DETERMINANTS OF COMPLEX EXPORTS: EVIDENCE FROM CROSS-COUNTRY DATA FOR 1985-1998*

1. Introduction

Exports have been widely viewed as an engine of economic growth for a long time, and government policies in many countries have been aiming to promote exports. A nation's export competitiveness depends in large part on its ability to sell high- and medium-tech products (hereafter complex exports) in the world market[1]. What are the major determinants of complex exports? Does the importance of these determinants vary over time?

This paper intends to investigate factors that explain the magnitude of a nation's complex exports in 1985-1998. It is motivated by the following considerations: (a) Complex exports have been viewed as a catalyst for economic growth through up-grading a nation's industrialization (UNIDO, 2002 and 2005), and thus many countries have been working hard to expand complex exports. (b) Complex exports have grown much faster than simple exports, with a rising share in the world trade (from 43% to 55%) in the period 1985-1998 (UNIDO, 2002). (c) While much work has focused on aggregate exports, studies on complex exports have been limited, especially on empirical analyses of its determination for recent data.

The objective of the current work is to fill this gap by assessing determinants of complex exports with cross-country data in the period 1985-1998 for 87 countries/regions. Besides the focus on the more recent data and the use of a large sample size, this study has several distinctive features. First, it employs a fairly straightforward specification that is parsimonious and yet includes most major

* Husniddin Mustafaev and Wayne Jiao, my research assistants, provided valuable assistance in data entry. Of course, the usual caveat applied.

[1] Complex exports are products and services exported by a nation's high- and medium-technology industries, while those exported by low-tech and resource-based industries are simple exports (UNIDO, 2002).

influences on complex exports. Second, it uses two proxies of complex exports in terms of per capita value and share in total manufactured exports as dependent variables in regressions. The share indicator may reveal importance of complex exports in a nation's total exports; while the per capita value may capture its absolute magnitude. Third, the identical set of explanatory variables is employed for each year of the same model to judge if the impact of determinants changed over time in 1985-98. Fourth, it considers estimates for changes in complex exports over the period 1985-98 as well as the amount of complex exports in 1985 and 1998.

2. The model

According to OECD (1996), high-tech industries include complex electrical and electronic (including telecommunications) products, aerospace, precision instruments, fine chemicals and pharmaceuticals. Medium-tech manufactures include heavy industry products such as automobiles, industrial chemicals, machinery and relatively standard electrical and electronic products. High-tech products, with advanced and fast-changing technologies and complex skill needs, have the highest entry barriers. As the most innovative industries, high-tech exports call for large R&D investment, advanced technology infrastructure and close interaction between firms, universities and research institutions (Lall, 2000). But many activities, particularly in electronics, have final processes with simple technologies, where low wages can be an important competitive factor. These products allow segments of the value chain to be broken up and located across different countries, in which foreign direct investment (FDI) by multinational firms is active (Zhang, 2006).

Medium-tech products tend to have complex but not fast-changing technologies, with moderate levels of R&D expenditures but advanced engineering and design skills and large scales of production. In engineering products there is emphasis on product design and development capabilities as well as extensive supplier and subcontractor networks (UNIDO, 2002). Barriers to entry tend to be high because of capital requirements and strong learning effects in operation, design and product differentiation. Innovation and learning in the engineering segment increasingly involves cooperation

in the value chain between manufacturers and suppliers (UNCTAD, 2002).

Complex exports reflect multidimensional interaction of many factors, including institutions, skills, technology, infrastructure, political and social stability and other factors. It is not possible to quantify all these in a comparable way across countries. Mapping the structural influences on complex exports calls for selectivity and simplification. Following what has been done in the literature (for example, Fugazza, 2004; Greenhalg, 1990; Lall, 2000; Laursen, 1999; Limao and Venables, 2001; Montobbio and Pampa, 2005; Potterie and Lichtenberg, 2001; Redding and Venables, 2004; UNCTAD, 2002; UNIDO, 2002; and Zhang, 2006), we may identify the following driving forces directly relevant to complex exports (CX), skills (S), inward foreign direct investment (FDI), infrastructure ($INFR$), and industrial technology capability (ITC). One can then specify a complex export function for country i fairly simply as:

$$CX_i = f(S_i, FDI_i, INFR_i, ITC_i) \quad (1)$$

The rationale for each independent variable is as follows. Skills (S) of the labor force have a significant influence on the capability and competitiveness of an industry and thus on its complex export performance. Therefore higher level of skills can enhance the industry's productivity and export ability (Fugazza, 2004 and Greenhalg, 1990). A positive link between inward FDI and complex exports is suggested widely in the literature, where the stimulative effects of FDI on host complex exports derive from the advanced technology and managerial know-how that multinational firms bring with them, along with access to global, regional, and especially home-country markets (Potterie and Lichtenberg, 2001 and Zhang, 2006). The size and growth of complex exports depend critically on the availability and quality of physical infrastructure ($INFR$), ranging from roads and ports to energy and telecommunication. Better infrastructure helps complex exports (Fugazza, 2004 and Limao and Venables, 2001). A nation's industrial technology capability (ITC) is its ability and capacity of producing high- and medium-tech products, measured by per capita value of production for complex goods, or by complex product share in total manufactures. Based on the traditional and new trade theories, the higher level of industrial technology capability in a nation, more complex exports it has because of comparative advantage and scale economies (Lall, 2000 and UNIDO, 2002).

Complex exports (CX) may be measured in terms of both per capita value and shares in total manufactured exports. So are FDI and ITC. Addition of a constant term and a stochastic component to equation (1) yields two econometric specifications as follows:

$$CXPC_i = \alpha_0 + \alpha_1 S_i + \alpha_2 FDIPC_i + \alpha_3 INFR_i + \alpha_4 ITCPC_i + \varepsilon_i \quad (2)$$

$$CXS_i = \beta_0 + \beta_1 S_i + \beta_2 FDIS_i + \beta_3 INFR_i + \beta_4 ITCS_i + \mu_i \quad (3)$$

In equation (2) $CXPC_i$ denotes per capita value of complex exports in current price of US dollars for country i, S_i is measured by share of tertiary enrollments in technical subjects in total population. $FDIPC_i$ is five-year average per capita inflows (1981-85 for 1985 regression, and 1993-97 for 1998 regression) in current price of US dollars. Infrastructure ($INFR_i$) is measured by number of telephone mainlines per 1000 people. $ITCPC_i$ is manufacturing value added per capita in current price of US dollars. In equation (3), CXS_i is the share of complex export in total manufactured exports, while $FDIS_i$ and $ITCS_i$ are measured as shares in gross domestic investment and in total manufacturing value added, respectively. S_i and $INFR_i$ are defined in the same way as those in equation (2). Regressions are run for each equation for year 1985 and 1998 separately to assess how important each determinant is to complex exports in the two years.

To see the extent to which structural changes in complex exports over 1985-98 can be explained by the independent variables, a difference-form of equations (2) and (3) may be developed, resulting in the following specifications:

$$\Delta CXPC_i = \gamma_0 + \gamma_1 \Delta S_i + \gamma_2 \Delta FDIPC_i + \gamma_3 \Delta INFR_i + \gamma_4 \Delta ITCPC_i + \eta_i \quad (4)$$

$$\Delta CXS_i = \lambda_0 + \lambda_1 \Delta S_i + \lambda_2 \Delta FDIS_i + \lambda_3 \Delta INFR_i + \lambda_4 \Delta ITCS_i + \nu_i \quad (5)$$

where Δ denotes changes from 1985 to 1998 for each variable.

3. The data and the main results

Equations (2)-(5) constitute the basis for our econometric analysis of complex exports for 87 countries/regions in 1985 and 1998. All data are taken from UNIDO Scoreboard Database (United Nations Industrial Development Organization, 2002). Every country/region for which data for the relevant variables are available in the source cited has been included. Thus, there is no direct selection bias in the sample. The countries/regions included are listed in the Appendix. The descriptive statistics for all variables used in the regressions are presented in Table 1.

TABLE 1 - *Descriptive Statistics for the Variables Used in the Study*

Variables	Mean	Standard Deviation	Maximum	Minimum
CXPC-1985	328.53	600.42	3055.42	0.00
CXPC-1998	1401.90	3314.29	24305.76	0.02
CXS-1985	18.91	19.62	80.00	0.10
CXS-1998	27.81	24.45	81.10	0.10
S-1985	0.33	0.24	1.00	0.01
S-1998	0.42	0.35	1.65	0.01
FDIPC-1985	35.33	76.04	563.40	-3.90
FDIPC-1998	199.39	372.38	2536.00	0.10
FDIS-1985	3.33	3.38	17.91	-1.37
FDIS-1998	8.74	6.89	30.72	0.07
INFR-1985	161.69	184.94	627.80	1.00
INFR-1998	255.14	232.52	675.40	2.70
ITCPC-1985	407.20	554.51	2200.88	4.20
ITCPC-1998	986.53	1389.82	5238.26	1.56
ITCS-1985	36.20	15.43	67.00	10.00
ITCS-1998	39.57	16.84	80.00	10.00
$\Delta CXPC$	978.42	2674.09	21250.34	-6.68
ΔCXS	8.72	12.92	64.20	-11.90
ΔS	0.08	0.18	0.87	-0.37
$\Delta FDIPC$	156.87	299.44	1972.60	-73.90
$\Delta FDIS$	5.71	6.23	25.30	-6.92
$\Delta INFR$	88.00	98.31	273.00	-417.40
$\Delta ITCPC$	517.88	874.11	3869.23	-199.35
$\Delta ITCS$	2.70	6.58	21.00	-16.00

Notes: *CXPC, FDIPC*, *ITCPC*, $\Delta CXPC$, $\Delta FDIPC$, and $\Delta ITCPC$ are in US dollars, *INFR* and $\Delta INFR$ are in number, and *CXS, S, FDIS*, *ITCS*, ΔCXS, ΔS, $\Delta FDIS$, and $\Delta ITCS$ are in percentages.

Tables 2-4 report ordinary least-squares (OLS) estimates of equations (2)-(5) for individual years (1985 and 1998) and changes over the period 1985-98. In general, the regression estimates seem reasonable and plausible, and the explanatory power of the parsimonious models in this highly diverse cross-country sample is fairly good. R^2 of regressions is reasonably high (from 0.70-0.87) except the model of equation (5). The fact that three quarters of the variance in complex exports can be accounted for in the regressions indicates the predominant influence of the four determinants.

TABLE 2 - *Determinants of Complex Exports: 1985 and 1998*

Dependent Variable: Complex Exports Per Capita (*CXPC*)		
Independent Variables	Eq. (2) for 1998	Eq. (2) for 1985
Constant (*C*)	84.04	-49.24
	(0.53)	(-0.80)
Skills (*S*)	875.80**	-48.66
	(1.98)	(-0.25)
Foreign Direct Investment Per Capita (*FDIPC*)	6.87***	3.50***
	(17.25)	(6.66)
Infrastructure (*INFR*)	-7.25***	-0.08
	(-7.28)	(-0.22)
Industrial Technology Capability Per Capita (*ITCPC*)	1.4***	0.70***
	(10.39)	(5.83)
Adjusted R^2	0.90	0.75
F-Statistic	203.42***	52.91***
Sample Size	87	70

Notes: Figures in parentheses are t-statistics. The asterisks *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

TABLE 3 - *Determinants of Complex-Manufactured-Export Shares: 1985 and 1998*

Dependent Variable: Complex-Export Share (*CXS*)		
Independent Variables	Eq. (3) for 1998	Eq. (3) for 1985
Constant (*C*)	-14.19***	-9.37**
	(-3.43)	(-2.24)
Skills (*S*)	5.73	10.72
	(0.92)	(1.56)
Foreign Direct Investment Share (*FDIS*)	0.07	-0.62
	(0.32)	(-1.58)
Infrastructure (*INFR*)	0.02*	0.04***
	(1.82)	(3.37)
Industrial Technology Capability Share (*ITCS*)	0.86***	0.57***
	(6.80)	(4.69)
Adjusted R^2	0.68	0.69
F-Statistic	46.59***	39.45***
Sample Size	87	71

Notes: Figures in parentheses are t-statistics. The asterisks *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

TABLE 4 - *Determinants of Changes in Complex Manufactured Exports in 1985-98*

Independent Variables	Equation (4)	Independent Variables	Equation (5)
Constant (C)	-277.93 (-1.34)	Constant (C)	5.83** (2.60)
Changes in Skills (ΔS)	-1160.53 (-1.27)	Changes in Skills (ΔS)	4.20 (0.52)
Changes in FDI Per Capita ($\Delta FDIPC$)	5.30*** (7.60)	Changes in FDI Share ($\Delta FDIS$)	0.29 (1.29)
Changes in Infrastructure ($\Delta INFR$)	-2.42 (-1.33)	Changes in Infrastructure ($\Delta INFR$)	-0.02 (-1.25)
Changes in Industrial Technology Capability Per Capita ($\Delta ITCPC$)	1.41*** (5.80)	Changes in Industrial Technology Capability Share ($\Delta ITCS$)	0.81*** (3.87)
Adjusted R^2	0.80	Adjusted R^2	0.17
F-Statistic	72.19***	F-Statistic	1.66***
Sample Size	70	Sample Size	71

Notes: Figures in parentheses are t-statistics. The asterisks *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

Industrial technology capacity seems to be a key factor influencing complex exports. The estimated coefficients of ITC, $ITCS$, ΔITC, and $\Delta ITCS$ in all equations are statistically significant at the 1% level in the expected positive direction. It is suggested that there is a strongly positive link of complex exports with domestic complex manufacturing capability. In particular, per capita value of complex exports is positively associated with per capita complex manufacturing value-added, and the enhancing effects are larger in 1998 than in 1985, as indicated by the larger value of the coefficient for 1998 in Table 2. The same pattern exists for the complex exports share and the complex manufacturing value-added share (Table 3). Moreover, changes in per capita value of complex exports can mainly be explained by changes in per capita complex manufacturing value-added, so are changes in the complex-export share, as suggested in Table 4.

The parameters for FDI and infrastructure ($INFR$) show somewhat variable patterns in the four specifications. The FDI term

has significant and positive coefficients in the models with per capita value of complex exports (equations (2) and (4)), but the term is insignificant in the models with complex export shares (equations (3) and (5)). The *INFR* term is significantly positive in the model with complex export shares for both years 1985 and 1998, but has the "wrong" (negative) sign in equation (2) for 1998. In all other cases it is insignificant and has negative sign. It seems that FDI inflows increase complex exports in absolute amount, with larger effects in the 1990s than the 1980s, and the quality of infrastructure helps raise complex-export shares, with declining effects over the period 1985-98.

The evidence in favor of skills (*S*) is not strong. A significantly positive coefficient appears only in the model with per capita value of complex exports for 1998. In all remaining cases, the skill term is insignificant or even has the negative sign. We believe our variable proxies and models to be reasonable, and we do find the positive skill-complex export link for the 1990s. If there was evidence of positive skill parameter for the 1985 and for the complex export share, as suggested by some theories, it is difficult to discern it for the 1980s. This aspect may need further study.

As stated earlier, we use a parsimonious specification that does not include several variables that may have an influence on complex exports. Also, there is always a possibility of some "feedback" from complex exports to its determinants. To check whether our model may have a major specification error, we use the diagnostic suggested by Halbert White (1980). The procedure is a joint test for the null hypothesis of no specification error and heteroskedasticity. The result of the White-test indicates that the values of the test statistic are too small to justify non-acceptance of the null hypothesis of heteroskedasticity and correct model specification, suggesting absence of both heteroskedasticity and other major specification errors in the models.

4. Concluding remarks

The main motivation for this work is to study empirically the important question about the determination of complex exports in the 1980s and 1990s that witnessed a massive increase in complex exports. It is probably the first study on this issue to cover the period 1985-98 with the largest possible cross-country sample. Using a straightforward and parsimonious specification, we assess

most major influences on complex exports (namely, skills, FDI, infrastructure, and industrial technology capability). Moreover, two proxies of complex exports in terms of per capita value and shares in total manufactured exports are employed as dependent variables in regressions, in which the identical set of explanatory variables is used to see if the importance of each determinant changed over time in 1985-98. Finally, we estimate changes in complex exports over the period 1985-98 as well as the amount of complex exports in 1985 and 1998.

Subject to the caveats appropriate for such cross-country studies, the most basic point we note is that a nation's complex exports are closely associated with its industrial technology capability in the period 1985-1998. In particular, per capita value of complex exports increases with per capita complex manufacturing value-added; complex export share in total exports rises with the complex manufacturing share in total manufactures; and both per capita value and share of complex exports from 1985 to 1998 increase with per capita complex manufacturing value-added and share in total manufactures. In addition, the complex export-FDI link is positive for the case of per capita value, but not for the case of shares. The impact of infrastructure on complex exports is positive only for the case of shares, not per capita value. Overall we do not find strong evidence for positive effects of skills, though its parameter is positive in 1998 for the case of per capita value of complex exports.

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APPENDIX
List of Sample Economies

Albania
Algeria
Argentina
Australia
Austria
Bahrain
Bangladesh
Belgium
Bolivia
Brazil
Cameroon
Canada
Central Africa
Chile
China
Colombia
Costa Rica
Czech Republic
Denmark
Ecuador
Egypt
EI Salvador
Ethiopia
Finland
France
Germany
Ghana
Greece
Guatemala
Honduras
Hong Kong
Hungary
India
Indonesia
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kenya
Korea
Madagascar
Malawi
Malaysia
Mauritius
Mexico
Morocco
Mozambique
Nepal
Netherlands
New Zealand
Nicaragua
Nigeria
Norway
Oman
Pakistan
Panama
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Russia
Saudi Arabia
Senegal
Singapore
Slovenia
South Africa
Spain
Sri Lanka
Sweden
Switzerland
Taiwan
Tanzania
Thailand
Tunisia
Turkey
Uganda
United Kingdom
United States
Uruguay
Venezuela
Yemen
Zambia
Zimbabwe

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ABSTRACT

High- and medium-tech exports (hereafter complex exports), reflecting a nation's technological capabilities, can bring a nation larger benefits from international trade than simple exports. What determines the complex exports? While the topic is quite important, the quantitative analysis on the issue in the literature has been limited. This paper attempts to close the gap by assessing factors that influence a nation's complex exports with cross-country data for 1985-1998. The estimates suggest the following conclusions: (a) a nation's industrial technology capability has a significantly positive impact on its complex exports; (b) inward FDI flows may help raise per capita value of complex exports, but have no effect on the complex export share in total manufacturing exports; (c) infrastructure seems to have a positive impact on the complex export share, but no effect on per capita value of complex exports; and (d) the impact of skills on complex exports seems to be weak.

JEL Code: F11, F12, and F14

Keywords: Complex Exports, Skills, FDI, Infrastructure, and Industrial Technology Capability

RIASSUNTO

Le determinanti delle esportazioni complesse: risultati empirici di un'analisi cross-country per il periodo 1985-1998

Le esportazioni ad alto e medio contenuto tecnologico (d'ora in avanti esportazioni complesse) riflettono le capacità tecnologiche di un paese possono apportare maggiori benefici rispetto alle esportazioni semplici. Che cosa determina le esportazioni complesse? Sebbene l'argomento sia importante, le analisi quantitative in proposito sono limitate. Questo articolo cerca di colmare il vuoto valutando i fattori che influenzano le esportazioni complesse di un paese sulla base di un'analisi cross-country per il periodo 1985-1998. Le stime offerte portano alle seguenti conclusioni: (a) la capacità tecnologica dell'industria di un paese ha un significativo effetto positivo sulle sue esportazioni complesse; (b) i flussi di investimenti diretti stranieri possono aiutare ad alzare il valore pro-capite delle esportazioni complesse, ma non hanno alcun effetto sulla quota di esportazioni complesse sul totale delle esportazioni di manufatti; (c) le infrastrutture sembrano avere un effetto positivo sul totale delle esportazioni complesse, ma nessun effetto sul valore pro-capite delle stesse; (d) l'effetto delle competenze professionali sulle esportazioni complesse sembra essere debole.