EXPORTS AND ECONOMIC GROWTH FOR THE 1960'S AND THE 1970'S

by

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TABLE OF CONTENTS

LIST OF TABLES

Chapter 1

INTRODUCTION

There have been many studies of the relationship between economic growth and export growth. The hypothesis which has been tested by many economists is that a rapid growth of exports will accelerate economic growth. The logical grounds supporting this hypothesis can easily be seen by investigating the reasons for exporting.

Why do countries export? Basically, because it is profitable to do so. Trade between countries, like trade between individuals, business firms and regions in the same country, results because both buyer and seller can gain from it. If both parties do not expect to gain, there will be no trade. The law of comparative advantage explains that mutual gains arise from specialization and exchange. Each trading partner gains by specializing in the production of goods which he can produce at the lowest opportunity costs while trading for those goods which he can produce at the highest opportunity costs. This specialization minimizes the cost of production and leads to a maximum joint output between trading partners. The principle works in exactly the same way for trade between countries. We know that the resource base of countries varies. A country may lack some vital resources that it can get only by trading with others. Also, a country's climate,

labor force, and other endowments may make it a relatively efficient (low opportunity cost) producer of some goods and a relatively inefficient (high opportunity cost) producer of other goods. As long as the difference in relative efficiency exceeds transportation and other transaction costs, trade will lead to mutual gain because it enables producers in each country to specialize in the production of those goods that they can do the best. Also, it will maximize the global output and enable countries to consume a combination of goods that lies outside the production frontier. This leads to the suggestion that export growth can serve to relax some major constraints on a country's economic growth. More specifically, increasing exports may relax the constraint of imported capital goods to economic growth by increasing the country's ability to import capital goods. Export development also helps to relax constraints that limit the utilization of all resources. Exports tend to stimulate more efficient use of resources, to encourage low cost production, to concentrate investment according to its competitive advantage, and to make economies of scale possible because of market expansion. These elements tend to increase the country's productivity. Furthermore, growing exports encourage the flow of technology, market innovation, and managerial skills which are crucial to economic growth. Finally, exports can indirectly stimulate an increase in consumption, and attract more domestic and foreign investment. All these factors tend to reinforce each other and contribute an increasing rate of growth in real gross national products.

Chapter 2

RECENT TESTS OF THE HYPOTHESIS

A) Spearman Rank Correlation Tests

There are many published tests of the hypothesis that a rapid growth of exports accelerates economic growth. Those tests can be divided into two types.

i) A bivariate relationship between GNP (or GDP) and exports is examined by a Spearman rank correlation coefficient. It is focused on measuring the strength of the relationship of these two variables. This section discusses these tests.

ii) The relationship between the rates of growth of GNP (or GDP) and exports is tested by regression. It is focused on using econometric models to measure and quantify the relationship between these two variables. The next section discusses these tests.

Before examining some of the recent works, three problems which arise in the testing of this hypothesis should be noted. First, since exports are themselves a component of the national product, it is suggested that there is a positive correlation of exports and GNP (or GDP), whatever their true relationship to each other. In order to solve this problem, various economists have suggested different adjustments to the variables for export performance. Second, in the selection of countries to be included in the samples, differences in size and homogeneity of sample may lead to different results. And third, economists often encounter either lack of data or poor data.

For example, different sources give different values of data, even though their definitions and derivation of data are presumably the same. It raises the question of how accurate the data are.

We now summarize several recent published studies which examined the relation of export performance and economic growth by means by Spearman rank correlation coefficient. Studies by Michaely, Heller-Porter, Balassa and Tyler are summarized.[1]

Because exports are bound to be positively related to GNP, Michaely measured export performance by the rate of change of the proportion of exports in the national product (the mean of the annual change of Export/GNP). The rate of growth of the economy is represented by the rate of change of per capita GNP (the mean of the annual change of per capita GNP). Using a sample of some 41 developing countries over the period 1950-1973, Michaely found a positive relationship between these two variables. The Spearman rank correlation coefficient was 0.38 and significant at the 1 percent level. The correlation was particularly strong for the more

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[1] Michael Michaely, "Exports and Growth: An Empirical Investigation," Journal of Development Economics, 1977, 4, pp. 49-53 .

Peter S. Heller and Richard C. Porter, "Exports and Growth: An Empirical Re-investigation," Journal of Development Economics, 1977, 5, pp. 191-193 .

Bela Balassa, "Exports and Economic Growth: Further Evidence," Journal of Development Economics, 1978, 5, pp. 181-189 .

William G. Tyler, "Growth and Export Expansion in Developing Countries: Some Empirical Evidence," Journal of Development Economics, 1980, 9, pp. 121-130 .

developed countries (countries with income per capita above $300 show a coefficient of 0.523), and practically zero for the least developed countries (countries with income per capita less than $300). Michaely concluded that "growth is affected by export performance only once countries achieve some minimum level of development."[2]

In a criticism of Michaely, Heller and Porter pointed out that Michaely's criticism about correlation between GNP and exports applies also to his own test. They argued that "any change in the growth rate of the export share of output will change the output growth rate in the same direction even if it causes no change at all in the growth rate of other components of output."[3] They suggested that the correct correlation is between the rate of growth of exports and the rate of growth of nonexport components of output. Using Michaely's data, they found a relatively high Spearman rank correlation coefficient (0.452) between the rate of growth of exports and the rate of growth of nonexport components of output. Furthermore, they supported Michaely's finding that "a minimum threshold of development is needed before export growth and economic growth are associated."[4]

A similar study by Balassa found a significant positive relationship between economic growth and export expansion. Balassa's sample included eleven countries, all of which had established an industrial base; the period of investigation chosen was 1960-1973. He also used the Spearman rank correlation analysis to examine the relationships between total exports and GNP, manufactured exports and GNP, and also manufactured

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[2]Michaely, p.52 .

[3]Hellner & Porter, p.192 .

[4]Hellner & Porter, p.192 .

output and GNP. Balassa found a significant relationship between exports and GNP growth; his results showed a rank correlation coefficient (0.703), higher than Michaely's. This is possibly due to the greater homogeneity of Balassa's samples.

Finally, Tyler wanted to determine if the results of Balassa's statistical analysis would hold for a wider, less restrictive, sample of developing countries. He omitted the poorest countries in his analysis because he believed that "some basic level of development is necessary for a country to most benefit from export oriented growth, particularly involving manufactured exports."[5] With this rationale, Tyler included all countries defined by the World Bank as middle income countries in 1977 in his sample; the period analyzed was 1960-1977. Using the Spearman rank correlation method, he examined the relationships between the rate of growth of GDP and the rate of growth of other economic variables such as manufacturing output, gross domestic investment, total exports, manufactured export earnings, foreign private investment, and change in the net barter terms of trade. Tyler reported that there existed positive, significant relationship between GDP growth and the growth of all those variables, especially manufactured exports. In fact, Tyler said, "Those countries enjoying the fastest rates of economic growth also have witnessed the fastest rates of growth for manufacturing exports."[6] A summary of all the above studies is shown in Table 1 .

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[5]Tyler, p.124 .

[6]Tyler, p.126 .

Table 1
SUMMARY OF PREVIOUS
STUDIES ON RELATIONSHIP BETWEEN
EXPORT PERFORMANCE AND ECONOMIC GROWTH
BY SPEARMAN RANK CORRELATION ANALYSIS

STUDY	SAMPLE	PERIOD OF INVESTIGATION	VARIABLES	CORRELATION COEFFICIENT
M. Michaely	41 developing countries	1950 to 1973	The mean of annual change of export/GNP and the mean of annual change of per capita GNP	0.380 (0.001)
Peter Heller & Richard Porter	(Michaely's sample)	1950 to 1973	Rate of growth of exports per capita and the rate of growth of nonexport component GNP per capita	0.452 (0.001)
Bela Balassa	11 countries that had already established an industrial base	1960 to 1973	Rate of growth of exports and the rate of growth of GNP	0.888 (0.001)
			Rate of growth of exports and the rate of growth of GNP net of exports	0.770 (0.003)
			Incremental export-GNP ratio and the rate of growth of GNP	0.813 (0.002)
W.G. Tyler	55 middle income countries defined by the World Development Report 1979	1960 to 1977	Rate of growth of gross domestic investment and the rate of growth of GDP	0.640 (0.001)
			Rate of growth of exports and the rate of growth of GDP	0.470 (0.001)
			Rate of growth of manufactured exports and the rate of growth of GDP	0.430 (0.002)
			Rate of growth of manufactured output and the rate of growth of GDP	0.730 (0.001)

Table 1 - Continued

STUDY	SAMPLE	PERIOD OF INVESTIGATION	VARIABLES	CORRELATION COEFFICIENT
W.G. Tyler	49 Non-OPEC middle income countries defined by the World Development Report 1979	1960 to 1977.	Rate of growth of gross domestic investment and the rate of growth of GDP	0.690 (0.001)
			Rate of growth of exports and the rate of growth of GDP	0.500 (0.001)
			Rate of growth of manufactured exports and the rate of growth of GDP	0.570 (0.001)
			Rate of growth of manufactured output and the rate of growth of GDP	0.820 (0.001)

* Level of statistical significance involving a one-tailed test, is shown in parentheses beneath the correlation coefficients.

SOURCES:

Michael Michaely, "Exports and Growth : An Empirical Investigation," Journal of Development Economics, 1977, 4, p.52 .

Peter S. Heller and Richard C. Porter, "Exports and Growth: An Empirical Re-investigation," Journal of Development Economics, 1977, 5, p.192 .

Bela Balassa, "Exports and Economic Growth: Further Evidence," Journal of Development Economics, 1978, 5, p.184, Table 1 .

William G. Tyler, "Growth and Export Expansion in Developing Countries: Some Empirical Evidence," Journal of Development Economics, 1980, 9, p.125, Table 1 .

B) Regression Analysis Tests

Since the Spearman rank correlation approach can only examine the interdependency between two variables, it gives no explanation of the direction of causality and the aggregate relationship involved in the analysis. Regression analysis is used by economists to measure and quantify the relationships that exist among a set of variables. In this case, it involves seeking out those independent (exogenous) variables (such as the rate of growth of exports, gross investment, etc...) as well as the nature of the functional relationship (such as lagged, or current values, linear or exponential) that best predicts or explains the dependent variables (in this case, the rate of growth of GDP or GNP).

We now summarize the regression studies of Emery, Syron-Walsh, Massell-Pearson-Fitch, Lubitz, Severn, and Batchelor.[7]

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[7] Robert F. Emery, "The Relation of Exports and Economic Growth," Kyklos, 20(2), 1967, pp. 470-484.

Richard F. Syron and Bredan M. Walsh. "The Relation of Exports and Economic Growth: A Note," Kyklos, 21(3), 1968, pp. 541-545.

Benton F. Massell, Scott R. Pearson, and James B. Fitch, "Foreign Exchange and Economic Development: An Empirical Study of Selected Latin American Countries," The Review of Economics and Statistics, 54, 1972, pp. 208-212.

Raymond Lubitz, "Export-led Growth in Industrial Economies," Kyklos, 26(2), 1973, pp. 307-321.

Alan K. Severn, "Exports and Economic Growth: Comment," Kyklos, 21(3), 1968, pp. 546-548.

R.A. Batchelor, Industrialization and Basis for Trade, Cambridge University Press, 1980, pp.192-227.

Emery used a simple regression with the rate of growth of GNP per capita as the dependent variable and the rate of growth of exports as the independent variable for a cross-section analysis of 50 countries. The period of investigation was 1953-1963. He used the slope of the orthogonal regression estimate to support his claim that "for each 1 per cent rise in exports, GNP increases by 0.4 per cent."[8] Also Emery boldly asserted that if countries want to increase their growth rates they should adopt policies that will stimulate exports.

Before examining other econometric studies, it is important to understand the aggregate relationship involved in this kind of analysis. According to R.A. Batchelor, "Emery attempted to summarize all export-led growth arguments into a single empirical generalization of the form $g(y) = \alpha + \beta\, g(E)$,"[9] where g(y) is the rate of growth of income per head and g(E) is the rate of growth of exports. However, Batchelor pointed out, a more general formulation should be

> $g(y) = \psi\{g(E), u, v\}$ where u is a set of variables additional to export growth which might explain variations in output growth - for example, investment in our open-economy model - and v is a set of variables determining β, the impact of export growth on income growth.[10]

Syron and Walsh argued that it was necessary to split the sample into group of countries with shared (u, v) characteristics in order to achieve a more meaningful relationship. First, they

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[8] Emery, p.480 .

[9] Batchelor, p.204 .

[10] Batchelor, p.200 .

split Emery's sample into high income and low income groups. By comparing the $\bar{R}^2$ of the regression equations for the high income group and the low income group, Syron and Walsh reported that "the association of exports with economic growth is closer in the developed countries than in the less developed countries."[11] Also, by comparing the slopes of the regression equations between those two groups, they suggested that "a 1 per cent increase in exports in a developed country have a larger impact on income than the same increase in exports in a less developed country."[12] Second, the sample was split again into groups with high (more than 66%), moderate (between 33% and 66%), and low (less than 33%) shares of foodstuffs in exports. They found that $\bar{R}^2$ fell to zero and the slope was negative for those countries which had high share of foodstuffs in exports. However, for those countries which had low share of foodstuffs in exports, $\bar{R}^2$ was 0.72 and the slope took a positive sign. Syron and Walsh concluded that "the more dependent a country is upon food exports, the lower the impact of an increase in exports upon GNP."[13] As a whole, based on the result of the research, Syron and Walsh argued that

> Emery's conclusions are not acceptable without qualification. It seems essential to examine the nature of the country's exports before one may conclude that an expansion of their exports will lead to accelerated economic growth.[14]

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[11] Syron & Walsh, p.542 .

[12] Syron & Walsh, p. 542 .

[13] Syron & Walsh, p. 544 .

[14] Syron & Walsh, pp. 544-545 .

A number of economists have attempted to determine variables additional to exports which might explain the variation in output growth. Massell, Pearson and Fitch added capital inflow as an independent variable. Using a sample of eleven Latin American countries and a time-series analysis of less than twelve years, they found that not only did current exports appear to make an important contribution to GNP, but also capital inflow which was estimated to have the greatest effect on GNP. They used their results to support the claim that annual changes in foreign exchange receipts had significant short-run effects on imports, investment, and gross national product. Among those three types of foreign exchange receipt (exports, net private capital inflow, and net public capital inflow), they suggested that private capital inflows have the greatest impact on imports, investments and GNP.

Lubitz suggested that export growth would stimulate industries with significant economies of scale, and , by insuring a strong balance of payments, export growth would encourage investment. Based on his hypothesis, he added the rate of growth of manufactured exports and the investment ratio (Investment/GNP) as additional independent variables in his cross-section regression. His sample consisted of eleven developed countries and the period for analysis was 1950-1969. Lubitz found that when the rate of growth of exports and the rate of growth of manufactured exported were both in the same equation, the variable for the rate of growth of manufactured exports took a negative sign. Based on that result, Lubitz suggested that the rate of growth of manufactured exports did not add any special contribution to growth. Furthermore, based on the significance of the investment

ratio in the regression analysis, Lubitz suggested that "the positive relationship of *exports to* growth probably does not run through the effect on investment, since investment has an independent effect."[15]

Severn attempted to modify β, pointing out that this growth coefficient should depend on the share of exports in total income. He explained that in order to avoid the effect of different currency units, and size per se (due to difference in openness), the equation $GNP = \alpha + \beta(\Delta \text{Export})$ should be normalized by GNP to become $\frac{\Delta GNP}{GNP} = \alpha' + \beta \frac{\Delta Export}{GNP}$. If the rate of growth of exports, $\frac{\Delta Export}{Export}$, is used as an independent variable, one should multiply the right side of the equation by $\frac{Export}{GNP}$: $\frac{\Delta GNP}{GNP} = \alpha' + \beta \frac{\Delta Export}{Export} * \frac{Export}{GNP}$. In short, Severn argues that Emery's export variable should be modified by an openness coefficient ($\frac{Export}{GNP}$).[16]

Batchelor attempted a comprehensive study of the aggregate relationships between the rate of growth of GDP and the rate of growth of exports. He formulated the following regression equations :[17]

Equation (1) $g(y) = \alpha_0 + \beta_0 g(E)$ ---------- Emery's type equation where g(y) is the rate of growth of GDP and g(E) is the rate of growth of exports.

Equation (2) $g(y) = \alpha_0 + \beta_1 eg(E)$ ---------- Severn's type of equation, where e is export/GDP .

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[15] Lubitz, pp. 318-319 .

[16] Severn, p.548 .

[17] Batchelor, p.208 .

Equation (3) $g(y) = \alpha_0 + \alpha i + \beta_0 g(E) + \beta_2 Emg(E)$ ------- Lubitz's type of equation, where $i = \frac{\text{investment}}{\text{GDP}}$, and $Em = \frac{\text{Manufactured exports}}{\text{GDP}}$.

Equation (4) $g(y) = \alpha_0 + \alpha' f + \beta_0 g(E)$ ---------- Massell etal's type of equation, where $f = \frac{\text{capital inflow}}{\text{GDP}}$.

Equation (5) $g(y) = \alpha_0 + \alpha' f + \alpha i + \beta_0 g(E) + \beta_1 eg(E) + \beta_2 Emg(E)$ ---------- Batchelor's full model.

Using a cross section regression analysis of 116 countries for the period of 1961-1970, Batchelor reported the results as shown in Table 2 . His full model (equation #5) explained about two-thirds of the observed variations in growth rates across countries in the 1960s. Both eg(E) and Emg(E), the modifiers to export growth, performed poorly. The former had a small coefficient (β_1)of the wrong sign and the latter had an insignificant, small, positive coefficient (β_2). Batchelor's full model suggested that 1 per cent per annum increase in the rate of growth of GDP per capita would require an average growth of $1/\beta_0$ = 4.3 per cent in exports, a higher figure than that found by Emery. Of all other equations, Batchelor suggested that perhaps the most stable alternative to the full model was Lubitz's type of equation.[18]

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[18]Batchelor, pp. 208-209 .

Table 2

BATCHELOR'S STUDY ON
HIS 5 REGRESSION EQUATIONS

Equations	Intercept	Capital Inflow	Investment ratio	g(E)	eg(E)	Emg(E)	$\bar{R}^2$
#1	2.08 (10.07)			0.13 (10.18)			0.54
#2	2.53 (11.89)				0.23* (8.37)		0.44
#3	0.88 (2.05)		0.06 (2.27)	0.12 (10.11)		0.68* (2.22)	0.61
#4	2.10 (9.83)	-0.01 (0.44)		0.15 (10.13)			0.53
#5	0.10 (0.21)	-0.05 (2.48)	0.10 (3.55)	0,23 (4.96)	-0.23* (2.48)	0.20* (0.59)	0.64

NOTES: t-ratios are given in the brackets.

*Actual coefficients multiplied by 10^2 .

SOURCE: R. A. Batchelor, Industralization and Basis for Trade, Cambridge University Press, 1980, p.208, Table 7.6 .

Chapter 3

CRITICISM OF THE RECENT TESTS

It is suspected that there is a strong correlation among independent variables such as the rate of growth of total exports, the rate of growth of manufactured exports, and changes in export share of national income.

First, when Lubitz regressed the rate of growth of GNP on both the rate of growth of total exports and the rate of growth of manufactured exports, the rate of growth of manufactured exports took a negative sign. Lubitz then concluded that manufactured exports did not add any special contribution to growth. This conclusion was incorrect because there was multicollinearity in this model. Since Lubitz's samples (eleven countries) were all leading manufacturing exporters, most of the exports of those countries are manufactured goods, there obviously existed a strong collinearity between those two growth rates (that is, the rate of growth of total exports equals the rate of growth of manufactured exports plus Z, where Z has a very small numerical value). Therefore, the rate of growth of manufactured exports took a negative sign when the rate of growth of GNP was regressed on those two growth rates. However, when the rate of growth of total exports was removed, the rate of growth of manufactured exports took a significant positive sign.

Similarly, there was multicollinearity in Batchelor's models.

According to Batchelor's equation (5), when the rate of growth of GDP per capita was regressed on the rate of growth of exports ($\frac{\Delta \text{Export}}{\text{Export}}$), changes in export shares of GDP ($\frac{\Delta \text{Export}}{\text{GDP}} = \frac{\Delta \text{Export}}{\text{Export}} * \frac{\text{Export}}{\text{GDP}}$), and changes in manufactured exports ($\frac{\text{Manufactured Export}}{\text{Export}} * \frac{\Delta \text{Export}}{\text{Export}}$), the second variable took a negative sign and the third variable became insignificant. It was probably due to the strong collinearity among those independent variables. when the rate of growth of GDP per capita was regressed on each variable by itself, each variable appeared to be positively significant to the rate of growth of GDP per capita.

In most Spearman rank correlation tests and regression analysis, export growth rate was used as the independent variable representing a country's export performance. It seemed that export proportion (Export/GDP) was unimportant to economists. In fact, Michaely claimed that "export proportions appeared to either bear no relationship to the growth of GNP or are negatively correlated with the latter."[19] However, this does not mean that the rate of growth of total exports is the best variable to represent export performance. Severn argued that the use of the rate of growth of total exports was incorrect due to lack of "openness coefficient". He suggested the correct functional form should be $\frac{\Delta \text{GNP}}{\text{GNP}} = \alpha + \beta \frac{\Delta \text{Export}}{\text{GDP}}$, where $\frac{\Delta \text{Export}}{\text{GDP}} = \frac{\Delta \text{Export}}{\text{Export}} * \frac{\text{Export}}{\text{GDP}}$.[20] Even Michaely acknowledged

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[19] Michaely, p.53 .

[20] Severn, p.548 .

the weakness of using the rate of growth of total exports as variable for export performance and suggested as a replacement variable, the mean of the annual change of export/GNP. This raises the question of the accuracy of using the rate of growth of total exports as variable for export performance in testing the hypothesis.

Referring to Michaely's rank correlation analysis, he reported that,

> it is interesting to note that the positive association of the economy's growth with the growth of the changes in export shares appears to be particularly strong among the more developed countries, and not to exist at all among the least developed.... This seems to indicate that growth is affected by export performance only once countries achieve some minimum level of development.[21]

Heller-Porter, Balassa and Tyler all agreed with Michaely's suggestion. And Syron-Walsh reported that,

> the more dependent a country is upon food exports, the lower the impact of an increase in exports upon GNP.... it may be possible for exports to have as great a stimulative effect on income growth in a less developed country as in a developed country, provided the less developed country is not specialized in a pattern of exporting foodstuff.[22]

Therefore, it may be the case that the effect of export performance on a country's growth depends not only on the achievement of some minimum level of development, but also on the type of exports a country specializing in.

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[21] Michaely, p.52 .

[22] Syron & Walsh, p.544 .

Chapter 4

A RE-TESTING OF THE HYPOTHESIS

A) Statistical Procedures and Descriptions

This paper will also examine the relationship between economic growth and exports. Specifically, this paper aims at the following objectives:

(i) To determine the extent of multicollinearity among the independent variables, and to solve the problem.

(ii) To test alternative measures of export performance and to select the one which will be most useful.

(iii) To determine which types of exports contribute the most to country's economic growth.

The statistical procedures begin with Batchelor's five regression equations.[23]

Equation (1) $g(y) = \alpha_0 + \beta_0 g(E)$

Equation (2) $g(y) = \alpha_0 + \beta_1 eg(E)$

Equation (3) $g(y) = \alpha_0 + \alpha_2 I + \beta_0 g(E) + \beta_2 Emg(E)$

Equation (4) $g(y) = \alpha_0 + \alpha_1 F + \beta_0 g(E)$

Equation (5) $g(y) = \alpha_0 + \alpha_1 F + \alpha_2 I + \beta_0 g(E) + \beta_1 eg(E) + \beta_2 Emg(E)$

where

g(y) : Annual real rate of growth of GDP per capita. It was computed by dividing (1 + annual real rate of growth

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[23] Batchelor, p.208 .

of total GDP) by (1 + annual rate of growth of population). Both of these growth rates are from the World Development Report 1982.[24]

I : The investment ratio, defined as gross capital formation divided by GDP. This ratio is from the World Tables, 1980.[25]

e : The export share defined as total exports divided by GDP. This is from the World Tables, 1980.

m : The import share defined as total imports divided by GDP. This is also from the World Tables, 1980.

F : The capital inflow share, defined as the import share (m) minus the export share (e).

Em : The manufactured export share defined as manufactured exports being divided by total exports. This is from the Year Book of International Trade Statistics, 1980.[26]

g(E) : Annual real rate of growth of exports. This data is from the World Development Report 1982.

eg(E) : Annual real rate of growth of exports weighted by the export share of GDP. That is, eg(E) equals to e times g(E).

Emg(E) : Changes in manufactured exports defined as Em times g(E).

Data for the 1960's and 1970's are shown in Appendix (1).

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[24] World Development Report 1982, World Bank.

[25] World Tables, 1980, World Bank.

[26] United Nations, Year Book of International Trade Statistics, 1980.

Following Emery, national income data was converted to a per capita basis because it eliminates the influence of different rates of change of population among countries. However, exports, investment and other independent variables were not put on a per capita basis because there was much less reason to believe that their growth rates reflect increases in population.[27] A cross-section analysis was used. As Lubitz explained, in spite of the assumption that both the behavior and structural relationship were the same for all countries, it is a common procedure to use international cross-section over time, because individual country time-series might induce difficulties such as estimating the lag structures of variables, problems of overstating the true number degree of freedom. Also, he recommended that a period of ten years (rather than breaking up in a number of sub-period) be used in order to prevent distortion induced by business cycles.[28] Thus, in the equations, each country was an observation and each variable was measured by using data "averaged" over a period of ten years (if data were available, otherwise it would be a less than 10 year average). The periods of investigation chosen were 1961 to 1970 and 1971 to 1980. Variables of these two periods are identified by their subscripts 60 and 70, thus I_{60} and I_{70} represent the investment ratio for 1961 to 1970 and 1971 to 1980, respectively.

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[27] Emery, p.475 .

[28] Lubitz, pp. 314-315 .

Due to the problem of insufficient data, only 86 countries were available for this analysis.

First, Batchelor's equations were estimated for the 1970's (since variable Emg(E) was not available for the 1960's), and the results are shown in Table 3 . Capital inflow (F) takes a negative sign throughout. Variables eg(E) and g(E) are more significant when they are not used simultaneously. Also, Emg(E) appears negatively related (but insignificant) to the growth of GDP per capita. Furthermore, the full model (equation 5) has the lowest mean square error (MSE) but the significance of each variable decreases. These results suggest that there is possible multicollinearity among independent variables.

B) The Multicollinearity Problem and the Appropriate Measure for Export Performance

Artificial regressions are used to determine the existence of multicollinearity. That is, independent variables are regressed on to each other to see whether they are collinear to each other. Theory tells us that if one of the K variables is a linear combination of the other K-1 variables, one will get a high R^2 in the artificial regressions. The results are shown in Table 4 .

The high R^2 of equations 3, 4, 5, and 12 to 17 suggests that there exists multicollinearity among independent variables $g(E)_{70}$, $eg(E)_{70}$, and $Emg(E)_{70}$. This means variable g(E) contains much of the same information as variables Emg(E) and eg(E). The simplest solution for the multicollinearity problem is to drop one

Table 3
REGRESSION OF GROWTH IN GDP PER CAPITA ON
GROWTH IN EXPORTS FOR THE 1970'S --- BATCHELOR'S EQUATIONS

Equations	Intercept	F_{70}	I_{70}	$g(E)_{70}$	$eg(E)_{70}$	$Emg(E)_{70}$	$\bar{R}^2$	MSE
1	0.014 (5.65)			0.211 (5.28)			0.24	0.000428
2	0.015 (6.23)				0.681 (5.37)		0.25	0.000424
3	-0.006 (0.88)		0.016 (3.02)	0.22 (3.13)		-0.076 (0.72)	0.30	0.000393
4	0.017 (6.53)	-0.076 (3.08)		0.218 (5.69)			0.31	0.000389
5	-0.004 (0.56)	-0.069 (2.92)	-0.102 (3.20)	0.17 (2.81)	0.329 (1.64)	-0.125 (1.24)	0.38	0.000346

NOTES: t - ratios are given in the brackets.
N (number of observations) = 86 .