index. The empirical results of the technological leader category of countries provides strong evidence of the positive impact of high technology exports on per capita growth. In the potential leader category of countries, the coefficient of high-technology exports has the expected positive effect but is statistically insignificant. The result of this category is not surprising given the limited range of high-technology export products.

The major policy implication is that countries aiming for high growth may wish to expand trading into technology specific products. However, in order to capitalise on this, technological capabilities will have to be improved in areas of technology creation, improvement of the technological base and product development. Such developments also call for investments in R&D and human capital formation and a more open trading environment. In addition, countries need to develop products in industries that show high technology growth potentials.

There is likely to be a lower level of disagreement among policy makers that trade can have beneficial effects on nations' growth and development. By changing the export structure, that is, exporting goods with greater growth potential such as those with high technological content, nations can gain from a rapidly expanding trading environment. Thus, countries with low technological achievement need to focus on new product development with high technological content. This in itself calls for more investments in research and development and expansion of the human capital base.

It is also worthy of note that countries with a protected trading environment have much to benefit from the import of goods with high technological content if an open trading regime is established. It has been noted that "trade is a mechanism by which more advanced foreign technology can be used to the advantage of a less developed country, not only to boost domestic innovation, but also as a means of benefiting from continued foreign innovation." (Connolly, 2003). In a further study, Yanikkaya's (2003) results provide strong evidence in favour of the hypothesis that countries that have more trade with the United States of America (one of the most highly innovative countries in the world), are likely to grow faster and this phenomenon is especially important for developing countries. Thus, even if countries cannot produce and export goods with high technological content, they have much to gain from imports of goods with high technological content and establishing trade links with countries that have higher levels of technological achievement.

While this analysis has been cross-sectional, future research should concentrate on more country-specific studies of high technology exports and growth of individual countries so as to develop more precise policy instruments with regard to stimulating economic growth at a country-specific level.

References

Alexander, W. R. 1997. Inflation and economic growth: evidence from a growth equation. *Applied Economics*, 25: 233-238.

Archibugi, D. and Coco, A. 2004. A new indicator of technological capabilities for developed and developing countries (ArCo). *World Development*, 32(4): 629-54.

Awokuse, T. O. 2006. Export-led growth and the Japanese economy: evidence from VAR and directed acyclic graphs. *Applied Economics*, 38(5): 593.

Balassa, B. 1978. Exports and economic growth: further evidence. *Journal of Development Economics*, 5: 178-89.

Barro, R. J. and Salai-i-Martin, X. 1995. *Economic Growth*. Boston: McGraw Hill.

Burney, N.A. 1996. Exports and economic growth: evidence from cross-country Analysis. *Applied Economics Letters*, 3: 369-373.

Chen, J-R and Yang, C-H. 2005. Technological knowledge, spill over and productivity: evidence from Taiwanese firm level panel data. *Applied Economics*, 37(20): 2361.

Coe, D. T., Helpman, E., and Hoffmaister, A. W. 1997. North-South R&D Spillovers. *Economic Journal*, 107: 134-49.

Connolly, M. 2003. The dual nature of trade: measuring its impact on imitation and growth. *Journal of Development Economics*, 72(1): 31-56.

Das, D. K. 1998. Changing comparative advantage and the changing composition of Asian exports. *The World Economy*, 21(1): 121-140.

Dreher, A. 2006. Does globalization affect growth? Evidence from a new index of globalization. *Applied Economics*, 38(10): 1089.

Edwards, S. 1993. Openness, trade liberalization and growth in developing Countries. *Journal of Economic Literature*, 31(3): 1358-93.

Engelbrecht, H-J. 2003. Human capital and economic growth: cross-section evidence for OECD countries. *The Economic Record*, S40-S51.

Fischer, S. 1993. The role of macroeconomic factors in growth, *Journal of Monetary Economics*, 32 (3): 485-512.

Fosu, A. K. 1996. Primary exports and economic growth in developing countries, *World Economy*, 19: 465-475.

Fu, X. 2005. Exports, technical progress and productivity growth in a transition economy: a non-parametric approach for China. *Applied Economics*, 37(7): 725.

Grossman, G. M. and E. Helpman. 1991. *Innovation and Growth in the Global Economy*. Cambridge, MA: MIT Press.

International Monetary Fund. 2001. *World Economic Outlook. October 2001. The Information Technology Revolution*. Washington, D.C.

Jones, C. I. 1998. *Introduction to Economic Growth*. New York: Norton.

Kelley, A. C. 1988. Economic consequences of population change in the Third World, *Journal of Economic Literature*, 26(4): 1685-728.

Kim, T. and Park, C. 2006. Productivity growth in Korea: efficiency improvement or technical progress? *Applied Economics*, 38(8): 943.

Kmenta, J. 1986. *Elements of Econometrics*. Macmillan: New York.

Liu, W-H and Lin, Y-C. 2005. Foreign patent rights and high-tec exports: evidence from Taiwan. *Applied Economics*, 37(13): 1543.

Mankiw, N. G., Romer, D. and Weil, D. N. 1992. A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, 107(2): 407-437.

Mehta, R. and Parikh, A. 2005. Impact of trade liberalisation on import demands in India: a panel data analysis for commodity groups. *Applied Economics*,37(16): 1851.

Miller, S. M. 1996. A note on cross-country growth regressions. *Applied Economics*, 28: 1019-1026.

Rodriguez, F. and Wilson, E. J. III. 2000. Are Poor Countries Losing the Information Revolution? University of Maryland at College Park. A paper prepared for *info*Dev. Available at http://infodev.org/library/working.html

Rogers, M. 2003. A Survey of economic growth. *The Economic Record*, 79(244): 112-135.

Sen, A. 2002. Globalisation, inequality and global protest. *Development*, 45(2): 11-16.

Sharer, R. 1999. Trade: an engine of growth for Africa, *Finance and Development*, 36(4): 26-29.

Stiglitz, J. E. 2002. Globalization and its Discontents. Penguin Books: London.

Tang, D. 2006. The effect of financial development on economic growth: evidence from the APEC countries, 1981-2000. *Applied Economics*, 38(16): 1189.

Temple, J. 1999. The new growth evidence, *Journal of Economic Literature*, XXXVII:112-156.

The World Bank. 2006. *World Development Indicators CD ROM 2006*. The World Bank, Washington, D.C.

The World Bank. 2000. *World Development Report 2000*. Oxford University Press: Washington, D.C.

United Nations Development Programme. 2001. *Human Development Report*. New York: United Nations.

Wolf, M. 2003. Is globalization in danger? *The World Economy*, 26(5): 313-412.

Wacziarg, R. 2001. Measuring the dynamic gains from trade. *World Bank Economic Review*, 15(3): 393-429.

Yanikkaya, H. 2003. Trade openness and economic growth: a cross-country Investigation. *Journal of Development Economics*, 72: 57-89.

Yao, S. 2006. On economic growth, FDI and exports in China. *Applied Economics*, 38(3): 339.