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THE STATE OF DEVELOPMENT AND THE NATURE AND MAGNITUDE OF EXPORT RELATED GROWTH

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Abstract

This paper examines the role of export expansion in the economic growth of countries at different levels of development. Results from a switching regression model with data-determined group selection indicate that exports contribute to growth through both an externality effect and an allocation effect for middle income countries, but only through an allocation effect for low income countries. The difference in the magnitude of the contribution of exports to growth between the two groups of countries is not very large, but it is greater for middle income countries.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>II. Background and Literature Review</td>
<td>2</td>
</tr>
<tr>
<td>III. Data and Methodology</td>
<td>6</td>
</tr>
<tr>
<td>IV. Estimation Results for the Switching Regression Models</td>
<td>13</td>
</tr>
<tr>
<td>V. Conclusion</td>
<td>17</td>
</tr>
<tr>
<td>Appendix</td>
<td>19</td>
</tr>
<tr>
<td>References</td>
<td>23</td>
</tr>
</tbody>
</table>
The Stage of Development and the Nature and Magnitude of Export Related Growth

I. Introduction

This paper empirically investigates the differences in the nature and magnitude of the contribution of exports to growth between low income countries and middle income countries. After nearly two decades of empirical work, considerable evidence has accumulated suggesting that exports are positively related to growth for less developed countries (LDCs).\(^1\) There persists, however, the suspicion that attempts to increase exports with more outward oriented policies is simply not appropriate for all LDCs in all cases. One particular concern is that exports do not contribute to growth in the same way and to the same degree for the low income countries as they do for the middle income countries. Theories of industrialization certainly suggest that an economy may need to reach some critical size (or degree of industrialization that may be associated with economic size) in

\(^1\) The empirical work originates with Michalopoulos and Jay (1973) and is further developed in Michaely (1977), Heller and Porter (1978), Balassa (1978b), Michaely (1979), Tyler (1981), Feder (1983), Kavoussi (1984), Balassa (1985), Rana (1988), and Moschos (1989), among others.
order to benefit from export-led growth. The previous empirical literature has not fully addressed this issue. This paper attempts a more comprehensive investigation.

II. Background and Literature Review

There is a substantial literature that has empirically investigated the contribution of exports, or an export-orientation, to overall economic growth in less developed countries. The underlying hypothesis is that exports positively influence growth because exporting will increase the efficiency of resource allocation, increase capacity utilization, allow taking advantage of scale economies, and promote technical change (Balassa, 1985). The results of most of the studies indicate that, on average, exports are positively and significantly related to growth for particular groupings of less developed countries (Michaely, 1977; Heller and Porter, 1978; Balassa, 1978; Krueger, 1978; Tyler, 1981; Feder, 1983; Kavoussi, 1984; and Balassa, 1985). Others are less optimistic and find that favorable market conditions or country selection were the driving forces behind the results obtained (Heller and Porter, 1978; Rana, 1988; and Singer and Gray, 1988). Still others suggest that a positive statistical relationship does not indicate causality and have undertaken causality studies with mixed results (Jung and Marshall, 1985; and Chow, 1987). Several of the authors indicate that they have an a priori expectation that the relationship will only hold once a

2 See References and particularly cites listed in footnote 1.
given level of development is obtained. These development levels are described variously as "middle income LDCs" (Michaely, 1977; Tyler, 1981), "relatively rich LDCs" (Heller and Porter, 1978), "semi-industrialized LDCs" (Feder, 1983), and "newly industrializing countries" (Chow, 1987). Indeed with the exception of Kavoussi (1984) and Moschos (1989), low income countries are specifically excluded from this type of investigation. Kavoussi (1984) divides LDCs into a low income group and a middle income group for analysis by taking the World Bank's arbitrary designation of $360 GNP per capita (in real 1978 US dollars) as the dividing point and he finds that the correlation between exports and growth is not limited to middle income countries; low income countries benefit as well. These studies [as well as Krueger (1978) and Balassa (1978), both of whom selected ten countries for their studies] arbitrarily determine the appropriate country group for analysis. Undoubtedly, data availability played a crucial role in country selection for many of the investigations. The most comprehensive of these studies (Kavoussi, 1984) has seventy-three countries; the rest have fewer.

Of the previous analyses, only Rana (1988), Krueger (1978), and Balassa (1978) have more than one observation per country. Krueger's analysis allows for country-specific fixed underlying growth rates but is limited by the fact that it does not control for labor force and capital. Rana allows for random effects by utilizing a Fuller-Batesse estimation procedure.
Moschos (1989), following the lead of Kavoussi (1984), considers the hypothesis that low income countries and middle income countries may benefit differently from export expansion growth. The innovation of Moschos (1989) was to allow the definition of the groups to be determined by the data, by employing a switching regression analysis. Moschos finds, among other things, that, contrary to the commonly held a priori view, low income countries benefit more from export oriented growth than do middle income countries (Moschos, 1989:99). There are some problems with the Moschos paper however. First, the procedure of the switching regression estimation necessitates a test of whether at discrete splits the estimated parameters in the two equations represent statistically different structures. Moschos utilized a Chow test which implicitly assumes that the variances of the two sets of observations are equal. This is very unlikely to be the case. The result is that Moschos' tests for significant splits may be erroneous. A second more serious problem exists. Moschos perpetuated a shortcoming of the previous literature first pointed out in Feder (1983) by estimating a model that implicitly imposes a nonsensical restriction on the more general model that Feder derives. In fact, this restriction is a testable hypothesis that we find to be clearly rejected by the data.

The objective of this paper is to extend and improve on the previous literature. The issue of whether the level of development has implications for the export-growth relationship is

---

3 See the Appendix equation (A19) and the associated text.
addressed. Additionally, the question of whether or not lower income countries benefit more or less from export growth or in a different way is considered. The improvement of this analysis over that of Moschos (1989) is made possible by the utilization of a richer (and more recent) data set and a more general base model. This more general model, besides avoiding the erroneous implicit restriction embodied in the Moschos analysis, allows us to find differences in the nature of the contribution of exports to growth as well as in the magnitude. The more general model, which is used in its single equation form by Feder (1983), allows for separate measurements of an externality effect and an allocation effect associated with export expansion growth.

The data set utilized here allows for consideration of a larger group of countries than are included in previous studies. Second, the data set provides a longer time series than has previously been available. This allows for specific countries to actually progress from the lower income group to the middle income group, suggesting that structural change actually occurs at a certain income level, not just that there are structural differences between countries that only happen to be at different income levels.

---

4 This more general model is developed fully in the Appendix. See equations (A18) and (A19) and the associated discussion in the Appendix for illustration of the restriction implied by the model utilized in the Moschos (1989) paper. It is difficult to interpret the parameters of the model in Moschos (1989), Kavoussi (1984), Tyler (1981), Balassa (1978b) and Michalopoulos and Jay (1973) except to take them as a (perhaps unlikely) special case of the more general Feder model.
The following section (section III) discusses the data used for this paper and the methodology for determining whether or not the level of development has an effect on the relationship between exports and growth. Section IV presents the results of the empirical analysis outlined in section III. Section V concludes the paper.

III. Data and Methodology

The primary data source is the World Tables of Economic and Social Indicators, 1960-1986. This data set includes annual data for 27 years for 126 countries. After dropping observations with missing data 110 countries remained in the sample. Next OECD member countries and other high income countries were dropped leaving a sample of 85 countries and 276 observations. Up to four time periods, or observations, for each country are used: 1960-1966, 1966-1973, 1973-1979, and 1979-1986. The annual data are not used because, as Feder (1983) notes, there is substantial noise in the annual data that tends to be eliminated by the procedure of averaging. Furthermore, the potential problem of lagged responses is less severe when using averages across a multiple year time period rather than annual data (Feder, 1983).

---

5 This data was acquired through the Inter-university Consortium for Political and Social Research in machine readable format (tape).
6 Specifically, Australia, Austria, Belgium, Canada, Denmark, Finland, France, West Germany, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, the Netherlands, New Zealand, Norway, Saudi Arabia, Spain, Sweden, Switzerland, the United Arab Emirates, the United Kingdom, and the United States were excluded.
This study, like many of the previous studies, utilizes a differenced production function structure for the parameter estimation. The explanatory variable of interest is, of course, exports. The dependent variable is GNP growth. Labor force and capital are included as control variables. The derivation and interpretation of the single equation versions of the models to be utilized here in switching regression estimations are developed in Feder (1983) and detailed in the Appendix. Both models captures export's contribution to growth through both an externality effect and a resource allocation effect. The second model is differentiated from the first in that it allows for separate identification of the the two effects. The externality effect measures the positive externality of the export sector on the non-export sector. The allocation effect measures the gain due to the higher productivity of factors in the export sector (indicating, when positive and significant, that fewer than optimal resources are allocated to the export sector). The major deviation from the Feder model is the utilization of a switching regression formulation of the model with an unknown sample selection criterion. The switching regression model is described in Goldfeld and Quandt (1976: Chap. 2). The sample selection criterion is GNP per capita (as a measure of the level of development).

The first model is the simpler specification of the two estimated and is based on equation (A15) from the Appendix.
\[
(\dot{Y}/Y)_{it} = r_1 + \alpha_1(I/Y)_{it} + \beta_1(\dot{L}/L)_{it} + \Gamma_1(\dot{X}/Y)_{it} + e_{it}
\]
for \( it \) if \( \text{GNPC}_{it} \geq \mu \)
and
\[
(\dot{Y}/Y)_{it} = r_2 + \alpha_2(I/Y)_{it} + \beta_2(\dot{L}/L)_{it} + \Gamma_2(\dot{X}/Y)_{it} + u_{it}
\]
for \( it \) if \( \text{GNPC}_{it} < \mu \)

(1)

The subscript \( i \) refers to the country, and the subscript \( t \) to the time period. \( Y \) is GNP, so \( \dot{Y}/Y \) is its annualized growth rate; \( I \) is Gross Domestic Investment for the period; \( L \) is labor (population), so \( \dot{L}/L \) is the annualized growth rate of labor; and \( X \) is exports, so \( \dot{X}/Y \) is the simplified form of the annualized growth rate of exports weighted by the proportion of exports in GNP [that is, \( \dot{X}/Y = (\dot{X}/X) \ast (X/Y) \)]. The \( \mu \) is the level of GNP per capita (GNPC) at which the structural split occurs. The \( r \)'s are the intercepts and are interpreted as the underlying rate of growth of \( Y \). The \( \alpha \)'s and \( \beta \)'s are structural parameters and the \( \Gamma \)'s are reduced-form parameters. \( \beta_1 \) and \( \beta_2 \) are interpreted (loosely) as elasticities of output with respect to labor in the non-export sector.\(^7\) \( \alpha_1 \) and \( \alpha_2 \) are interpreted as marginal products of capital in the non-export sector. \( \Gamma_1 \) and \( \Gamma_2 \) capture both the differential of factor productivities between the export and the non-export sectors (the allocation effect) and the externality of the export sectors on the non-export sectors (the externality effect).\(^8\) In this form

\(^7\) We must be willing to assume that the ratio of output to labor in the non-export sector is similar to that in the economy as a whole to strictly interpret these parameters as the stated elasticities. See the Appendix, equations (A14) and (A15).

\(^8\) See equation (A15) in the Appendix for the complete specification of \( \Gamma \).
[equations (1)], separate identification of the two effects is not possible. The structural parameters that measure the two effects can be recaptured in the second specification [equations (2) below].

This second version of the model is based on equation (A18) from the Appendix. This specification allows for the separation of the two effects picked up by the parameters on the export variables ($\Gamma_1$ and $\Gamma_2$) in equations (1). This model specification is given as:

\[
\begin{align*}
(\dot{Y}/Y)_{it} &= r_1 + \alpha_1(I/Y)_{it} + \beta_1(\dot{L}/L)_{it} + \Phi_1(\dot{X}/Y)_{it} + \theta_1(\dot{X}/X)_{it} + e_{it} \\
& \quad \text{for } it \text{ if } GNFC_{it} \geq \mu \\
& \quad \text{and} \\
(\dot{Y}/Y)_{it} &= r_2 + \alpha_2(I/Y)_{it} + \beta_2(\dot{L}/L)_{it} + \Phi_2(\dot{X}/Y)_{it} + \theta_2(\dot{X}/X)_{it} + u_{it} \\
& \quad \text{for } it \text{ if } GNFC_{it} < \mu.
\end{align*}
\]

The variables are defined as for equations (1) above with the addition of $\dot{X}/X$ which is the annualized growth rate of exports (un-weighted). The parameters $\alpha_1$, $\alpha_2$, $\beta_1$, and $\beta_2$ are interpreted as in equations (1), though they, of course, are not constrained to have the same point estimates. $\theta_1$ and $\theta_2$ are interpreted as the elasticities of output in the non-export sector with respect to the level of exports and thus measure the externality effect of exports. $\Phi_1$ and $\Phi_2$ are not to be interpreted the same way that $\Gamma_1$ and $\Gamma_2$ are in equations (1). The explicit expression for $\Phi$ is shown in equation (A18) in the Appendix. The parameter pairs $\Phi_1$
and $\theta_1$, and $\Phi_2$ and $\theta_2$ can be used to calculate the difference in the factor productivities between the export and the non-export sectors. For simplicity, we have assumed here that the sectoral productivity difference is the same for both inputs [e.g., $D = \lambda = \delta$ where $\lambda$ and $\delta$ are as defined in equation (A18) of the Appendix]. Specifically, $D$ equals the percentage by which the marginal factor productivities are higher in the export than in the non-export sectors and is calculated as:

$$D = \frac{\Phi_1 + \theta_1}{1 - (\Phi_1 + \theta_1)} \text{ if } GNPC_{it} \geq \mu$$

and

$$D = \frac{\Phi_2 + \theta_2}{1 - (\Phi_2 + \theta_2)} \text{ if } GNPC_{it} < \mu.$$

Estimation of the first model [equations (1)] will provide information on how the magnitude of the contribution of exports to growth differs between low and middle income countries. Estimation of the second model will allow us to identify differences in the nature of the contribution of exports to growth between the two groups of countries.

The procedure followed for estimating each of the two model specifications is similar. First the individual equations in each pair is estimated (using OLS) where discrete values of $\mu$ (GNP per capita) are chosen to divide the data set into the low and middle income groups.\(^9\) At each discrete value of $\mu$, a Wald test is

\(^9\) The discrete values for $\mu$ used for the split were 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, and 2000. The units of $\mu$ are real 1986 US dollars.
conducted to determine if the parameters in the two equations represent statistically different structures. Specifically, the Wald test is used to test the null hypothesis that $\alpha_1=\alpha_2$, $\beta_1=\beta_2$, and $\Gamma_1=\Gamma_2$ in the first model and that $\alpha_1=\alpha_2$, $\beta_1=\beta_2$, $\theta_1=\theta_2$ and $\Phi_1=\Phi_2$ in the second. In the event of more than one value of $\mu$ providing a statistically significant split, the log-likelihood function value for the equation system is calculated for each significant split to determine the split that is best supported by the data.

The specification of both models allows the marginal products of labor to vary across countries and time periods. Rana (1988) and Balassa (1985, 1978b) have not found the labor variable to be significant. Balassa (1985) attributes this to the use of labor force data instead of employment data and the fact that both countries with and without surplus labor are included in his studies. We have available only population growth as a proxy for labor force growth. This is not optimal, particularly for the lowest income countries where the problems of unemployment and labor surplus mentioned by Balassa (1985) would appear to be most severe.

Both model specifications force the marginal product of capital to be equal across countries. This is not theoretically

---

10 The Wald test is chosen over a Chow test to allow for unequal variances between the two sets of observations. See Honda (1982). Moschos (1989) used a Chow test.

11 This procedure is outlined in Quandt (1958) and has been used recently by Field (1988), and Hotchkiss (forthcoming).

12 The elasticity of labor to output is estimated (as constant across countries and time periods). The average product of labor varies across countries and time periods, hence so does the marginal product.
unappealing given an assumption of perfect mobility of capital internationally. Furthermore, it allows the elasticity of output with respect to capital to vary across countries and time periods. There are enough degrees of freedom to attempt and test a specification in which country dummy variables are interacted with the I/Y variable, allowing the marginal product of capital to vary across countries. This is done and, using an F test on each of the single equations, the parameters on these country-capital interaction variables are not found to be statistically significant. Lacking empirical or appealing theoretical support, these interaction variables are omitted from the equations.

The major and most obvious limitation of this study is that it does not specifically control for factors other than capital and labor that influence the growth rate. For example, Scully (1988) has found that institutional aspects such as political, civil, and economic liberty significantly affect economic growth. To the extent that these or other institutional characteristics are dynamically invariant, we may control for them by use of a fixed effects model. Scully (1988) reports a high degree of correlation across time of measures of the institutional variables used in his paper. In fact, he uses institutional data for 1973-1980 as an indicator for their levels for the entire period 1960-1980. This suggests, at least to a certain extent, dynamic invariance of these variables. Use of a fixed effects specification was tested, but the results are not reported due to
the discovery of colinearity between the country specific
intercepts and the labor (L/L) and capital (I/Y) variables.\textsuperscript{13}

IV. Estimation Results for the Switching Regression Models

In the estimation of the first model [equations (1)], the
Wald test results indicated that there were no significant splits.
Calculation of the log likelihood function values further
indicated that, among the alternatives, the single equation
version of the model better fit the data, than did any of the
switching regression estimations. The parameter estimates for the
single equation version of the first model are presented in Table
1, column 1.

The estimation of the second model [equations (2)] resulted
in significant splits as indicated by the Wald test at 450, 500,
600, 700, and 800. The log likelihood function values indicated
that, among the alternatives, the split at \( \mu = 450 \) best fit the
data.\textsuperscript{14} The parameter estimates for the second model are given in
Table 1, columns 2 and 3. Column 2 provides the parameter
estimates for the middle income countries as determined by the
data, and column 3 provides the parameter estimates for the low
income countries.

\textsuperscript{13} OLS regressions with (L/L) and (I/Y) as dependent variables and the
country dummies as independent variables yielded coefficient of determination
values of .97 and .95 respectively.

\textsuperscript{14} Moschos (1989) orders his countries by real GDP per capita and finds the
switch point occurs just before Indonesian (Moschos, 1989:98, fn. 7), which in
1970 (the first year of his data) had a GNPC = $90 US. Using the US GNP
deflator this is equivalent to $244.50 in real 1986 US dollars (the switching
variable of our analysis).
Table 1. Parameter Estimates

<table>
<thead>
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<th>Variables</th>
<th>Equations (1)</th>
<th>Model: Equations (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GNPc ≥ $450</td>
<td>GNPc &lt; $450</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0146*</td>
<td>0.0067</td>
</tr>
<tr>
<td></td>
<td>(0.0079)</td>
<td>(0.0097)</td>
</tr>
<tr>
<td>I/Y</td>
<td>0.0462*</td>
<td>0.0461*</td>
</tr>
<tr>
<td></td>
<td>(0.0229)</td>
<td>(0.0279)</td>
</tr>
<tr>
<td>L/L</td>
<td>0.4556*</td>
<td>0.4995*</td>
</tr>
<tr>
<td></td>
<td>(0.2057)</td>
<td>(0.2255)</td>
</tr>
<tr>
<td>X/Y</td>
<td>0.7201**</td>
<td>0.4502**</td>
</tr>
<tr>
<td></td>
<td>(0.0604)</td>
<td>(0.1006)</td>
</tr>
<tr>
<td>X/X</td>
<td>--</td>
<td>0.1570**</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>(0.0358)</td>
</tr>
<tr>
<td>R²</td>
<td>.39</td>
<td>.43</td>
</tr>
<tr>
<td>N</td>
<td>276</td>
<td>194</td>
</tr>
<tr>
<td>countries</td>
<td>85</td>
<td>65</td>
</tr>
<tr>
<td>log(L)</td>
<td>825.04</td>
<td>840.57</td>
</tr>
</tbody>
</table>

Note: Standard errors are in parentheses. *, ** indicate significance at the 90%, 95%, and 99% level, respectively.

Recall that the parameter estimates for the labor (L/L) variable are interpreted (loosely) as an elasticity of output with respect to labor in the non-export sector. For the first model, this elasticity is positive and significant. In the second model, for the low income group (GNPc < 450), the point estimate is positive, but not significant. This tends to indicate that surplus labor may have been the prevalent situation in the sample countries for the periods covered by the data. For the middle income countries (GNPc ≥ 450), the point estimate is both positive and significant, as expected. The parameter estimates for the capital (I/Y) variable are interpreted as marginal products in the non-export sector. These estimates are positive and significant.
in all cases. The point estimate is higher for the low income countries in the second model, perhaps indicating a relative scarcity of capital inputs.\textsuperscript{15}

In the first model, the parameter on exports ($\dot{X}/Y$) picks up both the externality effect and the allocation effect. Though we can not separate the two effects in this model, it is clear that the combined magnitude of the two effects is both positive and significant. The finding that the single equation model best fit the data when the two effects are jointly captured in the estimation process suggests that the overall magnitude of the contribution of exports to growth does not systematically differ widely between low and middle income countries when the model is correctly specified.\textsuperscript{16} This is at variance with the implicit assumption found in much of the earlier work in this area that low income countries can not be expected to benefit from export growth.

The parameter estimates for the two export variables ($\dot{X}/Y$, $\dot{X}/X$) in the second model allow for the separation of the two export effects. The parameter on $\dot{X}/X$ is interpreted as the elasticity of non-export output with respect to exports and measures the externality effect. This externality is positive and significant in the middle income country group, but is

\textsuperscript{15} Khan and Knight (1988) find that import compression resulting from official attempts to achieve external balance results in shrinking the imports of capital inputs that may be required for export industries.

\textsuperscript{16} Moschos (1989) found the contribution of exports to growth is greater in the lower income group of countries than in the higher for his data and model specification.
insignificant in the low income countries. This indicates that the nature of the contribution of exports to growth is different for low income countries as compared to middle income countries. Specifically, countries may need to first attain a minimum level of development (GNPc > $450) to benefit from a positive externality effect due to exporting.\textsuperscript{17}

Using the point estimates on both export variables and referring to equations (3), the difference, D, in the marginal factor productivities in the export and non-export sectors can be calculated and it measures the allocation effect. Specifically, for the middle income countries, D = 1.55. This indicates that, on average, the factors used in the export sectors are 155% more productive (at the margin) than those used in the non-export sectors. For the low income countries, D = 1.11. That there is a greater marginal factor productivity differential for middle income countries than for low income countries is further evidence of the difference in the nature of the contribution of exports to growth between the two groups of countries. That the factor productivity differentials are so large suggests that resource allocation is significantly distorted from the optimal allocation and that, therefore, significant productivity gains could be had with the allocation of more resources to the export sectors in both groups of countries.

\textsuperscript{17} Consistent with generalizations from theories of industrialization, this finding suggests that the type of exports likely to be more closely associated with low income countries (primary products) will not generate the positive externality effect that production of those products more closely associated with middle income countries (manufactured products) would.
Finally, it is interesting to note that when the second model is estimated the parameter estimates on the capital and labor variables differ substantially between middle and low income countries. Yet this difference (between the contribution of capital and labor in the two groups of countries), is not great enough to cause the switching regression model to be selected as the one that best fits the data when the first model specification is used. However, once the difference in the nature of the contribution of exports to growth is captured in the second model, the differences between low and middle income countries are now great enough to require the switching regression estimation.

V. Conclusion

This paper has undertaken the task of empirically examining the significance of the stage of development on the difference in both the nature and the magnitude of the contribution of exports to growth. This issue is examined using switching regression versions of the Feder (1983) models which capture the contribution of exports to growth from both an externality effect and an allocation effect. The switching regression estimation of the second model [equations (2)] which allows separate identification of the two effects, indicates that the level of GNP per capita (as a measure of the level of development) that best distinguishes low income countries from middle income countries is US $450 (in real 1986 dollars).
The empirical results indicate that differences of the contribution of exports to growth between low and middle income countries do, in fact, arise from differences in both the magnitude and the nature of the contribution. Concerning the nature of the contribution, we have found that while the contribution of exports to growth in low income countries is solely due to factor productivity differentials between the export and non-export sectors (an allocation effect), middle income countries also benefit from a positive externality effect from the export sector which is not enjoyed in low income countries.

Although the magnitude of the contribution of exports to growth was found to be greater in the middle income countries the benefit to low income countries is substantial. The difference in the magnitude of the contribution of exports to growth is due to both the lack of a significant externality effect for low income countries, as well as the greater productivity differentials (the allocation effect) in the middle income countries. When the model specification did not allow separate determination of the two types of export contribution to growth the difference in the magnitudes of the export effects was not significant enough to require separate estimation for low and middle income countries. This suggests that the difference in the magnitude of the contribution of exports to growth between low and middle income countries should not be considered to be very large.
Appendix

This appendix will describe the theoretical derivation of the models estimated [equations (1) and (2) in the text]. For the most part this follows Feder (1983), sections 2 and 3, pp. 60-67. There are some modifications.

First we assume an economy with two sectors, export and non-export, so GNP is equal to the sum of the output from each sector. Let \( Y = GNP \), \( N = \) output of non-export sector, and \( X = \) output of export sector. Then:

\[
Y = N + X \quad (A1)
\]

Then we specify production functions for \( N \) and \( X \) such that the production of \( X \) may provide an externality for \( N \). Then:

\[
N = F(K_n, L_n, X), \quad (A2a)
\]

\[
X = G(K_x, L_x), \quad (A2b)
\]

where \( K_n + K_x = K \) and \( L_n + L_x = L \).

The subscripts on \( K \) and \( L \) refer to the sectors.

Let the dot notation symbolize the change of the overstruck variable. From (A1):

\[
\dot{Y} = \dot{N} + \dot{X} \quad (A3)
\]

Let the subscripts on \( F \) and \( G \) refer to the marginal products with respect to the subscripted inputs. Taking total derivatives of (2), letting \( I = \dot{K} \) and substituting into (A3) yields:

\[
\dot{Y} = F_K I_n + F_L L_n + F_X \dot{X} + G_K I_x + G_L L_x \quad (A4)
\]
Note that the partial derivative of $F$ with respect to $X$ ($F_X$) captures the externality effect of exporting output.

Suppose that the respective marginal products in each sector are not equal. Specifically, let:

$$G_K = (1+\delta) F_K \quad \text{and} \quad G_L = (1+\lambda) F_L \quad (A5)$$

Note that $\delta$ and $\lambda$ allow us to capture the productivity differentials or the allocation effect due to exporting. Using (A5), (A4) becomes:

$$\dot{Y} = F_K I_n + F_L \dot{L}_n + F_X \dot{X} + (1+\delta) F_K I_X + (1+\lambda) F_L \dot{L}_X \quad (A6)$$

Combining terms (A6) simplifies to:

$$\dot{Y} = F_K I + F_L \dot{L} + F_X \dot{X} + \delta F_K I_X + \lambda F_L \dot{L}_X \quad (A7)$$

Data is readily available for the dependent variable and the first three RHS variables of (A7), but not for the last two RHS variables. We therefore derive an alternate expression for the last two terms in the equation above. Start with the total differentiation of (A2b):

$$\dot{X} = G_K I_X + G_L \dot{L}_X \quad (A8)$$

Substituting from (A5) into (A8) yields:

$$\dot{X} = F_K I_X + F_L \dot{L}_X + \delta F_K I_X + \lambda F_L \dot{L}_X \quad (A9)$$

Note that the last two terms of (A9) are the same as the last two terms of (A7). Now use (A5) and substitute back into the first two RHS terms of (A9).

$$\dot{X} = [G_K / (1+\delta)] I_X + [G_L / (1+\lambda)] \dot{L}_X + \delta F_K I_X + \lambda F_L \dot{L}_X \quad (A10)$$
Define $\rho = G_k I_x / \dot{x}$, now:

$$\dot{x} = G_k I_x + G_L L_x = \rho \dot{x} + (1 - \rho) \dot{x}$$  \hspace{1cm} (A11)

Substitute $\rho$ into (A10):

$$\dot{x} = \frac{\rho}{1+\delta} \dot{x} + \frac{1-\rho}{1+\lambda} \dot{x} + \delta F_k I_x + \lambda F_L L_x$$  \hspace{1cm} (A12)

Rearranging terms in (A12):

$$\delta F_k I_x + \lambda F_L L_x = (1 - \frac{\rho}{1+\delta} - \frac{1-\rho}{1+\lambda}) \dot{x}$$ \hspace{1cm} (A13)

Substitute (A13) in for the last two RHS terms in (A7) and simplify.

$$\dot{y} = F_k I + F_L L + [F_X + (1 - \frac{\rho}{1+\delta} - \frac{1-\rho}{1+\lambda})] \dot{x}$$ \hspace{1cm} (A14)

Now let $F_k = \alpha$ and $F_L = \beta (Y/L)^*$ and substitute these into (A14) and divide by $Y$. This yields:

$$\dot{y}/Y = \alpha (I/Y) + \beta (L/L) + [F_X + (1 - \frac{\rho}{1+\delta} - \frac{1-\rho}{1+\lambda})] (\dot{x}/Y)$$  \hspace{1cm} (A15)

This is the equation used as the base for the first switching regression model, equations (1) in the text [where we let $\Gamma$ represent the entire bracketed expression preceding $(\dot{x}/Y)$]. If we let $\lambda = \delta$ then (A15) collapses to Feder's equation (11). Note that the parameter estimated for the export variable $(\dot{x}/Y)$ includes both an externality effect ($F_X$) as well as the productivity differentials ($\lambda$ and $\delta$) or the allocation effect. Ideally we want

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* As Feder (1983:62) notes, this suggests that there exists a linear relationship between the marginal product of labor in the export sector and the average output of labor in the economy. For supporting arguments see Bruno (1968).
to be able to separately identify the allocation effect and the externality effect. To do this we let \( F \) have a specific separable form as follows:

\[
N = F(K_n, L_n, X) = X^\theta \Psi(K_n, L_n)
\]  

(A16)

Now the partial derivative of \( F \) with respect to \( X \) is (using also that \( N = Y - X \)):

\[
F_X = \theta(N/X) = \theta(Y/X) - \theta
\]  

(A17)

Substituting (A17) into (A15) and manipulating yields:

\[
\frac{\dot{Y}}{Y} = \alpha(I/Y) + \beta(L/L) + \left[(1 - \frac{\rho}{1+\delta} - \frac{1-\rho}{1+\lambda}) - \theta\right] \frac{\dot{X}}{Y} + \theta \frac{\dot{X}}{X}
\]  

(A18)

This is the equation used as the base for the second switching regression model, equations (2) in the text [where we let \( \Phi \) represent the entire bracketed expression preceding \( \dot{X}/Y \)]. If we let \( \lambda = \delta \) then (A18) collapses to Feder's equation (18).

Furthermore, as Feder (1983) points out, if one assumes that:

\[
\theta = (1 - \frac{\rho}{1+\delta} - \frac{1-\rho}{1+\lambda})
\]  

(A19)

then equation (A18) collapses into the form of the equation estimated in Michalopoulos and Jay (1973), Balassa (1978b), Tyler (1981), Kavoussi (1984), and Moschos (1989). Certainly a priori it would seem that the equality in (A19) is very unlikely to hold, calling into question the results from estimations that implicitly impose this restriction.
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<tr>
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<th>Title</th>
<th>Source</th>
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<tbody>
<tr>
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