The use of technology or ideas (as it is referred to in the above quote) is clearly an important element of a developing country's efforts to industrialise. Cross-country experience in the post-war era shows that the rapid growers in the developing world have been those countries best equipped to import and effectively use modern forms of foreign technology; and in some cases to develop their own forms or technology compatible with local supply and demand conditions.

Given the importance of technology to economic development, it is clearly important for the economist to be able to quantitatively assess both the level and
growth of technological capacity. There is, however, no clear-cut method of quantitatively measuring technology capacity. Technology is a multi-dimensional phenomenon whose complete characteristics can not be captured by the simple inclusion of a proxy variable in a growth equation or Cobb-Douglas production function. Analytical tools available to today's economist provide only illustrative but not precise or accurate assessments of a country's technological capacity.

The key objective of this paper is to employ a number of quantitative methods and indicators as a means to give a general illustration of the growth and trend of Indonesian technology capacity. The first method considered (section A) is that of the standard Neoclassical growth accounting or Total Factor Productivity (TFP) approach. However, due to the highly restrictive and unrealistic assumptions of the Neoclassical model, TFP is a proxy for technological progress as measured by the residual from a constant returns production function. This is found to have little or no economic meaning. The second method considered (section B) uses an important theme from the New Growth literature, i.e., the increasing returns to scale from the use of non-rival knowledge inputs in the production process. The third method (section C) uses export and import data to means to construct a number of technological indexes. Finally, in section D a number of other indicators such as the technological intensity/wealth of foreign investment, as well as patents applications and publication data are considered to complete the overall picture of Indonesia's technological capacity. The general result from the various approaches employed, except that of the TFP approach, is that Indonesia differs from regional comparators in failing to move into more knowledge-based production.

Section A - The Neoclassical Approach

The method of measuring technological progress most commonly used by economists over the past 3-4 decades is that of the Growth Accounting approach. Such an approach is closely associated with the one-sector neoclassical growth model developed by Solow (1956) and Swan (1956). One of the attractive features of the growth accounting approach is that it permits the decomposition of economic growth into a number of key determinants (Solow (1957) and Denison (1993), for example, use a growth accounting framework that distinguishes the contributions of labour, capital and exogenous technological progress to US economic growth. Their approach assumes a standard Cobb-Douglas production function of the form

\[ Y = A \cdot K^{\alpha} L^{\beta} \quad \alpha + \beta = 1 \]  

(1)

1 One of the major features of the neoclassical growth model is the assumption that technological progress is exogenous, i.e., determined by factors outside the model, in that is exogenous. This is the key point of departure from the many 'New Growth' models which are built upon the premise that technological progress (and therefore growth) is endogenous, i.e., determined by the stock of knowledge stocks of a nation operating within the system. Such behaviour includes investment in human and physical capital, R&D, innovation, etc.

1996

KELOKA No. 19, 1996
where $\alpha$ is an index of technology and the exponents on capital and labour sum to unity to ensure constant returns to scale. By differentiating with respect to time to find growth rates and then taking logs we get

$$ y = a + \alpha k + \beta $$

(2)

where lower case represent logs. If we assume competitive markets with factors being paid their marginal products then the capital and labour shares correspond with the exponents $\alpha$ and $\beta$ from (1) respectively, or the coefficients from (2). Most studies using this kind of analysis make the assumption that the exponent on capital is around 0.3 to 0.4 (which implies sharply diminishing returns to capital and therefore downplays the role of capital in the growth process) and 0.6 to 0.7 for the labour share. Fischer (1995) for example, uses 0.4 and 0.6 for the capital-labour share respectively.

Using the above information we can write the growth equation

$$ y = a + (0.4)k + (0.6)l $$

(3)

and rearranging to get $a$ (the rate of growth of exogenous technology) over to the left hand side we get

$$ a = y - (0.4)k - (0.6)l $$

(4)

The term $a$ is often referred to as the Solow residual, and in this style of growth accounting analyses is interpreted as a measure of total factor productivity (TFP), i.e. that portion of income growth that cannot be explained by growth in the capital and labour stocks. Using the above methodology, Solow (1957) concluded from US time series data over the period 1909 to 1949 that output per worker had doubled with 87.5 percent of the increase attributable to TFP (a proxy for technological progress) and the remaining 12.5 percent due to the increased use of capital. Similar results were arrived at by Denison (1993) using the same mechanical methodology.

The growth accounting approach described above has also been augmented to include human capital as represented by education enrolments, "ed." Moniców, Romer and Wei (1992) for example define their technology residual as follows

$$ a = y - (0.333)k - (0.333)l - (0.333)ed $$

where $ed$ is the human capital level as measured by school enrolments and the three growth determinants share equal weights of 0.333 such that the constant returns condition is maintained.

The TFP method described above appears to represent a simple and effective means of isolating the different determinants of growth.

1 According to the growth equation as specified in (3), a 1 percent increase in output growth for example, could be achieved by either a 4 percent increase in productivity growth, or a 1.6 percent growth in employment, or by a massive 5.5 percent increase in the capital stock. Sharply diminishing returns to capital clearly limits the model's ability to account for differences in growth rates across countries. Paneru (1992) notes that for capital accumulation to account for the fact that the US has 20 times the income per capita of Kenya, the capital stock per capita in the US would need to be about 6000 times the capital stock in Kenya. However according to Summers and Heston's 5.5 data, US capital per worker is only about 26 times that of Kenya.

2 Sometimes referred to as multi-factor productivity.

3 Other empirical analyses use literacy rates (e.g., Romer 1992) and the years of schooling attained (e.g., Barro and Lee, 1993) as a proxy for human capital.
### Table 1. Technology Residuals - Average Growth Rates 1960-1988

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Solow Residual</th>
<th>Mankiw et al. Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>-0.38%</td>
<td>-0.01%</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.12%</td>
<td>-0.21%</td>
</tr>
<tr>
<td>Japan</td>
<td>1.31%</td>
<td>1.64%</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.13%</td>
<td>0.21%</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.62%</td>
<td>0.45%</td>
</tr>
<tr>
<td>Korea</td>
<td>0.60%</td>
<td>0.41%</td>
</tr>
</tbody>
</table>


nates of growth (including technological progress). However as can be seen from Table 1, estimates of the growth of the technology residuals using the two approaches make little economic sense.

Using the growth of the Solow residual as a proxy for technological progress Indonesia outperforms all the other listed Asian countries, bar Japan. Singapore and Malaysia record the lowest rates of technological progress which is surprising given the rapid and successful development of many higher technology industries (particularly electronic) in these two countries over the past three decades. Also surprising is the high rate of TFP growth for Japan. Given Japan's role as a technological leader in the region, its TFP growth should be less than the follower countries. The relocation of many Japanese industries in the 1970's and 1980's which facilitated a degree of technological convergence in the Asian region is clearly not reflected in the above figures.

Incorporating the human capital proxy (column 3) reduces the average growth rate of Indonesia's technology residual, however this rate remains higher than that of Singapore and Malaysia. This variance of the TFP approach therefore does little to improve the descriptive ability of the model.

There are two major problems with the neoclassical growth accounting approach. First is the idea that technical progress can be treated as a separate input to the production process completely independent of capital and labour stocks or any other variable in the system. Technological change is thus assumed to be of disembodied exogenously type - exogenous in the sense that it simply descends upon...

---

1 Such results are similar to the World Bank (1993) which employed a similar approach.

2 A curious extension of the TFP growth accounting approach has been to explain what determines TFP (or the Solow residual) by regressing it against a number of key endogenous variables such as education levels, capital intensity, foreign investment, government policy type and so on - thus exploring what the endogenous determinants are of something assumed to be exogenous. This inconsistent approach has been employed by many including the World Bank (1993) in their comprehensive study of the high performing Asian economies and Schadler (1992) in his study of the determinants of technical change in Indonesian engineering industry.
an economy like means-from-heaven and disembodied in the sense that it is not embodied within capital or labour. The key problem with assuming that technical progress is exogenous is that it ignores the economic returns to innovative activity. As argued by Schumpeter (1942) and Schmookler (1966) and many of the New Growth writers, firms innovate to compete for profits thus technical progress within modern growth analyses should be considered to be endogenous.

Sheahan (1993) for example writes:

Many successful international firms invest 10-15 percent of their sales revenue in R&D; competition between firms, and indeed nations, is now more often determined on the basis of technological excellence than of price competitiveness; the key strategic goals of many successful firms are related to the development and strategic control of core technology rather than more traditional objectives.

This, however, is not reflected within the neoclassical growth model which simply assumes that technical progress - the product of innovation - is determined by factors outside the economy.

Another important implication of the assumption regarding the disembodied nature of technical progress was that there could be no obvious link between investment (in ideas and both human and physical capital) and technical progress; and then through extension of the model, between investment and growth. Clearly technical progress A, in equation (1) is determined by the nature of the physical capital stock (K) and the labour force (L) - i.e., technical progress is driven by the accumulation of both physical and human capital. As argued by De Long and Summers (1992, 1993) and De Long (1991, 1992) technology which is embodied within new capital equipment plays an important role in a country's technological development and therefore its growth rate. Quality of the labour force is also an important theme in the New Growth literature as technology is more likely to be absorbed and/or developed by those countries with higher skill or education levels (Romer 1992).

The second major criticism of the neoclassical growth accounting approach relates to the standard assumption of constant returns to scale. Many technological inputs, such as a blueprint or some other piece of knowledge, are non-rival by nature and can therefore be used over and over in the production process in little or no marginal cost. Thus if non-rival inputs (such as a design) are used in production we would expect to find increasing, not decreasing returns to scale as output would be increasing at a faster rate than input costs. Thus the impact of the very thing we are trying to measure might simply be overlooked because of the standard yet restrictive assumption of constant returns.
Given such difficulties associated with TFP measurement it could be argued that alternative methods are required to quantitatively assess the technological development of a country. Using the approach outlined above the measure of technology obtained is simply the residual from a constant returns production function (with assumed weights on both capital and labour) whereby that residual - which is assumed to be a proxy for technical progress - is totally independent of human and physical capital accumulation. However if we regard both human and physical capital accumulation to play an integral role in a country's technological development then it is difficult to define the TFP residual as a proxy for technical progress.

Section B-New Growth Themes

A more realistic treatment of the technology-grown relationship can be found within the contemporary macroeconomics literature. Collectively known as the New Growth theorists, writers such as Romer (1986,1990) Lucas (1988) and Grossman and Helpman (1991, 1994) argue that technological progress is endogenous, that is, technological progress is the direct outcome of firm and market level phenomena. Central to much of their work is the idea that investment (in ideas and in both human and physical capital), technical progress and growth are closely linked. A crucial feature of many of the New Growth models is the notion of non-rival technology - the idea that once a blueprint or design has been created it can be used again at little or no marginal cost. For example the research costs for the design of a new product may be high depending upon the complexity of the design and by what degree it differs from the existing product. However once the drawings are complete, the design (representing the ideas or knowledge embodied within the product) can be reproduced at virtual zero or marginal cost on a photocopy machine. Thus as Romer (1990) argues the use of non-rival technology generates non-convergent (increasing returns) in the model. That is, if it is possible to double output by doubling all input levels, then if non-rival inputs are used - which by definition do not require replicating - increasing returns will be inevitable. Consider that case of two input units - one rival (X) and one non-rival (Y) - to produce two units of output (Y).

\[ N, X \rightarrow Y, Y \]

To double output only rival inputs need to be doubled because the non-rival input (eg. the design) can be used again without replication.

\[ N, R, R \rightarrow Y, Y, Y \]

This three input units can produce four units of output - giving us increasing returns to scale.

This model has important implications for developing countries in that they need to make themselves open to and capable of importing and adopting modern technologies from the industrialized nations. Romer (1992) cites the case of Mauritius which has successfully exploited a development strategy that consisted almost entirely of trying to make use of ideas that already existed in industrial countries by encouraging foreigners to produce there. Another good example is found in the
recent and successful development of the manufacturing industries in the Asian NIC's (South Korea, Hong Kong, Singapore and Taiwan). Over the past 30 years these countries, through various means (including reverse engineering) have been able to successfully use a back-log of unexploited foreign technology as a means to develop highly competitive manufacturing export sectors.

Sengupta (1991, 1993) in an investigation of the applicability of New Growth theory to South Korea's development experience, found strong evidence in favour of increasing returns in the manufacturing export sector that was due, in large part, to the use of non-rival knowledge or technology inputs.

Evidence of increasing returns in the Korean manufacturing sector is found by the use of the following estimated cost function in log-linear form:\(^{1}\)

\[
\ln C = 0.168 + 0.797\ln Y - 0.77\ln z \\
R^2 = 0.92 \quad n = 19
\]

where \(C\) is total costs, \(Y\) is output and \(z\) is value added growth which he uses as a proxy for technological progress. The asterisk denotes significant coefficients at the one percent level. A value of the coefficient on \(\ln Y\) which is less than one suggests increasing returns to scale, i.e. costs increasing at a lower rate than output. In this case, total increasing returns are calculated to be 1.25 - the inverse of the output coefficient. The negative value on \(\ln z\) is indicative of the cost reducing influence of technological progress (Sengupta 1993: 347).

Similar results were obtained by the author using Singaporean industrial data 1973-1991 (UNIDO). The estimated cost function shows a) total increasing returns to be 1.23 and b) the cost reducing influence of technical progress.

\[
\ln C = 2.72 + 0.813 \ln Y - 0.016 \ln z \\
R^2 = 0.97 \quad n = 18
\]

A similar style of econometric analysis using Indonesian industrial data (1975-1992) produces dramatically different results. As can be seen from Table 2, the cost function approach shows that the nine industrial subsectors (2 digit data) display constant returns to scale or near to it. Slight increasing returns to scale are found in the basic metal industries (37) and fabricated metals products and machinery industries (38). Furthermore it is only in these two industries that technical progress as represented by \(z\) has the correct sign (negative) and is significant.

Sengupta (1991, 1993) explores the source of the Korean manufacturing sector's economies of scale by estimating the output elasticities for both rival and non-rival inputs through the use of an exogenous Cobb-Douglas production function.

\[
\ln Y = 4.92 - 0.47 \ln R1 + 0.16 \ln R2 - 0.57 \ln R3 + 1.51 \ln N \\
R^2 = 0.92
\]

where \(R1\), \(R2\) and \(R3\) represent capital, energy and materials respectively - i.e. rival goods - and \(N\) is a non-rival input measured by labour employed in the manu-

---

<table>
<thead>
<tr>
<th>Sector</th>
<th>Equation</th>
<th>( L = Y )</th>
<th>( L = X )</th>
<th>( r )-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>1</td>
<td>0.028</td>
<td>0.028</td>
<td>0.9899</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.125</td>
<td>0.028</td>
<td>0.00446</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.98876</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>1.055E4</td>
<td>0.04682</td>
<td>0.954177</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.459</td>
<td>0.02586</td>
<td>0.00471</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9520</td>
</tr>
<tr>
<td>33</td>
<td>1</td>
<td>-0.432E4</td>
<td>1.0549</td>
<td>0.06529</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.390E5</td>
<td>0.9395</td>
<td>0.06599</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9999</td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>-0.832E5</td>
<td>1.063</td>
<td>-0.00065</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.683E5</td>
<td>0.952</td>
<td>0.97766</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9779</td>
</tr>
<tr>
<td>35</td>
<td>1</td>
<td>-1.015E5</td>
<td>1.0394</td>
<td>-0.00027</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-1.383E5</td>
<td>0.9751</td>
<td>0.98262</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9825</td>
</tr>
<tr>
<td>36</td>
<td>1</td>
<td>-0.244E5</td>
<td>1.0777</td>
<td>0.976964</td>
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<tr>
<td></td>
<td>2</td>
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<td>37</td>
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<td></td>
<td>2</td>
<td>1.683E5</td>
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<tr>
<td>38</td>
<td>1</td>
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<td>0.95623</td>
<td>0.99543</td>
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<td></td>
<td>2</td>
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<td>0.93181</td>
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<td></td>
<td>0.99298</td>
</tr>
<tr>
<td>39</td>
<td>1</td>
<td>-0.407E5</td>
<td>1.01320</td>
<td>0.991927</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.426E5</td>
<td>1.01464</td>
<td>0.003888</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.99239</td>
</tr>
</tbody>
</table>
facturing export sector. Thus Sengopia assumes that ideas on technological know-
how are more likely to be embodied within labour than in capital. He notes that the
non-rival good (N) has a much higher output elasticity than the rival goods and in
itself exhibits strong increasing returns. This he argues is evidence of the key role
technology and knowledge have played in the sector successful development.

Using the same extended Cobb-Douglas approach the following growth equa-
tion is estimated for Indonesian manufactur-
ing (1975-92).

\[
\ln Y = -6.57 + 0.39 \ln R1 - 0.092 \ln R2 \\
(2.71) \quad (1.52) \quad (1.12)
+ 0.302 R3 + 0.7 \ln N \\
(1.07) \quad (2.65)
R^2 = 0.993 \quad n = 18 \quad DW = 1.72
\]

The key point to note here is the
relatively low coefficient on the non-rival
input (N as represented by the total labour
employed in the manufacturing sector).
Unlike Korea, labour, the non-rival input,
defies diminishing returns suggesting
the technology is not exhausting the pro-
ducivity of labour. Although lacking suf-
icient sophistication the two approaches described
above give general illustration of a manufac-
turing sector that is driven by the use of
physical inputs and low skilled labour.

The lack of technological or knowledge
inputs precludes the attainment of increas-
ing returns and therefore higher sectoral
growth.

C. Alternative Approaches

Using Export Data

Another useful way to judge the tech-
ological development of particular coun-
tries is to examine the type of goods it is
exporting and importing. Using the OECD
classification system as shown in Table 3,

Table 3. OECD Industry by Technology Intensity

<table>
<thead>
<tr>
<th>Technology Group</th>
<th>Industry Group</th>
<th>R&amp;D Ratio (%)</th>
<th>ECN Code</th>
<th>Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Aerospace</td>
<td>20.2</td>
<td>3845</td>
<td>Aircraft</td>
</tr>
<tr>
<td></td>
<td>Computers</td>
<td>12.4</td>
<td>3825</td>
<td>Off., comput., account, mach</td>
</tr>
</tbody>
</table>
|                  | Electronics    | 10.8          | 3832     | Radio, tel., commun. eq., opt.
|                  | Pharmaceuticals| 10.3          | 3822     | Drugs + medicines         |
| Medium-high      | Instruments    | 4.8           | 385      | Produc., manuf., eng., eq. |
|                  | Motor Vehicles | 3.8           | 3843     | Motor Vehicles           |
|                  | Chemise        | 3.4           | 3852     | Man. of indus. chem., etc.|
|                  | Elae. Machinery| 3.2           | 3831     | Paints, varnish, lacquers|
|                  |                |               | 3832     | Soap, etc., perf., cos., etc.|
|                  |                |               | 3839     | Elae. appl. + household app.|
|                  |                |               | 3833     | Elae. appl. + supplies nec.|

* see OECD (1994) - R & D ratios are the average R & D expenditures/production ratios for the OECD countries.
Continued from Table 3

<table>
<thead>
<tr>
<th>Technology Group</th>
<th>Industry Group</th>
<th>H&amp;I Ratio (Vol.)</th>
<th>SIC Code</th>
<th>In-Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium-low</td>
<td>Machinery</td>
<td>2.1</td>
<td>3821</td>
<td>Engines + turbines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3822</td>
<td>Agro machinery and equip</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3823</td>
<td>Metal + woodworking equip</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3824</td>
<td>Spec ind mach + cap ex 3823</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3829</td>
<td>Mach, equip or elect nec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3842</td>
<td>Railroad equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3844</td>
<td>Motor cycles + bicycles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3849</td>
<td>Transport equipment nec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3841</td>
<td>Shipbuilding + repairing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>353</td>
<td>Petroleum refiners</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>354</td>
<td>Mine prod of pet, coal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td>Man non-metal min prod</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>39</td>
<td>Other man indus</td>
</tr>
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<td></td>
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<td>355</td>
<td>Rubber products</td>
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<tr>
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<td></td>
<td></td>
<td>372</td>
<td>Non-fer metal basic ind</td>
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<tr>
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<td>Ferrous metals</td>
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<td>371</td>
<td>Iron and steel fis ind</td>
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<tr>
<td></td>
<td>Fabricated meta</td>
<td>0.6</td>
<td>381</td>
<td>Fab vert prod, ex mach, egn</td>
</tr>
<tr>
<td></td>
<td>Wood and paper</td>
<td>0.3</td>
<td>31</td>
<td>Man paper, prod, printing</td>
</tr>
<tr>
<td></td>
<td>Textile prod</td>
<td>0.2</td>
<td>34</td>
<td>Man paper, prod, printing</td>
</tr>
<tr>
<td></td>
<td>Clothing prod</td>
<td>0.2</td>
<td>32</td>
<td>Text, wearing app, leather</td>
</tr>
<tr>
<td></td>
<td>Wood &amp; furniture</td>
<td>0.2</td>
<td>33</td>
<td>Man wood + wood prod</td>
</tr>
</tbody>
</table>

Indonesia’s trade data can be separated into four technology intensity categories:
1. High technology
2. Medium-high technology
3. Medium-low technology
4. Low technology

1. Export Import Ratios

For many developing countries still dependent upon imported technology it is not surprising to find export-import ratios of a value less than one. As the developing country in question develops its own technologcal capacity and progressively re-lies less on imported technology based goods, the export-import (XM) ratios for the above mentioned technology groups should be increasing over time.

Figure 1 provides a comparison in this regard between Indonesia and a four Asian nation average which includes Malaysia, Korea, Singapore and Taiwan. The rebased index on the lower figure indicates relative performance in increasing the XM ratios for the 5 country set.
Figure 1. High Tech. Export-Import Ratio - Indonesia and the Region

Export-Import Ratios
High Technology Category

Export Import Ratios Index
Rebased 1970=100

Source: CSES estimates using IEDB data

\(^{13}\) Estimates from the Center for Strategic Economic Studies using data from the International Economic Data Base, ANU.

ISSN 0037-796
Figure 2. Medium-High Tech. Export Import Ratio - Indonesia and the Region

Source: CSIS estimates using EDB data
Over the past 2 decades the growth in the high and mid-high technology XM ratios for the four Asian nations has been impressive, particularly in the high tech category. In this category Indonesia's XM ratio remained below 0.2 for much of the 1970/80s but increased dramatically in 1992/93 due to rapid growth in electronic export. A more consistent growth in XM ratios is found in the medium-high technology category where, as shown in the lower section of Figure 2, in this category Indonesia has outperformed the four other Asian countries, particularly since the early 1980s. The improvement in XM ratios for both categories is however tempered by the fact that Indonesia started from an extremely low base in comparison to its regional competitors. In 1970, for example, Taiwan exported almost 6 times the value in high technology exports than Indonesia\textsuperscript{4}.

2. Index of Technology Competition

Further evidence of Indonesia's comparative technological backwardness can be found by using an index of technology competition of exports as developed by Steelman, Pappas, Tikhomirova and Sinclair (1995). Their approach is to divide a country's exports into 22 main industry groups according to their degree of knowledge intensity as measured by average level of R&D expenditure per unit of production in those industry groups for the OECD countries taken as a whole (see Table 3). The highest R&D - Production Ratio are found in industries such as aerospace (20.2 percent), computers (12.4 percent) and electronics (10.8 percent) whilst the lowest are in the wood and furniture (0.1 percent), paper and printing (0.2 percent) and textiles and clothing (0.2 percent) industries. Export values are then weighted using these R&D ratios, summed and reduced to produce an index of technology composition whereby an index value greater than one indicates that a country's exports are concentrated in industries with a high R&D intensity whilst a value less than one indicates a concentration in industries with low R&D intensities.

Index values for both 1970 and 1993 in Table 4 illustrate the development of technology composition for Asian exports over the past two and a half decades.

<table>
<thead>
<tr>
<th>Country</th>
<th>1993</th>
<th>1995 (Excluding Computers and Electronics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>0.34</td>
<td>0.24</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.72</td>
<td>0.47</td>
</tr>
<tr>
<td>Korea</td>
<td>1.07</td>
<td>0.53</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1.15</td>
<td>0.5</td>
</tr>
<tr>
<td>Singapore</td>
<td>1.79</td>
<td>0.57</td>
</tr>
<tr>
<td>Japan</td>
<td>1.3</td>
<td>0.88</td>
</tr>
<tr>
<td>China</td>
<td>2.58</td>
<td>0.36</td>
</tr>
<tr>
<td>Philippines</td>
<td>0.35</td>
<td>0.13</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.92</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Source: CIES estimates using JIDB

\textsuperscript{4} Similarly Singapore - 24 times and Korea - 19 times that of Indonesia in 1970.

ISSN: 0033-7906
Figure 3. Technology Composition Index

Source: CIES estimate using WIDB

Clearly evident in the above figure is the dramatic move into more knowledge R&D based export production for all the above mentioned Asian economies, except Indonesia. The most rapid improvement is in this regard being Singapore & Malaysia, both of which recorded a technology composition index value in 1993 in excess of 1.7. This compares extremely well with the same 1993 index values from a number of advanced western economies such as the EEC (0.50), USA (1.52), Canada (0.84), Australia (0.57) and New Zealand (0.21).

Unlike much of its immediate neighbours, Indonesia has yet to make any significant move into more knowledge intensive export production. Even the Philippines, the least successful developing economy in the Asian group, and China, Indonesia’s most visible competitor in the production and export of low technology labour intensive manufacturing, have been able to outperform Indonesia in the drive toward higher technology exports.

Indonesia’s comparative technological backwardness is further illustrated in Figure 3, which compares Indonesia’s technology index with that of a five nation average which includes Singapore, Malaysia, Thailand, Philippines, Korea and Taiwan.

Although starting from a lower base, Indonesia was able to keep pace with its Asian neighbours throughout the 1970’s and early 1980’s. However beginning in 1982/83 Indonesia’s drive toward higher technology export production lost momentum such that by the early 1990’s, Indonesia’s index of technology composition was dramatically lower than that of the five Asian nation average and, furthermore, yet to regain the high attained a decade before.

Another interesting exercise carried out by Shin-chai et al (1995) was to explore what industries have driven Asia’s rapid move into more knowledge based export production. For each of the countries listed...
Figure 4. Index of Technology Composition (Indonesia)

Figure 5. Index of Technology Composition (Malaysia)
Figure 6. Index of Technology Composition (Taiwan)

Figure 7. Index of Technology Composition (Singapore)
In Table 8, the index of technology composition was again constructed but with each of the 22 industry groupings progressively excluded. For most of the industry groupings their exclusion had little if any effect upon the country's export technology index. Two industries however—the automobile and electronics industries—stood out as key contributors to the development of the export technology index for the region. As can be seen in the fourth column of Table 4, excluding computers and electronics dramatically lowers the 1993 index values for all of the countries listed—except Indonesia. This suggests that the computer and electronics industries have played a leading role in the development of Asian industrial technological capacity. This matter is further illustrated in Figures 4-7.

For Indonesia the electronics and computer industries have had little if any effect upon the growth of the index of technology composition. In the other sample countries (Singapore, Malaysia and Taiwan) such industries represent the driving force behind the technological development of the export sector. Given Indonesia's low index value for all manufacturing in 1993, it could be concluded by this analysis that the country has failed to fully benefit from the development of local computer and electronic export industries.

There are a number of important caveats in regards to the use of the index of technology composition (ITC). First, it must be remembered that the ITC cannot be regarded as an absolute indicator of a country's technological development. The ITC has been constructed using R&D production ratios from the OECD countries from the late 1980s. However for any specific country, be it developed or developing, the R&D intensity of export production might be quite different to that of the OECD average reflecting the unique conditions of that country at that time. The best example in this regard is the electronics, computers and pharmaceutical industries—all considered high-tech using OECD technology classifications but in many cases in Asia limited to final assembly operations using imported parts and components—and should therefore be regarded as low in technology intensity.

Thus we must view the index of technology composition purely as a means to make useful cross-country comparisons of technological development. It by no means should be mistaken for measuring the actual R&D intensity of export production for a specific country. Nevertheless, the index is able to illustrate the nature of technological development in an international context. In Indonesia's case, the index shows that the country is falling further and further behind other countries in the region in the race to develop medium-high tech exports.

3. Index of Value Added

Using a similar approach to the ITC outlined above to account for the fact that knowledge intensity is not consistent across OECD and East Asian countries, we can construct another index—the Index of VA/L Composition—using Indonesian VA/L values for a given year (1989) for each of the 22 industry groups. It is not possible to make cross-country comparisons using this index due to the fact that the index is weighted using purely Indonesian VA/L values. The index does however show the trend composition of value added in Indonesian exports. An index value greater than one indicates that the majority of the country's exports are in the higher value

* or the mixing of imported active ingredients in the case of the pharmaceutical industry.
added industries whilst an index value less than one suggests a specialisation is export industries characterised by lower value added.

From the downward slope of the index in Figure 8, it can be seen that since mid-1970s the balance between higher and lower value added exports has been increasing in favour of the latter. This suggests that Indonesia’s export industries are failing to structure themselves in favour of more value-added intensive production.

4. Index of Specialisation

Another useful indicator of technology capacity using trade data is the index of specialisation (IS) as adapted by Sheahan et al. (1995) from the original standard measure developed by Balassa (1965). The index is a ratio of the share in high-tech (cr medium-high technology) exports in total exports for a particular country to the same high technology (or medium-high technology) share in world trade. Thus if the index is greater than 1 then the country in question has an above average degree of specialisation in high technology export production, whilst an index lower than one indicates a less high technology specialisation with a proportionally higher share in other areas.

Table 5 presents the estimates of specialisation using export data for the 22 industries across ten Asian countries for 1993.

From the third column in Table 5 it can be seen that of the ten country sample, Indonesia has the lowest specialisation index in both the high and medium-high technology groups, and conversely the highest specialisation is low technology exports. Most countries in the region have a high-tech IS value between 1 and 2 indicating above average specialisation. Singapore and Malaysia record particularly high IS values in the high technology ca-
### Table 5. Index of Specialisation (RCA) for Asian Exports 1993

<table>
<thead>
<tr>
<th>Technology Group</th>
<th>Industry Group</th>
<th>Tmt</th>
<th>Enterp</th>
<th>Exp</th>
<th>Sp</th>
<th>Mkt</th>
<th>Yrdy</th>
<th>Yrs</th>
<th>Thu</th>
<th>Hr.</th>
<th>Ctsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>X1</td>
<td>0.09</td>
<td>0.17</td>
<td>0.06</td>
<td>0.27</td>
<td>0.03</td>
<td>0.06</td>
<td>0.00</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X2</td>
<td>0.14</td>
<td>0.25</td>
<td>0.54</td>
<td>0.55</td>
<td>0.92</td>
<td>0.69</td>
<td>0.71</td>
<td>0.39</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X3</td>
<td>0.28</td>
<td>2.54</td>
<td>1.63</td>
<td>3.04</td>
<td>4.97</td>
<td>1.44</td>
<td>1.48</td>
<td>2.60</td>
<td>1.10</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>X4</td>
<td>0.36</td>
<td>0.06</td>
<td>0.29</td>
<td>0.64</td>
<td>0.03</td>
<td>0.12</td>
<td>0.17</td>
<td>0.32</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X H</td>
<td>0.33</td>
<td>1.47</td>
<td>1.48</td>
<td>2.50</td>
<td>2.80</td>
<td>2.13</td>
<td>1.14</td>
<td>0.64</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X S3</td>
<td>0.02</td>
<td>0.75</td>
<td>0.39</td>
<td>0.72</td>
<td>0.64</td>
<td>0.71</td>
<td>0.15</td>
<td>2.36</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X S6</td>
<td>0.03</td>
<td>0.10</td>
<td>0.61</td>
<td>0.04</td>
<td>0.06</td>
<td>0.13</td>
<td>0.01</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X7</td>
<td>0.39</td>
<td>0.50</td>
<td>0.66</td>
<td>0.67</td>
<td>0.30</td>
<td>0.28</td>
<td>0.05</td>
<td>0.36</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X 8</td>
<td>0.26</td>
<td>1.54</td>
<td>0.31</td>
<td>0.73</td>
<td>0.40</td>
<td>1.09</td>
<td>0.19</td>
<td>1.19</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>X M-H</td>
<td>0.21</td>
<td>0.57</td>
<td>0.59</td>
<td>1.32</td>
<td>0.40</td>
<td>0.37</td>
<td>0.42</td>
<td>0.38</td>
<td>0.60</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>X M-L</td>
<td>0.00</td>
<td>0.75</td>
<td>0.10</td>
<td>0.22</td>
<td>0.29</td>
<td>0.41</td>
<td>0.06</td>
<td>0.33</td>
<td>0.56</td>
<td></td>
</tr>
</tbody>
</table>

Source: CSIS estimates using IDEB data

### Figure 9. Specialisation Index

![Specialisation Index Graph](image_url)

- Indonesia
- Taiwan
- South Korea

ISSN: 0531-7846

92
Rebased Specialization Index

Source: CSIS estimate using ITDB data.

In the development of high tech export production, this dramatic reversal in the growth of Indonesia's high tech export share is more clearly illustrated by rebasing the specialization index whereby 1980 = 100.

Section D - Other Indicators of Technological Development

Foreign Investment

The type of foreign investment attracted to a country is also indicative of the host country's technological capacity. Higher human capital levels and a better developed science and technology infrastructure would not only attract more technology intensive foreign investment but also facilitate greater technology transfer. In Indonesia's case however there is widespread skepticism about the technological benefits or spinoffs from inflows of for-
ign investment. Much of the recent in-
flows of foreign investment has been in
low-technology labor-intensive manufac-
turing, such as textiles, garments, shoes,
consumer electronics consisting primarily
of assembly operations using imported
parts and components. Critics such as Tech-
ology Minister Tjahjono see such invest-
ment as footloose in that it will simply
relocate elsewhere whenever domestic
wages rates get too high and can therefore
not be relied upon to help generate a stron-
ger industrial structure.

Using a similar approach to the ITC
described above it is possible to observe
the trends in this technology intensiveness
of foreign investment. The foreign invest-
ment data in fact separated into 22 indus-
try groups according to R&D intensity and
then subsequently grouped into 4 technol-
ogy categories: high, medium-high, me-
dium-low and low technology. Figure 10
shows that much of the approved foreign
investment over the past decade and a half
has been in the medium and low technol-
ogy categories.

An index of technology composition
for foreign investment can be constructed
by weighing each of the 22 industry groups
by the OECD R&D/production ratios (as
before) and then summing and dividing so
that an index greater than one indicates
high technology composition and an index
less than one indicates lower technology
composition.

Figure 11 indicates a general upward
trend in the technology composition in-
vest. Five year averages are used to ac-
count for the uneven or specific nature of
the series which is due to the lumpiness of
the data, i.e. there is large discrete jumps in
investment approvals for certain indus-
tries in a number of years. Despite the
upward trend in the index, in 1995 it was
still below one suggesting that most for-
egn investment approvals continue to be in
low technology activities.

Similar caveats apply to this index as
they did for the ITC, i.e. there are differing
technology intensities in the 22 industries
cross countries, in particular between
OECD and non-OECD countries.

Another important caveat relates to
what exactly the data represents. Due to
data constraints, the above empirical analy-
sis utilises investment approvals rather
than realised investment. This has become
standard practice for those researching
both domestic and foreign investment in
Indonesia. Only about 40.80 percent of
approved investment is realised reflec-
ting, amongst others, the bureaucratic
difficulty in carrying out investment in
Indonesia and the fact that investors file
multiple applications and later seek capi-
tal backing for the successful project(s).

Some economists such as Arief (1999-8)
argue that there is little point in relying on
BKP data to accurately measure the
inflows of foreign investment. For the

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Footnotes:
1 For example the comment by Sunarto Samudro - the former head of LIPI - in BNPB Indonesia (22Mar 2.94) article "LIPI: hilalat publik elektronik di dunia menghasilkan ilaha teknologi" (LIPI: Radiation of electronic license does not generate technology anymore). Samarto argues that there is very little technologi-
cal progress in Indonesia in hosting education investment and in the electromonic sector as most companies who
emerges are simply "chasing lower production costs." The most important benefit to Indonesia investing in tech-
investments, he argues, is its job creation not technology transfer.
2 quoted in PEER (29 July 1993)
3 as foreseen in Table of Annexures 6,10,13,14,15,16,17,19 and 21 which frequently fall to zero.
4 Interview with an executive consultant, specialising in foreign investment approvals.

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Figure 10. Indonesian Foreign Investment

By Technology Category 1967-95

Source: Processed BKPM Data

Technology Index - Foreign Investment

purposes of this paper, however, the BKPM data is able to show what type of foreign investment that is attracted to the Indonesian manufacturing sector. As argued earlier, more knowledge intensive foreign investment would reflect a higher degree of industrial technological capacity.

Patents

Another important indicator of a country's technological development is the number of patent rights granted. Patent secure the right to monopolise the use of a product/process innovation for a given period of time. The theoretical justifica-

10 Badan Koordinasi Perumusan Modal - the Investment Coordinating Board
tion for the granting of patent rights is that in their absence there is less incentive to innovate as the economic returns to innovation cannot be fully internalised.

There are however many cases when potentially profitable inventions are not patented. First, given that patent documents are public documents many innovators may prefer to keep secret the ideas embodied within their invention for fear of giving valuable information to competitors. Second, weak intellectual property rights laws and implementation may also discourage application for patent protection. Third, it may be possible to internalise the benefits from innovation without applying for patent protection, eg when the innovator controls other parts of the production process and fourth, a rapid rate of obsolescence may remove the need for patent protection, i.e. by the time competitors are able to imitate the innovation the technology has been superseded (STAIID 1993: 91).

Thus patents are unable to give a totally unequivocal representation of qualitative measurement of a country’s innovatory capacity. Patent statistics do however provide some useful information about science and technology activities in the country concerned. The granting of a large number of patent rights is generally indicative of a high degree of innovatory activity. Moreover, given that the purpose of patents is to protect monopoly profits such innovative activity tends to be that which can be commercially applied.

Table 6. shows that the annual number of patent applications to the World Intellectual Property Organisation is low compared to other Asian countries. Prior to the introduction of the patent law in August 1991, inventors applied for provisional applications with the Indonesian Office for Patents and Trademarks as a means to secure patent protection in the event that true patent legislation was implemented. However only 4.5 percent of these applications 1953-1989 have been filed by locals suggesting that indigenous innovative activities have been minimal.
Table 7. Publications in International Journals

<table>
<thead>
<tr>
<th>Indonesia</th>
<th>Malaysia</th>
<th>Thailand</th>
<th>Singapore</th>
<th>South Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>47.8</td>
<td>171.2</td>
<td>164.4</td>
<td>88.6</td>
</tr>
<tr>
<td>1983</td>
<td>32.4</td>
<td>179.2</td>
<td>203.1</td>
<td>168.8</td>
</tr>
<tr>
<td>1986</td>
<td>60.0</td>
<td>162.7</td>
<td>206.1</td>
<td>316.5</td>
</tr>
</tbody>
</table>

Sources: STAITD (1993)

Publications

Another useful indicator of Indonesia's innovative efforts is the amount of Indonesia-sourced research publications found in international journals. STAITD (1995:86) reviews the Science Citation Index (the largest available data base for research literature maintained by the Institute for Scientific Information in the US) and finds that by regional and international standards Indonesia researchers have not been widely published.

International Standards and Quality Control

A crucial element of a country's drive toward internationally competitive export production is the internal development of an effective standardisation, testing and quality control system. Being able to produce at world class quality standards not only shows that exports from a particular country can compete internationally but also that within that country there is a highly competitive production environment (Thee 1995:32).

The attainment of international quality standards also has important implications for the development of firm level technological capability. According to Ernst and O'Connor (1989:26) it is quality considerations rather than rising costs which has represented the major inducement for the adoption of new technologies in the production systems of the Asian NICs. This is particularly the case for firms wishing to penetrate higher value added OECD markets who must be able to meet high standards of quality and reliability as well as short turnaround times. Standardisation also suggests a degree of openness to the international market as local firms would need to structure or coordinate their activities such that it is compatible with world class standards. Information regarding international standards would need to be accessed by the local firm through various means including sending production managers or engineers abroad for training or by receiving visiting trainers or quality assurance managers. Thus standardisation provides an important channel for potential technology transfer.

In Indonesia few industries meet international standards. A 1994 World Bank report on Indonesia's technological development found that the country's major measurement and testing laboratories have yet to be acknowledged internationally whilst manufacturing firms have little knowledge of and/or access to information regarding international standards.

Indonesia's relatively slow movement toward meeting international standards is illustrated in Table 8 which shows that of the 5978 ISO certificates issued to companies within East Asia by March 1995 only 55

18 Indonesia-Industrial Technology Development for a Competitive Edge, Industry and Energy Operation Division, Draft report, July
19 International Organization for Standards
<table>
<thead>
<tr>
<th>Country/Region</th>
<th>ISO 9000 Certificates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>55</td>
</tr>
<tr>
<td>Brunei</td>
<td>5</td>
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<tr>
<td>China</td>
<td>285</td>
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<tr>
<td>Hong Kong</td>
<td>551</td>
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<td>Japan</td>
<td>1827</td>
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<td>628</td>
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<td>Philippines</td>
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<tr>
<td>Singapore</td>
<td>1003</td>
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<tr>
<td>South Korea</td>
<td>390</td>
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<tr>
<td>Taiwan</td>
<td>1069</td>
</tr>
<tr>
<td>Thailand</td>
<td>95</td>
</tr>
<tr>
<td>Total (East Asia)</td>
<td>5978</td>
</tr>
<tr>
<td>Continental Europe</td>
<td>27,810</td>
</tr>
<tr>
<td>UK</td>
<td>44,107</td>
</tr>
<tr>
<td>South America</td>
<td>873</td>
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<td>North America</td>
<td>7244</td>
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<tr>
<td>Africa/West Asia</td>
<td>2875</td>
</tr>
<tr>
<td>Australia/NZ</td>
<td>6479</td>
</tr>
<tr>
<td>Other Countries</td>
<td>109</td>
</tr>
</tbody>
</table>

Source: Survey carried out by Mobi Europe Ltd in March 1995 quoted in Moerdjono (1995)

(0.9 percent) were awarded to Indonesia based companies. The ISO 9000 is the most well known international standard system in Indonesia. By adhering to this international standard the Indonesian producers shows that it possesses an effective quality management system that guarantees consistent world standards production (Thoe 1995:33). Thus the ISO 9000 has come to represent a kind of ticket necessary for competition in global markets (Moerdjono 1995: 3-4).

Conclusion

A consistent result from much of the analysis in this article is that the level and growth Indonesian industrial technological capacity remains low by regional standards. Of the various methods reviewed, the neoclassical growth accounting (TFP) approach was the only one which estimated Indonesia's rate of technology development to be higher than a regional average. However this approach was found to represent a poor measure of technological development due to unrealistic and highly restrictive assumptions of the model: first, technology is assumed to be disembodied and exogenous and is therefore treated as a separate input to the production process totally independent of human and physical capital accumulation; and second, production is assumed to be carried out under constant scale economies thereby precluding any possibility of increasing returns to scale from the use of non-rival technology inputs. An example of some unrealistic results using this approach are found in the low measure of...
TPP growth given to Singapore and Ma-
laya via o v i c; Indonesia.
A more realistic approach to the tech-
nology-growth relationship is found in the
New Growth literature. Using a cost func-
tion approach - as per Sengupta's (1991,
1993) investigation of a number of New
Growth themes in Korea's industrial de-
velopment - Indonesia's industrial sector
is found to be driven primarily by the use
of physical inputs and low skilled labour.
Unlike other Asian countries there ap-
pers to be little role for technological or
knowledge inputs in the production pro-
cess. This conclusion is supported by 1)
the use of an index of technology compa-
nition developed by weighing export val-
ues by R&D content; 2) an index of value
added per employee composition; 3) an
index of export specialization (or revealed
comparative advantage) as well as a num-
ber of other indicators such as patents,
international publications, ISO certificates
and the technological intensity of foreign
investment which show that Indonesia is
failing to keep up with its regional com-
petitors in the race toward more know-
ledge based production.

Given the likelihood of increased re-
gional competition in the production and
export of low tech labour intensive manu-
factures from countries such as China,
Vietnam and Bangladesh and the develop-
ment of a number of labour saving micro-
electronic based technologies in the devel-
oped countries, the empirical work out-
lined in this paper provides strong analyti-
cal backing for assertions continually made
by Indonesian politicians and economists
that Indonesian industry must intensify its
efforts to "move up the technological i-
dex" if it is to remain internationally com-
petitive in the future.

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