# Productivity Gains, Intersectoral Linkages, and Trade: Indonesia in the liberal era*

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**Abstract**

The importance of R&D spillovers for productivity growth has been well-documented in the literature. While studies in the context of developed countries have extensively focused on sectoral linkages, research on North-South spillovers has been largely confined to the aggregate level. This paper makes use of a novel data set, which combines OECD and Indonesian data sources to allow the estimation of international spillovers at the sectoral level. We pursue the objective of ascertaining the contribution of international R&D spillovers to manufacturing performance in Indonesia and to compare the results with those reported for the developed world. The longitudinal data-set developed allows us to assess the effect, on the one hand, of the liberal policy reforms of the last two decades on the long state-regulated and protected manufacturing enterprise, and the specific profiles of individual sectors in absorbing spillovers, on the other. Our results indicate a significant contribution of international technology spillovers in the performance of manufacturing industry in Indonesia, with the notable importance of sectoral characteristics.

## 1 Introduction. Technology and economic growth

Until the mid-eighties, mainstream economic research paid only scant attention to the role of technology, its production, diffusion and effects on an economy's

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performance. This has been due mainly to the treatment of technology as an exogenous factor in the neo-classical framework, which remained the dominant paradigm in economics for a long time. Knowledge- induced growth has attained renewed attention in economics with the emergence of the 'new' growth theories, which dominated discussion on growth and convergence across countries in the last two decades. The diminishing returns to capital predicted by the Solow model could no longer be the case with endogenous technological change resulting from research and development (R&D), technology spillovers and other sources. In the pioneering work of Romer, spillovers created by the aggregate physical and knowledge capital of all firms in the industry causes increasing returns to capital, similar in spirit to the Arrowian notion of learning by doing (Romer,1986). In an alternative formulation, division of labour, the importance of which was exemplified by Adam Smith long ago, lends itself to the production of greater variety of horizontally differentiated intermediate goods contributing to increasing productive efficiency (Romer, 1987). In Romer (1990) increasing variety of 'new-technology' intermediate goods result from the non-rivalrous nature of technical and organizational knowledge. Intermediate inputs are the drivers of growth also in the model of Aghion and Howitt (1992), which borrows from the Schumpeterian concept of creative destruction. Unlike in the model by Romer, here, intermediate inputs are vertically differentiated. Producers possess monopoly power, which is eroded only when an intermediate input with a new technology arrives.[1]

Furthermore, with empirical investigations suggesting evidence only for what is known as club convergence – convergence of per capital income of countries with similar initial conditions –[2], the question of development and catch-up in developing countries attracted renewed attention. Given that growth is influenced substantially by technological change and the diffusion of technology, and the limited resources at the disposal of developing countries for investment in R&D, human capital, etc., attention soon shifted to the ways with which less developed countries could speed up their growth. In this context, focus has mainly been in treating trade as a conduit of technology from advanced to less advanced countries (Grossman and Helpman,1991, Rivera-Batiz and Romer,1991a,b). There are in this respect some similarities with the 'technology gap' literature as it takes initial backwardness as favourable and stresses the potential of technology diffusion for imitation. Research in this tradition, however, also emphasises the importance of an existing capacity for spillover and technology absorption, like human capital, as a major prerequisite for successful catching-up in the receiving country (Abramowitz, 1986, Fagerberg, 1987, Verspagen, 1991)

However, while studies in the context of developed countries have extensively focused on sectoral linkages, research on North-South spillovers has been largely confined to the aggregate level. This paper, instead, makes use of a combined data set from OECD and Indonesian data sources to allow the estimation of

[1] Elaborate discussions on endogenous technological change in growth theories can be found in Verspagen, 1992 and, Schneider and Ziesemer, 1995.

[2] See for example De Long, 1988, and Baumol and Wolf, 1988.

international spillovers at the sectoral level. The remainder of the paper starts with a short discussion of its theoretical framework. Section 3 explains the data sources, the construction of the variables, the model and the results. A conclusion sums up the main findings and puts them into perspective.

# 2 Spillovers. Some theoretical and empirical considerations

## 2.1 Spillover as a source of growth

From a theoretical point of view, a formal notion of spillover can be deducted from the endogenous growth of Romer (1987) mentioned above. Thus, the output of a country is seen as a function of not only capital and labour but also of a range of differentiated intermediate inputs. In its simplest form this results in the augmented Cobb-Douglas production function,

$$Y_i = A_i K^\alpha N_i^\gamma L_i^\beta \tag{1}$$

with $Y_i$ as output, $A_i$ as a country-specific constant, $K_i$ and $L_i$ as capital and labour services, and $N_i$ as an index of the range of differentiated intermediates employed in country $i$ and $\alpha, \beta$ and $\gamma$ as elasticities.

Taking equation (1) as starting point, empirical investigation has either estimated the production function directly (in the line of Grilliches and Mairesse, 1984) or has tried to establish the contribution of the corresponding factors of production to the growth of total factor productivity (TFP) respectively (for a review of this research see e.g. Cameron, 1996). While the latter approach imposes the usual assumptions of TFP concerning constant returns to scale and perfect competition *a priori*, the former allows a higher degree flexibility in this respect.

A major conceptual issue, common to both approaches, is the construction of the 'spillover index' $N$, which bears important consequences for any interpretation of corresponding results.While it is common practice to employ a measure of aggregated R&D stock in the emitting country to operationalise the 'spillover potential', the modelling of spillover transmittance, i.e. the link between emitting and receiving country, and of spillover absorption on the receiving side needs some *a priori* clarification. It is in this context that Griliches (1979, 1993) pointed to the distinction between knowledge and rent spillovers.

**Knowledge spillover.** Technology exhibits certain public good characteristics, which enable industries, which are technologically *close enough* to each other, to benefit from their respective research efforts without the need to engage in economic transactions.[3] Knowledge spillover are thus 'true' externalities in the sense of Griliches (1979). In order to capture the aspect of technological

[3] This can be by means of licensing, reverse engineering, the exploitation of knowledge from academic and trade journals, turnover of researchers etc.

closeness, attempts have been made to construct measures of technological distance to use as a weight for the aggregation of the potential spillover stock. Such measures are derived amongst others from the type of performed R&D (Goto and Suzuki, 1989), the qualifications of researchers (Adams, 1990), the distribution of patents between patent classes (Jaffe, 1986) or patent classifications and citations (Verspagen, 1997). However, even with relatively close technologies, knowledge spillovers do not come as a 'free lunch' as their exploitation requires complimentary R&D investment by the receiver to create absorptive capacity (Cohen and Levinthal, 1989).

**Rent spillover.** Rent spillover, on the other hand, are not 'true' externalities but rather a shift of innovation rents from the producer to the user of a certain technology. Such shifts occur if, due to competitive market pressures, product prices do not account for quality changes, as in the case of information and communication technology. Of course, taking a bird's eyes view on a whole economy, rent spillovers equal an unwanted measurement error in attributing productivity increases to the wrong sector. Yet from the viewpoint of an individual firm, industry or country, such productivity increases are real and constitute indeed a spillover effect. Conceptually, the transmitting and absorption of rent spillovers is tied to market transactions, and, as a consequence, modelling and estimation has to rely on some measure of user-producer relationships. Thus, weights for aggregation can be derived from interindustry sales (Terleckyj, 1974, 1982), 'innovation-using/producing' matrices (Scherer, 1982, Putnam and Evenson, 1994) or from a standard input-output framework (Papaconstantinou *et al.*, 1996).

## 2.2 Imports, absorptive capacity and spillover

In the empirical reality, however, these conceptual differences are less clear-cut. Thus, imports of goods can contribute to domestic productivity growth in several ways. Firstly, import of intermediates of a higher quality or of a higher degree of specialisation can directly contribute to productivity growth as discussed above. Secondly, import of goods at prices lower than in the domestic market can contribute to increased productivity through scale effects resulting from increased demand and increasing competition. Thirdly, imported products can be copied or imitated by reverse engineering. Finally, international trade creates contacts and learning through interactions with foreign producers and users. The sum of potential effects therefore encompasses a mix of rent and knowledge spillover mechanisms. However, from a theoretical perspective, it may be argued that developing countries which lack their own R&D facilities are more likely to benefit from rent spillovers than from knowledge spillovers at least in the short run, as the former are based purely on the extent of transactions in technology intensive inputs and not on absorptive capacity.

Indeed, most of the studies on international technology spillovers have adopted a transaction-based approach. The pioneering empirical investigation has been by Coe and Helpman (1995), who for the first time found significant international R&D spillovers between OECD economies, as well as from OECD economies to developing countries (Coe *et al.*, 1997). Fagerberg and Verspagen (2000) has gone a step further by combining the perspectives of new growth theory on spillovers with the neo-classical prediction of convergence and the 'technology gap' approach which treats initial backwardness as favourable for accelerated growth. In the paper, it has been attempted as to why have studies on spillovers until CH, failed to capture the presence of international spillovers. An underlying requirement for absorption of technology diffusion as suggested by technology gap and new-growth theories is the absorptive capacity. The country specific differences in absorptive capacity contributed to cross section studies failing to capture spillovers, where as the use of panel data – which combines cross section and time series – with country and sector specific dummies, take care of country specific differences. Thus, international spillovers have been found to exist by a few studies which adopted the above mentioned approach (Coe and Helpman, 1995, Verspagen, 1997b). Following these considerations, the present study employs a panel-data framework, the details of which are discussed in the following.

# 3 International spillovers to Indonesia

## 3.1 Data and variables

The study builds a new data set for the period 1980-1993, combining the Indonesian data on large and medium sector industries with the OECD data sets, STAN, BITRA, and ANBERD. The Indonesian statistics on large and medium manufacturing Industries have been used for data on Gross Value Added (GVA), capital and labour inputs. Instead of the original data, we have made use of Timmer (1999), which made some corrections to the original data as well as estimated capital stock using incremental capital -value added ratio. The imported intermediate inputs matrix for the years 1980, 1985, 1990 and 1995 have been made use of to capture intersectoral flow of international R&D stock among domestic industries. These data have been obtained from the input output tables published by the *Biro Pusat Statistik (*BPS), Indonesia. The matrices have been converted into 1983 constant prices using the respective import price indices available in another BPS publication *Indikator Ekonomi.*There are 24 manufacturing sectors in the $66 \times 66$ matrix of imported intermediate inputs. There are 13 countries considered as sources of international R&D stock that enter Indonesia. The data on exports from these countries to Indonesia have been taken from the OECD BITRA database, the data on their GDP which is used for deriving the weighting measure for R&D as well as for deriving the implicit deflator for GDP has been taken from the OECD STAN database. And finally, the R&D data for the 13 countries have been collected from the ANBERD database. The data in 1983 constant prices have been converted into purchasing parity figures of the same year. The data on domestic R&D was not available at sectoral level and could not be made use of. However, given the small proportion of domestic R&D compared with international R&D as measured in this paper, this omission does not appear to be a major drawback.

### 3.2 The model

Again, we start from the augmented Cobb-Douglas production function as in equation (1)

$$Y_i = A_i K^{\alpha} RD_i^{\beta} L_i^{\gamma} \tag{2}$$

where $Y_i$ represents the output of sector $i$, $K$ and $L$ represent capital and labour inputs respectively and $RD_i$, the international R&D stock available in sector $i$.

We here, assume, following the theoretical consideration discussed before, that the production function exhibits constant returns to scale in capital and labour and increasing returns when taken along with the international R&D. Writing in labour intensive form, (1) becomes;

$$y_i - l_i = a_i + \alpha(k_i - l_i) + \beta rd_i + \eta l_i + \gamma t \tag{3}$$

where the lower case letters denote values in natural logarithms, $\eta$ is the returns to scale parameter equal to $(1 - (\alpha + \gamma))$ and $t$ is the time trend, that proxies the exogenous technical change.

- The derivation of international R&D stock, $RD$ is done in the following lines. First the sectoral R&D stock of each of the 13 exporting countries to Indonesia is derived by the perpetual inventory method (with the bench mark year taken as 1973) Next, the sectoral R&D stock of each country is multiplied by the share of exports to Indonesia in that country's GDP[4]. The R&D stocks so derived across countries are then combined for each sector

$$\sum_c RD_{ci} \frac{e_{ci}}{GDP_{ci}} \tag{4}$$

.

where $RD_{ci}$ is the R&D in sector $i$ of country $c$, $e_{ci}$ is the export from sector $i$ of country $c$ to Indonesia, and $GDP_{ci}$ is the GDP of country $c$ in sector $i$.

In the next step, the inter-industry distribution weights of R&D are derived by dividing each cell of the imported intermediate input matrix by its row sum

$$\left(\frac{m_{ij}}{\sum_j m_{ij}}\right) \tag{5}$$

[4] The use of exporting country's instead of the importing country's GDP - in our case Indonesia-to weight R&D as has been suggested by Litchenberg and Potterie (1996) vastly improves the results on the contribution of R&D to manufacturing performance. The results using the Indonesian output as the weighting variable turned out to be insignificant for R&D variable. (These results are not reported here due to space constraints.) This is due to the fact that while the share of Indonesia's import as a proportion of its GDP has been showing a declining trend, the export to Indonesia of most OECD countries did register an increase as a proportion of their respective GDP figures.

[5]. Here $m_{ij}$ is the intermediate input belonging to sector $i$ of all trading partners of Indonesia, imported into sector $j$ in Indonesia.

Each cell of the matrix so derived is multiplied with the R&D stock of the sector corresponding to the output of that row. Finally the column sum of this matrix is calculated that represents the international R&D stock of each sector of Indonesia for a given year. Table 1 shows the descriptive statistics of the variables used.

Table 1. Descriptive statistics

| | Mean | S.D. | Skew | Kurt | Mini | Max | NO |
|---|---|---|---|---|---|---|---|
| LnQ | 21.20 | 0.87 | 0.26 | 2.15 | 19.69 | 23.12 | 140 |
| LnK | 23.34 | 0.66 | 0.04 | 2.48 | 21.95 | 24.77 | 140 |
| LnQ/L | 9.27 | 0.47 | 0.35 | 2.59 | 8.28 | 10.38 | 140 |
| LnK/L | 11.42 | 0.40 | 0.59 | 2.84 | 10.65 | 12.44 | 140 |
| lnL | 11.93 | 0.84 | 0.65 | 2.35 | 10.63 | 13.99 | 140 |
| lnRD | 9.20 | 1.36 | -0.02 | 2.12 | 6.42 | 12.11 | 140 |

Note:S.D- Standard Deviation.Skew-Skewness.
Kurt-Kurtosis. Mini-Minimum Value. Max-Maximum Value
NO-Number of Observations

### 3.3 Estimation Results

As already mentioned, estimation has been done in a panel data framework. The Hausman statistic favoured a sector specific fixed effect against the choice of a Random effect specification. Three models have been estimated: The "Total" model with pooled data, the "Within" model with sector specific dummies, and the "Between" model based on the deviations from group means. The contrasting effects of these three modelling frame-works is discussed elsewhere in this paper (see for example, for an empirical investigation exploring the full scope of these models Fagerberg and Verspagen, 1998). In addition to estimating models with three variables, capital labour ratio, foreign R&D, and labour inputs variable capturing returns to scale, a time trend has been included to capture the contribution of exogenous technical change.

The model with lowest $R^2$ is the "Total" model. As has been pointed out before, this is on account of not taking into consideration the "unit" specific characteristics, which in this case is the sector. Inclusion of a time-trend vastly improves the explanatory power of the model in the "Total" as well as the "Within" model. Since the "Between" model takes care of the cross-sectional dimension alone, time trend was obviously not included.

[5] We did not use the Leontief coefficient to capture interindustry flow of technology. This was done because, spillovers through user-producer transactions result from the purchase by one industry of another industry's product embodying product innovation and not process innovation (see, Scherer, 1982). Thus, the higher order effects of an industry's sale of a product in terms of generating spillovers should be minimal.

| Table 2. Estimation Results | | | | | | | |
|---|---|---|---|---|---|---|---|
| | $a$ | $\alpha\,(kl)$ | $\beta\,(rd)$ | $\eta\,(l)$ | $\gamma\,(t)$ | $R^2$ | $s^2$ |
| **A.The "TOTAL" Model** | | | | | | | |
| **Without time trend** | | | | | | | |
| Coefficient | 3.74 | 0.37 | 0.10 | 0.01 | | 0.15 | 0.19 |
| t-value | 1.72 | 2.93 | 3.63 | 0.31 | | | |
| **With time trend** | | | | | | | |
| Coefficient | 8.75 | 0.16 | 0.03 | −0.18 | 0.07 | 0.44 | 0.12 |
| t-value | 4.71 | 1.54 | 1.41 | −3.35 | 8.45 | | |
| **B.The "WITHIN" model** | | | | | | | |
| **Without time trend** | | | | | | | |
| Coefficient | | 0.26 | 0.09 | 0.65 | | 0.86 | 0.33 |
| t-value | | 2.25 | 2.07 | 9.05 | | | |
| **With time trend** | | | | | | | |
| Coefficient | | 0.22 | 0.14 | −0.01 | 0.05 | 0.89 | 0.88 |
| t-value | | 2.15 | 3.39 | −0.10 | 5.80 | | |
| **C.The "Between" model** | | | | | | | |
| **Without time trend** | | | | | | | |
| Coefficient | 11.28 | 0.06 | 0.01 | −0.24 | | 0.31 | 0.15 |
| t-value | 1.18 | 0.12 | 0.08 | −0.90 | | | |

Let us first consider the R&D variable. This has been significant in the "Total" model without time trend, but not in the same model with time trend. In the "Between" model it turns out to be insignificant due to reasons noted earlier, especially sector specific characteristics. Expectedly, the R&D variable is significant with a higher coefficient value in the "Within" model with a time trend compared to all other models. The elasticity of 0.14 compares well with other studies[6]. This implies that Indonesian manufacturing sector is benefitting from imports of goods from advanced country sources in terms of its contribution to productivity growth. As to be expected capital is contributing substantially to growth in output per unit of labour inputs. Here again the sector specific dimension comes into play especially in the model with time trend. We note here that the coefficient earns a higher value with time trend in the "Within " model. While the cross-country, cross- sectoral studies found similar results as in Verspagen (*1997*), the specific sector effect appears to be an interesting result. This might point to the need for investigations at sector levels as well as

[6] Verspagen (1997), for example, estimates the highest elasticity of foreign R&D to be of approximately the same value for the low-tech sectors in his multi-country, multi-sector sample.

at more micro levels.

A negative value for the returns to scale coefficient – suggesting decreasing returns to scale – has been a regularity in empirical studies based on production function. That holds true for the present study as well in all models with a time trend included except the "Between" model. Finally, we note the importance of exogenous technical progress in productivity improvement, though of less significance vis-a-vis the foreign R&D contribution.

# 4 Concluding Remarks

The present paper is one of the many studies that aimed to bring out the contribution of international trade to productivity growth through the transmission of technology. Most of these attempts have been within the developed country scenarios. Were developing country countries have been considered it has essentially been at the country level. While such steps are of importance in understanding the broad nature of technology diffusion, the specific form of diffusion as for example, rent or knowledge spillovers was less clearly distinguished owing to the country specific nature of studies. In our study we tried to focus explicitly on technology spillovers to individual sectors in a developing country combining data on international trade flows and R&D with the input-out put transactions from imports as well as production data of the developing region considered. The results provide strong evidence of technology spillovers into the highly import intensive manufacturing industries of Indonesia. Admittedly, the fact that the use of intermediate inputs alone as carriers of interindustry transmission of technology may not accurately portray the actual contribution of spillovers of the "knowledge" variety noted before. This would warrant the use of technology based inter-sectoral flow matrices, such as the Yale concordance or the Verspagen matrices, but with a developing country focus. Given the low patenting by domestic industry, appropriate measures may include data on foreign as well as domestic technology contracts between firms. Such a step is required for obtaining a more realistic picture of the effect of Indonesian manufacturing industry's integration into high-technology markets abroad.

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