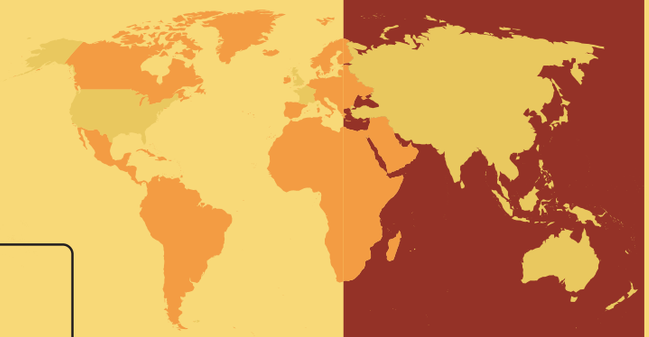

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United Nations
Economic and Social Commission for Asia and the Pacific
Poverty and Development Division
United Nations Building, Rajadamnern Nok Avenue
Bangkok 10200, Thailand
Fax: (66 2) 288-3007
E-mail: escap-pdd@un.org
escap-publicationsoffice@un.org
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Asia-Pacific Development Journal

Vol. 14, No. 2, December 2007

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ASIA-PACIFIC DEVELOPMENT JOURNAL

Vol. 14, No. 2, December 2007

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ASIA-PACIFIC DEVELOPMENT JOURNAL

Vol. 14, No. 2, December 2007

United Nations
New York, 2008

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

ASIA-PACIFIC DEVELOPMENT JOURNAL

Vol. 14, No. 2, December 2007

United Nations publication
Sales No. E.07.II.F.33

Manufactured in Thailand
ISBN: 978-92-1-120532-9
ISSN: 1020-1246
ST/ESCAP/2496

Editorial Statement

The *Asia-Pacific Development Journal* is published twice a year by the Economic and Social Commission for Asia and the Pacific.

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The *Journal* welcomes original articles analysing issues and problems relevant to the region from the above perspective. The articles should have a strong emphasis on the policy implications flowing from the analysis. Analytical book reviews will also be considered for publication.

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Chief Editor
Asia-Pacific Development Journal
Poverty and Development Division
ESCAP, United Nations Building
Rajadamnern Nok Avenue
Bangkok 10200
Thailand
Fax: (662) 288-1000 or 288-3007
E-mail: **escap-pdd@un.org**

ASIA-PACIFIC DEVELOPMENT JOURNAL
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Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.
References to pounds (£) are to pounds sterling, unless otherwise stated.
References to "tons" are to metric tons, unless otherwise specified.
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The following symbols have been used in the tables throughout the journal:
Two dots (..) indicate that data are not available or are not separately reported.
An em-dash (—) indicates that the amount is nil or negligible.
A hyphen (-) indicates that the item is not applicable.
A point (.) is used to indicate decimals.
A space is used to distinguish thousands and millions.
Totals may not add precisely because of rounding.
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GROWTH DETERMINANTS IN LOW-INCOME AND EMERGING ASIA: A COMPARATIVE ANALYSIS

*Ari Aisen**

This paper investigates the determinants of economic growth in low-income countries in Asia. Estimates from standard growth regressions using data for 146 developing countries for the period 1970-2000 indicate that a higher investment-to-GDP ratio, openness, primary school enrolment and rule of law all positively affect growth. Conversely, a higher government expenditure-to-GDP ratio is associated with lower growth. In addition, a comparative exercise between emerging countries and low-income countries in Asia shows that investment raises growth significantly more efficiently in the former. The paper concludes by recommending policy directions, based on the empirical results, that could help spur growth throughout low-income Asia.

I. INTRODUCTION

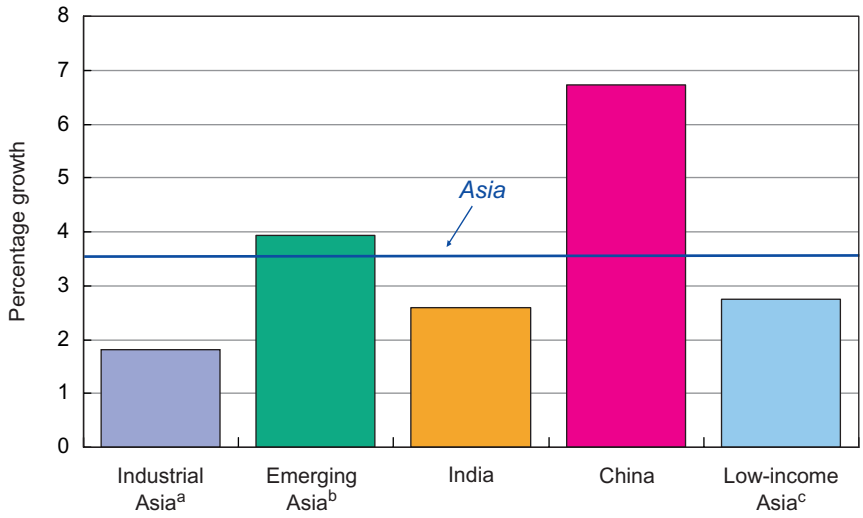
Understanding the process of economic growth and its ramifications has always been a concern to economists. Solow (1956, 2000) made seminal contributions to the development of the neoclassical growth model, laying the basis for extensive academic and policy-oriented research. Since growth is closely linked to development and poverty reduction, measuring the determinants of economic growth took centre stage in the profession. Growth regressions, popularized by Sala-i-Martin (1997) and Barro and Sala-i-Martin (2003) through their contributions to the empirical analysis of a cross-section of countries, have become a standard tool for economists in search of policies to stimulate economic growth and often lead to relevant policy recommendations.[1]

* Economist at the Asia and Pacific Department of the International Monetary Fund. Currently at the Central Bank of Chile.

[1] The view that growth regressions are a useful tool for policy recommendation is controversial. Pritchett (2006) argues that growth regressions did not help policymakers anticipate either the disappointments or the surprises of the 1990s. Nonetheless, he sustains that growth regressions can serve as a first descriptive set of partial correlations across various horizons and that such correlations can reveal patterns of relationships that smooth over a more complex dynamic.

The purpose of this paper is to analyze the determinants of growth in low-income countries in Asia (Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, Sri Lanka and Viet Nam). In the race to converge to the higher standards of living prevalent in industrial countries,[2] low-income countries in Asia experienced lower real per capita GDP growth rates than other countries in the region in the period 1970-2000. The average growth rate in low-income Asia was 2.75 per cent (see figure 1), lower than the averages in Asia (3.25 per cent) and in emerging Asia (4 per cent). The paper includes an exercise comparing growth and its determinants in low-income Asia with that of emerging Asia (China, India, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore and Thailand). The latter, is perhaps the best comparison group because it comprises developing Asian countries that experienced strong growth performance. The similarities between the two groups make the comparative

Figure 1. Average of real per capita GDP growth, 1970-2000



[a] Industrial Asia consists of Australia, Japan and New Zealand.

[b] Emerging Asia consists of Indonesia, Malaysia, Philippines, Republic of Korea, Singapore and Thailand.

[c] Low-income Asia consists of Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, Sri Lanka and Viet Nam.

[2] While convergence to the higher GDP in industrial Asia may not occur on an absolute basis, convergence conditional on initial economic conditions could take place (Barro and Sala-i-Martin (2003).

analysis an interesting exercise that could highlight economic policies that may successfully engender growth.[3]

In the analysis, attention is given to the following high-policy-content variables: investment, government expenditures, openness, primary school enrolment and rule of law. These variables in emerging Asia seem to be more consistent with higher growth rates (see table 1).

Estimates from growth regressions using a panel data set of 146 developing countries for the period 1970-2000 show that investment, rule of law and openness are the main variables explaining the difference in growth performance between low-income and emerging Asia. For example, estimates show that the impact investment has on growth in emerging Asia is almost three times greater than the impact it has on growth in low-income countries in Asia. Low-income Asia also invests less (as a percentage of GDP) than emerging Asia, magnifying the effect and further reducing growth. The substantial effects caused by lower levels of both openness and rule of law also play an important role explaining growth underperformance in low-income Asia. This analysis leads directly to policy recommendations for increasing growth in low-income Asia. Policies should stimulate investment by raising the marginal productivity of capital. This could be achieved by a combination of policies focused on: (a) educating and training the labour force, thus raising human capital; (b) facilitating the transfer of foreign technologies; (c) improving the business climate; and (d) deepening the financial sector. Other policies that can facilitate growth include those that open countries to trade and those that improve institutions, such as the judiciary system, that foster contract enforcement and the functioning of courts and police.

The analysis of the paper is structured in three sections. The data set and empirical estimates are described in section II. Section III presents a comparative exercise between low-income Asia and emerging Asia using the estimates of the regressions from section II. Section IV presents final remarks and policy recommendations.

---

[3] There is a long list of papers explaining why East Asia has a history of high growth rates. Easterly (1994), prominent among the authors, argues that high growth rates in Hong Kong, China; the Republic of Korea; Singapore; and Taiwan Province of China may have been pure luck, but also recognizes that these countries had above-average investment, education and financial depth as well as low budget deficits. Quite strikingly, but not surprisingly, a literature search produced almost no papers describing the growth experience of low-income countries in Asia, clearly much less of a success story than East Asia in terms of growth performance. Therefore, the present comparative analysis between the two groups of countries in Asia constitutes a significant contribution to the literature.

Table 1. Gross domestic product growth and policy variables: annual averages, 1970-2000

	Lagged log Real GDP (Percentage)	*Investment to GDP (Percentage)*	*Openness (Index)*	*Government expenditures to GDP (Percentage)*	*Primary school enrolment (gross) (Percentage)*	*Rule of law[a] (Index)*
Low-income Asia (group average)	2.7	21.3	43.5	26.4	100.0	-0.6
Bangladesh	1.0	17.1	19.3	..	77.1	-0.7
Bhutan	4.2	36.4	51.1	42.5	..	-0.5
Cambodia	4.2	11.1	85.6	10.4	110.2	-0.8
Lao People's Democratic Republic	2.9	14.0	23.7	21.2	104.0	-1.1
Mongolia	0.5	37.7	73.5	51.4	94.1	0.1
Myanmar	..	16.2	27.8	16.4	104.8	-1.3
Nepal	1.6	21.1	28.3	17.3	96.8	-0.4
Sri Lanka	3.1	21.6	53.7	30.0	104.4	-0.3
Viet Nam	4.3	16.1	28.6	22.2	108.8	-0.8
Emerging Asia (group average)	4.3	27.5	76.4	23.0	103.2	0.2
China	6.7	27.8	19.7	23.3	117.2	-0.4
India	2.6	19.7	13.9	26.0	95.3	0.2
Indonesia	4.1	22.7	41.3	18.0	108.2	-1.0
Malaysia	4.2	31.5	108.6	32.6	97.8	0.4
Philippines	1.0	22.2	46.6	18.9	111.4	-0.6
Republic of Korea	5.8	31.1	51.7	..	100.8	0.5
Singapore	5.5	36.6	276.3	23.7	102.4	1.9
Thailand	4.4	28.1	53.1	18.8	92.5	0.3
Emerging Asia, excluding China and India	4.2	28.7	96.3	22.4	102.2	0.3

Sources: Data from World Bank (1996-2007; 2007c).

[a] Rule of law index ranges between -2.5 to 2.5 and measures contract enforcement.

(..) data not available or not reported separately.

II. DATA AND ECONOMETRIC ANALYSIS

The data set is composed of annual data on economic, political and institutional variables for 146 developing countries for the period 1970-2000,[4] table 2 presents data sources and summary statistics of the variables used in the analysis.

Table 2. Summary statistics and data sources

Variable	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Lagged log annual per capita gross domestic product growth	1.098	2.596	-7.919	11.495
Enrolment in primary school	94.363	21.838	14.186	133.100
Investment to gross domestic product	22.199	6.543	6.177	39.168
Government expenditures to gross domestic product	38.217	42.724	9.326	546.174
Openness (exports plus imports as a share of gross domestic product)	59.728	40.786	12.655	310.923
Rule of law	-0.098	0.977	-2.370	2.110 [a]
Inflation (consumer price index)	16.835	17.821	1.874	103.224
Fertility: (logarithmic of population growth)	0.426	0.778	-1.976	1.950
Growth of terms of trade	-0.147	2.323	-8.003	5.796
Cabinet changes (political instability)	0.473	0.245	0.033	1.400 [b]
Democracy	0.388	6.470	-10.000	10.000 [c]

Source: Data from World Bank (2007c) unless otherwise indicated.

[a] World Bank (1996-2006).

[b] Databanks International (2005).

[c] Center for International Development and Conflict Management (2006).

In line with Barro and Sala-i-Martin (2003), the econometric strategy uses standard growth regressions to estimate the effects of the most important explanatory variables on real per capita GDP growth. The variables and their expected effect on growth are described below:

[4] Missing values for several variables reduce the actual number of countries in the regression to 84.

- *Lagged log (real GDP):* a measure of initial real per capita GDP. According to the Solow growth model, ceteris paribus, low-income countries should grow at higher rates than high-income countries. Thus, a negative sign is expected for this convergence term.

- *Enrolment in primary school:* the number of students enrolled in primary school as a share of children of primary school age. Because a better-educated labour force is more productive, the sign of this coefficient is expected to be positive.

- *Investment to GDP:* includes total public plus private investment as a share of GDP. Higher investment leads to higher capital accumulation and higher growth. Thus, a positive sign is expected.

- *Government expenditures to GDP:* government consumption as a share of GDP. Since large public sectors are usually more inefficient and government expenditures crowd out private investments, higher ratios are associated with lower growth. Thus, a negative sign is expected.

- *Openness:* imports plus exports as a share of GDP. Because the allocation of resources and transfer of technologies is more efficient in more open economies, the sign of this coefficient is expected to be positive.

- *Rule of law:* the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, the police and the courts, as well as the likelihood of crime and violence (World Bank, 2006). This variable ranges between -2.5 and 2.5 and its value at the year 2000 is used. Higher values should lead to higher growth and, therefore, a positive sign is expected.

- *Inflation:* the rate of change of the consumer price index. Higher inflation can cause volatility and distortions of relative prices, which lead to market inefficiencies in the allocation of resources and reduces growth. Thus, a negative sign is expected.

- *Fertility:* logarithmic population growth rates. Because higher population growth reduces income per capita, a negative coefficient is expected.

- *Growth of terms of trade:* the growth rate of the price ratio of exportable goods to importable goods. Higher ratios lead to higher net exports and growth. Consequently, a positive sign is expected.

- *Cabinet changes:* the number of times in a year that at least 50 per cent of a nation's cabinet ministers change. It is a measure of political instability and continuity of economic policies. Since higher political instability and policy disruption negatively affect growth, a negative sign is expected.

- *Democracy:* an index ranging from strongly autocratic (-10) to strongly democratic (10). According to Barro (1996), democracy favours the maintenance of the rule of law, free markets, small government consumption and high human capital. But once these variables are controlled in the regression, the effects of democracy become less important. All things considered, democracy tends to stimulate growth, so a positive sign is expected for this coefficient.

Even though the econometric model includes all explanatory variables, the analysis focuses mainly on the five economic and institutional determinants of growth that lead to direct policy recommendations: investment, government expenditures, openness, primary school enrolment and rule of law. Bivariate correlations between these variables and growth using the data set give broad support to the theory outlined above (see figure 2-6).

The basic model can be represented by the following equation:

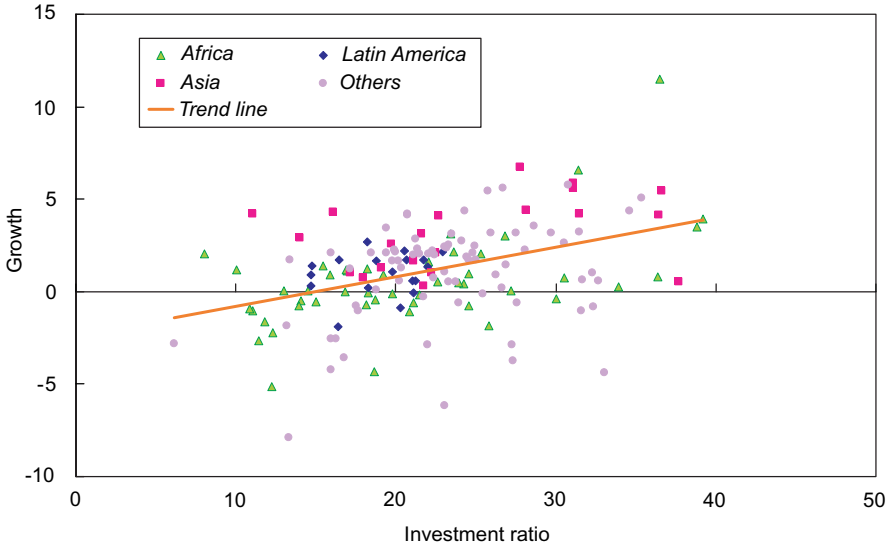
$$GDP\ growth_{it} = \alpha \log(GDP_{i,t-1}) + \mathbf{X}'_{i,t}\boldsymbol{\beta}_1 + v_i + \varepsilon_{it} \quad i = 1,...,N \quad t=1,...,T_i \quad (1)$$

where $\log(GDP_{i,t-1})$ is the lagged logarithmic GDP levels, $\mathbf{X}'_{i,t}$ is a vector of explanatory variables described above, v are country-specific effects, and ε is the error term.

Column (1) of table 3 shows estimates of equation (1) using random effects.[5] Column (2) shows estimates of the same equation using fixed effects for countries. In both equations most of the variables are statistically significant and have the expected signs. The exceptions are growth of terms of trade, fertility and democracy, which have the expected sign but are not statistically significant under

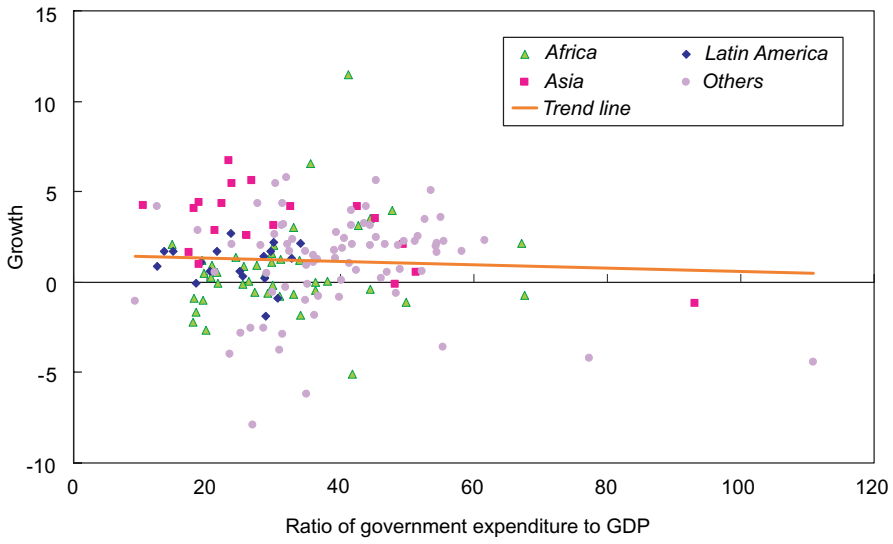
[5] The inclusion of rule of law, a time-invariant variable, in the regression makes necessary the use of random effects to avoid full multi-collinearity, which would occur if fixed effects were used.

Figure 2. Investment ratio and growth



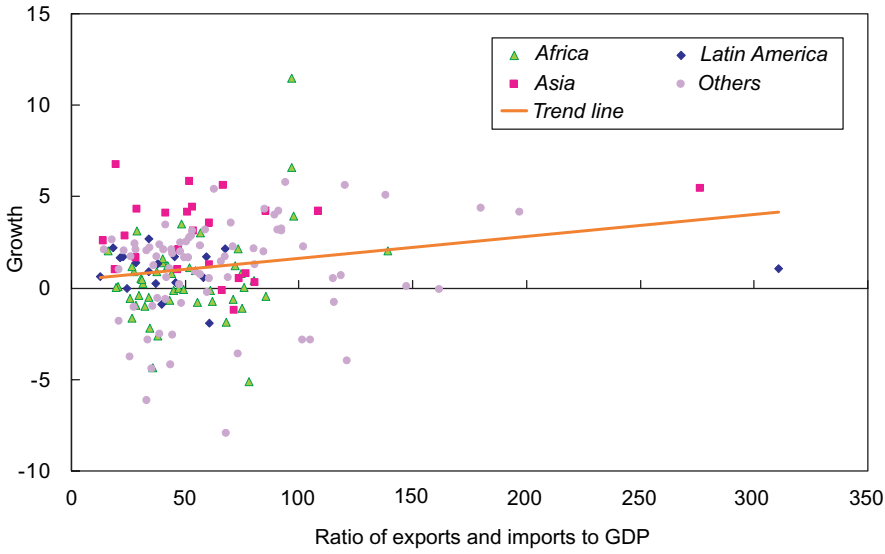
Source: Author's creation, based on data from World Bank (1996-2007, 2007c).

Figure 3. Government expenditures and growth



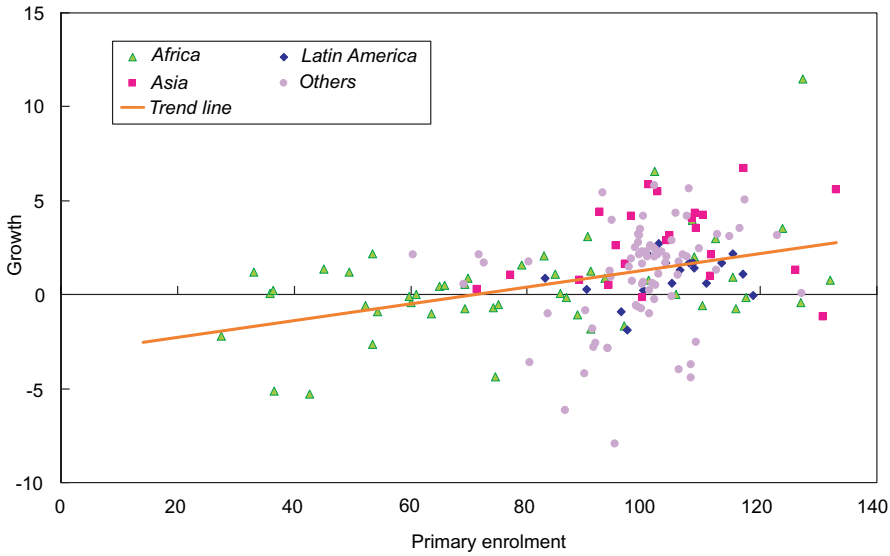
Source: Author's creation, based on data from World Bank (1996-2007, 2007c).

Figure 4. Openness and growth



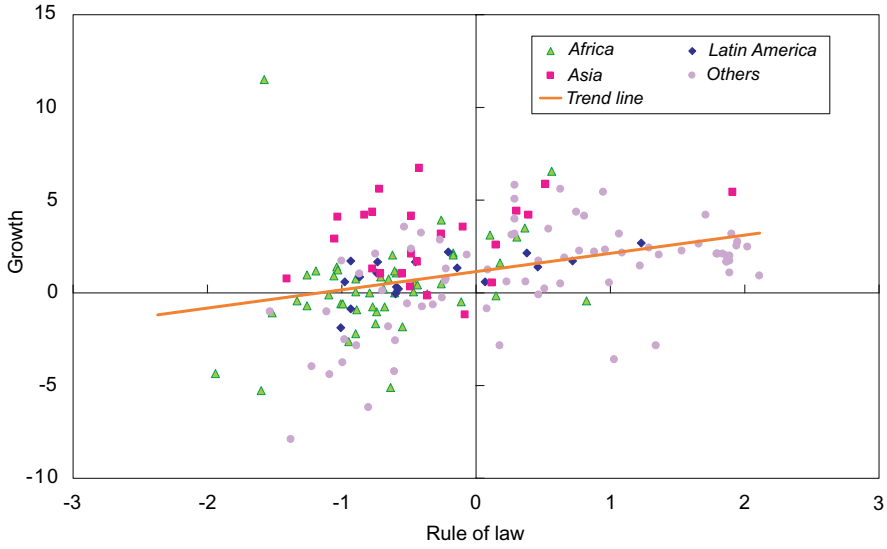
Source: Author's creation, based on data from World Bank (1996-2007, 2007c).

Figure 5. Primary enrolment and growth



Source: Author's creation, based on data from World Bank (1996-2007, 2007c).

Figure 6. Rule of law and growth



Source: Author's creation, based on data from World Bank (1996-2007, 2007c).

acceptable confidence levels. The model shown in column (2) has the advantage of controlling for the idiosyncratic effects of countries on growth and, therefore, is selected as the benchmark model. The estimation strategy proceeds by adding to the benchmark model group dummies (low-income Asia and emerging Asia) interacted with the main policy variables (investment, primary school enrolment, government expenditures, openness and rule of law). The addition of the interaction terms in equations (3) to (12) in table 3 allow for the comparative analysis in the next section.

III. COMPARATIVE ANALYSIS: LOW-INCOME VERSUS EMERGING ASIA

The analysis of the five selected policy variables focuses on the policy implications of the comparative results.[6] It is important to keep in mind that this comparative exercise is based on partial equilibrium, relying on the ceteris paribus

[6] Inflation is also a policy-related variable; results indicate that a 1 per cent increase in the inflation rate reduces growth by 0.02 percentage points. Since inflation in low-income Asia in the period 1970-2000 was, on average, 16 per cent and inflation in emerging Asia was, on average, 7.7 per cent, the inflation difference between the groups (8.3 per cent) would explain a difference of only 0.2 percentage points in growth.

Table 3. Cross-country growth regressions, 1970-2000

Dependent variable: real per capita gross domestic product growth	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
Lagged log (real per capital gross domestic product)	-1.07	-7.55	-7.77	-8.35	-7.60	-7.61	-7.55	-7.63	-7.84	-8.67	-0.88	-0.89
	(0.324) ***	(1.110) ***	(1.115) ***	(1.142) ***	(1.114) ***	(1.114) ***	(1.115) ***	(1.128) ***	(1.129) ***	(1.199) ***	(0.321) ***	(0.324) ***
Enrolment in primary school	0.03	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.03
	(0.010) ***	(0.017) ***	(0.017) ***	(0.017) ***	(0.017) **	(0.017) **	(0.017) **	(0.017) **	(0.017) ***	(0.017) ***	(0.011) ***	(0.011) **
Investment to gross domestic product	0.16	0.21	0.19	0.18	0.21	0.21	0.21	0.21	0.02	0.20	0.16	0.16
	(0.029) ***	(0.037) ***	(0.039) ***	(0.039) ***	(0.037) ***	(0.037) ***	(0.037) ***	(0.037) ***	(0.037) ***	(0.037) ***	(0.029) ***	(0.029) ***
Government expenditure to gross domestic product	-0.09	-0.19	-0.19	-0.18	-0.20	-0.20	-0.19	-0.19	-0.17	-0.17	-0.08	-0.09
	(0.021) ***	(0.032) ***	(0.032) ***	(0.033) ***	(0.032) ***	(0.032) ***	(0.033) ***	(0.033) ***	(0.034) ***	(0.034) ***	(0.020) ***	(0.020) ***
Openness	-0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	-0.01	-0.01
	(0.007) *	(0.012) ***	(0.012) ***	(0.012) ***	(0.012) ***	(0.012) ***	(0.013) ***	(0.013) ***	(0.012) ***	(0.012) ***	(0.007) *	(0.007)
Inflation	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	(0.004) ***	(0.004) ***	(0.004) ***	(0.004) ***	(0.004) ***	(0.004) ***	(0004) ***	(0.004) ***	(0.004) ***	(0.004) ***	(0.003) ***	(0.003) ***
Cabinet changes	-1.38	-1.23	-1.20	-1.18	-1.23	-1.23	-1.23	-1.24	-1.23	-1.23	-1.37	-1.37
	(0.254) ***	(0.258) ***	(0.258) ***	(0.257) ***	(0.258) ***	(0.258) ***	(0.259) ***	(0.258) ***	(0.257) ***	(0.257) ***	(0.254) ***	(0.254) ***
Democracy	0.02	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.02
	(0.036)	(0.046)	(0.046)	(0.046)	(0.047)	(0.047)	(0.047)	(0.046)	(0.047)	(0.047)	(0.035)	(0.035)
Terms of trade growth	0.19	0.65	0.71	0.75	0.64	0.64	0.65	0.62	0.59	0.59	0.19	0.19
	(1.082)	(1.142)	(1.141)	(1.138)	(1.143)	(1.143)	(1.146)	(1.145)	(1.139)	(1.139)	(1.085)	(1.084)
Fertility	0.17	-0.65	-0.44	-0.35	-0.68	-0.68	-0.65	-0.64	-1.03	-1.03	0.23	0.24
	(0.367)	(0.647)	(0.654)	(0.652)	(0.650)	(0.650)	(0.649)	(0.649)	(0.672)	(0.665)	(0.359)	(0.362)
Rule of law	2.73										2.60	2.66
	(0.523) ***										(0.513) ***	(0.517) ***
Investment to gross domestic product: Low-income Asia			-0.07	-0.04								
			(0.193)	(0.193)								
Emerging Asia, excluding China and India		0.24										
		(0.122) **										
Emerging Asia			0.33									
			(0.116) ***									
Rule of law: Low-income Asia											-2.96	-3.00
											(2.463)	(2.493)

Table 3. *(continued)*

Dependent variable: real per capita gross domestic product growth	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
Emerging Asia, excluding China and India												-0.69
												(1.204)
Emerging Asia											-0.27	
											(1.211)	
Government expenditure to gross domestic product:									-0.16	-0.18		
Low-income Asia									(0.253)	(0.252)		
Emerging Asia, excluding China and India										-0.33		
										(0.140) **		
Emerging Asia									-0.20			
									(0.163)			
Openness: Low-income Asia							0.00	0.00				
							(0.074)	(0.074)				
Emerging Asia, excluding China and India								0.02				
								(0.033)				
Emerging Asia							0.00					
							(0.033)					
Enrolment in primary school: Low-income Asia					0.04	0.04						
					(0.063)	(0.063)						
Emerging Asia						-0.01						
						(0.106)						
Emerging Asia, excluding China and India					0.00							
					(0.113)							
Observations	801	801	801	801	801	801	801	801	801	801	801	801
R-squared		0.17	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.18		
Number of countries	84	84	84	84	84	84	84	84	84	84	84	84

Source: Author's calculation based on data from World Bank (1996-2007; 2007c).

Notes: Regressions include a constant and dummies for decades. Estimates are obtained from a panel data set of 84 developing countries in the period 1970-2000 with fixed effects, with the exception of regressions in columns (1), (11) and (12), estimated using random effects. Robust standard errors are in parentheses.

*$p < .10$, **$p < .05$, ***$p < .01$.

assumption. When interpreting marginal effects extracted from a regression, it is assumed that all other variables remain unchanged—a useful simplification, but far from realistic. Nevertheless, the analysis is still instructive to help determine what variables have the largest quantitative effect on growth.

Investment

Estimates of the marginal effects of investment on growth for low-income Asia and emerging Asia are taken from column (1) in table 4. The impact of investment on growth in emerging Asia (0.51) is 2.7 times larger than that found in low-income Asia (0.19), which is the same as in the rest of the developing countries in the region. Even excluding China and India from emerging Asia does not significantly reduce this difference. This striking result means that investment is more efficient at raising GDP growth in emerging Asia than in low-income Asia. There may be many reasons for this. One hypothesis is that Government investments are simply more productive in emerging Asia than in low-income Asia, especially if problems of governance are more widespread in the latter.[7] Another possibility is lower marginal productivity of capital in low-income Asia, a paradox given the lower stock of capital present in low-income countries.

Table 4. Marginal effects of investment on growth

	Investment [a]	*Government expenditure*[b]	*Openness*[c]	*Primary school enrolment*[d]	*Rule of law*[e]
	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Low-income Asia	0.19	-0.18	0.04	0.04	2.60
Emerging Asia	0.51	-0.51	0.04	0.04	2.60
Emerging Asia, excluding China and India	0.43	-0.18	0.04	0.04	2.66
Rest of developing countries	0.19	-0.17	0.04	0.04	2.60

Source: Estimates of marginal effects are taken from the growth regressions in table 3.

[a] Table 3, columns (3) and (4).

[b] Table 3, columns (9) and (10).

[c] Table 3, columns (7) and (8).

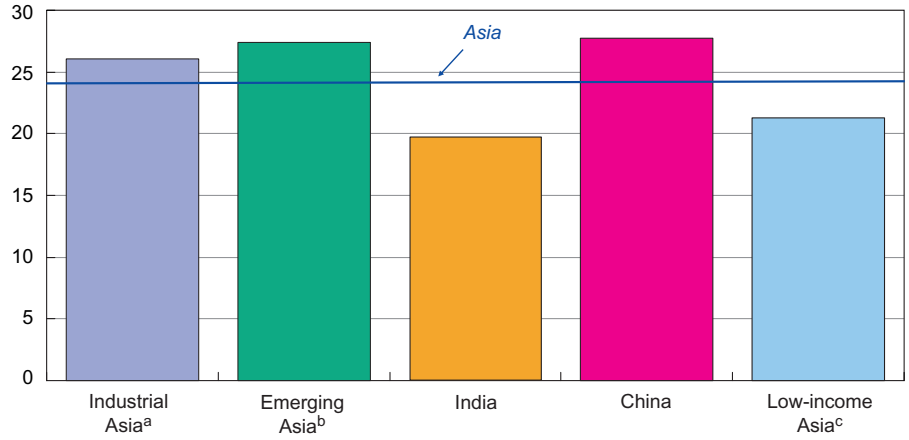
[d] Table 3, columns (5) and (6).

[e] Table 3, columns (11) and (12).

[7] While the regressions are controlled for the rule of law, there might be additional aspects of governance which are not necessarily captured by this variable.

Not surprisingly—perhaps even a direct consequence of the higher efficiency of investment in emerging Asia—the difference in investment levels between these sub regions is also large (see figure 7). Average investment in emerging Asia (27.5) is 6.2 percentage points of GDP higher than that in low-income Asia (21.3). If investment in low-income Asia grew to the levels found in emerging Asia, GDP growth would increase by 1.2 (0.19 x 6.2) percentage points per year.

Figure 7. Average of investment ratio in 1970-2000
(Percentage of gross domestic product)



[a] Industrial Asia consists of Australia, Japan and New Zealand.

[b] Emerging Asia consists of Indonesia, Malaysia, Philippines, Republic of Korea, Singapore and Thailand.

[c] Low-income Asia consists of Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, Sri Lanka and Viet Nam.

These results lead to an important policy implication: namely, that countries in low-income Asia not only should increase investment to raise growth but, more importantly, they need to implement policies that raise the impact of investment on growth through increases in the marginal productivity of capital. Raising the productivity of the labour force by facilitating human capital accumulation through education and training, and eliminating barriers for the free transfer of foreign technologies are good examples of such policies. Improving the business climate by reducing the costs of doing business (which, as shown in table 5, are significantly larger in low-income Asia as compared to those in emerging Asia) is also essential in order to increase investment and raise the marginal productivity of capital. Lastly, deepening the financial sector can improve financial intermediation and capital

Table 5. Doing business rankings, 2006

Country	Ease of doing business	Starting a business	Dealing with licenses	Employing workers	Registering property	Getting credit	Protecting investors	Paying taxes	Trading across borders	Enforcing contracts	Closing a business
Low-income Asia (group average)	108.3	78.0	94.8	99.9	82.1	113.0	84.0	76.6	128.9	103.0	116.4
Bangladesh	88	68	67	75	167	48	15	72	134	174	93
Bhutan	138	79	145	116	41	159	118	68	150	56	151
Cambodia	143	159	159	124	100	174	60	16	114	118	151
Lao People's Democratic Republic	159	73	130	71	148	173	170	36	161	146	151
Mongolia	45	55	34	61	17	65	19	56	162	41	115
Myanmar	..	..	..	..	..	..	..	..	..	..	..
Nepal	100	49	127	150	25	101	60	88	136	105	95
Sri Lanka	89	44	71	98	125	101	60	157	99	90	59
Viet Nam	104	97	25	104	34	83	170	120	75	94	116
Emerging Asia (group average)	69.4	88.9	91.0	80.6	64.0	51.8	53.3	90.9	60.1	75.6	74.1
China	93	128	153	78	21	101	83	168	38	63	75
India	134	88	155	112	110	65	33	158	139	173	133
Indonesia	135	161	131	140	120	83	60	133	60	145	136
Malaysia	25	71	137	38	66	3	4	49	46	81	51
Philippines	126	108	113	118	98	101	151	106	63	59	147
Republic of Korea	23	116	28	110	67	21	60	48	28	17	11
Singapore	1	11	8	3	12	7	2	8	4	23	2
Thailand	18	28	3	46	18	33	33	57	103	44	38
Emerging Asia, excluding China and India	54.7	82.5	70.0	75.8	63.5	41.3	51.7	66.8	50.7	61.5	64.2

Source: World Bank, (2007b).

Note: Lower index values indicates lower costs of doing business.

allocation so that the investment projects with the highest returns can be funded. Given the relatively low credit to GDP ratios in low-income Asia, there is significant scope for financial deepening (table 6).

Table 6. Ratio of private credit by deposit money banks and other financial institutions
(Percentage of gross domestic product)

	Credit ratio
Low-income Asia (group average)	22.4
Bangladesh	27.4
Bhutan	17.1
Cambodia	8.1
Lao People's Democratic Republic	5.9
Mongolia	29.5
Myanmar	6.5
Nepal	27.7
Sri Lanka	28.5
Viet Nam	51.1
Emerging Asia (group average)	78.9
China	..
India	32.8
Indonesia	21.0
Malaysia	121.6
Philippines	33.5
Republic of Korea	125.4
Singapore	122.7
Thailand	95.2
Emerging Asia, excluding China and India	86.6

Source: IMF (2004).

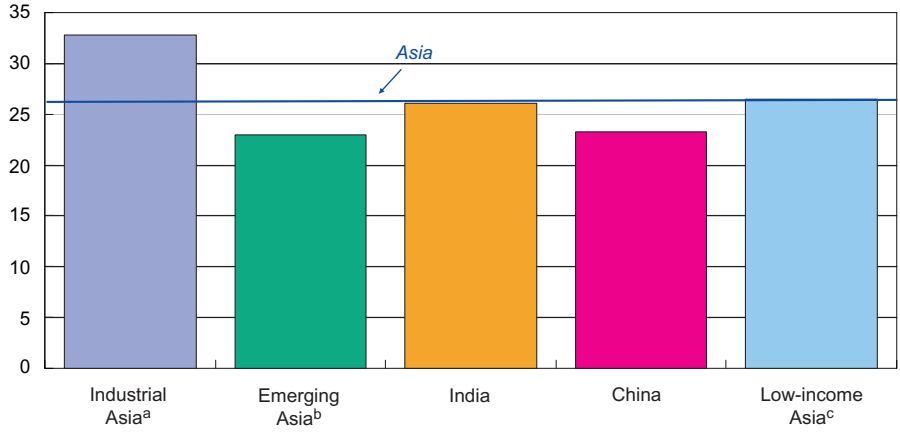
Note: Ratios at 2004, with the exception of Nepal (2000) and Myanmar (2003).

Government expenditures

Estimates of the marginal effects of government expenditures on growth are taken from column (2) in table 4. The negative impact of government expenditures on growth is much larger in emerging Asia than in low-income Asia (-0.51 compared to -0.18). The reasons why government expenditures are more disruptive to growth in emerging Asia than they are in low-income Asia are not clear, but this difference may help explain why emerging Asia has a lower ratio of government expenditures to GDP than low-income Asia (23 per cent compared

to 26.4 per cent, see figure 8).[8] If government expenditures in low-income Asia were reduced to the levels prevalent in emerging Asia, growth in low-income Asia would increase by 0.6 percentage points per year [(-0.18) x (-3.4)]. Thus, to raise growth, low-income countries in Asia should reduce government consumption as a percentage of GDP.

Figure 8. Average government consumption in 1970-2000
(Percentage of gross domestic product)



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Openness

Estimates of the marginal effects of openness on growth are taken from column (3) in table 4. The positive impact of openness on growth is equal to 0.04. An increase in openness of 1 percentage point increases growth by 0.04 percentage points per year, in both low-income and emerging Asia.

[8] One possible explanation for the differing effects of government expenditures on growth is that there is more scope for crowding-out effects in emerging Asia, since the investment to GDP ratio is higher. The sensitivity of investment to interest rates may be higher in emerging Asia since capital markets are more developed and firms are more accustomed to raising money for domestic investments. In low-income Asia, on the other hand, investments rely more on aid and remittances.

This would be a small effect if it were not for the difference in openness levels existent in both sub regions. While plus exports imports as a share of GDP is on average, 76.4 per cent, in emerging Asia, the level is only 43.5 per cent in low-income Asia (see figure 9). If the level of openness in low-income Asia reached that of emerging Asia, growth would be 1.3 percentage points higher per year (0.04 x 32.9). Therefore, low-income countries in Asia could benefit substantially from further opening of their economies to trade flows. This could be achieved by stimulating exports through the elimination of export taxes and improving infrastructure to reduce transportation costs. Reducing tariffs, which are higher in low-income Asia than in emerging Asia, should stimulate higher imports (table 7).

Primary school enrolment

Estimates of the marginal effects of primary school enrolment on growth are taken from column (4) in table 4. The positive impact of primary school enrolment is equal to 0.04 per cent for both low-income Asia and emerging Asia. The difference in primary school enrolment between both groups, however, is not

Figure 9. Average of openness in 1970-2000
(Percentage of gross domestic product)

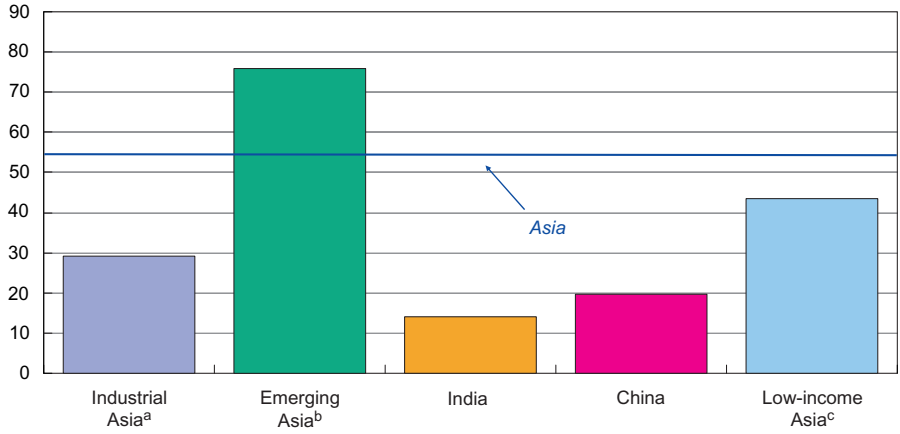

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Table 7. Average tariff rate

Country	*Year*	*Tariff rate*
Low-income Asia (group average)	..	12.9
Bangladesh	2006	16.0
Bhutan	2005	23.0
Cambodia	2003	16.9
Lao People's Democratic Republic	2005	9.5
Mongolia	2005	4.3
Myanmar	2005	5.3
Nepal	2005	13.9
Sri Lanka	2006	10.8
Viet Nam	2005	16.7
Emerging Asia (group average)	..	9.0
China	2005	9.8
India	2005	17.8
Indonesia	2005	7.0
Malaysia	2005	7.4
Philippines	2005	6.3
Republic of Korea	2004	11.7
Singapore	2005	0.0
Thailand	2005	12.0
Emerging Asia, excluding China and India	..	7.4

Source: World Bank (2007d).

significant: 103.2 in emerging Asia compared to 100 in low-income Asia (see figure 10). Low-income countries in Asia that adopted the higher levels of primary schooling prevalent in emerging Asia would gain 0.13 percentage points of additional growth. While this gain is statistically significant and increasing primary schooling levels is always a social priority, the analysis suggests that focusing on other areas could have a higher return in terms of additional growth. In particular, other policies that facilitate human capital accumulation, such as spending on research and development, could yield higher returns than those that increase primary school enrolment.[9]

[9] It is important to note that the variable primary school enrolment does not measure the quality of schooling. If the quality of education in low-income Asia is poor, then improving the quality of primary schools could be effective in raising growth.

Figure 10. Average of primary enrolment in 1970-2000

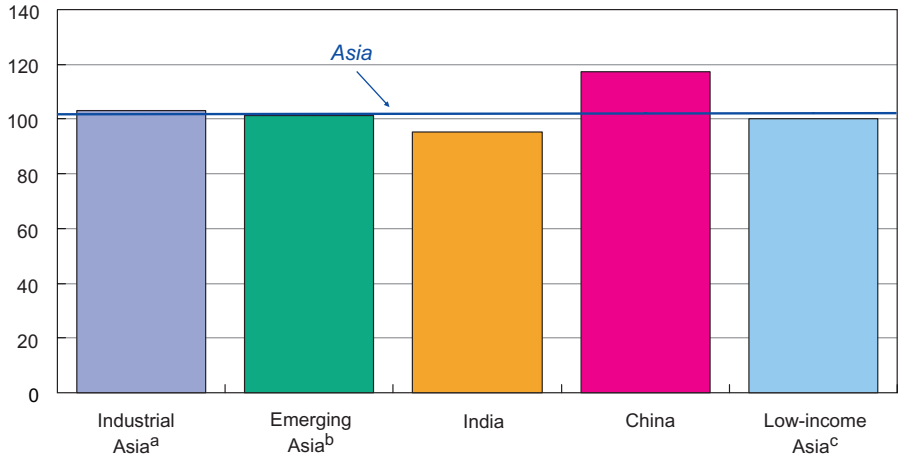

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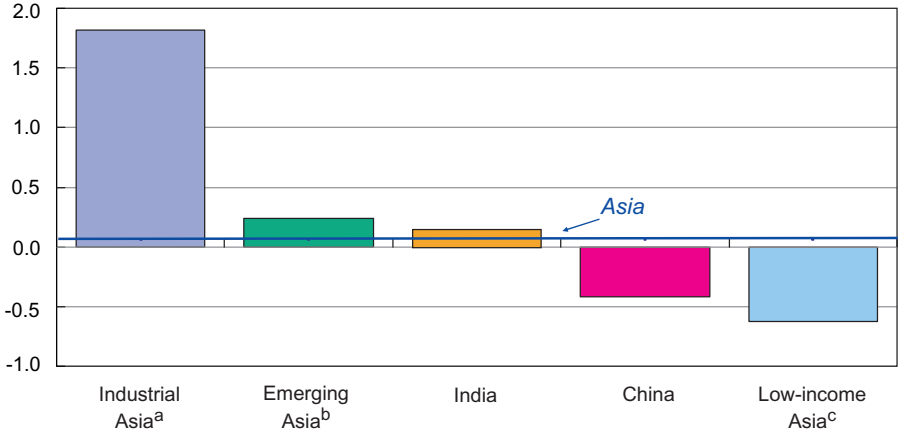
Figure 11. Average of rule of law in 1970-2000



[a] Industrial Asia consists of Australia, Japan and New Zealand.

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Rule of law

Estimates of the marginal effects of rule of law on growth are taken from column (5) in table 4. The positive impact for an additional point in the rule of law index (ranging from –2.5 to 2.5) increases growth by 2.6 percentage points per year in low-income Asia. The impact in emerging Asia is of similar magnitude (2.6); however, the level of the index is significantly higher than that in low-income Asia by a margin of 0.8 (0.24 compared to -0.63). If low-income Asia had the same level of rule of law as emerging Asia, growth would be 2.1 percentage points higher per year. Thus, reforming the judicial system to improve contract enforcement, the police and courts could reduce the likelihood of crime and violence. This more stable environment, in turn, would be more conducive to higher growth.

IV. POLICY RECOMMENDATIONS AND FINAL REMARKS

This paper has focused an analysis of the determinants of growth in low-income countries in Asia. Using a data set of 146 developing countries for the period 1970-2000, standard growth regressions indicate that higher levels of investment, openness, primary school enrolment and rule of law increase GDP growth, while higher levels of government expenditures reduce growth. The analysis included an exercise using emerging Asia as a comparator group to low-income Asia. The exercise serves to identify the policies that low-income Asia could implement that seem to have been effective in emerging Asia—a group of developing countries with stronger growth performance than that of low-income Asia. In the analysis, investment, openness and rule of law are shown to be the variables with the highest impact on growth. Therefore, economic policies in low-income countries in Asia should prioritize areas that favour higher levels of these variables. As regards to investment, policymakers in low-income Asia should pursue economic policies that increase the marginal productivity of capital. Removing barriers to the free flow of technology, raising human capital through education and training of the labour force, improving the business climate and deepening the financial sector are examples of such policies. As for openness, policymakers in low-income Asia should pursue more decisively the removal of barriers to trade as a means to achieve more efficient allocation of resources conducive to higher growth. Finally, low-income countries could benefit significantly from an improvement of the judicial system, which could strengthen contract enforcement, police and the functioning of the courts. These, in turn, could decrease the likelihood of crimes and violence, reducing uncertainty and contributing to higher growth. The growth performance of emerging Asia in the past three decades offers a good example of the opportunities that lie ahead for low-income countries in Asia. Looking forward, policymakers should engage in reforms in the above areas to improve the well-being of their citizens through higher economic growth.

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EFFICIENCY, TECHNOLOGICAL PROGRESS AND REGIONAL COMPARATIVE ADVANTAGE: A STUDY OF THE ORGANIZED MANUFACTURING SECTOR IN INDIA

Dipa Mukherjee and *Rajarshi Majumder**

Technological upgrading and increases in capital intensity have been championed in the organized manufacturing sector in India on the grounds that such measures improve productivity, efficiency and competitiveness. In a developing economy, these are costly propositions. Also, the effect of technological changes on productivity and efficiency levels must be estimated before implementing such policies. This paper seeks to estimate trends in factor productivity, technological progress and technological efficiency in the manufacturing sector in India and examines the relative importance of each component. It is observed that technical efficiency was moderate in the period studied, showing declines in the 1990s. Substantial disparity exists among regions and product groups regarding efficiency, technological progress and efficiency changes. It is found that increasing capital intensity was associated with falling productivity, efficiency and technological deceleration in the 1990s. Wider diffusion of technology, rather than greater capital use, is thus recommended for increasing productivity. A regional efficiency matrix is also provided to help states focus on the specific areas in which they have comparative advantages.

I. INTRODUCTION

India has met the challenges of globalization head on and now has one of the world's fastest growing economies. A major contributor to such a strong performance has been the high growth of the country's manufacturing sector. However, this performance can be sustained in the long run only if the sector runs

* Dipa Mukherjee, Senior Lecturer, Department of Economics, Narasinha Dutt College, Howrah, West Bengal. Rajarshi Majumder, Reader and Head, Department of Economics, University of Burdwan, West Bengal.

efficiently and is able to compete globally. This requires that the sector come out of the protective shell it has been enjoying for better part of the post-independence period in India.

The grounds for such a transition were laid in the late 1980s, when it was felt that the policies of State control over the economy, especially in the manufacturing sector, were losing their effectiveness. The Structural Adjustment Programme (SAP) initiated in the early 1990s attempted to streamline the economy by doing away with red-tapism and State control and bringing in competition. Global players were ushered-albeit slowly-into almost every economic sphere, particularly the industrial sector. It was argued that competition would breed efficiency and provide incentives to expand output; furthermore, the resulting high gross domestic product (GDP) growth would naturally use the country's abundant factor labour more intensively, leading to substantial job growth.

In this context it seems important to analyze the movements in the manufacturing sector. It has been a hotbed of reform, including a major shift from the controlling regulation-nationalization-protection regime to a liberalization-privatization-globalization environment. Given the central position of this sector, such trends will likely appear in other sectors, causing a ripple effect in the economy as a whole. Thus, to understand the productivity, efficiency and comparative advantage of the Indian economy in the long run, it is crucial to understand what has been happening in the manufacturing sector.

As efficiency and competitiveness are the buzzwords of the new regime, economists have called for technological upgrading of the Indian manufacturing sector (Ferrantino, 1992; Mamgain and Awasthi, 2001; Kathuria, 2002; India, 2006). However, almost all their proposals focus on increasing capital use or importing advanced technology, which may turn out to be costly for a capital-scarce developing economy, in terms of the lack of adequate resources and the impact such upgrades may have on the job market. Moreover, desired changes in the production process may also be brought about by better mastering or diffusion of the existing technologies. From this standpoint, it is important to focus on the aspects of total factor productivity growth (TFPG) and technical efficiency changes (TEC).

A few studies have attempted to estimate productivity trends, efficiency levels and technological progress in this sector (Joshi and Little, 1996; Agarwal, 2001; Forbes, 2001; Kathuria, 2002; Mitra, Varoudakis and Veganzones-Varoudakis, 2002; Rajan and Sen, 2002; Ray, 2002; Driffield and Kambhampati, 2003; Kambhampati, 2003). Those that deal with efficiency levels tend to do so in either

of two ways. Some consider the manufacturing sector in its totality, disregarding the fact that different industry groups have different production functions. Such papers do not provide industry-level estimates, which are crucial. Other works consider only a single period or point in time, and consequently do not attempt to determine trends in efficiency levels, and are especially silent on efficiency levels of the post-SAP period.

In addition, it is recognized that in a large country like India, production efficiency for different commodities varies by region. A schema of comparative advantage could be created to enable states to concentrate on developing and encouraging the industries in which they have comparatively greater efficiency.

To address the considerations, in the present analysis the authors will:

1. Calculate TFPG in the organized manufacturing sector in India before and after the SAP, by major industry group and by state;

2. Determine the productive efficiency of the sector;

3. Disassociate the effects of pure technological progress (TP) from those of TEC, diffusion and learning by doing;

4. Examine the relative importance of TP, TEC and TFPG in the sector;

5. Explore factors that may have caused inter-industry differences in levels of efficiency and changes in efficiency over time;

6. Explore factors that may have caused regional disparity in productivity and efficiency levels; and, finally

7. Build a state-level comparative advantage matrix to enable states to focus on the development of specific industries.

The paper has eight sections. In the next section we discuss the methodological background of the study. In the third to fifth sections the results obtained are analysed and interpreted. The sixth section explores factors affecting TEC and TP, while the seventh section builds a regional comparative advantage matrix. The final section summarizes the main findings and provides policy suggestions.

II. TECHNOLOGICAL PROGRESS AND TECHNOLOGICAL DIFFUSION: METHODOLOGICAL ISSUES

Theoretical background

Improvements in labour productivity gained through increases in capital stock have often been termed cosmetic, because capital-deepening shifts in techniques of production necessarily lead to a rise in labour productivity and a fall in capital productivity. Therefore, changes in productivity levels should be measured by changes in either total factor productivity or TFPG. According to the growth accounting approach as formulated by Solow (1957), output growth can be decomposed into two components: growth due to changes in inputs, and growth due to other factors.[1] The latter component is referred to as TFPG and is generally taken as a measure of TP—more specifically, as the contribution of TP towards productivity rise. Positive TFPG implies that the production frontier has expanded outward and that an increase in inputs has led to a more than proportionate rise in output. By decomposing output growth into TFPG growth accounted for by changes in inputs, researchers have been able to compare the relative importance of the two components (Felipe, 1997; Krishna and Mitra, 1999; Kim, 2000; Unel, 2003; among others). Where TFPG has been found to be substantial and positive, researchers have concluded that TP led to productivity rise. Consequently, technological upgrading has been suggested as the main policy instrument for productivity improvement (Mukherjee, 2004; Mukherjee and Mathur, 2002).

However, one must remember that TFPG in the growth accounting approach is a residual measure and encompasses not only the effects of TP, but also those of better utilization of capacities, learning by doing, improved labour efficiency, etc. In other words, TFPG is a combination of improved technology and the skill with which known technology is applied by the units (technological efficiency).

[1] The growth accounting approach involves the assumptions of constant returns to scale, competitive markets and the payment of factors of production according to their marginal products. These assumptions can be questioned, especially in the context of developing countries. However, we have used the translog index of total factor productivity in this paper. This is a discrete approximation to the Divisia index of technical change. The advantage is that the translog index does not make the kind of rigid assumptions found in the Solow index regarding the elasticity of substitution between factors of production, thus allowing for variable elasticity of substitution, and dispensing with the requirement that technological progress be Hicks neutral. The growth accounting approach can also be criticized in light of endogenous growth theories (Grossman and Helpman, 1991; Romer, 1992; Barro and Sala-i-Martin, 1991), which emphasize the importance of knowledge spillover for growth. However, endogenous growth models have been empirically questioned by Jones (1995), and theoretical support from recent models show that policies affect levels and not growth rates of income. We therefore follow the growth accounting approach here.

The factor of technological efficiency, which leads to growth in output through greater experience and skill of workers, better organization by entrepreneurs, better utilization of existing resources, etc., is quite significant in a capital-scarce developing economy. In such countries, diffusion of technology is more important than the modernity of the technology itself. It is therefore important to try to distinguish the effects of pure TP and those of TEC.

In technical terms, TP may be measured by the outward shift of the production frontier. Realistically, this frontier will be achieved by only a few units; most will operate within the envelope. Output growth may occur in response to a conbination of any of the three factors indentified above: (a) a rise in input or resource use (a lateral movement on the two-dimensional input-output plane); (b) improvement in technology (an upward shift of the production frontier); and (c) improvement in technological efficiency (a movement from a sub-frontier position towards the frontier). Following the approach of Kalirajan, Obwona and Zhao (1996), this decomposition of total output growth into input growth (INPG), TP and TEC can be seen in figure 1, where the production frontiers are F_1 and F_2. For a firm on the frontier, output would be Y_{11}^* in period 1 and Y_{22}^* in period 2. But, as noted, most firms will operate within the envelope. Figure 1 illustrates a case in which the realized output of a representative firm is Y_1 in period 1 and Y_2 in period 2. The vertical distance between the frontier output and the realized output of the firm, that is, TE1 [= $(Y_{11}^* - Y_1)$] in period 1, and TE2 [= $(Y_{22}^* - Y_2)$] in period 2, are measures indicating technical efficiency. The difference between TE1 and TE2 is the TEC over time. The distance between F_1 and F_2—expressed as $(Y_{22}^* - Y_{21}^*)$ using period 2 input levels, and $(Y_{12}^* - Y_{11}^*)$ using period 1 input levels—is a measure of TP. The contribution of INPG to output growth between periods 1 and 2 would be $(Y_{22}^* - Y_{12}^*)$ using the F_2 frontier, or $(Y_{21}^* - Y_{11}^*)$ using the F_1 frontier.

The output growth from A to D can therefore be decomposed into AB + BC + CD.

$$\text{Output growth} = Y_2 - Y_1 = CD + BC + AB$$

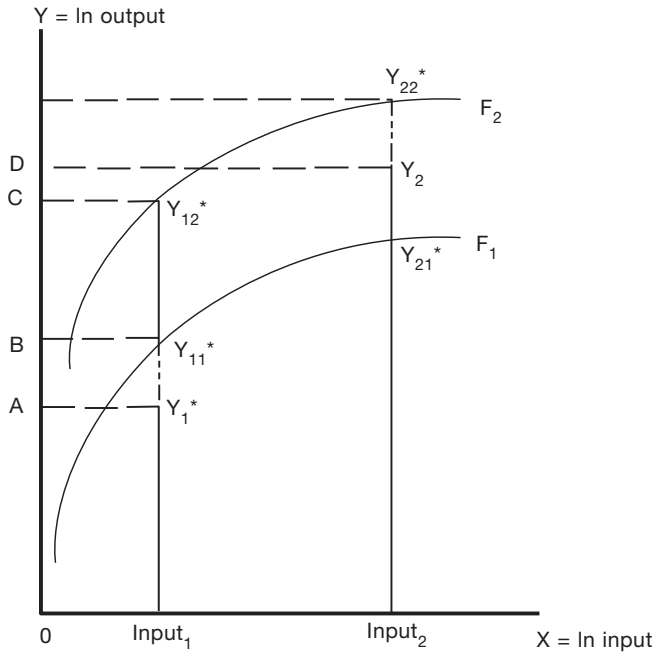
$$= (Y_2 - Y_{12}^*) + (Y_{12}^* - Y_{11}^*) + (Y_{11}^* - Y_1)$$

$$= [(Y_{11}^* - Y_1) - (Y_{22}^* - Y_2)] + (Y_{12}^* - Y_{11}^*) + (Y_{22}^* - Y_{12}^*)$$

$$= [TE1 - TE2] + TP + INPG$$

$$= (TEC + TP) + INPG = TFPG + INPG$$

Figure 1. Decomposition of output growth into technological progress, technical efficiency change, input growth



Source: Derived from Kalirajan, Obwona and Zhao (1996).

Figure 1 breaks down observed output growth into lateral movements on or beneath the production frontier (INPG), movement towards the production frontier (TEC) and shifts in the production frontier itself (TP).

Using a stochastic frontier production function in its translog form, one can obtain estimates of efficiency for each firm in the initial and final periods and thereby calculate TEC.[2] Figures on TFPG can be obtained using Solow's growth

[2] For theoretical details on frontier production functions, see Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). These original specifications have been altered and extended in a number of ways. For comprehensive reviews of this literature see Forsund, Lovell and Schmidt (1980), Schmidt (1986), Bauer (1990) and Greene (1993). Battese and Coelli (1992) propose a stochastic frontier production function for (unbalanced) panel data, which has firm-specific inefficiency effects that are assumed to be distributed as truncated normal random variables (as inefficiency can be zero when the firm is on the frontier). The inefficiency effects are also permitted to vary over time. This model has been supplemented by the Frontier Version 4.1 computer programme, used to empirically measure the efficiency of firms over a number of periods. This programme has been used here.

accounting approach using a translog formulation.[3] The contribution of INPG and TP can thereafter be obtained as output growth – TFPG and TFPG – TEC, respectively. One can then study the relative importance of the roles played by each of the three players—inputs, technology and diffusion—in achieving output growth.

In the present paper, we follow the above methodology to study the roles of these three factors in the organized manufacturing sector in India. We consider a translog production function that is operative with value Added being dependent on number of workers, number of administrative employees, and fixed capital (fixed assets). The value terms are at constant 1981-1982 prices.

Data and operational methodology

The study covers the period 1980-2000. It draws directly and indirectly from the organized manufacturing sector data collected in various years through the Annual Survey of Industries conducted by the Central Statistical Organization (CSO) of India. Data for the periods 1998-1999 to 2000-2001 were taken directly from the CSO website. Data for the earlier periods were taken from the Economic and Political Weekly Research Foundation (EPWRF), which has compiled a comparable series of databases using the CSO publications for the periods 1973-1974 to 1997-1998. To make the more recent data comparable with that of the earlier databases, we have applied the concordance table (also available on the CSO website) that was created to facilitate comparisons between the National Industrial Classifications of 1987 and 1998. This required that some of the industrial activity groups be clubbed together, resulting in 14 separate industry groups for the study.[4] Thus, we have continuous panel data for 14 industry groups and 24 states for the 1980-2000 period, in addition to all-India and all-industry data, providing us with 375 observations [(24 states + all-India) X (14 sectors + all-industry)] for each year during the period 1980-2000. We consider these 375 observations as individual firms (e.g. the leather product industry in West Bengal as one firm, the textile industry of Gujarat as another, and so on). We also analyse

[3] In this formulation TFPG can be obtained from $\Delta \ln TFP = \Delta \ln Y_t - \varpi.\Delta \ln L_t - (1 - \varpi).\Delta \ln K_t$, where $\Delta \ln Y_t = \ln Y_t - \ln Y_{t-1}$, $\Delta \ln L_t = \ln L_t - \ln L_{t-1}$, $\Delta \ln K_t = \ln K_t - \ln K_{t-1}$, ϖ = average of share of labour in output in periods t and (t-1).

[4] The industry groups after clubbing are: food and beverages; textiles; textile products; wood products; paper products; leather products; basic chemicals; rubber and plastic; non-metallic minerals; basic metals; metal products; electrical, electronic and non-electrical equipment; transport equipment; and manufacture not elsewhere classified. The textiles sector, in accordance with the National Industrial Classification 1998, includes cotton textiles, natural fibre products and wool and silk textiles.

regional and sectoral dynamics by combining industries into broad groups and by grouping states into regions.[5]

A significant contribution of this study is that, unlike some previous studies (such as Mukherjee and Ray (2004)), we estimate the efficiencies, TFPG and related parameters separately for each of the industries, as it is natural that different industries will have different production functions. Moreover, we try to analyse not only the efficiency levels themselves, but also changes in them over time, especially in the post-SAP period, as well as some factors that may help explain regional variation in efficiency levels. In addition, to facilitate decentralized planning, we have also built a regional comparative advantage matrix to provide state-level focus areas. Let us now explore the results in detail.

III. FACTOR PRODUCTIVITY

One of the major successes of the Indian economy in the post-SAP period (the 1990s) has been the substantial growth of the organized manufacturing sector, which clocked a 6.5 per cent per annum growth rate in value added between 1990 and 2000, compared to 4 per cent during the previous decade (table 1). Historically, a substantial part of growth in value added in developing economies has been due to rapid increase in input use and little is attributed to improvements in factor productivity. In fact, the average contribution of inputs to output growth in developing nations has been estimated to be close to 70 per cent (Chenery, Robinson and Syrquin, 1986). The performance of India especially that of the organized manufacturing sector, has been much worse in regards to TFPG. Between the periods 1959-1960 and 1985-1986, the TFPG rate was –0.4 per cent per annum (Ahluwalia, 1991). This situation had improved by the later decades, and the TFPG rates for the period 1979-1990 are estimated to have been 1.8 per cent per annum (Unel, 2003). However, the post-SAP period of high growth witnessed a substantial drop in factor productivity, with a TFPG of -1.5 per cent per annum. The growth in output is therefore mainly due to input growth. Among the industries, this drop in factor productivity was highest in the non-durable sectors; among the regions, factor productivity dropped most in the southern and eastern states.

[5] The product groups are as follows: non-durables: food and beverages, and textiles; durables: textile products, wood products, paper products, and leather products; intermediates: basic chemicals, rubber and plastic, non-metallic minerals, basic metals, and metal products; machinery and equipment: electrical, electronic and non-electrical equipment, and transport equipment; and manufacture not elsewhere classified. The 16 major states are regionalized in the following manner: north: Punjab, Haryana, Himachal Pradesh and Delhi; east: Bihar, West Bengal and Orissa; west: Rajasthan, Gujarat and Maharashtra; south: Andhra Pradesh, Karnataka, Kerala and Tamil Nadu; and central: Uttar Pradesh and Madhya Pradesh.

Table 1. Average annual rates of growth in value added, inputs and total factor productivity
(Percentage)

	Value added growth		*Input growth*		*Total factor productivity growth*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*	*1980-1990*	*1990-2000*
Region						
Central	5.7	6.3	4.3	6.6	1.4	-0.4
East	1.2	1.3	-1.4	2.3	2.6	-1.0
North	5.9	7.3	3.5	8.9	2.4	-1.7
North-east	10.9	-1.8	4.8	7.9	6.1	-9.7
South	4.9	7.3	3.3	9.3	1.6	-2.0
West	3.3	7.8	3.2	9.7	0.1	-1.9
All India	**4.0**	**6.5**	**2.4**	**8.0**	**1.6**	**-1.5**
Product group						
Non-durables	3.2	4.2	1.6	7.1	1.6	-2.8
Durables	0.8	5.5	0.7	6.1	0.1	-0.5
Intermediates	4.6	8.4	3.2	9.1	1.4	-0.7
Machinery and equipment	3.7	5.4	2.2	6.9	1.5	-1.5
Others	12.1	8.6	12.1	11.5	0.0	-2.8
All industries	**4.0**	**6.5**	**2.4**	**8.0**	**1.6**	**-1.5**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

The falling factor productivity is more evident if we look at the frequency of positive TFPG across industries and states (table 2). Of the 375 possible observations, 155 showed positive TFPG during the period 1980-1990, whereas the number declined to 124 during the period 1990-2000. Incidence of positive TFPG dropped drastically in the non-durables and durables, but increased in the intermediate industries.

Even in the limited number of cases where TFPG was positive in the post-SAP period, the component played of second fiddle to input growth (table 3). Whereas in the earlier decade TFPG was greater than input growth in 74 out of 206 cases of positive value added growth (VAG), in the next decade the number declined to 40 out of 212 cases of positive VAG. That is, the role of factor productivity outstripped that of inputs in less than 20 per cent of cases where real value added actually increased.

Table 2. Incidence of positive growth in value added, inputs and total factor productivity
(Number of cases)

	Value added growth		*Input growth*		*Total factor productivity growth*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*	*1980-1990*	*1990-2000*
Region						
Central	27	25	27	25	19	11
East	26	25	28	22	21	21
North	49	46	52	52	37	26
North-east	17	16	13	13	17	14
South	56	62	54	62	38	38
West	31	38	31	42	23	14
All India	**13**	**14**	**14**	**14**	**11**	**4**
Product group						
Non-durables	43	47	35	48	49	25
Durables	39	29	42	33	26	17
Intermediates	78	83	79	87	47	57
Machinery and equipment	30	34	32	29	23	18
Others	16	19	17	19	10	7
All industries	**20**	**19**	**18**	**17**	**19**	**15**
All total	**206**	**212**	**205**	**216**	**155**	**124**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

Table 3. Relative strength of total factor productivity growth and input growth

	Percentage of cases where TFPG > INPG			
	Among all cases		*Among cases reflecting positive VAG*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*
Region				
Central	33.3	23.3	37.0	16.0
East	33.3	35.0	34.6	40.0
North	32.0	24.0	34.7	17.4
North-east	21.3	26.7	58.8	50.0

Table 3. *(continued)*

	Percentage of cases where TFPG > INPG			
	Among all cases		*Among cases reflecting positive VAG*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*
South	28.0	21.3	28.6	22.6
West	33.3	8.9	38.7	7.9
All India	**33.3**	**0.0**	**30.8**	**0.0**
Product group				
Non-durables	72.0	30.0	53.5	19.1
Durables	21.0	18.0	41.0	24.1
Intermediates	24.8	19.2	33.3	15.7
Machinery and equipment	28.0	26.0	23.3	26.5
Others	12.0	20.0	12.5	10.5
All industries	**44.0**	**44.0**	**45.0**	**36.8**
All total	**28.3**	**20.0**	**35.9**	**18.9**

Source: Authors' calculation based on CSO (Various years) and EPWRF (2002).

Technical efficiency

In this paper, however, we are more concerned about how efficiently the organized manufacturing sector utilizes available resources. Table 4 and 5 show that substantial inefficiency exists in this sector, which had mean all-India efficiency levels of 64 per cent in 1980, 71 per cent in 1990 and 70 per cent in 2000. Consistently high efficiency levels are exhibited by the states of Gujarat, Kerala, Maharashtra and Himachal Pradesh. While Tamil Nadu and West Bengal had satisfactory efficiency levels during the 1980s, their positions declined alarmingly in the next decade. In contrast, Karnataka and Delhi sharply improved their mean efficiency levels in the immediate post-SAP period (1990-1995), though declining thereafter. Among the industry groups, comparatively higher efficiency levels are exhibited by the textiles, wood products and equipment sectors in every year, by leather products during the 1980s, and by paper products during the 1990s. In the most recent period, regional efficiency levels were highest in the south, followed those in the west; among the product groups, efficiency levels were highest in the machinery and equipment sector.

Table 4. Technical efficiency levels of the organized manufacturing sector in India all industies by state
(Percentage)

State	Mean technical efficiency level					Average annual rate of change	
	1980	1984	1990	1994	2000	1980-1990	1990-2000
Andaman	0.0	25.5	83.9	73.5	90.6	8.4	0.7
Andhra Pradesh	69.0	70.5	53.9	82.7	77.6	-1.5	2.4
Assam	62.1	97.0	92.6	94.4	67.9	3.1	-2.5
Bihar	52.2	69.9	91.6	89.4	75.9	3.9	-1.6
Delhi	66.6	64.0	85.8	95.0	81.7	1.9	-0.4
Gujarat	100.0	91.2	82.0	88.0	97.4	-1.8	1.5
Haryana	99.5	57.9	76.2	71.5	94.5	-2.3	1.8
Himachal Pradesh	92.6	78.6	69.3	75.9	96.2	-2.3	2.7
Jammu and Kashmir	43.8	39.4	83.9	89.2	90.6	4.0	0.7
Karnataka	71.7	76.9	83.9	88.3	67.0	1.2	-1.7
Kerala	97.2	90.1	89.0	87.7	100.0	-0.8	1.1
Madhya Pradesh	65.6	52.3	79.2	70.1	88.3	1.4	0.9
Maharashtra	92.3	92.8	94.2	84.5	91.9	0.2	-0.2
Manipur	0.0	59.3	83.9	59.4	90.6	8.4	0.7
Meghalaya	0.0	24.9	83.9	85.5	90.6	8.4	0.7
Nagaland	0.0	91.9	83.9	73.6	90.6	8.4	0.7
Orissa	71.9	36.4	86.3	77.3	64.5	1.4	-2.2
Pondicherry	0.0	44.1	83.0	92.7	90.6	8.3	0.8
Punjab	67.5	52.8	83.0	58.2	86.8	1.6	0.4
Rajasthan	83.5	59.5	69.4	85.8	88.6	-1.4	1.9
Tamil Nadu	90.3	85.2	83.5	79.8	89.2	-0.7	0.6
Tripura	0.0	51.7	81.1	57.2	90.6	8.1	1.0
Uttar Pradesh	52.5	52.1	81.1	87.5	76.4	2.9	-0.5
West Bengal	82.5	64.8	56.8	54.9	63.9	-2.6	0.7
Region							
Central	58.2	54.8	61.0	56.8	61.3	0.3	0.3
East	63.8	60.3	59.7	58.5	58.5	-0.4	-0.1
North	67.6	54.8	62.1	61.5	61.6	-0.6	-0.1
North-east	68.5	66.7	70.3	66.3	60.6	0.2	-0.5
South	64.9	58.2	62.3	57.8	63.7	-0.3	0.1
West	65.1	64.7	67.8	64.5	61.9	0.3	-0.6
All India	**64.4**	**65.5**	**70.8**	**61.5**	**70.1**	**0.6**	**-0.1**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

Table 5. Technical efficiencies of the organized manufacturing sector in India, all-India, by industry

Industry groups	Mean technical efficiency level					Average annual rate of change	
	1980	1984	1990	1994	2000	1980-1990	1990-2000
Food and beverages	52.4	75.0	42.9	71.7	56.7	-1.0	1.4
Textiles	76.1	75.8	79.8	83.8	94.6	0.4	1.5
Textile products	50.5	23.0	100.0	40.0	46.1	5.0	-5.4
Wood products	86.1	77.3	100.0	86.8	73.5	1.4	-2.7
Paper products	62.7	41.5	73.5	43.2	78.1	1.1	0.5
Leather products	100.0	60.1	20.5	60.5	61.0	-8.0	4.1
Basic chemicals	39.6	71.7	52.4	34.2	53.5	1.3	0.1
Rubber and plastic	15.4	21.1	53.5	55.3	30.5	3.8	-2.3
Non-metallic minerals	76.1	46.8	66.8	17.7	42.3	-0.9	-2.5
Basic metals	53.6	70.0	57.1	60.9	60.0	0.4	0.3
Metal products	78.3	51.1	78.8	75.7	79.8	0.1	0.1
Electrical and non-electrical equipment	77.6	63.7	82.3	64.4	73.4	0.5	-0.9
Transport equipment	72.6	69.6	34.2	68.0	86.6	-3.8	5.2
Other	40.2	82.3	81.8	70.9	60.0	4.2	-2.2
Product group							
Non-durables	59.7	57.9	74.2	65.2	65.8	1.5	-0.8
Durables	82.9	59.6	64.7	63.5	70.9	-1.8	0.6
Intermediates	52.6	52.1	61.7	48.8	53.2	0.9	-0.9
Machinery and equipment	75.1	66.7	58.3	66.2	80.0	-1.7	2.2
Other	57.8	78.4	82.9	62.8	75.3	4.2	-2.2
All industries	**64.4**	**65.5**	**70.8**	**61.5**	**70.1**	**0.6**	**-0.1**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

IV. TECHNICAL EFFICIENCY VERSUS TECHNOLOGICAL PROGRESS

Technical efficiency changes

Improvements in technical efficiency should be a major thrust area in today's globalized environment, where success depends on international competitiveness. In terms of such improvements, however, the organized manufacturing sector in India has not done well. We have already noted the fall in

efficiency levels in the immediate post-SAP period. Though a partial recovery occurred in the second half of the 1990s it could not outweigh the initial decline. As a result, the average annual rate of technical efficiency change was -0.1 percentage points over that decade, compared to an average increase of 0.6 percentage points per annum during the 1980s (table 6). However, there are also substantial regional and inter-industry disparities regarding TEC. While there was a consistent drop in technical efficiency in the eastern and northern states, positive TEC—even in the post-SAP period—was exhibited by the southern states. Among the industries, efficiency levels in the non-durables and intermediate sectors had increased during the 1980s, but declined during the 1990s. In contrast, TEC in the durables and machinery and equipment sectors was negative during the 1980s but turned positive during the 1990s. The picture is similar if we compare the incidence of positive TEC between the two periods, which decreased from 179 to 173 at the aggregate level, but increased in the southern states and in the product categories of durables, intermediates, and machinery and equipment.

Table 6. Average annual rates of technical efficiency change and incidence of positive technical efficiency change

	Average annual rates of TEC		*Incidence of positive TEC*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*
Region				
Central	0.3	0.3	17	19
East	-0.4	-0.1	28	29
North	-0.6	-0.1	34	32
North-east	0.2	-0.5	43	36
South	-0.3	0.1	35	37
West	0.3	-0.6	22	20
All India	**0.6**	**-0.1**	**9**	**7**
Product group				
Non-durables	1.5	-0.8	45	28
Durables	-1.8	0.6	39	43
Intermediates	0.9	-0.9	56	60
Machinery and equipment	-1.7	2.2	23	30
Others	4.2	-2.2	16	12
All industries	**0.6**	**-0.1**	**17**	**18**
All total	**–**	**–**	**179**	**173**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

Technological progress

It is generally perceived that technological progress is the main driving force behind productivity growth, especially in manufacturing industries. In fact, TFPG has often been considered synonymous with TP, though that is not so. The performance of the organized manufacturing sector in terms of TP had been fairly satisfactory during the 1980s, with an average annual rate of 1 per cent (table 7). The highest TP was exhibited by the machinery and equipment sector, followed by the durables sector. Among the regions, eastern and northern states showed quite high rates of TP. In the western states however, TP was negative. Post-SAP, the TP rate became negative (-1.4 per cent per annum) in the aggregate and in all product groups except the intermediates. Among all observations, TP was positive in 142 cases during the 1980s, but only in 132 cases during the 1990s.

Table 7. Average annual rates of technological progress and incidence of positive technological progress

	Average annual rates of TP		*Incidence of positive TP*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*
Region				
Central	1.1	-0.7	18	8
East	3.0	-0.9	16	23
North	3.0	-1.6	36	28
North-east	5.9	-9.2	10	18
South	1.8	-2.1	40	40
West	-0.2	-1.3	22	15
All India	**1.0**	**-1.4**	**7**	**5**
Product group				
Non-durables	0.1	-2.0	37	29
Durables	2.0	-1.1	30	14
Intermediates	0.5	0.2	38	56
Machinery and equipment	3.1	-3.6	27	23
Others	-4.2	-0.7	11	10
All industries	**1.0**	**-1.4**	**16**	**17**
All total	**–**	**–**	**142**	**132**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

It can therefore be said that in the post-SAP period covered in this analysis, the organized manufacturing sector in India suffered structural setbacks, notwithstanding the high value added growth. Factor productivity declined, efficiency levels decreased and TP decelerated. The output growth was therefore the result of more than just a proportional increase in inputs. Some possible causes of such dynamics will be discussed in the next section.

Diffusion versus upgrading

If we now compare the two components of TFPG—TEC and TP—further observations can be made.

Table 8. Relative strengths of technical efficiency changes and technological progress in total factor productivity growth

	Percentage of cases where TEC > TP			
	Among all cases		*Among cases reflecting positive TFPG*	
	1980-1990	*1990-2000*	*1980-1990*	*1990-2000*
Region				
Central	46.7	63.3	36.8	45.5
East	77.8	71.1	57.1	28.6
North	38.7	57.3	24.3	26.9
North-east	52.0	49.3	58.8	100.0
South	41.3	38.7	31.6	18.4
West	44.4	51.1	26.1	28.6
All India	**73.3**	**60.0**	**72.7**	**50.0**
Product group				
Non-durables	74.0	70.0	30.6	16.0
Durables	36.0	47.0	34.6	41.2
Intermediates	52.8	47.2	40.4	17.5
Machinery and equipment	36.0	54.0	39.1	22.2
Others	48.0	56.0	50.0	28.6
All industries	**40.0**	**40.0**	**36.8**	**26.7**
All total	**45.1**	**48.5**	**36.8**	**21.8**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

During the 1980s, when TP was positive (1 per cent), TEC was also positive (0.6 per cent) but increased at a lower rate. During the 1990s both rates were negative, but TEC declined at substantially a lower rate. TEC was therefore weaker than TP in the organized manufacturing sector in India. TEC was greater than TP in about half of the 375 observations for both periods (table 8). However, if we consider only those cases where TFPG was positive, we find that TEC was greater than TP in only about one third of the cases during the 1980s and about one quarter of the cases during the 1990s. The balance is therefore substantially tilted towards TP. Thus, at the aggregate level, diffusion of technology and learning by doing seem to be quite restricted. This is quite alarming, becasue it is expected that, even in the face of technological deceleration, units will strive that much harder to achieve better organization and utilization of available inputs and to improve their efficiency levels—even more so in a globally competitive environment. It is evident that this has not happened in India, putting into question the sustainability of manufacturing-sector output growth. Unless efficiency levels improve drastically, the sector is at risk of becoming uncompetitive, and its growth is bound to be stifled. We will examine some of the factors behind such dynamics, especially in the post-SAP decade, later.

Disaggregated results

The results regarding TEC and TP that we have outlined so far vary across industries, and quite expectedly so. Looking back at table 1, it can be observed that the non-durables sector suffered the most in the post-SAP period, as it showed the highest growth rate of inputs and the highest decline in TFPG. This was accompanied by technological deceleration and a drop in efficiency levels. The intermediates sector exhibited the highest growth rates of both value added and inputs. TFPG and efficiency levels declined here, even though positive TP occurred in this sector in the post-SAP period. The role of TP also increased in this sector vis-à-vis TEC. In the durables and machinery-and-equipment sectors, growth rates of value added increased, but TFPG rates declined. These two sectors witnessed efficiency gains along with a drop in TP. They were therefore driven more by efficiency changes than by pure TP in the later period (see tables 6 and 7).

What explains such inter-industry difference? The answer perhaps lies in the sectoral dynamics of the post-SAP period. The non-durables sector experienced sluggish growth with a declining share in investment, output and value added. Consequently, it neither increased efficiency nor gained access to better technology. The intermediates sector cornered the majority of investment in the 1990s – in terms of both domestic and foreign capital. As a result, it gained access to sophisticated technology and output growth took place, along with substantial

technological progress. For the durables and machinery-and-equipment sectors, the quanta of investment, both domestic and foreign, were lower and thus their access to advanced technology was limited. Faced with substantial global competition, they had to focus on better utilization of available technology. Thus their growth depended more on efficiency improvements rather than on pure TP. In this regard, the presence of larger numbers of small and medium-sized firms with lower capital intensity in these two sectors has also played a significant role.

V. FACTORS AFFECTING TECHNOLOGICAL PROGRESS AND TECHNICAL EFFICIENCY

Capital intensity

TP has frequently been associated with the use of improved technology and increased capital intensity. It should therefore follow that a rise in the capital-labour ratio will be accompanied by positive TP and a rise in factor productivity. However, this has not been the experience of the organized manufacturing sector in India. Throughout the study period, capital intensity increased, with the trend accelerating in the post-SAP period. The capital-labour ratio increased at 5.3 per cent per annum in the post-SAP period compared to 3.2 per cent per annum in the earlier decade. But TFPG and TP, which were positive in the 1980s, turned negative after SAP (see tables 1 and 7). This is perhaps attributable to an indiscriminate application of highly capital-intensive modern technology in the mid-to late 1990s in a bid to raise productivity levels. It seems to have been forgotten that having the technology is not sufficient—it is the mastery of technology that matters. As a result, efficient use of available resources, diffusion of existing technology and improved skill formation fell by the way side, as evident from the faltering efficiency levels in the post-SAP period.

The inverse relationship between capital intensity on one hand and improvements in efficiency and TP on the other is confirmed by the significant negative correlation coefficient between the capital-labour ratio and technical efficiency and also between growth in the capital-labour ratio and growth in TEC, TP and technical efficiency (table 9). Therefore, the claim that higher capital intensity (and hence better technology) is essential to increasing productivity, efficiency and TP in the manufacturing sector seems to be unfounded. In reality, this fixation with modern technology has stifled employment and wages in the post-SAP period by moving away from labour, the most abundant factor in India; furthermore, the associated increases in the use of capital and its share in output have led to efficiency losses.

Table 9. Interlinkages of technical efficiency changes and technological progress

Period	*Variables*	*Technological efficiency change*	*Technological progress*	*Technical efficiency growth*
1980-1984	Growth in capital-labour ratio	-0.08	-0.18**	-0.09
	Growth in value added	0.37**		0.25**
1984-1990	Growth in capital-labour ratio	-0.15**	-0.08	-0.18**
	Growth in value added	0.26**		0.26**
1990-1994	Growth in capital-labour ratio	-0.13**	-0.02	-0.13*
	Growth in value added	0.31**		0.21**
1994-2000	Growth in capital-labour ratio	-0.10*	0.14*	-0.16**
	Growth in value added	0.37**		0.28**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

Note: Coefficients with a significance level of above 20 per cent are not reported.
*$p < .10$ ** $p < .05$.

And yet, many still believe that technological upgrading through greater infusion of capital is a panacea to low productivity (CII, 2006; Magarinos, 2005; FICCI, 2005; India, 2005; Reddy, 2005). This view should be re-examined, and efforts should be geared towards better use of available resources, rather than increases in inputs.

Output growth

We have seen that the changing factor intensity affected efficiency levels negatively. We must next try to identify factors that would improve efficiency levels. It is sometimes argued that learning by doing increases with doing and that efficiency levels improve as output increases. These correlations are in the organized manufacturing sector in India, as TEC and technical efficiency growth are found to be significantly and positively associated with growth in value added (see table 9). The results are similar when disaggregated by state or industry.

VI. REGIONAL DIMENSIONS

In our discussion of levels and trends in productivity, efficiency and TP in the organized manufacturing sector in India so far, we have identified certain factors that affect such efficiency levels, primarily at the macro level. Substantial regional variation in levels of productivity, efficiency and TP also exist.

As discussed above (see technical efficiency), the post-SAP drop in factor productivity in India was highest in the southern and eastern states. As noted previously, consistently high efficiency levels were exhibited by the states of Gujarat, Himachal Pradesh, Kerala and Maharashtra. While Tamil Nadu and West Bengal had satisfactory efficiency levels during the 1980s, their position declined alarmingly in the next decade. In contrast, Karnataka and Delhi sharply improved their mean efficiency levels in the immediate post-SAP period. In 2000, the most recent period covered, efficiency levels were highest in the southern region, followed by the western region. While there was a consistent drop in technical efficiency in the eastern and northern states during both pre- and post-SAP periods, positive TEC—even in the post-SAP period—was exhibited by the southern states.

What causes such regional disparity in levels of productivity, efficiency and TP? It is argued that the regional infrastructure plays a vital role in determining the productivity and efficiency level of the regional industrial sector (Hall and Jones, 1998; Mitra and Ural, 2007). In addition, the investment climate of a state also affects how much new investment, accompanied by modern technology, will flow into the state (Veeramani and Goldar, 2004). In other words, the competitiveness of the state, in terms of infrastructure, governance and human resources, seems to be an important determinant of productivity, efficiency and TP. Let us now explore the veracity of this hypothesis.

Infrastructure

Regional disparities in efficiency levels have sometimes been explained in terms of differences in the availability of support facilities—mainly infrastructure. As we indicated earlier, prospective investors look at the quantity and quality of the support systems present in a region before investing. In this selection process, the level of available infrastructure plays a crucial role, separate from the considerations of business sentiments, socio-political stability and ease of operation, which we discuss later. Today's investors demand a smooth transport system, an uninterrupted and reliable power supply, availability of healthcare facilities and proximity to educational institutions. Since the 1990s, regional disparities in infrastructure availability have widened in India, leading to an increasingly unequal distribution of private investment—quite naturally in favour of regions with more advanced infrastructure. Since new investment, especially foreign capital inflow, plays a key role in technological improvement, productivity rise and efficiency improvement, such differences in investment spread are also likely to lead to differences in productivity, efficiency and technological progress in the manufacturing sector. To test this hypothosis, we have used a principal component analysis to construct indices of infrastructural availability for three subsectors of infrastructure:

physical financial and social. Further subdivided, physical infrastructure includes agro-specific services transport and communications and power. Financial infrastructure consists mainly of banking services, and social infrastructure supports educational and health services. In turn, each of these infrastructure components consist of several variables and indicators.[6] Our analysis is based on these measures.

We find that the composite indices of physical, financial and social infrastructure have positive associations with efficiency levels (table 10). Moreover, the associations are significantly positive both at the aggregate level and also when disaggregated by industry group. This indicates that better infrastructure allows a regional manufacturing sector, and each of its sub-parts, to achieve not only better productivity, but also a faster rise in productivity levels and greater technical efficiency levels. In addition, the associations became significantly stronger in the post-SAP period, indicating that infrastructural bottlenecks have been crucial factors behind the faltering efficiencies of the manufacturing sector since the 1980s. Further examination reveals that the association is strongest with social infrastructure

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[6] The indices were prepared for an earlier study by Majumder (2005). The constituent indicators of the composite indices are as follows. Agricultural infrastructure: irrigation intensity (net irrigated area as a percentage of net sown area), agricultural credit per primary labourer, number of primary agricultural credits per 100,000 population. Transport infrastructure: road length per thousand-square-kilometre area, surfaced road length as a percentage of total road length, the percentage of roads as highways, railway length per thousand-square-kilometre area, number of post offices per thousand-square-kilometre area, number of letter boxes per thousand-square-kilometre area, postal articles carried per capita. Power infrastructure: percentage of villages electrified, per capita power generated, per capita power sold, plant load factor. Educational infrastructure: number of primary and secondary schools and colleges (both per thousand-square-kilometre area and per thousand population), teacher-pupil ratio in primary schools, per capita expenditure on primary education. Health infrastructure: hospitals and dispensaries (both per thousand-square-kilometre area and per thousand population), number of beds in hospitals and dispensaries per population.

Researchers have often used the simple principal component analysis method to arrive at composite indices. This method suffers from the drawback that heterogeneity due to varied units implies that changes in units may lead to higher values of indices. To solve this problem, Ghosh and De (2004) divide the original values of the individual variables by their standard deviation. This, however, makes the variance of all the transformed variables equal to unity, thus eliminating their individual variability. The modified principal component analysis method (for details see Kundu 1980, 1982) used here standardizes the data set by dividing the variables by the respective column-wise means, thus the variables become scale-free, yet retain their individual variances.

It is often argued that the mean used should be a weighted, rather than simple, average of the indicators, with the weights being either the area or population of the states, depending on the factor by which the indicator was standardized. However, here the purpose is to make the variables scale-free and express them relative to a common factor. Hence, a simple mean serves our purpose. Also, the second and third sets of composite indices (physical and social infrastructure), and the composite infrastructural scores are prepared as a simple sum of sectoral indices to give equal representation to the sectoral achievements.

Table 10. Correlation coefficients between infrastructure and technical efficiency

Interlinked variables	*1980*	*1984*	*1990*	*1994*	*2000*
Capital-labour ratio	-0.22**	-0.14**	-0.19**	-0.13*	-0.08
Physical infrastructure	0.11*	0.03	0.10*	0.14**	0.12**
Financial infrastructure	0.06		0.05	0.13**	0.14**
Social infrastructure	0.07	0.02	0.10	0.16**	0.14**
Composite infrastructure	0.07		0.08	0.14**	0.13**

Source: Author's calculations.

Note: Coefficients with significance level above 20 per cent are not reported. Detailed industry group level tables available on request from authors.

*$p < .10$ ** $p < .05$.

(education and health), underscoring the importance of a skilled and healthy labour pool to the efficient utilization of available resources. The results are thus in line with those observed by researchers (Brox and Fader, 1996; Kim and others, 1999). Therefore, infrastructural development should form a major area of policy intervention in order to improve efficiency levels in the organized manufacturing sector.

Governance and the business environment

Generally, private investment tends to stay away from poorly governed regions and flow to better-managed (and richer) states. This has also been true for India; furthermore, such regional disparity in investment increased after the implementation of the SAP. As a result of this programme, states were empowered with increased autonomy in key areas, such as infrastructure, industrial policy and tax concessions. Slowly but surely the states realized that they were able to shape their own destiny, and interstate competition intensified when states started agressively selling themselves as investment destinations.

Several recent studies have underlined the key role that states still have in shaping the environment in which enterprises from both public and private sectors operate, despite the influences of globalization and liberalization (Shand and Bide, 2000; Karnik and Others, 2000). A significant part of the competitive advantage of states is believed to arise from far reaching incentive policies that are designed to attract foreign investment. States that succeed in attracting greater investment are also successful at ensuring efficient investment. The competition from new entrants and the technological diffusion from modern factories forces the existing organized manufacturing sector units to be more productive and efficient. As a result, well-governed states are expected to have higher productivity and efficiency levels.

To test this hypothesis, we referred to the State Competitiveness Report – 2004 prepared by the National Productivity Council of India. The study identified about 95 socio-economic and technological criteria through the extensive research of economic literature and feedback from the business community, government agencies and academia.[7] These were then grouped under five competitiveness factors: economic strength, business efficiency, governance quality, human resources and infrastructure.

In this section, we look at the governance and business efficiency scores, as well as the composite competitiveness score. The association of these scores with productivity and technical efficiency levels, both at aggregate and disaggregated (by industry group) levels indicate that well-governed states indeed have higher productivity and efficiency levels (table 11). This supports the hypothesis that good governance and business efficiency has allowed the organized manufacturing sector to achieve higher productivity levels and greater technical efficiency in some states. The role of the enabling environment in shaping the regional productivity and efficiency profile is therefore confirmed.

Table 11. Correlation coefficients between the enabling environment and productivity and efficiency levels

Variables	*Product group*	*Association with*	
		Business efficiency	*Governance quality*
Total factor productivity	Non-durables	0.85**	0.28*
	Durables	0.52**	0.78**
	Intermediates	0.10	0.58**
	Machinery and equipment	0.31*	0.58**
	Others	0.84**	0.45**
	All industries	0.86**	0.98**
Technical efficiency	Non-durables	0.26*	0.11
	Durables		
	Intermediates	0.12	0.10
	Machinery and equipment	0.17*	0.19*
	Others	0.31**	0.31**
	All industries	0.16*	0.10

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

Note: Coefficients with significance level above 20 per cent are not reported.

* $p < .10$ ** $p < .05$.

[7] The *State Competitiveness Report* derives states' scores in terms of economic strength, business efficiency, governance quality, human resource base and infrastructural factors. A composite score is also derived.

Human resource and knowledge bases

In the ongoing struggle for market share, regional economies should not rely solely on infrastructure and governance. The ability of a state to develop an excellent education system and improve the knowledge base of the labour force through training is perhaps even more vital to productivity and efficiency, especially in the present era of knowledge economies. As states move up the economic scale, they thrive more on the "brains", or knowledge, of the workforce, and their ability to compete with other regions improves. Here we examine whether the human resource bases of the states are related to the productivity and efficiency level of the organized manufacturing sector. The human resource competitiveness score from the State Competitiveness Report was used to reflect the human resource base. In addition, the percentage of school graduates among workers (obtained from the National Sample Survey Organization (India, 2007) have also been used. Table 12 shows productivity and efficiency are positively related to both the human resource score and the incidence of school graduates among workers. This indicates that the condition of the organized manufacturing sector also depends on the knowledge quotient of the regional population.

Table 12. Correlation coefficients between human resources and productivity and efficiency levels

Variables	*Product group*	*Association with*	
		Human resource base	Incidence of *school graduation among workers*
Total factor productivity	Non-durables		0.07
	Durables	0.10	0.11*
	Intermediates	0.19*	0.09
	Machinery and equipment	0.25*	0.41**
	Others	0.37**	0.16*
	All Industries	0.12	0.23*
Technical efficiency	Non-durables	0.12	0.18*
	Durables		
	Intermediates	0.10	0.06
	Machinery and equipment	0.10	0.36**
	Others		0.14
	All Industries	0.37**	0.34**

Source: Authors' calculation based on data from the CSO Annual Survey of Industries database (1998-1999 and 2000-2001) and EPWRF (2002).

Note: Coefficients with significance level above 20 per cent are not reported.

* $p < .10$ ** $p < .05$.

It can be concluded that the productivity and efficiency levels of the organized manufacturing sector in India depend crucially on the regional conditions. Those states that are more competitive in terms of infrastructure, business environment, governance and human resource base are also the states where the organized manufacturing sector is more productive and more efficient. These regional factors must form the core of industrial policies in the country.

VII. REGIONAL EFFICIENCY MATRIX

So far, we have discussed levels and trends in productivity, efficiency and TP in the organized manufacturing sector in India and have identified certain factors that affect such levels. While policies must aim to improve the efficiency levels of the sector in general, it would be worthwhile to concentrate on areas of strength. Encouraging industries that exhibit high efficiency levels may be one major dimension of policy thrust. It is also recognized that in a geographically vast country like India different states will demonstrate greater efficiency in different industries because of natural, traditional and socio-economic factors. Though federal in nature, states in India are quite independent in framing their industrial and economic policies. This provides ample scope for each to focus on industries in which they are efficient. Two major types of strength, or comparative advantage, can be identified: interstate and intrastate. In the former, within a given industry a state is more efficient relative to other states. In the latter, a state demonstrates greater efficiency in a particular industry as compared to other industries within that state.

While from the national macroeconomic standpoint it is optimal that industries be located according to interstate comparative advantage each state's industrial policy should also take into account the intrastate comparative advantage among industries. Policy should focus on industries where a state enjoys both types of comparative advantage.

We have constructed a regional comparative advantage matrix where each state-industry combination is denoted by (X_{ij}, Y_{ij}). In this matrix, X_{ij} refers to the efficiency rank of i^{th} state in j^{th} industry among all states, and Y_{ij} refers to the rank of j^{th} industry in i^{th} state among all industries in that state. Interstate comparative advantage is expected to exist if X_{ij} 10 and intrastate comparative advantage is expected to exist if Y_{ij} 5. Fr om such a matrix, we have identified the focus areas for each state in table 13. We hope this will help in policy formulation at the regional level, particularly in regards to industrial incentives. At the national level, the comparative advantages of India seem to be in the production of textiles, paper products, metal products, machinery and equipment, and transport equipment.

Table 13. Identification of focus areas for major states

State	*Inter state efficiency*	*Intra state efficiency*	*Focus area*
Andhra Pradesh	Paper products; metal products; machinery and equipment	Paper products; leather products; metal products; machinery and equipment	Paper products; metal products; machinery and equipment
Assam	Textile products; paper products; leather products; rubber and plastic; non-metallic minerals	Paper products; leather products; rubber and plastic; non-metallic minerals	Paper products; leather products; rubber and plastic; non-metallic minerals
Bihar	Food and beverages; textile products; paper products; leather products; basic metals	Food and beverages; paper products; leather products; basic metals	Food and beverages; paper products; leather products; basic metals
Delhi	Food and beverages; textiles; textile products; wood products; paper products; leather products; basic chemicals; metal products; machinery and equipment; transport equipment	Textiles; wood products; basic chemicals; transport equipment	Textiles; wood products; basic chemicals; transport equipment
Gujarat	Textile products; wood products; rubber and plastic; basic metals	Textile products; wood products; paper products; basic metals	Textile products; wood products; basic metals
Haryana	Food and beverages; wood products; non-metallic minerals; basic metals	Food and beverages; paper products; non-metallic minerals; basic metals	Food and beverages; non-metallic minerals; basic metals
Himachal Pradesh	Food and beverages; textile products; leather products; basic chemicals; non-metallic minerals; machinery and equipment	Leather products; basic chemicals; non-metallic minerals; machinery and equipment	Leather products; basic chemicals; non-metallic minerals; machinery and equipment
Jammu and Kashmir	Textile products; basic chemicals; rubber and plastic; machinery and equipment; transport equipment	Basic chemicals; rubber and plastic; machinery and equipment; transport equipment	Basic chemicals; rubber and plastic; machinery and equipment; transport equipment

Table 13. ***(continued)***

State	Inter state efficiency	Intra state efficiency	Focus area
Karnataka	Food and beverages; textiles; wood products; paper products; basic chemicals; non-metallic minerals; metal products	Textiles; wood products; paper products; metal products; machinery and equipment	Textiles; wood products; paper products; metal products
Kerala	Paper products; leather products; rubber and plastic; non-metallic minerals; basic metals; transport equipment	Paper products; leather products; rubber and plastic; basic metals; transport equipment	Paper products; leather products; basic metals; transport equipment
Madhya Pradesh	Textiles; paper products; leather products; non-metallic minerals; basic metals	Textiles; paper products; leather products; basic metals	Textiles; paper products; leather products; basic metals
Maharashtra	Textiles; wood products; basic chemicals; rubber and plastic; non-metallic minerals; machinery and equipment	Textiles; basic chemicals; rubber and plastic; machinery and equipment	Textiles; basic chemicals; rubber and plastic; machinery and equipment
Orissa	Textile products; leather products; basic metals	Textile products; wood products; paper products; leather products; basic metals	Textile products; leather products; basic metals
Punjab	Food and beverages; textiles; basic chemicals; rubber and plastic	Basic chemicals; rubber and plastic; metal products; machinery and equipment	Basic chemicals; rubber and plastic
Rajasthan	Textile products; leather products; basic metals; metal products	Textile products; paper products; leather products; basic metals; metal products	Textile products; leather products; basic metals; metal products
Tamil Nadu	Textiles; paper products; non-metallic minerals, metal products; transport equipment	Textiles; paper products; non-metallic minerals; metal products; transport equipment	Textiles; paper products; non-metallic minerals; metal products; transport equipment
Uttar Pradesh	Food and beverages; textile products; wood products; basic metals, machinery and equipment	Wood products; paper products; basic metals; metal products; machinery and equipment	Wood products; basic metals; machinery and equipment
West Bengal	Food and beverages; textiles; textile products; wood products; metal products; transport equipment	Textiles; textile products; paper products; metal products; transport equipment	Textiles; textile products; metal products; transport equipment

VIII. CONCLUSION

We have seen that the tremendous growth of the organized manufacturing sector in India in the 1990s, was fuelled more by rising input use and less by productivity gains. Moreover, efficiency improvement seemed to slow down along with technological deceleration. Consequently, policies to increase growth in the sector should prioritize on these issues rather than try to change the basic technology applied in the sector. Innovation and adaptation processes should be encouraged through knowledge sharing. Training programmes may be organized to better orient workers to the machines with which they work. Entrepreneurs must be provided the basics of optimum organizational skills. Forming local groups, sharing experiences of successful units, and even sharing of "idle" resources may prove helpful in all these areas. In other words, efficiency enhancement should be the prime target for the organized manufacturing sector if its present production boom is to be translated into sustained growth.

Moreover, any effort to upgrade technology involves greater use of capital goods and requires a substantial amount of financial resources. Given the nature of the economy in India, this is costly—and often difficult. In contrast, the diffusion of existing technology and improvements in organization, skill and efficiency require less capital and more human involvement, the latter being abundant in the labour-surplus economy. Also the fact that of efficiency and efficiency changes are closely related to educational and health infrastructure and to the human resource quotient of the region underlines the importance of investing in human resources as a way to raise productivity and efficiency. Thus, as a policy choice, efficiency upgrading appears more viable, effective and lucrative than to technological upgrading alone. In this regard, the role of good governance, business efficiency and overall competitiveness of the regions has also been observed to be crucial. Therefore, states must look at ways and means to sell themselves by improving the enabling environment that they provide to the manufacturing sector in particular and to entrepreneurs in general. Moreover, given the limited resources at the disposal of the economy, it would be better to concentrate on regional focus groups of industries rather than scatter the energy (and money) across all types of industries. The matrix prepared in this study provides suggestions of focus areas.

It also must be acknowledged that technological progress does have a role to play and that technological upgrading may be used to help raise productivity and improve performance. Among the various product groups, a few have benefited more from TP than from TEC. This diversity must be borne in mind and policies must be framed accordingly. But only when better technology is combined with wider diffusion can one expect enterprises in the organized manufacturing sector to come out of their shell and ensure better returns for the economy, both now and in the future.

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EFFICIENT REMITTANCE SERVICES FOR DEVELOPMENT IN THE PACIFIC

John Gibson, Geua Boe-Gibson, Halahingano Rohorua and *David McKenzie**

Capital inflows to the Pacific islands from aid, foreign investment and remittances are an important source of development finance. Remittances are the fastest growing; they now total US$ 400 million per year and can be expected to grow even further as labour mobility is used to deal with seasonal labour shortages in Australia and New Zealand and limited job opportunities in the Pacific. The transaction costs of sending remittances to the Pacific islands are very high for the most widely used methods. This paper examines the New Zealand-Tonga remittance corridor, where typical transactions involve costs in the order of 15 to 20 per cent for bank drafts and transfers through money transfer companies such as Western Union. Cheaper transfer methods using automated teller machines (ATMs) are feasible and have transaction costs of less than 5 per cent but are not widely used. This spread of 10 percentage points between the most popular and the cheapest remittance methods means a potential loss for Tonga of the equivalent of 4 per cent of GDP. Extrapolating from this remittance corridor to the rest of the Pacific, avoidable transaction costs may total US$ 40 million per year. Hypotheses about the continued reliance on high transaction cost methods are examined and implications for development policy are discussed.

* John Gibson, Geua Boe-Gibson and Halahingano Rohorua are, respectively, a professor, a research officer and a post-doctoral fellow at the Department of Economics, University of Waikato, New Zealand. David McKenzie is at the Finance and Private Sector Development Unit, Development Research Group, World Bank.

The survey data used here were originally funded by the World Bank, the Waikato Management School and a Marsden Fund grant. This funding is gratefully acknowledged, as are the assistance with data provided by the Ministry of Lands, Surveys and Natural Resources; the Statistics Office of Tonga; and survey respondents, helpful comments contributed by Alastair Bisley, Karen Nero and an anonymous reviewer and the hospitality extended during the drafting of this article by the Macmillan Brown Centre for Pacific Studies at the University of Canterbury.

I. INTRODUCTION

Most poor people around the world lack access to competitive and efficient financial services. Very few benefit from a savings account, insurance, loans or a convenient and cheap way to transfer money. As Helms (2006, 1) notes:

> "Financial services for the poor, often referred to as microfinance, cannot solve all the problems caused by poverty. But they can help put resources and power into the hands of poor and low-income people themselves, letting them make those everyday decisions and chart their own paths out of poverty."

While finance for economic development was traditionally viewed in a more aggregate sense, with large aid-financed transfers to State-run development banks, in recent years an emphasis has been placed on financial flows at the household and individual levels. This reflects the fact that market failures, in the form of imperfect and unequally distributed information (e.g. borrowers typically know more than lenders do about the risks of the project for which they are seeking financing), and high transaction and contract enforcement costs particularly affect poor or small entrepreneurs who lack collateral, credit histories, and connections (Beck, Demurgic-Kunt and Peria, 2007).

Migrants are one of the main sources of these microlevel financial flows; worldwide, they remit billions of dollars to their points of origin. These remittances have risen rapidly and now exceed the amount of money that developing countries receive as foreign aid (Ratha, 2003). They are especially important for small island developing countries, which have an average of 17 per cent of their population working overseas (Mckenzie, 2007).[1] In Polynesian countries, such as Tonga and Samoa, emigration is even higher, with typically over one quarter of the population overseas (similar to the Caribbean). Consequently, remittances are very important in Polynesian countries, comprising 39 per cent of gross domestic product (GDP) for Tonga, 36 per cent for Tuvalu and 14 per cent for Samoa (World Bank, 2006).

While aid is still more important overall in the Pacific islands (see section II), remittances are growing faster than either aid or foreign direct investment and now total US$ 400 million per year. Remittances can be expected to grow even further as short-term labour mobility is used as a mechanism to deal with seasonal labour shortages in Australia and New Zealand and limited job opportunities in the Pacific (Benson-Pope and Cunliffe, 2006; Maclellan and Mares, 2006; World Bank, 2006a).

[1] This average is for island countries with populations below 1.5 million.

Remittances provide a major source of investment, especially for human capital formation and microenterprises. For example, in the data from the authors' Pacific Island-New Zealand Migration Survey discussed below, almost one quarter of cash remittances reported by the sampled households in Tonga are earmarked for paying school fees.[2] Brown (1994) and Brown and Connell (1993) also find that many remittances of both money and goods to Tonga and Samoa are used for investment, especially to set up microenterprises such as petty trading, and that, overall, remittances make a significant contribution to savings and investment.

However the transaction costs for the most widely used methods of sending remittances to the Pacific islands are very high. These high costs are unlikely to reflect the small size of the remittance market in the Pacific islands since the country we focus on, Tonga, receives approximately the same level of total remittances as much larger countries. For example, Ghana and Tonga both received approximately US$ 65 million in remittances in 2003 (World Bank, 2006), but transaction costs to Ghana are only one third of those to Tonga. Since transaction costs are presumed to be higher the smaller the volume of remittance inflows, it seems likely that remittance services are even less efficient and the transaction costs even higher in other Pacific island countries where remittances are less common than in Tonga. These high transaction costs are linked to the remittance destination country rather than the country of origin; for example, the effective exchange rate commission when using Western Union to send 200 New Zealand dollars (NZ$) from New Zealand is 10 per cent when the destination is Tonga versus only 3 per cent when the destination is the United States and 4 per cent when the destination is Australia.

The issue of transaction costs also matters because they vary widely. If all feasible methods of remitting to the Pacific were equally costly, there would be little room for public policy to reduce costs. However, according to estimates by Gibson, McKenzie and Rohorua (2006), the transaction costs on money transfers from New Zealand to Tonga range from 15 to 20 per cent when sending bank drafts or using money transfer companies like Western Union but are only 4 per cent when the recipient uses an automatic teller machine (ATM) to withdraw funds from an account set up by the remitter.

[2] Similar patterns of remittance use are reported in other parts of the world. For example, Adams (2006) finds that in Guatemala, households receiving international remittances spend 58 per cent more on education than do households which receive no remittances. Households receiving remittances also spend a smaller portion of extra income on consumption and more on investment than those that do not receive remittances (Mckenzie, 2007).

This spread of at least 10 percentage points between the most popular and the cheapest remittance methods could lead to a potential loss for Tonga of up to 4 per cent of GDP (given that remittances are 39 per cent of GDP) if remittances are sent through costly rather than cheap channels. In fact, the loss may be even greater since higher transaction costs may reduce the gross amount that remitters send if there is a negative cost elasticity of remittances. Thus, the net remittance received is lower both because the transaction costs take a larger share of the amount sent and because the transactions costs act like a tax and induce remitters to send less. According to calculations reported by Gibson, McKenzie and Rohorua (2006), the negative cost elasticity in the New Zealand to Tonga remittance channel means that Tonga might gain up to 28 per cent more in net remittance receipts if transaction costs could be lowered to the level prevailing in other regions.

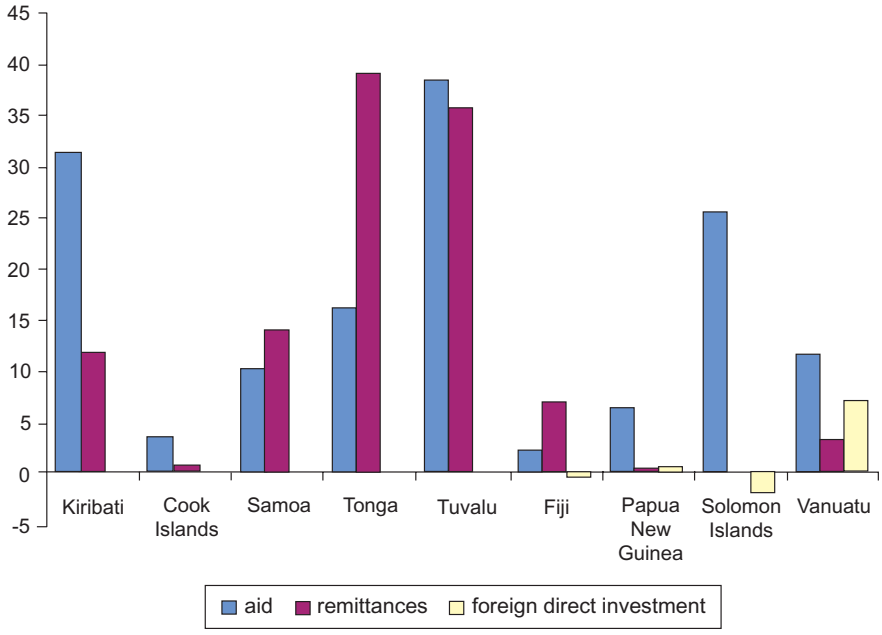
The next section of this paper provides evidence of the growing importance of remittances in the Pacific. The data used to measure transaction costs and to examine hypotheses about the continued reliance on high-cost methods for the New Zealand-Tonga remittance corridor are discussed in section III. The transaction costs of remittances from New Zealand to Tonga are then described in section IV. Several hypotheses about the continued reliance on high transaction cost methods are examined in section V and the implications for development policy are discussed in section VI.

II. FINANCIAL FLOWS IN THE PACIFIC

Figure 1 presents evidence on the importance of aid, foreign direct investment and remittances in the most recent year available for each of the Melanesian and Polynesian countries and for Kiribati. Data on remittances to the other Micronesian countries are less readily available from international sources. Even for the countries with reported data, it is likely that remittances are understated, as some transfers probably occur through informal means such as travellers carrying cash back with them. Moreover, the data in figure 1 only relate to monetary remittances rather than the provision of goods in kind, for which there are no comparable cross-country data.[3]

[3] McKenzie (2006) reports survey evidence that cash remittances from New Zealand to Tonga constituted only 63 per cent of the value of total gross remittances, with the remaining 37 per cent taking the form of goods. There are also substantial reverse flows, mainly of goods, particularly in the form of items that have cultural or symbolic value. The issue of non-cash remittances and their impact on the difference between the values of gross and net receipts requires more detailed research.

Figure 1. Financial flows in the Pacific
(Percentage of GDP)



Sources: AusAID (2006), Asian Development Bank (2006).

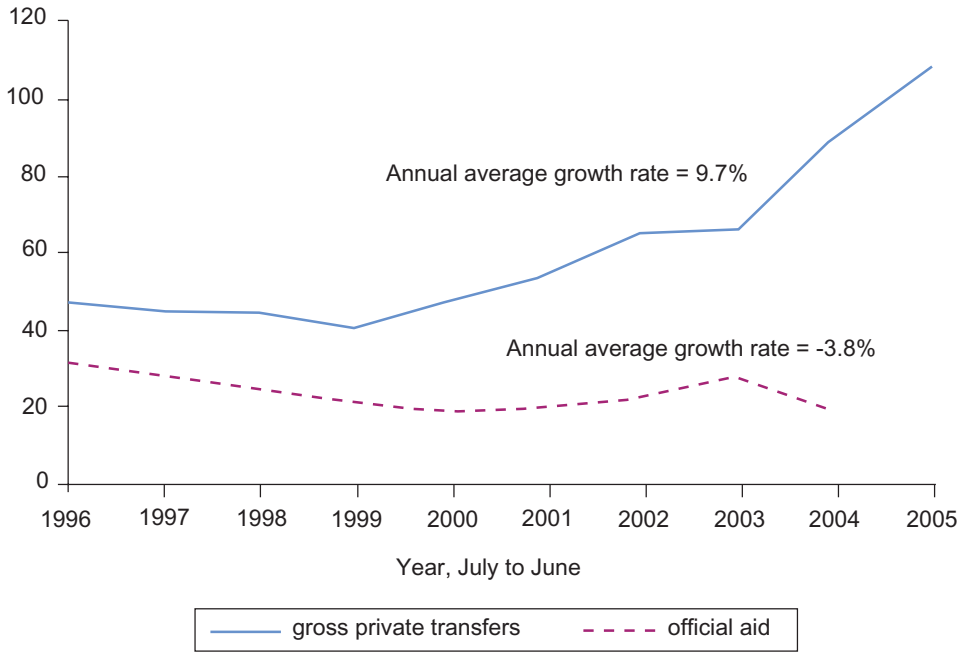
For the countries in figure 1, aid is equivalent to 16.3 per cent of GDP, on average. This is somewhat higher than remittances, which amount to 12.5 per cent of GDP, far exceeding foreign direct investment, which represents only 0.6 per cent of GDP. Total remittances to the nine countries in figure 1 equal about US$ 350 million per year. Thus, across all Pacific island economies (including those not in figure 1), it is likely that total remittances are now in the order of US$ 400 million per year.

There is considerable regional variation in the relative importance of aid and remittances, reflecting the much more limited options for labour mobility in Melanesia compared with those in Polynesia. Outside of Fiji, where remittances have grown rapidly due, in part, to the participation of Fijian soldiers in overseas military and peacekeeping operations, remittances in Melanesia average only 1.2 per cent of GDP versus 14.6 per cent for aid. However, across the Polynesian countries, remittances average 22.5 per cent of GDP versus 17.2 per cent of GDP for aid receipts. Remittances are most important in Tonga, at 39 per cent of GDP,

and for that reason the rest of the discussion and analysis in this paper is based on the Tongan experience.

The trend for remittances to increase much faster than aid receipts is illustrated in figure 2 for the case of Tonga. While aid receipts declined from US$ 32 million in 1996 to less than US$ 20 million in 2004, remittances grew substantially from US$ 47 million to US$ 90 million over the same time period. In terms of growth rates, remittances are increasing at almost 10 per cent per year versus a 3.8 per cent per year decline in aid receipts.

Figure 2. Financial flows to Tonga, 1996-2005
(Millions of United States dollars)



Sources: Remittance data from Connell and Brown (2005); National Reserve Bank of Tonga (various issues); aid data from World Bank (2007).

The trend in figure 2 emphasizes the importance of reducing the transaction costs of remittances for countries like Tonga. While aid efficiency is undoubtedly important, it relates to a declining source of external finance for some of the Pacific island countries, whereas the much less studied issue of remittance transaction costs relates to a rapidly increasing source of external finance for development in Tonga, and more broadly in the Pacific.

III. DATA

Three types of data are used to measure transaction costs in the New Zealand-Tonga remittance corridor and to examine hypotheses about why high-cost methods continue to be chosen. The first consists of information gathered from banks and money transfer operators to measure both the fixed charges they impose on senders and recipients and the effective exchange rate commissions implied by the rate of exchange they offer. Detailed notes on these data are reported in Gibson, McKenzie and Rohorua (2006).

The second type of data comes from a sample of 101 recent Tongan immigrants to New Zealand who were surveyed as part of the Pacific Island-New Zealand Migration Survey (PINZMS), a comprehensive survey designed by the authors to measure multiple aspects of the migration process. A detailed description of the PINZMS sample and methods and various descriptive statistics on the data are reported by McKenzie, Gibson and Stillman (2007). The relevant aspect for the current study is that this survey has a detailed module on remittances, recording remittances sent and received in the form of money and goods and the channels used to send remittances. In addition to questions about knowledge and use of various methods of sending money back to Tonga, those interviewed after February 2006 (the last third of the sample, $n=36$) were also asked questions about factors such as accessibility and security that affected their choice of remittance method.

The third type of data is geographic data on population distribution, the road network and the location of all ATMs and Western Union outlets on the main island of Tonga, Tongatapu. This island contains two thirds of the Tongan population and most of its financial infrastructure, so it is a good location for considering the role that service accessibility for remittance recipients plays in determining the choice of remittance method. Specifically, the eight ATMs and five Western Union outlets on Tongatapu were geocoded and placed onto a digitized version of the road network to simulate the travel distance that the population would have to cover to reach the nearest ATM or Western Union outlet.

IV. THE TRANSACTION COSTS OF REMITTANCES

There are two types of transaction costs associated with remittances. The first consists of fixed charges, such as the NZ$ 25 that banks charge senders of a telegraphic (wire) transfer, the NZ$ 5 to NZ$ 8 that they charge for ATM withdrawals in another country (using a card linked to the remitter's account in New Zealand) or

the NZ$ 20 that Western Union charges for a money transfer.[4] There may also be fees imposed on the recipient for receiving wire transfers or depositing bank drafts, in addition to costs for the remitter and the recipient to communicate with each other (e.g. mailing a bank draft or telephoning to provide the code number for collecting a Western Union transfer).

The second type of transaction cost is the effective exchange rate commission:

$$\frac{100*(\text{interbank rate} - \text{offered rate})}{\text{interbank rate}}$$

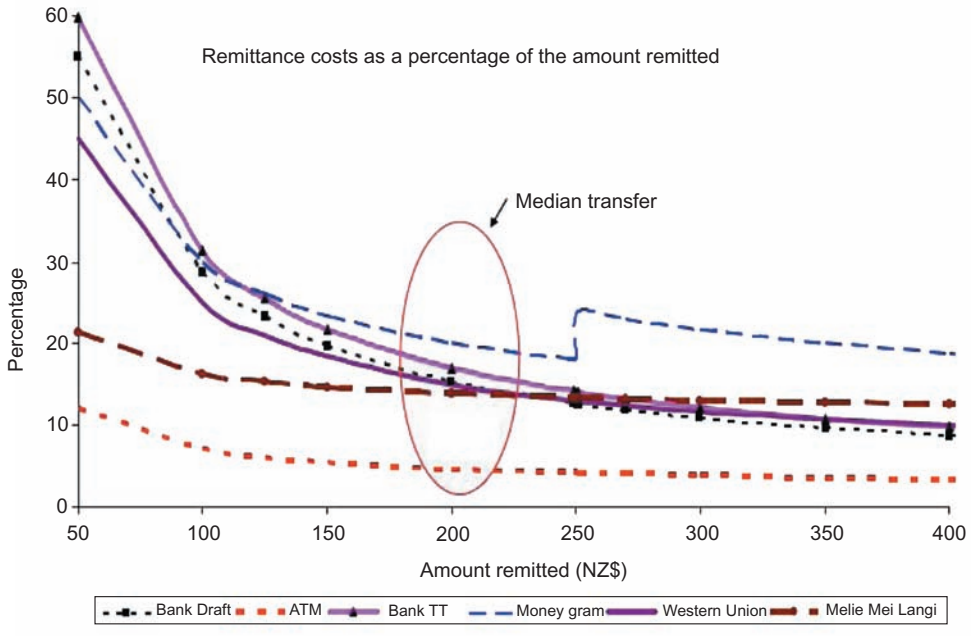
which depends on the gap between the offered exchange rate and the interbank rate. The exchange rate commission varies from 2 to 4 per cent for the various New Zealand banks that offer money transfers in Tongan pa'anga. However, for both the international money transfer operators (Western Union and Moneygram) and for a local Tongan operator (Melie mei Langi) the effective exchange rate commission averages almost 10 per cent.

Figure 3 plots the effective transaction costs of remitting (taking into account both fixed charges and the effective exchange rate commission) as a percentage of the amount remitted for a selection of the methods available in the New Zealand-Tonga remittance corridor. The presence of fixed fees causes the percentage cost to fall as the amount remitted increases, with the greatest percentage costs incurred for remittance amounts under NZ$ 200. The exception is Moneygram, where the step function in the fees causes the percentage cost to jump upwards between NZ$ 250 and NZ$ 251. It is notable that the survey of Tongan remitters indicated that the median transfer amount in any given transaction was NZ$ 200 (US$ 130), with 10 or more such transactions typically carried out each year. Remitters, therefore, incur greater percentage costs by sending for example, 10 transfers of NZ$ 200 each than they would if they sent a single transfer of NZ$ 2,000.

According to figure 3, it costs between 19 and 31 per cent to send NZ$ 100 by any method except the recipient using an ATM card to make a withdrawal. The cost to send NZ$ 200 is between 15 and 20 per cent, and for NZ$ 300, it is between 11 and 22 per cent (excluding the ATM card method). Using an ATM card is always the cheapest way to remit money. Melie mei Langi and Western Union are the next cheapest for amounts under the median transfer

[4] The other major money transfer operator, Moneygram/Travelex, uses an escalating fee structure, charging more for amounts above NZ$ 250, and more again for amounts above NZ$ 500. All of the data on these costs were collected in early 2005, when NZ$ 100 = US$ 65.

Figure 3. Transaction costs (as percentage of amount remitted) for the New Zealand-Tonga remittance corridor



of NZ$ 200, after which the bank draft becomes cheaper. Bank drafts and telegraphic transfers are the cheapest, apart from ATMs, for larger amounts.

It is notable that for smaller transfers, the indigenous Tongan company, Melie mei Langi, is more competitive than either the international money transfer operators or the banks (except when using an ATM card). Melie mei Langi is run by a Tongan church but is open to people of any denomination. It charges a fixed fee of NZ$ 5 for amounts under NZ$ 1,000 and NZ$ 10 for higher amounts, and these fees are doubled for transfers to the outer islands of Tonga. Money is transferred in under one hour and can be received at two branches on the main island of Tongatapu and at branches on the outer islands in Vava'u and Ha'apai and on 'Eua. There is one branch in Auckland. The fact that a new entrant without the reputation and financial infrastructure advantages of incumbent banks and money transfer operators can provide a competitive service is suggestive of the presence of some economic rents in the New Zealand-Tonga remittance

corridor.[5] Such rents might be competed away, to the benefit of remittance recipients and/or remitters, if additional competitive pressure could be introduced.

Table 1 compares the costs of sending money from New Zealand to Tonga with data from an international comparison of remittance costs undertaken by Orozco (2002). Note that these data are four years old, so competition and technological improvements may have lowered costs further. Despite this caveat, the costs of sending money from New Zealand to Tonga are higher than for all of the country pairs listed, for both banks and money transfer operators. Orozco reports an average cost of 5 per cent for bank-to-bank transfers, and 12 per cent for transfers by money transfer operators, which is almost half the cost of a bank transfer and two thirds the cost of using a money transfer operator to send the same amount from New Zealand to Tonga.

Table 1. Percentage cost of sending US$ 200 by country

Countries of destination and origin	*Banks (Percentage)*	*Money transfer operators (Percentage)*
Pakistan (from Saudi Arabia, United States, United Kingdom)	0.4	13.0
Mozambique (from South Africa, United States)	1.0	..
Turkey (from Germany, United States)	3.1	9.5
Portugal (from France, United States)	3.4	12.3
India (from Saudi Arabia, United States, United Kingdom)	6.0	13.8
Greece (from Germany, United States)	6.8	9.5
Philippines (from United States)	8.0	10.3
Mexico (from United States)	8.6	10.6
El Salvador (from United States)	..	7.2
Dominican Republic (from United States)	..	8.5
Tonga (from New Zealand)	**12-13**	**15-23**

Source: Orozco (2002, Tables 7 and 14) and Gibson, McKenzie and Rohorua (2006).

One objection to comparisons such as those in table 1 might be that the volume of remittances being sent to Tonga is lower than that being sent to many of these comparison countries, meaning that differences in scale might explain the higher fees in Tonga. However, two good comparison countries in this respect are Ghana and Mozambique since all three countries received between US$ 65 million

[5] Economic rent is the name given by economists to returns that are higher than those needed to keep resources in their current use, where this higher payment for the resources is typically due to the exploitation of market power.

and US$ 70 million in remittances in 2003.[6] The cost of sending 100 British pounds (approximately US$ 76) to Ghana is under 5 per cent for seven money operators in the United Kingdom of Great Britain and Northern Ireland, while the cost of a bank transfer from South Africa to Mozambique is only 1 per cent.[7] Based on these comparisons, it appears that transferring money from New Zealand to Tonga is approximately twice as expensive, on average, as bank transfers to a wide variety of countries from the United States and the United Kingdom, including countries with similar remittance volumes as Tonga.

V. RELIANCE ON COSTLY METHODS OF REMITTING FROM NEW ZEALAND TO TONGA

The evidence in section IV suggests that transaction costs are high in the New Zealand-Tonga remittance corridor. However, there is at least one lower-cost alternative, which is for the remittance recipient to have an ATM card linked to a New Zealand bank account set up by the sender. This is a fast and cheap way to send money, with withdrawal fees in the range of NZ$ 5 to NZ$ 8 and effective exchange rate commissions that are much lower than those charged by money transfer operators.

Money transfers using ATM cards are also reported by Isern, Deshpande and van Doorn (2005) to be the least expensive of any remittance method in the Latin American market. Moreover, even cheaper methods based on cell phones are becoming available in some remittance markets such as the Philippines.[8] However, such methods are quite technologically sophisticated compared with the simplicity of setting up a bank account for an immigrant that provides an ATM card for their own use and one for their recipient to use overseas. Hence, the lower transaction costs of cell phone-based methods may not be a good benchmark because they may also entail additional investments (in both hardware and cultural/technical acceptance) that is not feasible in the Pacific. In contrast, remittances based on ATMs are already known to be feasible in the Pacific, so their transaction

[6] The source of this comparison is the World Development Indicators. It is clear from figure 2 that remittance receipts for Tonga have increased sharply since 2003, which would make any scale effect even less likely to account for the higher cost of remitting to Tonga, unless there was a similarly rapid increase in remittances for Ghana and Mozambique.

[7] These transaction costs were obtained from <www.sendmoneyhome.org>.

[8] See Box 6.6 of World Bank (2006), which describes how Filipino immigrants can use a cell phone to deposit money into an “electronic wallet” that can be used by the recipient in the Philippines to either make a withdrawal from an ATM or to pay for a variety of purchases. The transaction cost of this method is about 1 per cent.

costs provide a feasible benchmark against which the other existing methods can be compared.

Despite their lower cost, ATM cards are an infrequently used method in the New Zealand-Tonga remittance corridor. Instead, a (slight) majority of the Tongan immigrants in the PINZMS sample who had remitted appeared to be using Western Union, which has a transaction cost of 15 per cent for the median transfer of NZ$ 200 (see table 2). The other popular choice was Melie mei Langi, which has a similar transaction cost for a transfer of NZ$ 200, but is cheaper for small transfers and more costly for larger transfers. But even for Melie mei Langi, whose transaction costs range from 12 to 16 per cent for transfers between NZ$ 100 and NZ$ 500, it is unclear why this channel is preferred over the much cheaper ATM card method.

Table 2. Most frequently used remittance method

Method	*Frequency (Percentage)*
Giving money to someone to take back when traveling	6.9
Bank transfer through Westpac	5.6
Bank transfer through other bank	1.4
Western Union/New Zealand Post Office	51.4
Travelex	4.2
Melie mei Langi	29.2
ATM card or credit card given to recipient	1.4

Source: Author's calculation from PINZMS data (from n=72 remitters).

While many factors are likely to affect a remitter's choice of method, three are discussed here: *knowledge, access* and *trust*. These headings provide a way of examining hypotheses about the continued reliance on high transaction costs methods in the New Zealand-Tonga remittance corridor and more broadly throughout the region.

Lack of knowledge

In addition to questions about the most frequently used method of remitting, the sample of Tongan immigrants were also asked about methods they had ever used and methods they *knew about* but had not used. Although a total of 17 methods were covered by the questionnaire, remitters in the PINZMS sample only knew about 3 other methods, on average, besides their most commonly used method. Significantly, only 5.5 per cent of the sample of remitters knew that it

was possible to use an ATM card linked to a New Zealand bank account to send remittances to Tonga.

The most widely known method was Western Union, with which 97 per cent of the remitters were familiar. The next most widely known methods were Melie mei Langi (known about by 63 per cent) and bank drafts or wire transfers through the major trading banks (ANZ and Westpac), which were known about by 62 per cent. In general, there appears to be limited knowledge of the alternatives to the channels used by the respondents. This lack of knowledge of other remittance methods could account for the continued reliance on high-cost methods, especially given the successful advertising that Western Union undertakes in both Tonga and New Zealand.

Lack of access

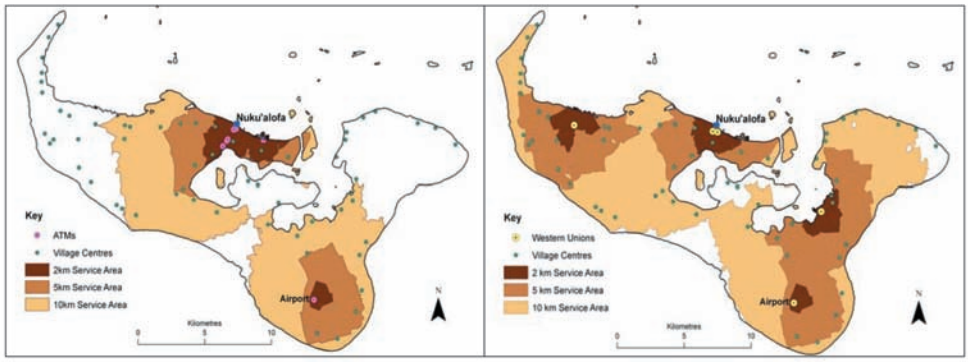
Alternative methods of remitting that have lower transaction costs may not be used if either senders or recipients cannot access them. Lack of access is most likely to affect recipients rather than senders due to the much denser financial infrastructure in New Zealand than in Tonga. In terms of physical access, there are more than 500 New Zealand Post shops in New Zealand where Western Union services can be accessed, a similar number of bank branches and even more ATMs. Moreover, all of the remitters from the sample of Tongan immigrants had bank accounts and 98 per cent of them had ATM cards, so technical access to ATM-based remittance methods is almost universal on the sender side.

However, access for remittance recipients may be more limited and this may be a determining factor in the choice of remittance method. Indeed, Maclellan and Mares (2006) note that an attraction of sending money through Western Union is the ease of access in rural areas and outer islands in the Pacific. A proper understanding of access cannot be obtained without studying the spatial distribution of facilities. Otherwise, a service with many outlets clustered in one location may erroneously seem to be more accessible than one with fewer outlets which are distributed in closer proximity to the population. It is also important to model spatial access using the travel methods that the population relies on rather than assumed methods (such as, as the crow flies straight line distances).

In the light of the above points, the access to ATMs and Western Union outlets was considered for the population on the main island of Tongatapu. The location of each of the eight ATMs (seven of which are located in the capital city of Nuku'alofa) and the five Western Union outlets were geocoded and placed onto a digitized version of the road network to simulate the travel distance that the population would face in reaching their nearest remittance receiving facility. The

spatial distribution of the population is based on the village-level counts from the Tongan census, which should be an adequate proxy for the distribution of remittance recipients, since 78 per cent of households in Tongatapu received remittances in the most recent survey, (Tonga, 2002) and the PINZMS data reveal no spatial patterns in remittance receipts. The resulting service areas for road travel to the nearest remittance-receiving facility are shown in figure 4.

Figure 4. Service areas for ATMs and Western Union outlets on Tongatapu, Tonga



Source: Boe-Gibson (2006).

It is apparent from figure 4 and from table 3, which provides statistics derived from the maps, that even though there are only five Western Union outlets, their combined service areas for the longest specified travel distance of 10 kilometres covered 97 per cent of the population. In contrast, the corresponding coverage for the eight ATMs is only 77 per cent due to their clustering in Nuku'alofa. The greater population coverage for Western Unions is also apparent within a 5 kilometre service area, where they cover 68 per cent of the population versus 53 per cent for ATMs.

In terms of average travel distance rather than population covered in service areas, the population-weighted mean distance by road from village centres to the closest ATM on Tongatapu is 5.91 kilometres, while the mean distance to the nearest Western Union outlet is 3.97 kilometres (see table 3). The median distance is 4.34 kilometres for ATMs and 3.97 kilometres for Western Union outlets. These results suggest that ATMs are about 50 per cent further away than are Western Union outlets for the average person on Tongatapu.

Table 3. Distance to nearest remittance-receiving facility, Tongatapu

	ATM	*Western Union*
Mean distance for road travel (kilometres)	5.91	3.97
Median distance for road travel (kilometres)	4.34	2.74
Percentage of population outside 2 kilometres service area	61	68
Percentage of population outside 5 kilometres service area	47	32
Percentage of population outside 10 kilometres service area	23	3

Source: Author's calculations from Boe-Gibson (2006).

The lack of ATMs outside of Nuku'alofa (and the airport) is not due to a lack of potential sites. There are several branches of the Tonga Development Bank and private sector commercial facilities, such as service stations, that have the cash, electricity, security and telecommunications required. Indeed, when the data in figure 4 are used in a simulation analysis to locate two additional ATMs so that they best service the population, while minimizing travel times, the locations chosen are the same as those where Western Union has already located its outlets outside of Nuku'alofa and the airport. In other words, the Western Union outlets appear to be situated in the optimal locations if the aim is to cover the greatest proportion of the population possible with a given number of outlets. Thus, one reason for the continued reliance on costly methods of sending money from New Zealand to Tonga may be that ATMs in Tonga are geographically less accessible for the recipients than Western Union outlets.

Lack of trust

An even more important reason explaining why high-cost remittance channels like Western Union may be the most popular with remitters is security concerns. Transfers made with Western Union require the remitter to contact the recipient and give them a unique, transaction-specific code in order to obtain the funds from the Western Union outlet. In contrast, the automation provided by ATMs, which gives them a transaction cost advantage, also may cause remitters to feel that they do not have full control of the transactions.

Evidence of these security concerns is found in the responses to questions about the reasons for the choice of remittance method that were asked of a sub-sample of the Tongan immigrants in New Zealand.[9] Three quarters of these

[9] Specifically, those interviewed after February 2006 ($n = 36$). These were recent immigrants, mostly arriving in late 2005, and even within their first few months of residence in New Zealand 24 had already sent remittances back to Tonga; it is this group of 24 whose responses are reported here.

respondents indicated that they would not use ATMs as a method of remitting because they either did not trust the ATM machines in Tonga[10] or they did not trust their relatives to withdraw only the required amount. This second problem could be easily addressed by having an account dedicated to making transfers which contains only a minimum balance and has no way of accessing the account-holder's other funds in New Zealand. The use of similar accounts in other countries is described by Isern, Deshpande and van Doorn (2005). The security changes made by New Zealand banks after the thefts of ATM details by criminal gangs in early 2006 could also help address the first security concern. However, until those in the remitting community are aware of these ways of guarding the security of their funds, they may be likely to continue using more costly methods of sending money that give them the desired degree of control over the transaction.

VI. DISCUSSION AND CONCLUSIONS

The results reported here suggest that the average cost of sending money from New Zealand to Tonga is high by international standards, comprising 15-20 per cent of the amount sent for the median remittance transaction of NZ$ 200. Lower transaction costs (less than 5 per cent) are available if remittances are made using ATM cards, but this method is very rarely used. Instead, a (slight) majority of remitters use Western Union most frequently, followed by Melie mei Langi, which is a local church-run Tongan company. This cost difference between the most popular and the cheapest remittance methods results in a potential loss of remittance funds actually received in Tonga of an amount equivalent to 4 per cent of GDP.

Three possible reasons for the continued reliance on high transaction cost methods have been discussed: *knowledge, access* and *trust*. In terms of *knowledge*, Tongan immigrants in the PINZMS sample do not appear to be aware of many of the alternatives to their own most frequently used method of sending remittances. In terms of *access*, ATM machines in Tongatapu are shown to be less geographically accessible than Western Union outlets. Indeed, the Western Union outlets appear to be situated in the optimal locations to reach the greatest portion of the population with a given number of outlets. In terms of *trust*, remitters appear to have concerns about the security of the ATMs in Tonga and about the security of their money in New Zealand if they provide unrestricted access to their bank account by providing an ATM card to the recipient of the remittances in Tonga.

[10] The survey was done at the same time as a large amount of publicity in New Zealand about a criminal gang in Auckland which modified ATMs so that the ATM card details were revealed and then used to make unauthorized withdrawals. This circumstance may have coloured the results.

Whether these concerns about loss of control over the amount remitted, the security and accessibility of the remittance method and remitters' knowledge of the alternatives can be overcome is a subject for separate research. However, there should be a substantial incentive for innovations along these lines given the very large and potentially avoidable transaction costs that are currently being borne in the New Zealand-Tonga remittance corridor. It should take rather less than 4 per cent of Tongan GDP to inform remitters about alternative methods, to provide additional ATMs and to solve the issues of security and loss of control that will still act as a constraint even if knowledge and access are improved.

Although the empirical results reported in this paper relate only to the New Zealand-Tonga remittance corridor, estimates reported by McKenzie (2007) suggest that transaction costs for remittances from Australia to Fiji, Samoa, Tonga and Vanuatu are at least as high as for those from New Zealand to Tonga. Moreover, transaction costs for sending money from the United States to Tonga are higher than for sending it from New Zealand.[11] Thus, it is likely that the spread of 10 percentage points between the cheapest and the most widely used remittance methods in the New Zealand-Tonga remittance corridor is similar for other remittance corridors into the Pacific. Consequently, the Pacific as a whole (including the immigrant populations in Australia, New Zealand and the United States) may be losing up to US$ 40 million per year because remittances (from all sources) are sent through costly rather than cheap channels. This amount might be justified as the price of the services, such as accessibility, familiarity and security, that are provided by the incumbent banks and money transfer operators. However, it can also be viewed as a rent available to be competed away by lower cost operators who introduce more technologically advanced methods into these remittance corridors while still providing sufficient accessibility and security. Finding ways to achieve these more efficient financial services would be a useful activity for the developed countries in the region, which already control many of the banking services and which have all undertaken considerable financial deregulation and sector rationalization in recent years.

A simple but highly effective starting point with benefits for both Pacific island emigrant remitters (who are mainly in New Zealand, Australia and the United States) and for Pacific island economies would be for a non-governmental organization, a Government or a donor agency to maintain a publicly searchable database of the costs and other characteristics of various remittance providers.

[11] An exception is an Internet-based money transfer product found at www.lkobo.com which has lower transaction costs than most methods of sending money from New Zealand, but no members of the PINZMS samples in either New Zealand or Tonga had any knowledge of this method.

There are at least two examples which could serve as model for such a service. The first is the website www.sendmoneyhome.org, which was created as part of a remittance project of the Department of International Development (DFID) in the United Kingdom. This website has a searchable database that enables would-be remitters to easily compare the services provided by various money transfer operators and banks for transfers from each of 7 immigrant host countries to each of 32 emigrant countries of origin. The fees for both small (£100) and large (£500) transfers are reported along with the net amount that should be received by the recipient and the speed of the transfer. According to DFID (United Kingdom, 2007), the cost of sending money from the United Kingdom to the countries profiled by the www.sendmoneyhome.org website has fallen by 30 per cent, in part due to the greater competition that has resulted from publicizing remittance costs.

The second example is from Profeco, the national consumer protection agency of Mexico, which works with the Mexican consulates in nine United States cities to collect weekly data on the costs of sending money to Mexico. A worksheet is published each week for each city at www.profeco.gob.mx/envio/cuadsacra.asp, showing the cost of sending US$ 300, the amount in pesos that would be received, the amount of time needed for delivery and where the money can be picked up in Mexico. This additional information has increased competition in the market for transfers to Mexico, which has been associated with a decrease in costs (Hernández-Coss, 2005). Moreover, Orozco (2002) shows that the cost of sending money to different countries from the United States correlates with the amount of competition in each market.

These examples show the potential benefits to remittance receiving-countries, along with their remittance-sending emigrants, from efforts like these that help to improve the information available to those people involved in remittance transactions. Greater transparency and choice should lead to lower transaction costs, which should help to improve the development impact of remittances in the Pacific.

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PUMP-SET CLUSTERS IN CHINA: EXPLAINING THE ORGANIZATION OF THE INDUSTRY THAT REVOLUTIONIZED ASIAN AGRICULTURE

Qiuqiong Huang, Scott Rozelle and *Dinghuan Hu**

This paper studies the pump-set industry in rural China, which has led to the widespread diffusion of inexpensive and readily repairable pumping technology in countries such as Bangladesh, Pakistan and Viet Nam. To do so, we first describe the rise of China's pump-set industry, which includes hundreds of small family-owned enterprises that are doing business in a manufacturing cluster located in a single small town in southern China. We then discuss the advantages and disadvantages associated with this type of industrial structure. We conclude by examining the dynamics of the industry that have emerged during the past decade and speculate on future developments of China's pump-set industry and the ways that it may continue to support the further expansion of food production in Asia.

I. INTRODUCTION

The most important development in Asian agriculture during the past 40 years has been the Green Revolution (Pingali, Hossain and Gerpacio, 1997). However, the Green Revolution did not affect all countries the same. For example, while rice yields in India and Indonesia increased by more than 1.5 per cent during the late 1960s and 1970s (and after), those in Bangladesh and Pakistan grew more slowly during the same period (FAO, 2007). The Green Revolution was clearly missing in parts of South and South-East Asia in the 1960s and 1970s. However, beginning in the mid-1980s, something changed. Rice production in Bangladesh suddenly accelerated, increasing by 2.6 per cent annually between 1985 and 2000

* Qiuqiong Huang is an Assistant Professor in the Department of Applied Economics, University of Minnesota. Scott Rozelle is a Professor and Senior Fellow at the Walter H. Shorenstein Asia-Pacific Research Centre in the Freeman Spogli Institute for International studies Stanford University. Dinghuan Hu is a Professor and Senior Researcher at the Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences.

(FAO, 2007). Bangladesh, once a large importer of rice, almost achieved 100 per cent self sufficiency in the 1990s (Baffes and Gautam, 1996). The same thing happened in Pakistan.

Researchers, in their search for the factor that was missing in the earlier phase of the Green Revolution, have found that the rapid diffusion of pumping technology was the reason for the take off of rice production in the 1980s and 1990s (Barker and Molle, 2004; Dawe, 2005; Molle, Shah and Barker, 2003). In Bangladesh, the total number of shallow tubewells increased from 45,000 in the early 1980s to more than 800,000 by the end of 1990s (Bangladesh, 2001). The number of small pumps used in these tubewells grew even more rapidly. More significantly, most of these small pumps were privately owned, as relatively reliable and easily repairable pumps became affordable for small farmers. In 1980, tubewell irrigation accounted for just 15 per cent of irrigated area and surface-water irrigation, but by 2000, this percentage had increased to 71; using low-lift pumps accounted for another 15 per cent (Bangladesh, 2003). The diffusion of pumping technology also revolutionized access to water in other Asian countries (Dawe, 2005; Kikuchi and others, 2003). For example, between 1980 and 2000 the number of pumps in Viet Nam increased from less than 30,000 to more than 800,000 (Barker and Molle, 2004). The number of pumps in Sri Lanka rose to more than 100,000 from almost zero.

While researchers have documented the expansion of pumping technology adoption and studied its impact on crop production, few have studied where these small pumps came from. In fact, other pumps were available in the 1960s and 1970s. In the case of Bangladesh, for example, there were pumps from both India and Japan (Bangladesh, 2007). However, these pumps were not always appropriate for use in the poor, undeveloped countryside. Pumps from India were heavy, difficult to move around and unreliable. Pumps from Japan were lighter and more reliable but also were more expensive than farmers could afford. Additionally, it was not easy to repair Japanese pumps. If they broke down, often they had to be shipped back to Japan for repairs, which was expensive and time-consuming.

So why is it that small, affordable pump sets were quite rare in the 1970s and then suddenly there was a veritable explosion of growth in the 1980s? Two changes over the past two decades may explain the rapid diffusion of cheap pumping technology in some nations. First, many South and South-East Asian countries changed their trade policies and opened their markets to the import of pumps and engines. For example, the Government of Bangladesh began to liberalize agricultural input markets and deregulate the import of irrigation equipment in the mid-1980s (World Bank, 1999). Viet Nam liberalized its markets significantly between the 1970s and 1980s as part of the *doi moi* (reform) program (Pingali and Xuan,

1992). Trade liberalization also has taken place in Pakistan since the late 1980s (Social Policy and Development Centre, 2006). With these changes in trade policies, falling tariffs contributed greatly to lower prices of and easier access to imported irrigation equipment.

Second, market forces in the global pump-set industry may be responsible for an additional, and perhaps even greater, downward shift in the price and availability of appropriate pumping technology. In particular, one of the most important forces appears to be the emergence of China as a major pump producer and exporter in the 1980s.

The expansion of irrigated acreage in rural China that began in the 1960s stimulated the development of the agricultural pump-set industry in China. During the beginning phases, the industry tended to focus on larger pump sets that were used by communes, factories and municipalities. It was not until decollectivization in the early 1980s and the subsequent reduction in the size of farms in China (Lin, 1992) that there was a shift in the demand for smaller pumps. However, although all pump manufacturers were initially state owned, the rapid change in demand was not met by the unresponsive state sector. The industrial reforms allowed small-scale, profit-oriented manufacturers to appear (Oi, 1999). When this happened, the production of small pump sets rose rapidly and the cost of manufacturing pumps and engines in China fell.

The number of pumps used inside China for agriculture increased steadily from zero before the late 1970s to more than 16 million in 2000 (figure 1). During this time, manufacturing capacity in China rose so fast that the country began to export pump sets in the early 1980s. Moreover, although China had exported pump sets before 1985, the export amount started to increase rapidly only after 1986, which coincided with the time when rice production started to rise rapidly in some Asian countries (figure 2).[1] Between 1986 and 1989, the total export amount increased by more than four and half times.[2]

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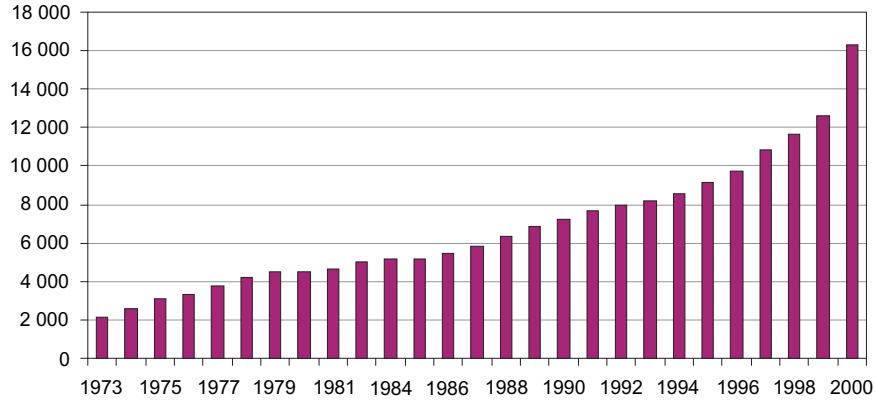
[1] The dollar amount of the export total includes the export of agricultural pumps as well as pumps used in other sectors (industrial or residential). This is because the General Administration of Customs of China was using the Standard International Trade Classification before 1993. The system classifies pumps according to their types (reciprocating pumps, centrifugal pumps or rotary pumps), but it does not further classify each type of pump according to their usage (agricultural, residential or industrial). As a result, we can see the trend of the total export of all types of pumps only in the 1980s. After 1993, the General Administration of Customs of China adopted the Harmonized Commodity Description and Coding System, which classifies commodities according to usage as well as type. Because of this, we are able to obtain the data that describe the export trend for agricultural pumps for the period beginning in 1993 (figure 3).

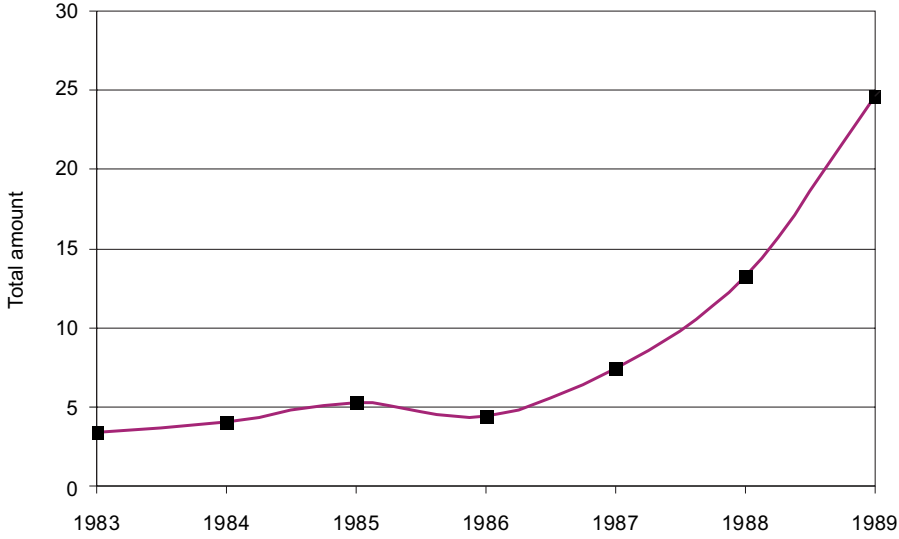
[2] The monetary unit in China is the yuan. For the purposes of this paper, monetary values have been converted into United States dollars, using an exchange rate of US$1= 8 yuan.

Figure 1. Number of pumps for agricultural use in China
(Thousands of units)



Source: Data from China (1973-2000).

Figure 2. Total value of pump exports between 1983 and 1989
(Millions of United States dollars)



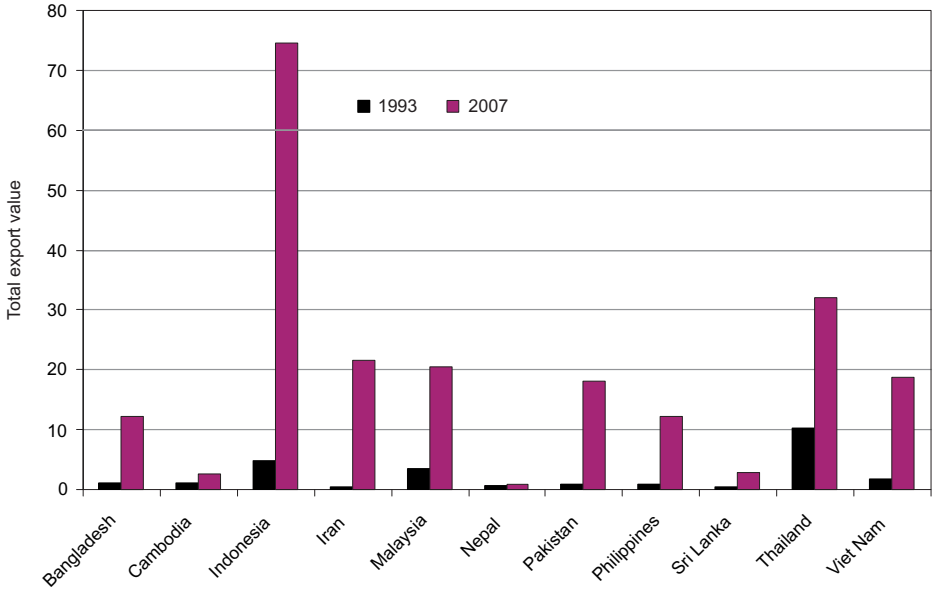
Source: Data from China (1993; 2007).

Note: Dollar amounts are adjusted for inflation, according to the consumer price index.

The rise of China as a pump exporter together with changes in the trade policy led to the increasing availability of affordable and readily repairable pumping technology globally. Because of its comparative advantage in producing light, industrial products, and due to favourable foreign exchange policies, China was able to move into international markets soon after the liberalization of the agricultural input markets in South and South-East Asia. Between 1993 and 2007, the export of agricultural pump sets from China to most Asian countries increased rapidly. The value of the total imports of Chinese pump sets increased by more than six times in Sri Lanka and more than 10 times in Bangladesh, the Philippines and Viet Nam (figure 3). Today Chinese pump sets dominate the market for mechanized irrigation pumps in Bangladesh and other South Asian countries (International Development Enterprises and Winrock International, 2002; Kabir and Ahmmed, 2005). Pump sets from China also have become common in Sri Lanka and Viet Nam (Barker and Molle, 2004; 2005).

Figure 3. Total export value of Chinese agricultural pump sets in 1993 and 2007

(Millions of United States dollars)



Source: Data from China (1973; 2007).

Note: The export value in 2007 does not include exports in December 2007 since the data was not available at the time. Dollar amounts are adjusted for inflation according to the consumer price index.

More importantly, the inexpensive small pump sets from China have made pumping technology affordable to poor farmers in developing countries and given them a tool that is readily repairable. Most of the small pump sets sell for less than $10. In Pakistan, where pump subsidies were removed and free import of Chinese pumps was allowed, pumps sold for 35 to 40 per cent less than in India, where Chinese pumps were still not available (International Water Management Institute, 2002). These pumps, although not of superior quality, were still reasonably reliable for the purpose of shallow tubewell irrigation and low-lift surface-water irrigation. Of equal relevance, because of their less sophisticated nature they were also much more repairable. In fact, the rise of the pump repair industry in Bangladesh—which occured after the large inflow of pumps from China—has been noted to be an important factor is triggering broader rural development. Researchers in India have suggested that removing the pump tariff altogether would be one of the best ways to deliver pumps faster to poor communities in India.

Surprisingly, even though the pump-set industry in China has contributed so significantly to food production growth in South and South-East Asia, almost nothing is known in academic circles about this industry. To our knowledge, there is no study that documents the rise and current status of this source of small pumps and engines and why it has been able to produce such a reasonably reliable and easily repairable product at such an affordable price.

The overall goal of this paper is to increase our understanding of the small-pump-set industry in China. To meet the overall goal, the paper pursues three specific objectives. First, we describe the nature of the small-pump-set industry and explain the organization of the industry in China. Second, we examine the factors that have contributed to or limited its development and success as the supplier of pumps to markets in China and other countries. Finally, we speculate on the future of the pump-set industry and its potential to support the continuing growth of food production in Asia.

In order to achieve our objectives, we will focus on the Daxi pump-set industry cluster. Inside China, Daxi is undisputedly the leader of small-pump-set manufacturing. The Daxi township is located in Zhejiang Province, a coastal province in eastern China that has been undergoing rapid industrial development over the past 25 years (figure 4). Pump manufacturing in Daxi started in the late 1970s and has grown rapidly since then.[3] The Daxi pump-set industry has been

[3] In fact, Daxi was not the first site of the pump-set industry in China. Originally, Fu'an city in Fujian Province was the industry centre. Pump manufacturing in Fu'an actually started 10 years before Daxi broke into the industry. However, over the years, manufacturers in Daxi have out-competed those in Fu'an.

Figure 4. Location of Daxi township

extremely successful. In 2002 the title "Hometown of China's Small Water Pumps", was conferred on Daxi by the China Pump-set Industry Association.

Unfortunately, throughout our studies of Daxi, we have encountered a systematic lack of statistical data. The nature of the industry—tens of thousands of small, unregulated, family-run firms—has made it difficult for the Government's statistical bureau and the local government to collect data on these enterprises. A large share of the pump enterprises in Daxi are small factories that can best be characterized as backyard-like, self-employed firms. These small enterprises operate on an informal basis. Many business owners in Daxi do not register their enterprises with either the local bureau of industry or the local chamber of commerce. Officials from the township government told us that many of the smallest enterprises paid no taxes. If they borrowed money to finance any part of their operations, it was typically from relatives or friends on a handshake. Since these enterprises are outside the formal system of regulation, industrial management and finance, it has been difficult for the local government to keep record of them. In fact, there is not even a complete list of the Daxi enterprises.

In order to learn about the Daxi pump-set industry, we made multiple field trips to Daxi between December 2003 and March 2004.[4] During our field trips, we interviewed the owners and managers of nearly 50 factories. The factories where we conducted interviews spanned the spectrum from extremely small parts

[4] We also visited Fu'an to get a complete picture of the small-pump-set-industry in China.

producers to the largest assembly enterprises in Daxi. Most information in this paper comes from the interviews and observations we made during the field trips.

II. FEATURES OF THE PUMP-SET INDUSTRY IN DAXI

Features of the pumps and engines produced in Daxi

Small-scale electric pump sets are a common product used by agricultural producers and rural consumers in many Asian countries and elsewhere in the world. The pump set consists of two major components: a pump unit and an electric engine (figure 5). Although they come in many sizes, pump sets produced in Daxi are mostly powered by engines that are less than 8 kilowatts. Although lacking in horsepower, these types of pump sets are light enough to be lifted and moved by a single individual. On average, pump sets weigh between 10 and 15 kilograms and are about the size of the small electric home generators commonly found in the United States or other developed countries.

Because of their compact nature and because they are self-contained units (each pump-set unit contains both a pump and an engine), pump sets have many uses in developing countries. Farmers use them for different irrigation operations. In some cases pumps are used to lift water out of canals or rivers for irrigating field crops. In other cases, they are used to deliver water from canals to home gardens and greenhouses. Typically, farmers place the pump unit on the bank of the river or the edge of the shallow well. The pump operator puts an intake hose into the water source. Once connected to an electrical power source, the pump draws water and pushes it out to the field through an outtake hose.

The pumps manufactured in Daxi are highly homogeneous and based on simple technology. Almost all factories there produce centrifugal or submersible pumps. The pumps and engines manufactured by the different factories are similar in terms of size and shape. Although relatively simple in design, functions that these pumps usually serve do not require a sophisticated technology.

The procedure used in manufacturing these small water pumps is also simple, and labour intensive. In fact, local manufacturers designed the earliest pump sets manufactured in Daxi by reverse engineering pumps brought in from elsewhere. At an early stage of the development of the industry (1980s), no enterprises branded its products. It was almost impossible for a consumer to distinguish between these undifferentiated and unbranded pump sets.

Features of the industry in Daxi

Clustering of a large number of enterprises

The most distinctive characteristic of the pump-set industry in Daxi is that it is made up of thousands of pump-related enterprises. An enterprise can be classified as one of two major types: a pump-set assembly plant or a parts supplier. Parts suppliers produce the intermediate inputs that are needed to assemble the pump sets. Assembly plants purchase parts from suppliers to produce the final product, pump sets. It is estimated that there are about 800 pump assembly plants and more than 1,000 parts suppliers in Daxi (Chen, 2004; Wang, Chen and Chen, 2003).

The sheer number of pump enterprises was immediately visible as we drove into Daxi on our first field trip. From the time we entered the outskirts of the town, buildings with signs and posters indicating that the establishments housed a pump assembly plant or parts supplier lined both sides of the street. Along the 2-kilometre main street, almost 90 per cent of the stores sold pumps or pump-related parts. There were some other small shops—grocery stores, pharmacies and clothes shops. However, even some of the convenience stores would have a shelf of daily goods for sale in the front and a pump parts-manufacturing facility in the back of the store or on the second floor.

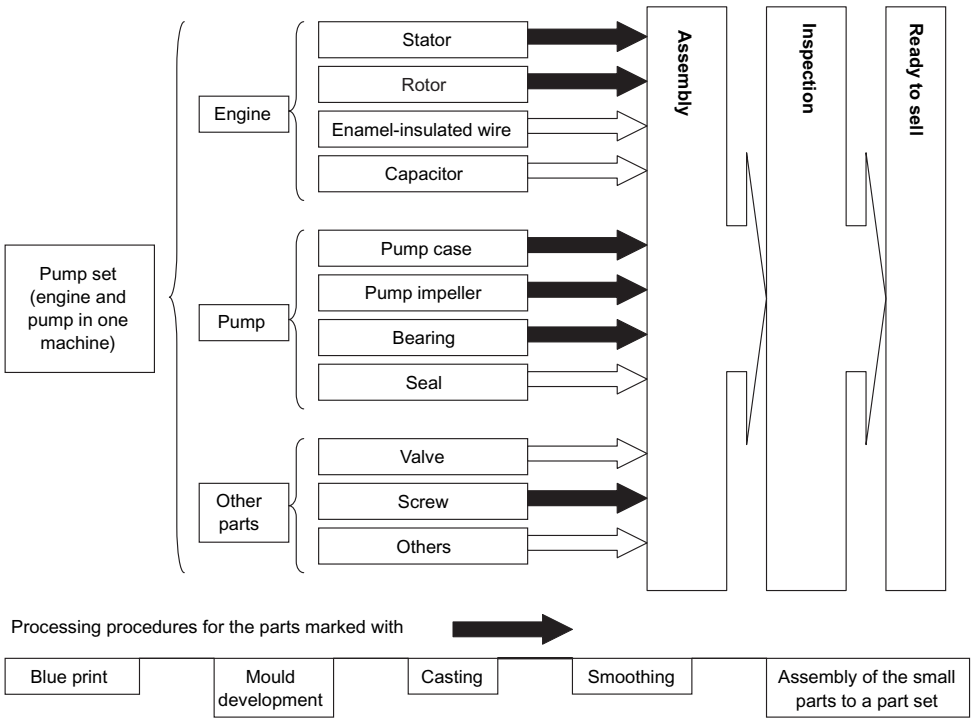
Close physical proximity of enterprises

Since Daxi is a small town of only 129 square kilometres, another distinctive characteristic is that almost all enterprises are located in close physical proximity to one another. The assembly plants and parts suppliers form a veritable cluster of enterprises. Almost all of the enterprises are located inside the town centre. During our field trips, the managers we interviewed at the pump assembly plants told us that they could purchase any given part of their pump sets within a 30-minute travel radius. Indeed, we accompanied an assembler as he was buying parts to complete an order of pumps, and he was able to walk to the three parts suppliers. In making his purchases (he bought a box of bearings, a crate of rotors and 10 plastic casings), our interviewee was never more than 200 meters away from his own plant. The three transactions took less than 45 minutes. Literally, every partner and competitor of every enterprise is a neighbour. When asked about the process of ordering and purchasing parts, the owner of one assembly plant put it best: “Purchasing supplies is just like going to grocery stores; they are just around the corner and there are lots of options to choose from”.

High degree of specialization

The enterprises in the Daxi cluster are highly specialized. Typically, each enterprise produces one particular pump or engine part or provides a single type of service. As shown in figure 5, a pump set requires many parts. During our field trips, simply by looking at the names of the stores along the main street in Daxi, we identified factories that produce each of the parts of a pump-set: Old Chen's Stator Factory, Lucky Rotor Company, Daxi Capacitor, Wang and Sons Enamel-Insulated Wire Enterprise. Looking down the first three lanes and alleys of the west side of town, we could see factories that produced the rest of the parts: pump cases, impellers, bearings, valves and seals. There were even enterprises that produced specialty screws and other hardware for the different types of Daxi pump sets.

Figure 5. Parts of a typical pump



Source: Author's creation.

Producing pump sets also requires a number of different services, provided by other businesses that are equally as specialized. In particular, grouped on the road that radiates out from the centrally located township-government complex are enterprises that design pumps, inspect product quality, book transport logistics or provide marketing information.

Small scale

Given the extraordinarily large number of pump enterprises clustered in such a small town, it is not surprising that most of the factories are small. The production spaces of most of the 800 assembly plants are smaller than one-fifth of a hectare. The parts suppliers are even smaller. In fact, some parts suppliers do not even have a dedicated factory building. Many small enterprises are producing in the backyards of their houses. The main street is lined with several three-story houses, and the first two floors of each are workshops for production. The family and some of the enterprise's workers usually live on the third floor.

In such a small space, of course, enterprises have little need for large labour forces or large volumes of capital. Although we do not have systematic data on Daxi, we do have detailed information on 159 small enterprises in Zhejiang from the 2000 China Rural Land and Labour Survey (China, 2000).[5] These businesses are much like those found in Daxi. According to this survey most self-employed, rural enterprises in China have fewer than 10 employees (table 1). On average, each business hires two wage-earning labourers. In addition, more than 40 per cent of these self-employed businesses have assets of less than $650 (table 2). Therefore, assuming that many of the Daxi enterprises (with the exception of some of the larger ones discussed below) are much like those in the rest of our Zhejiang sample, these enterprises might best be characterized as "nano-enterprises," as opposed to micro enterprises.

[5] The 2000 China Rural Land and Labour Survey (Zhong Guo Nong Cun Geng Di Lao Dong Li Diao Cha) was conducted by one of the authors, Scott Rozelle, jointly with the Centre for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Sciences. The businesses in the survey were randomly selected from a set of 5 counties, 10 townships and 20 villages. The counties, towns, village and households form a small but representative sample of Zhejiang Province. After ranking the counties of Zhejiang by per capita income, one county was chosen from each income percentile (that is, one from the poorest 20 per cent of the counties); one from the second poorest (20-40 percentile); one from the middle income counties (40-60 percentile); one from the second richest (60-80 percentile); and one from the richest (top 20 per cent of Zhejiang counties). A similar procedure was used to choose two towns in each county (one from the richest half of each county's towns and one from the poorest) and to choose villages in each town.

Table 1. Employment distribution of self employed enterprises in Zhejiang Province

Number of employees	*Number of enterprises*	*Percentage*
1	102	64.15
2	31	19.50
3	12	7.55
4	3	1.89
5	2	1.26
8 and above	9	5.67
Total	**159**	**100.00**

Source: Data from China, 2000.

Note: The survey was conducted in late 2000 and collected information on the year 2000. We studied five counties in Zhejiang province, each randomly selected from a different income quintile. In each county, we selected two townships. In each township, we randomly selected one village and then randomly selected 20 households in each village.

Table 2. Joint distribution of total assets and liabilities, self employed enterprises in Zhejiang Province, 2000
(Percentage)

		Liabilities		*Total*
		$650	*> $650*	
	$650	40.8	1.3	42.1
Assets	> $650	37.5	20.4	57.9
Total		**78.3**	**21.7**	**100.0**

Source: Data from China, 2000.

Family owned

One of the unique features about the enterprises in Daxi is that none is state-owned; 100 per cent of the firms are family owned and operated. Even the largest enterprises are owned and controlled by a single family. This is similar to the findings of Cai and others (2007) that studied the overriding pre-eminence of the family enterprise in Zhejiang. Even when enterprises have corporatized, most have only family members as shareholders. Family members also make most of the decisions regarding production, investment, salaries, hiring, firing and enterprise reorganization. Typically, the father (that is, the household head) is the enterprise head; his wife, sons and daughters manage different aspects of the enterprise.

Personal business relationships

Most enterprises in Daxi have developed close relationships with one another. Most business owners are local residents. They know each other personally. Indeed, during our 2004 field trip, we found that in one part of Daxi Township that is known for producing pump cases, a large share of the business owners have the same surnames and belong to the same extended family. While not everyone are close relatives, a large share of the owners of factories or service providing firms were close acquaintances who had grown up together. In many cases, we found that competing suppliers or close collaborators were classmates in school. Most noticeably, during our field trips, it became clear to us that each business owner we interviewed knew most other enterprises well. When we randomly pointed to a firm across the street or referenced an enterprise down the road, the interviewee could almost always tell us who the manager was, what type of pump or parts were produced and, more importantly, what it was like to do business with that enterprise.

Because of this, and because almost all of the key components are produced locally in Daxi, most assembly plants purchase their parts from their neighbours, friends and relatives. Most orders can be placed by a phone call or during an evening stroll down the street or alley. Parts suppliers frequently allow assembly plants to buy on credit. To finalize the supplier credit arrangement, however, there is almost never more than an implicit agreement that the supplier would be paid as soon as the assembler was paid.

While this pump-set cluster in Daxi is almost assuredly unique in the pump-set manufacturing sector worldwide, clustering is not unique in China. In China, clusters have emerged in many other industries. There is a large motorcycle cluster in Chongqing that is made up of more than 200 assemblers and more than 1,000 parts suppliers (Hu, 2003). In southern Jiangsu, printed—circuit board clusters have emerged in the midst of a number of other industrial clusters (Sonobe and Otsuka, 2006).

The pump-set industry in Daxi also shares characteristics with industrial clusters in other countries.[6] For example, the shoe industry in Rio Grande do Sul in Brazil is a super cluster of more than 1,200 shoe manufacturers and hundreds of supporting enterprises (Schmitz, 1995). A knitwear industrial cluster in Tiruppur,

[6] Industrial clusters are defined as concentrations of a large number of enterprises in a single local area and the development of a system of supporting industries that specialize in providing inputs or services (Gordon and McCann, 2000; Porter, 1990).

India has more than 800 small knitted-cotton textiles factories (Chari, 2000). There are clusters of auto parts supply firms in Thailand (Lecler, 2002).

Despite the commonality of clusters in other parts of China and worldwide, it is arguable that Zhejiang Province, where Daxi is located, is one of the largest centres of industrial clustering in world (Zhang, 1999). For example, in Zhili town (a name that translates literally to "weaving town"), a place near Daxi, a clothing manufacturing cluster has formed in which all the factories produce only simply designed cheap pillowcases and children's clothes (Sonobe, Hu and Otsuka, 2002). Within Wenzhou city, several clusters have formed that produce low-voltage electric appliances, and cigarette lighters (Sonobe, Hu and Otsuka, 2004). A footwear industrial cluster consisting of over 4,000 shoemaking factories, 200 leather enterprises, 380 footwear-sole enterprises, 200 footwear-machine manufacturers, 168 footwear-laces factories and a number of other footwear-related industries is also located in Zhejiang province (Huang, Zhang and Zhu, 2007).

III. ADVANTAGES OF THE PUMP-SET-INDUSTRY CLUSTER IN DAXI

The clustering of a large number of small, highly specialized and family-owned enterprises that are physically close to each other has brought a range of advantages. Some of these advantages were identified by Marshall (1920): the formation of labour markets; information spillover among enterprises; and the division and specialization of labour among enterprises. These advantages allowed easy entry to and exit from the industry and rapid expansion of production in its early stages. In addition, there are also several other advantages that fit the reality of Daxi: most players are farmers who have little formal training in engineering, management or marketing. In this section, we analyze some of the factors that have allowed the industry to grow since the early 1980s.

Advantages that facilitate entry and exit of firms as well as expansion of production

Availability of local labour

The clustering of a large number of enterprises in Daxi has created a rich pool of affordable labour. According to the Wenling Bureau of Investment (2005), the local population is far too small to satisfy the demand for labour of the factories. However, the employment opportunities offered by the numerous enterprises in the pump-set cluster have attracted a large number of migrants from nearby provinces. Migrants now account for more than 40 per cent of the population. The constant

flow of unskilled migrants also generates an affordable supply of workers, since migrants are willing to work for a wage that is far below what most local residents would accept. The average wage of an unskilled worker in Daxi is about $3.50 per day. When we asked any of the local residents what they expected to earn, it was always $10 per day or more. Access to a reliable pool of low-cost labour has significantly reduced hiring costs for enterprises that are already in the industry.

With access to such a large pool of labour, search costs are also much lower. When asked how they hire new workers, managers and owners told us that they can usually find new workers within a couple of hours. Because there is such a high concentration of factories, each of which has its own workers, there is always a large cohort of labour looking for work at any given time. A manager in search of a worker can simply ask his current employees or a neighbouring manager if they know of anyone looking for a job. According to our interviews, it is not unusual for the manager to return to the factory (after making the inquiries) to find one or more prospective workers waiting for an interview. At the very longest, the manager has to wait until the next day. If a manager is looking for a worker at the end of a workday, he and his workers ask around that evening. By the next moring, there are usually many prospective workers lined up waiting at the plant.

Rapid spread of technology and marketing information

The close physical proximity of enterprises facilitates the exchange of information and technology. The exchange of information, however, is not orchestrated by any government bureau. From our interviews it is clear that even if an enterprise does not want to share information, it is difficult, if not impossible, to keep secrets in Daxi. Although the industry is undergoing change, enterprises often imitate the new designs of products brought from the large state-owned factories in nearby metropolitan areas such as Shanghai and Hangzhou. As soon as any new product begins to sell well, it is almost immediately ("within several days," according to one small-enterprise owner) copied by a large number of competing enterprises. The same thing happens when a plant receives a new order from a new part of the country or from a new overseas market. Every other plant owner knows who is scaling up and within days or even hours everyone in Daxi knows about the new market or new marketing channel. The rapid spread of information among the enterprises has enabled firms to procure market information and product knowledge without investing heavily in research and development (R&D) or marketing.

Low initial capital investment

Access to hundreds of parts suppliers also significantly reduces the initial capital investment required to start an assembly plant. An assembly plant can purchase all the material inputs needed for manufacturing pumps locally. Instead of investing a great deal in equipment to be able to manufacture parts on its own, an assembly plant has needed only to finance a stock of inventory. In the eyes of many, there is no need to invest in building marketing channels because each assembly plant can use local sales agents. During our interviews, several pioneers in the industry told us that that they needed only to invest a few hundred dollars to rent a room and hire several workers to start their businesses.

Low production costs

In addition to the easy access to the large pool of low-cost labour, access to hundreds of parts suppliers also lowers production costs significantly. Most obviously, the production of one single product lowers the cost of producing each part through economies of scale. In addition, competition among parts suppliers lowers prices of the material inputs. During our interviews, owners of the assembly plants told us that when they purchased parts, one common strategy was to negotiate with several suppliers at the same time. The fierce competition among parts suppliers induces the parts supplier as a group to lower their prices. Being close to parts suppliers also reduces transportation, inventory and other logistic costs.

Low transaction costs

The close personal relationships among Daxi enterprises form business relationships that greatly decrease transaction costs. Since people know each other, they can trust each other. With these localized circles of trust, almost 100 per cent of the transactions among enterprises in Daxi are carried out without a written contract. One of the most obvious manifestations of this trust is that while there are thousands of factories and service enterprises in Daxi, in the phone book there is not one listing for a lawyer. In nearly 50 interviews, not one owner or manager reported any serious conflict that went unresolved. If there are major conflicts, even though there are no legal procedures, the punishment of the party that is at fault is loss of reputation, and it becomes difficult, if not impossible, for that person to do business with others in Daxi. Because reputation in such a setting is so important, one manager told us that no one would ever do anything to endanger one's reputation (implying this is the reason that there are so few unresolved conflicts).

Competitive and cooperative relationships

In such an environment, although most of the assembly plants are competitors (as are parts suppliers at another level), enterprises also cooperate from time to time. For example, when we were in Daxi, one small enterprise secured an order for more than 1,000 pump sets. This order needed to be finished in less than one month. There was no way that the firm could have built that many pump sets in the time available. Therefore, the enterprise owner sub-contracted different parts of the order to other small assembly plants. The manager told us that usually the other party would reciprocate later—either by giving an order back or by lending workers if needed. These low transaction costs and the competitive cooperation that distinguish business relationships in Daxi helped many enterprises develop in their early stages.

Flexibility

In many cases, being small in size also makes enterprises more flexible and more adaptable to changes in market conditions. Although this is changing, entering or exiting the industry has generally been easy for a small enterprise, since it requires little capital investment to enter and there are few sunk costs to consider when exiting. The small nature of the firms also make it easy for firms to adjust their levels of production. For example, when market demand is high, as seen above, assembly plants sometimes sub-contract a share of their orders to other assembly plants. Being small, these factories can start production on short notice.

Advantages in industry accessability

In addition to the advantages that have made it easy for firms in Daxi to enter, exit and expand production efficiently, a number of cluster facets facilitated the industry's rapid early growth by making it easy for individuals—especially those in this relatively underdeveloped area of China—to develop their businesses. Before entering the business, most plant owners were either farmers or working as migrant workers; few plant owners or managers had any advanced training or formal vocational education. Prior to the 1980s, literally none had had any experience in running a business. Hence, in such a case, the simpler business was, the better.

Ease of the organization of production

Also of great importance is the high degree of specialization, which lowers the level of organization skills required. Since Daxi contains the entire spectrum of parts suppliers, each enterprise typically only has to produce a single product

(either the assembled pump set or one of the parts in the pump set). Since there is such a high degree of specialization, the production process for each is also simple from an engineering point of view. For example, there is almost no need to hire different types of specialized workers to produce the different parts. Additionally, small enterprises do not require extremely complex management skills to organize production activities.

The simple nature of the technology

Small-water-pump manufacturing, although labour intensive, does not require a lot of skill or technical knowledge. The low technical content in the manufacturing process of pumps makes it relatively easy for newcomers—usually rural residents from surrounding areas—to enter the industry. Technological changes, can be easily adopted by enterprises. This is the case in Daxi. In interview after interview, we were told that although at first the manufacturing process seemed difficult to the new operators and managers, all had quickly been able to master the skills involved.

Low requirements for marketing

The production of undifferentiated products also has tended to make it easier to target consumers and requires less sophisticated (and less expensive) marketing. There has been no need to conduct marketing research to develop or hold niche markets. With such products, retail buyers have cared most about price. There are few expectations about other characteristics of the product, such as a manufacturer guarantee or the convenience of use. The homogeneity of products has also enabled all the enterprises in the industry to compete as a whole with enterprises outside the cluster.

Strong incentives

Although we raise this last, it is not the least important of the features of the Daxi pump-set cluster. The family nature of businesses in the town provides the key figures in each firm with strong incentives to work hard and make careful and timely decisions. In their paper on family enterprises in China, Cai and others (2007) argue that a significant share of the rise of China as a manufacturing giant is attributable to family enterprises. When managers and key employees are members of the family who owns the enterprise, there is a gain in productivity. In these cases the incentives are strong in that such employees share in the profits of the enterprise; as such, they require relatively little monitoring.

The industrial strategy of clustering in the pump-set industry in Daxi—at least at this stage of development—has succeeded. Thousands of parts suppliers and pump assemblers have produced literally millions of small and cheap pumps. On average, Daxi pumps were and continue to be about 30 per cent cheaper than similar pumps produced in other parts of China. This low price has made the pump-set industry highly competitive in the domestic market. Pumps produced in Daxi account for more than half the market share in the domestic small-pump market (Zhu, 2002). Daxi almost certainly exported more of these small pumps than any other single (or cluster of) factories in the rest of the world. Because of this, to an extent never possible before, these cheap small pumps offer an affordable irrigation option to farmers from China and other developing countries. As the owners and managers of the Daxi pump-set assembly plants who we interviewed told us, their products were exported to many South-East and South Asian countries. The value of the exported pump sets was more than $30 million per year in the early 2000s. Because of the pumps and engines imported from China, the rice economies in many countries of South-East and South Asia have developed rapidly over the past two decades (Barker and Molle, 2004).

IV. DISADVANTAGES OF THE PUMP-SET INDUSTRY CLUSTER IN DAXI

In this section, we examine the factors that limit the further development of the industry. As discussed in the previous section, the organization of the Daxi pump-set industry was quite successful in its earlier stages of development. Its success depended in part on a number of the features of the pump-set technology and the organization of the industry in Daxi. However, for a number of reasons, Daxi also faced (and continues to face) a number of disadvantages. Although they may not have posed high barriers in the earlier stages of development, it is possible that, in the longer run, some of these disadvantages could restrict the growth of the industry in Daxi. Ironically, as we will see, some of the factors that bestowed advantages on the industry in its earlier phases have the potential of becoming disadvantages as the industry matures and as China develops.

Weak intellectual property rights protection and limited R&D investment

Despite the advantages that enterprises enjoy from the clustering of enterprises, this structure has generated strong disincentives to invest in R&D. During our interviews we sought out the owners and managers of enterprises that were considered leaders in the industry because they had taken initiatives in developing new products or investing in differentiating their current products. All

these innovators told us the same story. As soon as their enterprises develop a new way of manufacturing or assembling a pump set or in any way made changes to differentiate their products from those of their competitors, innovations are almost instantaneously imitated by their neighbours. In many cases the innovators told us that others often begin copying their new product before it is even introduced to the market.

Given the nature of the cluster, technology passes from one enterprise to another in many ways—most of them simple and direct, since the imitating enterprises are often just next door. Sometimes information leaks out through exchanges of workers. Sometimes information gets out accidentally through the usual daily interactions. In one case the wife of an innovator passed the new breakthrough to a competitor (the nephew of the innovator) after an hour of evening gossip with the nephew's wife.

Although the high degree of specialization makes entry into the industry easy since it reduces the required level of initial capital investment (as well as production costs), the reliance on a large number of parts suppliers outside an enterprise (which is called outsourcing in Daxi) also increases the probability that any new technological innovation will be stolen. New technologies are often passed on by those involved in the design service sector. In the creation of pump sets, one of the most technical steps is the design and manufacture of the moulds for some important parts (such as the impellor). The mould determines the shape of the parts, and is one of the key determinants of quality. When an assembly plant designs a pump, it must hire an enterprise to design moulds for key parts that the parts supplier can use to manufacture the parts. Few assembly plants have the capacity to develop moulds by themselves. Consequently, even innovative assembly plants need to provide information on the new technologies to designers and mould developers. Even though the assembly plants plead with the mould designers to keep the design secret, according to the assemblers, new secrets are never secrets for long. In many cases the interviewees said that the leaks could have only come from the design enterprise. Sometimes design employees sold the design to a competitor assembly plant. In other cases assembly plants bribed design company engineers to leak the new product. Whatever the channel, design enterprises are notoriously porous.

As a result of the poor protection of technology, there has been little motivation for enterprises to invest seriously in refining the manufacturing process or upgrading the quality of a pump set as a way to gain a competitive edge in the market. Even when a change is made to improve the pump set and the change is protected, imitators are able to mimic the outside of the pump. This has made it difficult for buyers of pump sets to distinguish between the old and new styles of

pumps. Leading enterprises quickly lose their chances to charge a price premium for the improved product. Because buyers can not tell which product is better, demand for improved products has grown sluggishly, if at all.

Few measures can be taken to protect a brand. In some cases, enterprises even suffer losses in their attempt to stay a step ahead of imitation from other factories. For example, the Jinlong (or Golden Dragon) Water Pump Factory—one of the earliest innovators in terms of creating materials that made their pumps last longer and perform more reliably—had to change its brand name every several years. The problem was that as soon as it started making above-average profits on its new variety of pump sets, scores of small assembly plants began manufacturing gold coloured pump sets with dragon patterns on the outside of the pump. When orders began to fall and complaints rose from buyers that thought they were buying the premium pump sets, the enterprise changed its name to Crocodile. Within months, numerous small assembly plants were painting their pump sets green and changed the dragon pattern to crocodile patterns. In 2001 the enterprise changed its name again to Pump King. Each change of name, according to the owner, cost the enterprise tens of thousands of dollars and a lot of effort. In addition, each time the enterprise changed its brand, it lost some of its old customers because they had trouble locating the products.

Poor quality control

In the process of outsourcing, since it is difficult for the pump assembly plant to monitor the production of parts, an enterprise loses much of its control over parts quality. Because of competitive pressures, parts suppliers are always looking for a way to shave fractions of pennies off their cost bases and often compromise quality if they can get away with it. A pump made with low quality parts, of course, is low quality itself. During our interviews, we heard repeated complaints from the pump assembly factories about the reliability of their parts suppliers.

General lack of management expertise

Although the family-owned nature of enterprises provides strong incentives, it also brings with it limitations. A family's members do not always have the range of skills needed to run a complex enterprise. In several of our interviews, we were told that the greatest limitation to expanding the size and profitability of the enterprise was that there was no member of the family that understood a specific aspect of the business: e.g., engineering, financing, management or marketing. Hiring professional managers did not work well, partly due to the family-owned

nature of the enterprises. Because families in the area are tightly knit, managers that are hired often feel like outsiders and believe they are not treated fairly. Family business owners complained that in many cases they invested a lot to train a manager, who, because of the low start-up costs, took the technology and skills of the family business and started up a competitive enterprise. Such ex-employees would often also steal workers and customers.

Vulnerability to market shocks and lack of access to bank loans

Although being small fosters flexiblity, it also imposes costs. Above all, the small size of Daxi enterprises makes them vulnerable to unexpected changes in market conditions. Ups and downs in the market easily force enterprises out of business. For example, during our field visits, we learned that quite a few small pump assembly plants went out of business because the price of copper (the key input in producing insulated wires) rose significantly. Furthermore, the small size of many of the enterprises limits their ability to expand production or upgrade quality. Small enterprises are less likely to invest in longer term projects that may be risky in the short term. Additionally, the small size of enterprises also diminishes the chance of enterprises to apply for and receive bank loans. As a result, enterprises often do not have enough capital to invest in upgrading equipment or hiring more or higher skilled workers. As a result, most small enterprises have stayed small for most of the past two decades.

Low value-added and low quality products

Because of the limitations on the ability to expand production or upgrade the quality of the product, most enterprises have stayed small and continue to manufacture basic and undifferentiated pump sets. Simple technology has made it difficult to create a high value-added product. The fierce competition has driven profit margins down to just about zero, covering only the costs of land, labour and capital. The homogeneity of products has meant that every pump enterprise is competing in the exact same market. In order to increase their profit margins (or according to the many interviewees: “to keep from losing money”), many assembly plants and parts factories have opted to use inferior materials for inputs and parts. The enterprises have not invested in maintaining their equipment; most do not have the resources. Most of the factories we visited were still using old machines even though the precision of the equipment had deteriorated over time. Several of these factories had eliminated all pre-market testing of their assembled pumps. Quality, according to our interviews, had declined sharply.

Because of the extreme cost pressures, the pump assemblers have not been able to respond to the needs of their customers. Partly due to the low quality of their products, at the time of our visit no pump assembly plant in Daxi offered after-sale service. Warranty programs have been discontinued. The township government official told us that the industry's low quality has become a barrier to its further development. He said plain and simply that, although inexpensive, "Daxi pump sets have become a symbol for inferior quality manufacturing." The Bureau of Technical Supervision in Zhejiang Province named Daxi as a "Zhejiang Province Regional Quality Problem" town. In some sense, part of the industry is in a low-level equilibrium trap: low profits have led to low quality; low quality limits profitability; and weak intellectual property protection reduces the willingness of enterprises to invest in further development of new designs or new plants with old designs.[7]

V. THE DYNAMICS OF THE DEVELOPMENT OF THE INDUSTRY

Despite the early success that was, in large part, fuelled by a number of special advantages that were inherent to Daxi and those involved with the industry, as seen in the previous section the remaining disadvantages may be putting the future of the industrial cluster in doubt. However, it is possible that a new dynamic is emerging. In the midst of this race to the bottom, a group of elite firms has emerged. The four largest and most prominent are SHIMGE, Dayuan, Dafu and Taifu. These elite firms have adopted and continue to develop new strategies to expand their production and upgrade the quality of their products. The development of these elite firms can be divided into two phases: the quantity expansion phase before 1998 and the quality upgrade phase after 1998. In fact, emergence of this trend of quality upgrading may be seen in the later development stages of other industrial clusters in rural China (Sonobe, Hu and Otuska, 2004).

[7] Although low quality has increasingly become a problem in the development of the industry in the twenty-first century, it does not discredit the contributions of the small pumps in the past. These pumps, although not of superior quality, are reasonably reliable for the purpose of shallow tubewell irrigation or low-lift surface water irrigation. These simple functions do not require high-quality irrigation equipment. Partly due to the fact that they are relatively low quality (when compared to pumps from Japan), these pumps are affordable. Even relatively poor farmers in developing nations, such as Bangladesh and Viet Nam, are able to access enough capital to buy the pumps. Many of the small pump sets generally sell for less than $10. Because of the low prices, almost all small pumps are privately owned. Furthermore, because of their less sophisticated nature, they are also much more repairable.

Before 1998, the elite firms focused on increasing their production capacity by investing in equipment and facilities and reforming production processes. For example, the Dayuan company invested more than $1.3 million in purchasing equipment and buildings. In fact, the owner of Dayuan used the profits from his transportation business in Guangzhou to finance his expansion in pump production capacity. The elite firms also invested in the creation of more streamlined assembly lines, which enhanced their production efficiency and reduced their labour costs. After making such investments, the production capacity of these elite firms rose. For example, the production of Taifu increased from only 500 pumps in 1985 to more than 10,000 annually in the early 1990s.

With the larger production capacity, the elite firms gradually began the process of vertically integrating their operations. Whereas in the past they would purchase all their parts from surrounding suppliers, the elite firms have now begun to produce more of their own parts—especially the key ones. The firms also found that while their costs may have risen, by producing their own parts, they are able to control the quality more closely and guard their technology better.

Although the elite firms started to reform their businesses in the early 1990s, significant changes to the industry did not take place until after 1998, when the Daxi township government signed on to a quality rectification plan. This action was initiated by the provincial government to tackle the quality problems of several different commodities in Zhejiang province (e.g., low-voltage electrical appliances, footwear, etc.). Although the provincial government did not design the plan to target Daxi specifically, most firms in the pump-set industry were hit hard. The Daxi township government started with submersible pumps. As the name suggests, the entire pump-set is placed fully in water during operations and is supposed to be completely waterproof. Because of a number of accidents caused by the use of low-quality products, the government began to crack down on the quality problem. Production licenses became mandatory before a firm was allowed to produce submersible pumps. The township government put a lot of effort into implementing and monitoring the licensing regulation. Many enterprises had to stop production for a while or even exit the industry because they could not reach the quality standards specified in the approval of production licenses. New firms also found it much more difficult to enter the industry than before. The number of pump enterprises assembling submersible pumps fell by more than half during this period. The growth of many enterprises has been stagnant since then.

The quality rectification, however, did not impose negative effects on elite firms such as Dafu and SHIMGE since they were able to meet the production-license requirements. They also learned other lessons. For example, we were told during interviews that the rectification campaign increased their awareness of the

importance of quality. For the first time since the mid-1980s, the elite firms began to invest heavily in quality inspection and the equipment that they needed to maintain quality. Quality control facilities are crucial in helping manufacturers of metallurgy products control product quality. For example, the investment into equipment by one of the elite firms was less than $26,000 in 1989. By the late 1990s, the firm increased expenditures to more than $0.8 million. Since so few firms originally inspected the quality of their products, there were no trained inspectors. Therefore, elite firms had to train their own technicians to operate and maintain the quality-inspecting equipment.

After upgrading the quality of their products, the elite firms began to signal the superior quality of their products by getting their products certified. Most elite firms obtained national certificates under programmes such as Zhejiang Province Famous Trademarks or Zhejiang Province Excellent Products. These certificates are issued by quasi-governmental bureaus whose objective is to promote higher-quality manufacturing in China. Some elite firms have even obtained quality certificates that are internationally recognized. SHIMGE, Taifu and Duyuan are all now ISO9001 and ISO9002 certified. SHIMGE also introduced an environmental management system that helps it meet the ISO 14001 standard.

With the new and safer environment, the elite firms also started to invest in R&D. They realized that as long as their products were based on simple and easily adoptable technology, they could be easily copied and would never be able to be sold as high value-added commodities. The best way to prevent imitation, according to the manager of one firm, was to produce products that were technically more difficult. To do so, these elite firms began to hire their own engineers and technicians from colleges and research institutes such as Hangzhou Machine and Electric Research Institute in the School of Mechatronical Engineering at Hangzhou Dianzi University and Nanjing Technology University. They also hired employees with particular skills away from large State-owned enterprises. According to the manager of SHIMGE, out of their 600 employees, more than 150 are well-trained technicians.

Recently there has been a trend to hire even more expertise. In 2004, SHIMGE hired an engineering professor, Dr. Tun Lin from Jiangsu University, who is the leading researcher in pump technology. Dr. Lin comes to the SHIMGE factory in Daxi several times each year to work on developing new technology.

The investment in R&D has paid off for the elite firms. With its high-profile R&D team, SHIMGE became the leading producer of larger pumps that are used for deeper wells, a market in which there has been less competition and higher profits. The company also produced the first screw pump, a type of pump that

can be used to extract water from more than 80 meters below the ground surface. The screw pump is more energy efficient. Deep water submersibles and submersible screw pumps are much more difficult to copy than the smaller pumps sets that can be used only in shallow wells or for lifting surface water. In fact, during our field trips, we saw only a few enterprises that produced and sold the more technical products.

Furthermore, as the quality of the product rose, the elite firms started to develop new marketing strategies, including branding and advertising. To differentiate their products from those in the traditional segment of the industry, the elite firms have begun to mark each part of their pump with their trademark. These firms now advertise on local agricultural and rural radio stations. They have begun to put up billboards on highways. Two firms have contracted with a national advertiser and have placed commercials that air nationally and internationally. For example, Dayuan spent $430,000 on advertising on the central TV station in China (CCTV), about 60 per cent of which was on the national channel (CCTV1) and the rest on the international channel (CCTV4).

The importance of the changes of strategy and new directions of the industry can be seen clearly in the relative performance of the elite firms as compared to the undifferentiated firms. The elite firms that had the business foresight to upgrade the quality of their products have continued to grow. For example, SHIMGE produced only around 7,000 pump sets annually in 1989. Due to rapid expansion, since 2000, it has been producing more than 500,000 units annually. When SHIMGE was first established in 1989, it purchased 100 per cent of its parts from outside suppliers. The share of outsourced parts fell to 20 per cent in 1995. Today, SHIMGE produces 100 per cent of its parts internally. The production capacity of Taifu increased from 500 pumps in the late 1980s to more than half a million units in 2003.

We interviewed several enterprises that started at the same time as the elite firms but stayed small. These firms invariably have been able to produce only low-quality pumps during the past 20 years. In fact, one of the interviewees—the owner of Changhong told us that the owner of SHIMGE had advised him more than a decade ago to upgrade his firm's quality. He did not follow the advice. He now laments the fact that it is too late, and that he missed the best opportunities.

Clearly, a revolution is taking place, with the rise of the elite large firms and the reduction in the number of small enterprises. During our last visit, many small firms recognized that their industry was going through a transformation. Smaller firms were hoping that their businesses could last another 10 years. Medium-sized to large firms were looking for ways to expand and join the elite

firms. The largest firms were hoping that they could move out of their old cluster-bound, low-level equilibrium trap. They were planning new strategies to modernize further and keep their competitive edge. It is clear that the race is not over.

VI. CONCLUSION

Without the access to cheap pumping technology, farmers in South and South-East Asia would not have been able to take advantage of the miracles of the Green Revolution. In this paper we have traced the origins of the small pump sets that revolutionized agriculture in Asia. Our analysis has taken us back to both the geographical source of the pump sets and their economic beginnings. Specifically, we have documented the story of how China became the supplier of the developing world's small pump sets. In its metamorphosis from a Socialist country that as recently as the 1970s restricted private entrepreneurship or any pursuit of profits to one of the world's most unfettered, capitalistic industrial clusters in the reform era, China has been able to supply the missing link for many farmers who need a source of power to lift water from wells, canals and rivers to irrigate their crops at an affordable price.

Several lessons here may be worth studying. First, when left to itself, a country with a motivated, entrepreneurial population can organize its own industry to supply key products that are in demand. The formation of industrial clusters, including that of pump sets, were not directed by any government agency but emerged on their own. In doing so, the economic activity was a good fit for the features of the local economy and its actors, which provided a competitive edge. Hundreds of small firms clustered together so they could tap the economies of scale enjoyed by large factories without the need for the capital input, risk-coping assistance or industrial organizations that often act as barriers for developing countries that are trying to industrialize. While the strategy was dependent on preconditions in China (e.g., sources of liquidity and a minimum level of technological expertise) and thus may not be universally replicable, in many parts of the world these conditions do apply. China has shown that small rural firms, when allowed to emerge free of government interference and to become competitive, can make inroads into world markets while at the same time provide employment and profits for the domestic economy.

Second, it has also become clear that, in the long run, such simple forms of technologies also have a number of disadvantages. While close interaction among firms facilitates the flow of information, inputs and managerial skills, it can also hamper investment in R&D and discourage the development of quality products

and higher value-added manufacturing and services. If this goes unchecked, industrial clusters run the risk of entering a "race to the bottom." It is perhaps at this point in the development of industries that governments may want to encourage the development of branding and research. If effective ways are created, it has been shown that out of the same industrial forces that created the intense competition among microfirms, large, respectable firms with coherent strategies for R&D quality improvement and branding can emerge.

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VOLUNTARY CARBON TRADING: POTENTIAL FOR COMMUNITY FORESTRY PROJECTS IN INDIA

Rohit Jindal, John Kerr and *Shailesh Nagar**

Voluntary carbon markets, such as the Chicago Climate Exchange (CCX), were worth $90 million in 2006. This paper finds that community forestry interventions of three organizations in India are eligible to sell carbon sequestration credits on CCX. Their combined annual sequestration potential is 104,427 tons of carbon dioxide (tCO_2), worth $417,708 at 2007 prices. Although this value will be difficult to realize immediately, it indicates the potential for carbon sequestration to raise rural incomes in India. These benefits can be actualized by first linking small pilot projects with CCX and then scaling up operations. Projects will also need to reduce transaction costs to raise the shares of carbon revenue that farmers receive. The diversion of land to raise tree crops needs to be balanced with food security concerns. A potentially viable approach would be to take up carbon plantations on common lands with concerned agencies acting as a liaison between farmer groups and the market.

* Rohit Jindal is a doctoral candidate at the Department of Community, Agriculture, Recreation, and Resource Studies, Michigan State University, United States. John Kerr is Associate Professor, Department of Community, Agriculture, Recreation, and Resource Studies, Michigan State University. Shailesh Nagar is a freelance consultant based in New Delhi.

The authors would like to thank the Michigan Agricultural Experiment Station for partially funding this study. Thanks are also due to the respective staff members at Seva Mandir, the Foundation for Ecological Security and the International Small Group and Tree Planting Program for providing field support and to those who participated in the carbon stakeholder workshop in Udaipur, India. The authors also express gratitude to the villagers of Chitrawas, Rawach, and Nayakheda, India for sharing their views on the implications of a carbon payment system.

I. INTRODUCTION

This paper looks at the potential for community forestry projects in India to sell carbon sequestration credits[1] on voluntary carbon markets. Ever since the ratification of the Kyoto Protocol[2] in 2005, there has been an expectation that forestry projects in developing countries could improve local incomes by selling carbon sequestration credits to industrialized countries.[3] However, the slow approval of forestry projects by the Protocol's Executive Board has meant that the Kyoto-based market for carbon sequestration credits has hardly taken off (Murphy, 2006).[4] Instead, voluntary carbon markets have emerged in many parts of the world.

Voluntary carbon markets pertain to trading in all carbon offsets that are not required by regulation. Unlike markets, such as the European Union Emission Trading Scheme, that exist to support compliance with legislated carbon emissions caps, voluntary markets represent voluntary attempts by individuals and organizations to reduce their carbon emissions (Bayon, Hawa and Hamilton, 2007). These markets have shown impressive growth in recent years. They grew 200 per cent by volume between 2005 and 2006 and are now valued at more than $90 million (Hamilton and others, 2007). One important voluntary market operates through the United States-based Chicago Climate Exchange (CCX). CCX is a voluntary cap-and-trade programme that requires its members (businesses and other large entities such as Ford, DuPont, IBM, Motorola and the city of Chicago) to reduce their carbon emissions by 1 per cent every year starting from their average annual emissions for the period 1998-2001. Members that cannot reduce their own emissions can buy carbon credits from others. Since its inception in 2003, CCX has traded 26.3 million tons of carbon dioxide (tCO_2), including 10.3 million tCO_2 worth $36.1 million transacted in 2006 alone, making it one of the world's largest carbon markets (see table 1). A key point to note is that voluntary carbon markets, including CCX, have sourced a significant proportion of their carbon credits from forestry projects that sequester carbon (Hamilton and

[1] Carbon credits or offsets are units of carbon dioxide (CO_2) that forests absorb (or sequester) from the atmosphere.

[2] FCCC/CP/1997/7/Add. 1, decision 1/CP. 3, annex.

[3] The Protocol requires industrialized countries to reduce their carbon emissions by an average of 5 per cent by 2012. Under its Clean Development Mechanism, developing countries can sell carbon sequestered by their forests to industrialized countries as carbon credits or carbon offsets (UNEP, 2004).

[4] Under the Kyoto Protocol, all forestry practices that are eligible to generate carbon sequestration credits are part for what is called the LULUCF sector, i.e. land use, land use change and forestry.

Table 1. Global status of voluntary carbon markets, 2006

	Volume (Millions of tCO_2)	*Value (Millions of United States dollars)*
Over-the-counter trades[a]	13.4	54.9
Chicago Climate Exchange	10.3	36.1
Total voluntary carbon market	**23.7**	**91.0**

Source: Hamilton and others, 2007; www.chicagoclimatex.com

[a] Over-the-counter, or project-based trades, are not undertaken through an exchange but rather on the basis of an agreement between a single buyer and a single seller. The trades of the International Small Group and Tree Planting Program (TIST) are over-the-counter trades.

others, 2007). Accordingly, carbon sequestration for international voluntary carbon markets could be a viable income-earning opportunity for community forestry projects.

Most researchers and policymakers in India and elsewhere appear to be unaware of the growth of the voluntary carbon sector. While there are several studies that look at the potential for selling carbon credits under the Kyoto Protocol's Clean Development Mechanism (CDM) (e.g. Aune, Alemu and Gautam, 2005; Ravindranath, Pandey and others, 2001), there are hardly any that explore the feasibility of linking forestry projects with CCX or any other voluntary market. The aim of this paper is to fill this gap in the literature by examining how forestry projects can sell carbon sequestration credits on voluntary markets. Although the paper focuses on India, the discussion here is also relevant for community forestry projects in other developing countries.

To preserves clarity in discussions and with a view towards practical application, the paper mainly considers the case for selling carbon credits on CCX. Where necessary, it also considers broader issues and areas of concern. It is based on our field research with three prominent organizations in India: Seva Mandir, the Foundation for Ecological Security (FES) and the International Small Group and Tree Planting Program (TIST). These organizations provide a diverse institutional backdrop for the study. Seva Mandir and FES are non-governmental organizations (NGOs) that implement forestry activities but have not traded any carbon credits. TIST, on the other hand, is one of the few organizations in India to have successfully sold forest-based sequestration credits. We compare and contrast the experiences of the three organizations to draw lessons for others who wish to enter carbon markets. What kinds of forestry projects are eligible to sell carbon credits? What important rules govern such sales? We also focus on the economic

benefits of carbon trading by estimating additional income that local farmers can make from selling carbon credits. Finally, we look at the policy implications of important issues such as leakage, permanence and transaction costs that affect the sustainability of carbon sequestration projects.

II. DATA AND METHODS

This study draws on project records of the three community forestry programmes in India and interviews with both project officials and villagers participating in the programmes. Data include the areas of tree plantations for all projects and the actual number of trees per hectare in areas working with TIST. For FES and Seva Mandir, project records indicate the areas of community forestry plantations but tree growth must be estimated based on typical growth rates in the study area. Potential income from carbon sequestration is then estimated based on conversion to carbon and prevailing CCX prices.

Interviews with project officials and villagers yielded qualitative data regarding the three community forestry programmes and perceptions of issues that might arise if efforts are made to sell carbon credits on CCX. The study was exploratory, seeking to gain an initial understanding of these key issues. As such, it was conducted through informal interviews with no formal sampling.

The context: community forestry initiatives in India

Seva Mandir, FES, and TIST all implement various kinds of forestry activities in India. The common aim of these activities is to strengthen rural livelihoods by improving the productivity of local resources.

Seva Mandir works in more than 580 villages of the Udaipur and Rajsamand districts in south Rajasthan to reverse the ecological degradation of village common lands,[5] which are often overexploited and unable to fulfil local needs (Seva Mandir, 2006). Seva Mandir pursues several approaches to restore productivity, including:

[5] Apart from privately owned lands, there exist several kinds of common lands in India: revenue lands (owned by the Government Revenue Department), forest lands (owned by the State Forest Department) and *panchayat* grazing lands (owned by the Revenue Department, but the *village panchayats* are the custodians).

- *Pasture land development* on *panchayat* grazing lands. *A panchayat* is a democratically elected village level government in India. Such *panchayats* exist all over India and, apart from being responsible for local level administration, they are also custodians of certain kinds of common lands, particularly grazing lands. Each village's project management institution[6] obtains permission from the local *panchayat* to manage the land by planting trees to create tree plantations and protecting them from open grazing. Protection also helps in the regeneration of existing root stock that further improves the tree density on such lands. Villagers can collect grass, dried tree branches, and bamboo shoots through manual harvesting.

- *Joint forest management* of forest lands, which allows local communities to manage forest lands under the relevant 1991 guidelines of Indian state governments. Seva Mandir assists village institutions in obtaining permission from the Forest Department of their respective state before constructing a boundary wall and creating tree plantations by adding to existing forests. Joint forest management regulations stipulate that villagers can harvest grass and other non-timber forest products from the forest land in addition to receiving a fixed share of timber revenues if the mature trees are harvested at any time.

- *Plantations on private lands* under which small and marginal farmers receive financial and technical support for tree plantations on small patches of land that are usually less than 1 hectare in size.

The Foundation for Ecological Security is working to restore about 73,000 hectares of degraded lands in ecologically fragile areas across seven states in India.[7] The target beneficiaries are about 100,000 rural households, 80 per cent of which belong to the landless, small or marginal farmer categories. Through its work, the foundation has been able to generate more than 4.4 million days of employment for these poor households (Foundation for Ecological Security, 2005). Its approaches include the following:

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[6] In each village where it works, Seva Mandir helps establish a village-level institution to help manage its projects. This management institution is elected by the local people but is entirely separate from the *panchayat*. Acting as an apex body to oversee all the projects, it can appoint committees to deal with individual projects or the management of specific natural resources.

[7] The states concerned are Gujarat, Rajasthan, Orissa, Madhya Pradesh, Andhra Pradesh, Karnataka and Uttaranchal.

- *Regeneration of panchayat grazing lands and revenue wastelands* through plantation and protection activities. Village communities obtain permission from respective *panchayats* or from the Revenue Department (in the case of revenue wastelands) before initiating the work. Villagers have access to all non-timber forest products from regenerated sites.

- *Joint forest management* activities carried out by the Foundation for Ecological Security are similar to those of Seva Mandir, except that the Foundation works in multiple agro-ecological zones in India while Seva Mandir works in only one region.

- *Watershed development*[8] consists of several different interventions, such as soil and moisture conservation, afforestation and construction of water harvesting structures on contiguous patches of land that include both private and common lands.

Unlike Seva Mandir, the Foundation does not normally work with individual farmers on private lands and its groups tend to be somewhat larger than those in Seva Mandir projects. Also, while Seva Mandir's activity is limited to new afforestation, the Foundation also works to regenerate existing forested lands.

To gather data from officials and farmers participating in projects under these two organizations, the first author visited five villages in each of their project zones and held informal interviews with villagers and project staff. Some discussions were held in villages and others in farmers' fields and at afforestation sites. The author cross-checked his findings by engaging in multiple discussions in different locations, probing deeper to resolve points of contention or where explanations were unclear. He also organized a half-day workshop for programme staff and farmer representatives from the Forest Department, the Foundation for Ecological Security, Seva Mandir and other local non-governmental organizations to discuss the major issues and hear different perspectives on them.

The International Small Group and Tree Planting Program is a community forestry initiative of the United States-based Clean Air Action Corporation and Institute for Environmental Innovation. The initiative was launched in the state of Tamil Nadu, India, in 2003 with the objective of helping local farmers improve their incomes by engaging in carbon sequestration activities on their farms. Participating farmers are organized into small groups and encouraged to create tree plantations.

[8] Seva Mandir also has a watershed development programme. The area covered under its forestry sub-component is already included in the above estimates.

The major tree species preferred by these groups include casuarina *(Casuarina equisetifolia), neem (Azadirachta indica)*, various eucalyptus species and fruit trees such as mango *(Mangifera indica)*. Each group has a separate contract with TIST under which carbon sequestration credits are transferred by the group members to TIST in return for annual payments of 1.48 Indian rupees (₹s) ($0.037) per live tree.[9] TIST then sells these carbon credits to various business entities at a price of $5-$20 per ton of CO_2, depending on volume and timing. In recent years, TIST has even sold carbon credits to individuals through the web auction site eBay (Hawn, 2006). In all, TIST has formed 260 groups consisting of about 2,500 local farmers in India. These groups manage more than 670,000 trees and receive a total annual carbon payment of ₹s. 991,600 (about $24,790) for protecting these trees.

To collect data on TIST projects, the first author travelled to project areas and met farmers in their fields. Some of these meetings were arranged by TIST, while others occurred by chance. Discussions were held with members of 10 different tree growing groups under TIST out of the more than 200 groups that operate in Tamil Nadu.

III. TRADING CARBON ON THE CHICAGO CLIMATE EXCHANGE

CCX offers a feasible opportunity for community forestry projects to sell carbon credits where the Kyoto Protocol's Clean Development Mechanism did not. Even though the CDM envisaged the transfer of carbon sequestration credits from developing to industrialized countries (Fenhann and others, 2004), it has hardly worked in practice. This is because the current rules of the CDM are very restrictive: they only allow afforestation and reforestation projects, they exclude avoided deforestation and they have rigid guidelines on how carbon stocks are monitored and verified in the field. In addition, projects face high transaction costs in terms of paying for third-party verification of their carbon stocks and in searching for potential investors to buy their carbon credits. Studies estimate that an average project adds $200,000 to its costs in order to be approved as a CDM project (Murphy, 2006). Since each project also needs to be approved by the host country, any delay in getting this approval further escalates the transaction costs. As a result, it is very difficult and expensive for community forestry projects to sell carbon sequestration credits through the CDM (only one forestry project has been

[9] These payments are distributed in four quarterly instalments so that farmers receive money on a regular basis rather than a single annual payment. $1 = ₹s 40.

approved to date). Finally, as 2008 approaches, the window of opportunity for new projects will close, as there will not be enough time for projects to get approval and sell carbon sequestration credits before the Kyoto Protocol's current commitment period ends in 2008 (Lecocq and Amrosi, 2007).

Instead, voluntary carbon markets, such as CCX, offer an attractive alternative. The rules for selling carbon sequestration credits are simpler (as explained below), avoided deforestation projects are included, and most small and medium-sized projects do not need to hire third-party verifiers. Unlike CDM, projects follow a simple registration process with no requirement of separate host country approval.

CCX is one of the few carbon markets to allow trading in carbon sequestration credits from land use and forestry projects (called CCX forest carbon emission offsets). In order to sell carbon credits on CCX, forestry projects must meet certain requirements. First, they need to have been initiated after 1 January 1990 on deforested or degraded land. Second, afforestation projects are eligible for carbon sequestration, but conservation (reforestation and avoided deforestation) projects are only eligible if they are carried out in conjunction with afforestation on a contiguous site.[10] Third, projects are required to demonstrate a long-term commitment to maintaining carbon stocks in forestry. Projects that fulfil these three requirements are classified on the basis of their annual carbon sequestration potential: projects that sequester less than 2,000 tCO_2 per annum are small, those that sequester between 2,000 tCO_2 and 12,500 tCO_2 per annum are medium and those that sequester more than 12,500 tCO_2 per annum are large. Size determines monitoring requirements for each project, with independent third-party verification of carbon stocks required for large projects.

If the three rules and the monitoring requirements are satisfied, the three forestry projects in India can potentially sell carbon credits on CCX based on their annual carbon sequestration potential. It is worth noting that the three rules allow some flexibility, within reason. For example, projects must demonstrate that they are serious about the long-term conservation of the trees that are planted. In India, building a fence or wall around an afforested site helps to demonstrate seriousness because it is essential for keeping out animals that would prevent tree growth by grazing the seedlings.

[10] CCX is developing a new set of guidelines for avoided deforestation, but they have not yet been finalized.

Estimating carbon sequestration potential

Carbon sequestration potential is the amount of CO_2 fixed by plants through their photosynthetic activity. Although plants fix CO_2 both as above-ground biomass and below-ground soil carbon, CCX rules currently allow trading only in above-ground biomass contained in live plants.[11] Poffenberger and others (2002) estimate that in India, the above-ground mean annual growth in degraded forests from protection and plantation was 3 tons of carbon per hectare (tC/ha).[12] Similarly, Murali, Murthy and Ravindranath (2002) quote Seebauer (1992) to report a national mean annual increment of 3.6 tC/ha for plantations. Aggarwal and others (2006) arrive at a higher estimate of 5.24 tC/ha for Rajasthan, but their sample plots also include primary forests under protection, which skews their calculations upward. Fewer estimates are available for plantations on revenue or *panchayat* lands. A relevant study by the Foundation for Ecological Security reports a mean annual increment of 1 to 3 tC/ha (Mondal, Sing and Dhameliya, 2005). Annual carbon sequestration is usually taken as half of the mean annual increment (Poffenberger and others, 2002). By taking the lower bounds of the above estimates (to account for various uncertainties related to species mix, survival rates and specific soil conditions), the total carbon sequestration potential of projects under the three organizations works out to be 104,427 tCO_2 per year (tables 2 and 3).[13]

Compatibility with CCX rules

All three organizations have a significant number of carbon sequestration credits that can potentially be sold through CCX. Since these credits pertain to post-1990 plantations on unforested (in the case of *panchayat*, revenue or privately owned lands) or degraded (in the case of forest lands) lands, they satisfy the first rule.

The second rule is important for plantations on forest lands. All three of the organizations create new tree plantations on degraded or deforested lands, which qualify them under rule two. In addition, both Seva Mandir and the Foundation for Ecological Security encourage the regeneration of old trees on forest lands as, typically, forest lands in India have a residual rootstock that can quickly

[11] Below-ground carbon sequestration is difficult to measure and depends on a number of variables. CCX does not trade in below-ground carbon credits from forestry because it does not have a standard protocol for doing so.

[12] 1 ton C = 3.67 tCO_2

[13] TIST carbon credits are presented in a separate table because data comparable to the other two projects are not available.

Table 2. Estimated carbon sequestration

	Seva Mandir	*Foundation for Ecological Security*	*Total*
Total area under post-1990 plantations (hectares)	7 878	33 415	41 293
Annual above-ground biomass growth (tons)[a]	8 950	42 096	51 046
Annual carbon sequestration (tCO_2)[b]	16 423	77 246	93 669
Annual market value on CCX[c] at $4 per tCO_2	$65 692	$308 984	$374 676

Source: Basedon data from the monitoring records of Seva Mandir and the Foundation for Ecological Security.

[a] Based on a conservative mean annual increment (green, above-ground) of 1 tC/ha for revenue and pasture lands and 2.5 tC/ha for forest lands.

[b] Assumed to be 50 per cent of mean annual increment, measured in terms of tC/ha, which is multiplied by 3.67 to get tCO_2/ha.

[c] CCX price as of 6 March 2007.

Table 3. Estimated carbon sequestration potential

Total number of live trees[a]	670 000
Annual carbon sequestration (tCO_2)[b]	10 758
Potential annual market value on CCX at $4 per tCO_2	$43 032

Source: Authors' calcultions from data on the TIST website (www.tist.org).

[a] TIST keeps a record of the total number of live trees.

[b] Ideally, estimates of carbon sequestration should be based on the specific dimensions of each tree, but age and size distribution is not known. Based on information from TIST, we have used the following approximation to estimate annual sequestration potential from TIST plantations: The average number of trees per hectare is 400. The mean annual increment is 3.5 tC/ha. Annual carbon sequestration is assumed to be 50 per cent of mean annual increment, measured in terms of tC/ha, which is multiplied by 3.67 to get tCO_2/ha.

regenerate through protection (Ravindranath, Sudha and Rao, 2001; Poffenberger and others, 2002). It is important to note that, apart from constructing a boundary wall around these old forests, both Seva Mandir and the Foundation for Ecological Security also begin new tree plantations on the same forest lands. This qualifies their forest land projects under the second CCX rule, which states that forest conservation is eligible in conjunction with new afforestation efforts on contiguous sites.

Additionality, leakage and permanence

A review of CCX rules indicates that Seva Mandi, the Foundation for Ecological Security and TIST are all eligible to sell carbon sequestration credits from their forestry activities. Typically, international trading in carbon sequestration credits also requires fulfilling additionality, leakage and permanence clauses (Fenhann and others, 2004).

Additionality requires proving that carbon sequestration credits being claimed by a project are additional to any that would have occurred in the absence of the project. There are various ways to ascertain additionality, one of them being the timing of the project, requiring developers to demonstrate that they initiated the project after a specific date (Bayon, Hawn and Hanitton, 2007). CCX follows this method by allowing carbon trading from forestry projects that were established after 1 January 1990. This may not be as strict as the additionality clause under the Kyoto Protocol's CDM, which is precisely why community forestry projects should sell carbon credits on voluntary markets. Since only the post-1990 forestry activities of the three organizations are considered in this study, they qualify under the CCX additionality clause.

Carbon trading requires sequestration projects to prove that there is no *leakage* of carbon dioxide and that all carbon stocks are permanent. No leakage means that project beneficiaries do not cut any trees, even outside the project boundary. This is a contentious issue, as local communities often depend on forest resources for their livelihood needs, such as obtaining fodder for livestock, firewood for energy needs and fruits for consumption or sale in nearby markets. Leakage occurs if people simply shift tree-cutting to lands not under contract. *Permanence* refers to a long-term commitment to protect carbon plantations. For local communities, permanence is inextricably linked with leakage. If communities are allowed to harvest a certain percentage of the annual biomass growth in terms of dead and fallen trees, manually harvested grass and mature bamboo poles, they will be more willing to protect the growing trees.

In this case, carbon sequestration credits can be calculated by subtracting annual biomass harvest from total annual biomass growth on a specific project site. CCX already incorporates this element by paying for only 80 per cent of the eligible forestry offsets. The balance of 20 per cent is saved in a CCX forest carbon reserve pool to account for any net losses in the carbon stocks. These reserves may be sufficient to fulfil local communities' annual biomass needs.

IV. SUSTAINABLE DEVELOPMENT FROM CARBON TRADING

Carbon credits generated by existing projects operated by Seva Mandir and the Foundation for Ecological Security are worth about $374,600 per year on CCX (see table 2), all of which represents potential additional income for local farmers. TIST already sells carbon credits on a project basis and the effects of selling on CCX would be mixed. The CCX market price tends to be lower than what TIST is able to sell for on a case-by-case basis but, on the other hand, it could raise its volume substantially by selling on CCX. However, TIST would need to reduce its transaction costs in order to manage with lower sale prices on CCX.

This additional income has the potential to extend local conservation efforts, reduce livelihood pressure on forests and provide for the sustenance needs of many poor families. The experience of TIST demonstrates that, for many farmers, carbon sales are the primary source of cash income. Farmers often reinvest their carbon sequestration income in agriculture or use it to pay for important household expenses. For instance, TIST formed the Salsa group in 2003 with 12 farmers. Since then, the group has planted 28,923 trees and has encouraged many neighbouring farmers to form groups and grow trees. Over the past three years, the Salsa group has received Rs. 57,114 ($1,428) as carbon payments from TIST. This money has improved the economic status of many group members and has helped them to reinvest it in agriculture.

Similarly, community members interviewed in areas where the Foundation for Ecological Security and Seva Mandir are active say that carbon payments will give them a direct incentive to conserve local forests. For instance, in Chitravas in Rajasthan, Joint forest management activities over 276 hectares of forest land have yielded benefits for local villagers, mainly by providing non-timber forest products and some employment opportunities under the Foundation project activities. The sale of carbon credits totalling 1,266 tCO_2 per year from these forests could generate additional annual income of $5,064. When divided equally amongst all households in the village, these carbon payments will be equivalent to a 15 per cent increase over the average cash income of $100 per year for most of the poor households.

Additional funding support for forestry

Carbon payments also represent opportunities for attracting additional funding support. Many Indian non-governmental organizations which are actively involved in forestry interventions are in constant need of financial assistance. Seva Mandir for example, submits regular project proposals to international donor organizations to fund its forestry activities (Seva Mandir, 2006). Similarly, the

Foundation for Ecological Security receives financial support from the Indian National Dairy Development Board and from some international organizations. This funding support is however, often limited and insufficient to meet local requirements.

Carbon markets, on the other hand, are growing rapidly (Point Carbon, 2007). Demand for carbon credits on CCX has risen sharply, with trade of 11.85 million tCO_2 during the first six months of 2007 already exceeding the total volume of 10.27 million tCO_2 transacted in 2006 (CCX, 2007). Combined with a 300 per cent increase in the average price of tCO_2 on CCX between January 2004 and January 2007, CCX presents an attractive opportunity for forestry projects to raise money through the sale of carbon sequestration credits. A relationship with CCX can, in fact, help Seva Mandir and the Foundation for Ecological Security learn the intricacies of international carbon trading, while also helping all three organizations to find more carbon buyers to generate additional financial support for their forestry programmes. As international carbon rules are still being formulated, these organizations also have an opportunity to share their own experience of how these rules actually play out in the field and suggest necessary modifications.

Benefits for CCX and its members

CCX is a voluntary emission reduction programme. However, rising environmental awareness, the growing threat of global warming and changing market perceptions have convinced more and more firms to commit to emission reduction, leading to increasing demand for carbon credits on CCX. To date, CCX has mainly met this demand for carbon credits from emission reduction and carbon sequestration programmes within the Unite States. However, judging from its recent growth, demand will grow rapidly in the coming years, and CCX has started looking for additional carbon credit suppliers in order to avoid a sharp increase in prices. The three organizations covered in this study are well qualified to act as suppliers for CCX.

Building a relationship with organizations like TIST, the Foundation for Ecological Security and Seva Mandir will help CCX to tap into a relatively large supply of carbon sequestration credits. For its part, CCX will also get to experience the particulars of a relationship with grass-roots forestry projects, which may gain more significance as carbon markets continue to grow. Finally, CCX members can gain satisfaction and goodwill from the fact that their carbon payments are able to contribute to sustainable development initiatives among poor communities in India.

V. VILLAGE-LEVEL ISSUES CONCERNING CARBON TRADING

This section presents the findings of qualitative investigations among programme officials and villagers participating in the three community forestry programmes. They include concerns about transaction costs, the implications of converting land under food crops to forestry, managing carbon sequestration on common lands and problems arising from sequestering carbon from intensive plantations of timber tree species. This section looks at these issues in detail and discusses some relevant alternatives.

Reducing transaction costs

The transaction costs of a carbon sequestration project include negotiating, contracting, implementing and monitoring costs. These costs are usually high when establishing new projects or when looking to sell carbon credits through the more formal compliance markets governed by the Kyoto Protocol. For instance, Krey (2004) estimates that emission reduction projects in India that wish to sell carbon credits through the Clean Development Mechanism face an average transaction cost of $74,885 per project. For the three community forestry projects considered here, transaction costs will be lower in dealing with CCX than the Clean Development Mechanism, but monitoring and verification costs are still expected to be substantial at about $16,000 per project. These project costs will reduce the proportion of carbon revenue that ultimately reaches local farmers.

One way to reduce these costs is to aggregate carbon credits from individual farmers and then sell them in one lot. The aggregator thus avoids the cost of setting up multiple contracts by establishing a single contract with CCX on behalf of all the local participants. TIST already plays this role by purchasing carbon offsets from local farmers and then selling them to international buyers in aggregated lots. Since the Foundation for Ecological Security and Seva Mandir will be new to carbon trading, they can consider collaborating together to act as a common aggregator for their target participants. Together, they can promote market access and ensure that poor households can participate in the sequestration programme, with equitable sharing of carbon benefits amongst the community members.

Monitoring and verification are major transaction costs. They would be substantial for Seva Mandir and the Foundation for Ecological Security where individual carbon sites are located far away from each other. One possible solution is to introduce site-specific monitoring through hand-held Global Positioning System (GPS) units, which are relatively inexpensive and easy to use and can help to provide more rigorous tracking of carbon plantations. TIST has already trained

village-based volunteers to take field measurements using GPS. A single carbon expert in the central office then uses the field measurements to calculate carbon sequestration credits for each site.

Food insecurity concerns

Many smallholders in India meet their food requirements from their farms and local forests. As the rural population continues to grow, there is a demand for additional agricultural land to grow food crops. Land that is locked in multi-year carbon plantations cannot be used for food production and some villagers interviewed in this study expressed fear that local communities will be threatened with food insecurity if they invest heavily in carbon sequestration. TIST addresses this issue by promoting carbon sequestration primarily on marginal and low-productivity lands, which have a low substitutability for agriculture and are thus well suited to long-term carbon plantation projects.

A greater concern is that farmers who do not understand long-term contracts will enter into agreements without understanding their full implications, and when they want to cut their trees, they may find they are legally unable to do so. In fact, the Foundation for Ecological Security and Seva Mandir are well aware of this concern and it is one reason why they hesitate to link their community forestry programmes to CCX. Helping farmers appreciate the nature of carbon sequestration contracts and the need to understand legal obligations fully is an important role for non-governmental organizations to play should they decide to help link farmers to CCX.

Carbon sequestration on common lands

A large proportion of the land in rural India is common land, including revenue lands, Forest Department lands and *panchayat* grazing lands. Although village communities can obtain permission from the respective authorities to manage these lands for a fixed period of time, there is no provision to carry out carbon sequestration projects on them. Villagers and project managers alike pointed out that, as carbon payments become more significant, there is a possibility that the Forest Department and local *panchayats* may, in fact, stop transferring management rights to local communities.

For example, Nayakheda village in Rajasthan obtained permission from the local *panchayat* to manage plantations on 29 hectares of common pasture land. The villagers also planted trees on 100 hectares of individually owned lands. These plantations are sequestering 236 tCO_2 per year, worth $946. However, the *panchayat* is now threatening to take over the pasture land, which is a direct result

of the fact that the villagers have identified a way to generate cash income from these lands as opposed to income in kind, like fodder, fuelwood and non-timber forest products. If this land and similar *panchayat* land were to start selling carbon credits, the problem would be greatly exacerbated. This potential area for conflict needs to be resolved soon. A practical solution may be to share carbon payments between local communities and the respective authorities.

Even where the *panchayat* or Revenue Department grants access rights, experience shows that poorer and politically weaker groups may have difficulty maintaining access to common lands. As carbon sequestration services make these lands more valuable, powerful landowners may grab them and drive the poor away, further threatening their livelihoods (Kerr and others, 2006). There is ample evidence both of private encroachment on common lands (e.g. Jodha, 1997) and of de facto appropriation of productive common lands by some groups at the expense of other groups.[14]

In this regard, the approach of the Foundation for Ecological Security developing farm forestry cooperatives—may be a viable way to generate secure access to land for carbon sequestration with equitable sharing of benefits. The Foundation has worked extensively with such cooperatives to develop local pastures across several states in India. The cooperatives obtain long-term leases from local governments to regenerate pastures and to share benefits amongst their members. As a result, they are successful not only in improving the productivity of local resources but also in securing tenure rights for their members (Foundation for Ecological Security, 2005).

Intensive plantations with per tree carbon payments

TIST carbon payments to local farmers are calculated on the basis of the actual number of live trees, irrespective of the tree species being planted. This system introduces two problems. First, farmers tend to look at carbon payments on a per acre basis rather than per tree. For instance, an acre of densely planted casuarina (1,600 trees per acre) can earn $59.2 per annum, whereas an acre of mango (which can only be planted at a rate of 100 trees per acre) earns only $3.7 per annum. Second, the densely planted trees like casuarina and eucalyptus fetch high prices for sale as timber and, as the trees mature, the pressure will grow to cut them. The TIST per-tree carbon payment is a constant annual payment, so while it is very attractive when the tree is first planted, it becomes less so as the

[14] This behaviour was observed personally by the authors in south Rajasthan on common lands which had been made more productive by a Government project.

tree grows and gains value as timber or pulp. Selling the tree for timber or pulp would undermine its carbon sequestration contribution, potentially eliminating any carbon benefits accrued over the entire life of the tree.

Fruit trees such as mango have the potential to be much more effective as sources of carbon sequestration. Mango *(Magnifera indica*) is a long-gestation tree crop that generates income by bearing fruit, so in contrast to casuarina and eucalyptus, the incentive to cut the tree shrinks as it matures. The long-term potential for carbon sequestration is, therefore, probably greater for fruit trees than for timber trees, but the higher annual payment per acre of timber trees under the TIST payment scheme may lead to more timber tree plantations, which may eventually be cut down, thus reversing the carbon sequestration gain.

In addition, intensive plantations can be ecologically harmful, especially if they are raised as monocultures and comprise species such as eucalyptus that require large quantities of water. Instead, experts recommend slow-growing indigenous species that do not disturb the local ecology (Farley, Jobbagy and Jackson, 2005). Therefore, as TIST-India's carbon initiative grows, it will need to come up with new payment systems that provide economic incentives to local farmers to plant ecologically diverse tree crops rather than relying primarily on fast-growing monocultures.

VI. CONCLUSION

The rules for carbon sequestration projects under the Kyoto Protocol are often perceived as being too rigid and difficult to follow (Murphy, 2006). In comparison, the CCX rules for carbon sequestration projects are relatively simple and easy to follow. From the perspective of local communities, some modifications in these rules will make them even more attractive. For instance, CCX only allows trading in above-ground carbon stored in live matter. However, forests often fix substantial amounts of carbon in the soil as organic matter. If CCX is able to develop usable protocols for measuring below-ground carbon in forestry projects, it will greatly increase the incentive for communities to participate in carbon sequestration activities.[15]

[15] Given farmers' dependence in semi-arid areas on biomass such as fodder, fuelwood and non-timber forest products, it may be that below-ground carbon offers a greater opportunity for them to sell carbon credits. As a carbon source, above-ground biomass may not be able to compete with other sources of demand (Walsh, 2005).

Seva Mandir, the Foundation for Ecological Security and TIST can all potentially sell carbon sequestration credits on CCX on behalf of local farmers, and establishing a relationship with CCX may, in fact, open avenues for carbon trading with other international players. A viable strategy in this regard would be to start with simple payment arrangements on small contiguous sites that are easy to monitor and administer. Experience gained during these pilot projects may come in handy in expanding the scale of operations as international demand for carbon sequestration credits continues to grow. Such performance-based payments may also ensure that local communities have a long-term stake in conserving these plantations. For a global society, this relationship may open ways to achieve a win-win situation for both environmental conservation and economic development.

Finally, and most importantly, carbon sequestration programmes have the potential to help alleviate rural poverty. This potential will, however, remain unfulfilled unless policymakers and various carbon players make conscious efforts to elicit participation from the poor. In order to benefit small and marginal farmers in developing countries, carbon sequestration projects will also need to incorporate improvements in carbon accounting and innovations that can reduce the transaction costs inherent in their implementation. Institutions such as farmers' cooperatives and federations under the leadership of non-governmental organizations can further ensure that carbon payments are channelled to the poor. Only then can carbon sequestration truly lead to local sustainable development.

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Printed in Bangkok
December 2008 – 1,410

United Nations publication
Sales No. E.07.II.F.33

ISBN: 978-92-1-120532-9
ISSN: 1020-1246
ST/ESCAP/2496