

# WORLD TRADE ORGANIZATION

RESTRICTED  
WT/WGTTT/W/1  
2 April 2002

(02-1462)

---

## Working Group on Trade and Transfer of Technology

### TRADE AND TRANSFER OF TECHNOLOGY

#### Background Note by the Secretariat

<b>I.</b>	<b>INTRODUCTION .....</b>	<b>2</b>
<b>II.</b>	<b>TECHNOLOGICAL DIFFERENCES .....</b>	<b>2</b>
A.	HOW ARE NEW TECHNOLOGIES CREATED? .....	3
B.	HOW IS INNOVATION DISTRIBUTED GEOGRAPHICALLY? .....	5
C.	HOW DOES TECHNOLOGY DIFFUSE ACROSS COUNTRIES? .....	7
<b>III.</b>	<b>TRADE AND TECHNOLOGY DIFFUSION .....</b>	<b>8</b>
A.	HOW DOES TRADE LEAD TO TECHNOLOGY TRANSFERS? .....	8
B.	WHAT FAVOURS THE ABSORPTION OF FOREIGN TECHNOLOGY ? .....	9
C.	WILL MORE TRADE LEAD TO MORE TECHNOLOGY TRANSFER? .....	11
D.	WHAT IS THE EMPIRICAL EVIDENCE ON THE ROLE OF TRADE FOR INTERNATIONAL TECHNOLOGY DIFFUSION? .....	13
<b>IV.</b>	<b>FOREIGN DIRECT INVESTMENT AND TECHNOLOGY DIFFUSION .....</b>	<b>15</b>
A.	HOW DOES FDI TRANSFER TECHNOLOGY? .....	15
B.	WHAT TYPE OF FDI EMBODIES THE HIGHEST POTENTIAL FOR TECHNOLOGY DIFFUSION? .....	18
C.	WHAT FACTORS DETERMINE THE TYPE OF FDI THAT A COUNTRY ATTRACTS? .....	19
D.	HOW DOES TECHNOLOGY TRANSFERRED THROUGH FDI DIFFUSE INTERNALLY? .....	24
E.	WHAT IS THE EMPIRICAL EVIDENCE ON THE ROLE OF FDI IN INTERNATIONAL TECHNOLOGY DIFFUSION? .....	28
<b>V.</b>	<b>PARTNERSHIP AGREEMENTS AND TECHNOLOGY TRANSFERS .....</b>	<b>31</b>
A.	WHAT DETERMINES THE DECISION BETWEEN FDI AND PARTNERSHIP AGREEMENTS? .....	32
B.	WHAT IS THE POTENTIAL FOR TECHNOLOGY TRANSFERS FROM PARTNERSHIP AGREEMENTS? .....	33
C.	WHAT IS THE EMPIRICAL EVIDENCE ON THE ROLE OF LICENSING AND JOINT VENTURES FOR TECHNOLOGY TRANSFERS? .....	33

## I. INTRODUCTION

1. The Working Group on Trade and Transfer of Technology was established in accordance with the mandate in para. 37 of the Doha Ministerial Declaration, which states that Members

"agree to an examination, in a Working Group under the auspices of the General Council, of the relationship between trade and transfer of technology, and of any possible recommendations on steps that might be taken within the mandate of the WTO to increase flows of technology to developing countries. The General Council shall report to the Fifth Session of the Ministerial Conference on progress in the examination."

2. The Working Group held an open-ended informal meeting on Wednesday, 6 March 2002, presided over by the Chairman designate of the body, at which he suggested, and the meeting agreed, that the Working Group begin with an examination of the relationship between trade and transfer of technology and proposed that the Secretariat be asked to produce a factual background document for the first formal meeting of the Working Group. That document was to contain a factual survey of the issues related to trade and transfer of technology that have been dealt with elsewhere.

3. The present document responds to that request. It has been prepared by the Secretariat on its own responsibility and is intended only for the purpose of analysis in order to assist delegations in their work on trade and transfer of technology. The note begins by examining how new technologies are created and how they diffuse geographically. Many factors are active in the process by which developing countries acquire and exploit technologies to their advantage; trade (and *a fortiori*, trade rules) is but one of these factors. The note therefore moves to an examination of empirical evidence on the role of trade in technology diffusion internationally, focussing on how trade leads to technology transfer and what factors favour the absorption of technologies. Another factor in the acquisition/exploitation process is foreign direct investment (FDI), which is sufficiently closely linked to trade to merit a discussion in the present context. The note considers FDI from the perspectives of how it leads to technology transfer, what types of FDI embody the highest potential for technology diffusion, what factors determine the type of FDI attracted by a country and how technology acquired through FDI diffuses internally. Empirical evidence of FDI's role in technology diffusion internationally is also reviewed. Finally, certain of the most important practical mechanisms for the transfer of technology (licensing, franchising and partnerships) are examined.

## II. TECHNOLOGICAL DIFFERENCES

4. Technological differences across countries are an important determinant of income levels. Empirical economic research has shown that accumulation of physical and human capital can only partially explain different income levels across countries (Easterly and Levine, 2001; Prescott 1988).<sup>1</sup>

5. The standard way to measure the technology level of a country is to look at either productivity or unit cost. Productivity is a measure of an economy's efficiency in transforming inputs into outputs. A country's Total Factor Productivity (TFP) is defined as output per unit of all inputs (usually capital and labour) combined<sup>2</sup>. Table 1 presents data on TFP for a select range of countries

---

<sup>1</sup> This and subsequent bibliographic references in this paper can be found in WT/WGTTT/W/1/Add.1.

<sup>2</sup> Total factor productivity is measured as the ratio between a country's total production and a weighted sum of the inputs used.

and the per capita income in these countries relative to the US.<sup>3</sup> It illustrates the importance of TFP for determining income differences across societies.

Table 1: Per Capita Income and Total Factor Productivity in 1988 (relative to US)

<i>Country</i>	<i>Per Capita Income</i>	<i>Total Factor Productivity</i>
United States	1.000	1.000
Canada	0.941	1.034
West Germany	0.818	0.912
France	0.818	1.126
United Kingdom	0.727	1.011
Hong Kong	0.608	1.115
Singapore	0.606	1.078
Japan	0.587	0.658
Mexico	0.433	0.926
Argentina	0.418	0.648
U.S.S.R	0.417	0.468
India	0.086	0.267
China	0.060	0.106
Kenya	0.056	0.165
Zaire	0.033	0.160
Average, 127 countries	0.296	0.516
Correlation per capita income with labour input (Y/L)	1.000	0.889

Data Sources: Penn World Tables Mark 5.6. Barro and Lee (1993). The labour input measure used in these calculations has been calculated using Mincer regression results with variable returns from different types of schooling.

6. What determines the level of technology of a country? Economic literature has shown that the rate of technological change is determined not only by domestic innovation but also by the international diffusion of technology. In developing countries, where domestic innovation is low, the international diffusion of technology acquires a relatively greater importance from the perspective of economic development. The degree of international diffusion of technology is a major determinant of the world's distribution of income. Rapid international diffusion of technology is a force toward convergence.

#### A. HOW ARE NEW TECHNOLOGIES CREATED?

7. Technological progress is only to a limited extent driven by scientific research or chance. Most of the process of technological innovation is the result of economic forces. It is the outcome of firms' research and development (R&D) activities. Industrial R&D expenditure accounts for between 2 per cent and 3 per cent of GDP in each of the major industrialised countries: the United States, France, Germany, Japan and the United Kingdom. About 75 per cent of the roughly one million US scientists and researchers are employed by firms. UK firm's R&D spending represent more than 20 per cent of their spending on gross investment (Blanchard, 1997).

8. Firms spend on R&D to increase profits or to keep up with competition from other innovating firms. The higher the expenditure on R&D the higher is the probability that a firm innovates, i.e. introduces a new or higher quality good or a new technique of production. This innovation if

<sup>3</sup> The data given is for 1988 and taken from Hall and Jones (1999). The original data set contains 127 countries and the average value for the 2 measures as well as their correlation is given in the table.

successful will increase the firm's profits or will avoid profit loss if another firm in competition with the former innovates.

9. There is an important difference between spending in R&D and buying a new machine. The outcome of the R&D activity is an idea, and as such it can be appropriated by a competitor at a lower price than the expenditure originally needed to generate the idea. This can reduce or eliminate the advantage brought by the innovation.

10. Three factors determine the level of R&D of a firm: the productivity of the R&D activity, the degree of appropriability of research results and the level of R&D expenditure of other firms.

## **1. Productivity of R&D**

11. The productivity of R&D is defined by the number of innovations that result from the R&D activity. The higher the productivity, the higher will be firms' incentive to spend in research and therefore the faster the process of technological innovation.

12. What determines the productivity of R&D?

- (a) The successful interaction of basic research (the research for general principle) and applied research and development (the application of the results of basic research to specific uses, and the development of new products) is one factor. In the computer industry for example, many of the innovations are applications of the invention of transistors or microchips. Linkages between academic research and R&D activity conducted in the private sector would favour productivity of research.
- (b) The quality and the type of the education system are important determinants of the productivity of R&D. The higher the level of education of the researchers and scientists the higher the rate of innovation in a country.

13. The type of education is also an important factor in determining the level of productivity of research. Some countries are more successful in basic innovation than in the development of new products. An education system directed toward abstract thinking is shown to produce better researchers in basic research than in applied research. An education system directed to develop a "culture of entrepreneurship" is more likely to lead to success in developing and marketing a new product.

- (c) The speed at which basic knowledge leads to the development of new products is also an important determinant of productivity of research. The profitability of introducing a new product or process in a country is therefore an important determinant of the rate of productivity of research. For example, the upgrading of the performance of a new generation of computers also depends on the extent of demand, the number of people that have acquired the knowledge to use it and the potential for applications.

## **2. Appropriability of research results**

14. The appropriability of research results is defined by the extent to which firms can benefit from the reward derived by the results of their own research. If the degree of appropriability is low a firm will not engage in R&D activity and technological progress will be slow.

15. What determines the extent of appropriability of the benefits from innovation?
- (a) The nature of innovation. If the innovation is such that it can be easily upgraded, the firm can very easily lose the advantage of being the first innovator. As a consequence the incentive to innovate will be low.
  - (b) The degree of legal protection granted to innovation. Patents give a firm the right to exclude other firms from the use of its innovation.

**3. The level of R&D expenditure of a competitor firm**

16. The decision of a firm to spend on R&D is a strategic decision, which also depends on the expenditure on R&D of its competitors. A high level of expenditure on R&D of a competitor gives the firm a high incentive to innovate. The reason is that if the competitor innovates first, the firm is likely to lose market share, experience losses and possibly be forced to exit the market.

17. In this respect, the degree of competitiveness of product market is an important determinant of the level of R&D.

**B. HOW IS INNOVATION DISTRIBUTED GEOGRAPHICALLY?**

18. In order to provide an indication of the geographical and sectoral distribution of innovation we use both R&D and patent statistics. R&D activity is highly concentrated both geographically and by industry. Almost the entire R&D activity in the world economy is concentrated in the industrial countries.<sup>4</sup> And patent ownership is highly concentrated in developed countries. (Table 2 provides data on the geographical origin of Patent Cooperation Treaty (PCT) patent applications filed in 1998 and 2000.)

---

<sup>4</sup> According to UNESCO (1993) in 1990, the industrial countries accounted for 96 per cent of total world R&D expenditure. Moreover, within the OECD the seven largest economies accounted for 92 per cent of R&D in 1991. (Coe et al., 1997).

Table 2: Geographical distribution of PCT patent applications filed in 1998 and 2000  
(from figures published on WIPO Website)

Region	Country of origin	No. patents filed 1998	No. patents filed 2000	% of total 1998	% of total 2000
North America	USA	28,356	38,171	42.3	42.0
	Canada	1,315	1,600	2.0	1.8
<i>Total North America</i>		<i>29,671</i>	<i>39,771</i>	<i>44.3</i>	<i>43.8</i>
Western Europe/EU	Germany	9,112	12,039	13.6	13.2
	UK	4,383	5,538	6.5	6.1
	France	3,322	3,601	5.0	4.0
	Sweden	2,554	3,071	3.8	3.4
	Netherlands	2,065	2,587	3.1	2.8
	Switzerland	1,293	1,701	1.9	1.9
	Finland	1,092	1,437	1.6	1.6
	Italy	925	1,354	1.4	1.5
	Denmark	624	789	0.9	0.9
	Austria	421	476	0.6	0.5
	Norway	394	470	0.6	0.5
	Others	1,101	1,463	1.6	1.6
<i>Total Western Europe/EU</i>		<i>27,286</i>	<i>34,526</i>	<i>40.7</i>	<i>38.0</i>
East Asia and China	Japan	6,098	9,402	9.1	10.3
	South Korea	485	1,514	0.7	1.7
	China	322	579	0.5	0.6
<i>Total East Asia &amp; China</i>		<i>6,905</i>	<i>11,495</i>	<i>10.3</i>	<i>12.6</i>
Eastern Europe	Russia	429	590	0.6	0.7
	Others	402	627	0.6	0.7
<i>Total Eastern Europe</i>		<i>831</i>	<i>1,217</i>	<i>1.2</i>	<i>1.3</i>
Australasia	Australia	1,048	1,627	1.6	1.8
	New Zealand	178	264	0.3	0.3
<i>Total Australasia</i>		<i>1,226</i>	<i>1,891</i>	<i>1.9</i>	<i>2.1</i>
<i>Total Middle East</i>		<i>707</i>	<i>925</i>	<i>1.1</i>	<i>1.0</i>
<i>Total Rest of Asia</i>		<i>146</i>	<i>473</i>	<i>0.2</i>	<i>0.5</i>
<i>Total Latin America/ Caribbean</i>		<i>209</i>	<i>252</i>	<i>0.3</i>	<i>0.3</i>
<i>Total Africa</i>		<i>26</i>	<i>398.0</i>	<i>&lt;0.1</i>	<i>0.4</i>
<b><i>Total applications</i></b>		<b><i>67,007</i></b>	<b><i>90,948</i></b>	<b><i>100.0</i></b>	<b><i>100.0</i></b>

19. R&D spending is also highly concentrated by industry. Among OECD countries, for instance, Keller (2001a) reports that about 80 per cent of all manufacturing R&D is conducted in four three-digit ISIC industries: chemical products (including drugs), electrical and non-electrical machinery (including computers and telecommunication equipment), and transportation equipment.

20. Table 3 reports indicators of sectoral technology intensity. Indexes refer to the average for the five most industrialised countries (France, Japan, UK, US and Germany) over the period 1973-1992. Data about R&D are computed as the share of R&D on value added and patent intensity is computed as patents per thousand employees.

Table 3: Some sectoral indicators: average 1973-92 <sup>1</sup>

Sector	R&D	Patents
Food, beverages & tobacco	0.008	0.01
Textiles, apparel & leather	0.006	0.01
Chemical products excl. drugs	0.09	0.28
Drugs and medicines	0.21	0.19
Rubber & plastic products	0.03	0.09
Non-metallic mineral products	0.02	0.05
Basic metal industries	0.02	0.02
Metal products	0.01	0.09
Non-electrical machinery	0.04	0.18
Office & computing machinery	0.16	0.20
Electrical machines	0.11	0.12
Radio, TV & communic. equip.	0.18	0.21
Transport equipment	0.14	0.05
Professional goods	0.07	0.45
Manufacturing sector	0.08	0.09

<sup>1</sup> The first column reports values of R&D intensity (i.e. R&D expenditure over value added). In the second column, patents are per thousand employees.

### C. HOW DOES TECHNOLOGY DIFFUSE ACROSS COUNTRIES?

21. There are two ways in which technology transfers across countries:

- (a) Using technologically advanced intermediate products that have been invented abroad.
- (b) Through learning about foreign technology. There are three *channels* through which a country can learn about a foreign technology. These are:
  - (i) Accessing the knowledge codified in a blueprint. This may lead to copying of the foreign technology and adjustment of the technology to domestic use.<sup>5</sup>

---

<sup>5</sup> Two important factors limit the potential of technology diffusion through this channel. First, the right to use this technology is usually protected by a patent. Second, not all knowledge is codified. It is in the interest

- (ii) Communication that stimulates cross-border learning. This channel of diffusion of knowledge is particularly important to transmit tacit knowledge, non-codified information. Part of this is learning-by-doing, which is the cost lowering effect of cumulative production.
- (iii) Interaction between domestic and foreign firms.

22. The following section discusses the role of trade, foreign direct investment, licensing, franchising and partnership (*mechanisms* for technology transfer) in the diffusion of technologies. In particular, the channels of technology transfer used by each of these mechanisms are identified.

23. Moreover, since there are two parties that play a role in the diffusion of technology across countries (the provider and the recipient of the new technology), the factor which favours the absorption of a new technology and its internal diffusion in the recipient country are singled out.

### III. TRADE AND TECHNOLOGY DIFFUSION

#### A. HOW DOES TRADE LEAD TO TECHNOLOGY TRANSFERS?

24. Technological knowledge is typically the design, or blueprint, of a new product. Therefore, technological knowledge is embodied into a product and travels with it. Trade leads to international technology diffusion because (a) it makes available for production technologically advanced intermediate goods, (b) it makes available for the study of their technological specifications intermediate and final goods, (c) it favours person-to-person communication.

25. There is an important difference between the technology transferred via the use of advanced intermediate inputs and that acquired via the learning of the technology embodied into a product. In the former case, employing the foreign intermediate good involves the implicit usage of the design knowledge that was created with the R&D investment of the foreign inventor. The technological knowledge of the blueprint is embodied in the intermediate good and the use of the technologically advanced intermediate good increases the importing country TFP. This is because, as long as the intermediate good costs less than its opportunity costs, which include the R&D costs of product development, there will be a gain from having access to foreign intermediate goods. This gain is sometimes called *passive* technology spillover (Keller, 2002). However, although an importing country has access to the results of foreign R&D activity, the technological knowledge embodied in the imported intermediate as such is not available to domestic inventors, only the manufactured outcome of it is. It is the action of importing itself that leads to technology transfer and thus a productivity increase. If imports of the relevant intermediates are interrupted for one reason or the other, the productivity increase cannot be maintained by the country as it is not able to reproduce itself the knowledge embodied in the intermediate goods.

26. This contrasts with the situation when the importing country acquires the knowledge embodied in the imported good, whether intermediate or a final good. Knowledge is acquired by reverse engineering, copying, or communicating with the suppliers of the product. In this case, the knowledge obtained through communication and/or the copying of imported goods will probably not be lost even if communication or imports are interrupted. Once the technology transfer has taken place, the foreign technology thus remains in the country.

---

of the inventor not to reveal all information and some of the information is "tacit" knowledge, in the sense that it would be very difficult to codify.



27. This process of learning is likely to be less expensive than the original expenditure needed to create the knowledge. There is therefore a gain (spillover) that result from this process. This gain is commonly defined in the economic literature as *active* spillover, as it requires the active participation of the importer.

28. For each of the channels discussed above through which trade affects technology transfers, the following discussion will consider:

- (a) the conditions that need to be satisfied in the importing country for technology transfer to occur;
- (b) the way the link between trade and technology transfer can be expected to be reflected in the data.

29. The empirical evidence on trade and technology diffusion will also be reviewed in this light.

#### B. WHAT FAVOURS THE ABSORPTION OF FOREIGN TECHNOLOGY ?

30. The following are the channels of technology transfer through trade:

##### 1. **Employing specialized and advanced intermediate products that have been invented abroad**

31. In order for trade to lead to technology transfers through this channel, it is required that the imported intermediate products be used efficiently in the domestic production process. It might also be needed that workers have a certain skill level to be able to use more technologically advanced machines and to efficiently organize the production process.

32. Meyer (2001) provides some evidence of a positive and significant effect of the combination of the stock of human capital and imports of machinery on economic growth. In particular, different levels of education seem to influence growth through different channels. Tertiary education and completed secondary education have a role in domestic R&D activities, whereas it is above all medium levels of education that interact with intermediate imports.

##### 2. **Copying foreign technologies and adjusting them to domestic use**

33. Trade enables a country to learn about a product, to copy foreign technologies and to adjust them to domestic use. Imitation is widespread and it has played a major role in the growth of high performing economies such as Japan and the newly industrialising economies of east Asia.

34. In order for it to be possible to copy a foreign technology embodied in a good, it must be the case that the blueprint on which the production of the good is based can be reproduced by analysing the final product (which may be an intermediate or final good). This implies that the technological knowledge behind the blueprint is codified and that the code is directly reproducible from the good. If part of the knowledge is not codified ("tacit"), communication with the suppliers need to complement the activity of reverse engineering.

35. If knowledge embodied in a good is codified, the skill level of the workforce of the importing country will be important in determining whether a product can be successfully imitated. The word "reengineering" in itself already indicates that relatively high levels of education and technical knowledge may be required in order for individuals to be able to copy imported products.

36. Another important aspect is the entrepreneurial environment in which the activity of copying takes place. The transfer of technologies will only take place if individuals or firms actually have an incentive to invest in the attempt of imitating. For this to be the case it is important for them to have the possibility of commercializing the product once it has been copied.

**3. International trade provides channels of communication that stimulate cross-border learning of production methods, product design, organisational methods and market conditions**

37. Knowledge is to some extent tacit. This is because for example the person who is actively engaged in a problem-solving activity may not necessarily be able to define what exactly he or she has been doing, and it may be impossible to reconstruct certain actions by only having access to the final product. In order to transfer this non-codified knowledge demonstrations, personal instruction and/or expert services may be needed. The more knowledge is non-codified, the more person-to-person communication becomes important for the diffusion of knowledge.

38. As Nelson and Pack (1999) point out, even if both the product and communication channels are available it may not be easy to reproduce the product. Indeed the attempt to reproduce a foreign technology may involve significant uncertainty and economic risk. They illustrate their point with the description of Hyundai's efforts to produce a car after it had purchased the foreign equipment, hired expatriate consultants, and signed licensing agreements with foreign firms. Their description is based on Kim (1997) who concludes:

Despite the training and consulting services of experts, Hyundai engineers repeated trials and errors for fourteen months before creating the first prototype. But the engine block broke into pieces at its first test. New prototype engines appeared almost every week, only to break in testing. No one on the team could figure out why the prototypes kept breaking down, casting serious doubts even among Hyundai management, on its capability to develop a competitive engine. The team had to scrap eleven more broken prototypes before one survived the test. There were 2,888 engine design changes. Ninety seven test engines were made before Hyundai refined its natural aspiration and turbocharger engines. In addition, more than 200 transmissions and 150 test vehicles were created before Hyundai perfected them in 1992.

39. Table 4 gives an overview of the differences between the three channels through which trade affects transfer of technology.

Table 4: Characteristics of the different channels of technology diffusion

	<i>imports of intermediates</i>	<i>copying</i>	<i>communication</i>
<i>conditions</i>	<ul style="list-style-type: none"> <li>• availability of medium skilled work force</li> </ul>	<ul style="list-style-type: none"> <li>• technology is codified and reproducible directly from good.</li> <li>• availability of medium to highly skilled work force (re-engineering).</li> <li>• appropriate entrepreneurial environment.</li> </ul>	<ul style="list-style-type: none"> <li>• technology may be partly tacit.</li> <li>• availability of medium to highly skilled workforce (re-engineering).</li> <li>• appropriate entrepreneurial environment.</li> </ul>
<i>will data reflect a positive relationship between the size of trade flows and the level of growth?</i>	<ul style="list-style-type: none"> <li>• only imports of intermediate goods are relevant.</li> <li>• yes, we expect to find positive relationship in data.</li> </ul>	<ul style="list-style-type: none"> <li>• both imports of intermediate and of final goods may potentially be relevant.</li> <li>• not clear whether to expect positive relationship in data.</li> </ul>	<ul style="list-style-type: none"> <li>• both, imports of intermediate and of final goods may potentially be relevant.</li> <li>• not clear whether to expect positive relationship in data.</li> </ul>

#### C. WILL MORE TRADE LEAD TO MORE TECHNOLOGY TRANSFER?

40. Before turning to the evidence on the impact of trade on technology transfer, consider what is the relationship between trade flows and transfer of technology to be expected. First of all it should be noted that while transfer of technology occurring through the use of technology advanced inputs into the production process refers only to trade in intermediate goods, transfer of technology occurring via copying or communication channels can result from trade of both intermediate and final goods. Testing the role played by each of the three channels of transfer of technology through trade, therefore requires data on trade in intermediate goods or total trade depending on the channel under examination.

41. A large proportion of trade of developing countries with rich OECD countries does take the form of intermediary inputs, as is evident from table 5. The large share of machinery and transport equipment in imports suggests that there are relatively large amounts of knowledge entering the country embodied in intermediary inputs.

Table 5: Trade Structure between High-Income OECD Countries and Low- and Middle-income economies (LMI)

	Composition of Trade (in %)
	Imports by LMI from OECD
Food	7.3
Agricultural raw materials	2.0
Ores and nonferrous metals	2.1
Fuels	2.0
Manufactured goods	83.2
Chemical Products	11.4
Mach. and transp. equip.	49.0
Other	22.9
Miscellaneous goods	3.3

Source: World Development Indicators, 2001 (World Bank).

High Income Countries in 1999: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden and the United Kingdom.

42. The volume of imports is a crucial aspect of transfer of technology through the use of intermediate goods. Not only would technology transfers stop if imports ceased, but also more imports of the appropriate type of product should lead to more technology transfers. If more sophisticated technologies increase a country's productivity and if a country manages to use imported intermediates efficiently in its production process, empirical analysis should find a positive correlation between the size of trade flows in intermediate goods and a country's level of factor productivity.

43. This does not necessarily imply that importing countries manage to reach productivity levels close to the ones of the country exporting the intermediate goods. As Nelson and Pack (1999) point out:

Even within the OECD countries, there is a considerable body of evidence indicating that many firms operate substantially below the best practice frontier achieved by the most efficient firms. Even the best firms in LDCs often fail to achieve the efficiency levels of firms utilising the identical technology as that of the developed countries.

44. In the case of technology transfers through copying, it is not clear whether one should expect to find a positive correlation between the size of trade flows and a country's productivity. In principle it is only necessary to import one good in order to copy it. On the other hand one could argue that higher imports increase the probability that the imported good falls into the hands of an individual or company capable of imitating the product. If this is the case, there would indeed be a positive link between the volume of trade and the incidence of technology transfer.

45. Yet, the mere imitation of the imported product will not automatically be reflected in a productivity increase of the domestic economy. In order for this to happen, the imitated good needs to be produced and the knowledge of how to produce the good needs to be spread across the economy. In other words, in order for the imitation to have a growth effect it may not be enough that only one producer acquires access to the foreign technology. If the new technology is not diffused within the country, it is again not clear whether one should expect to find a positive relationship between trade flows and total factor productivity when looking at the data.

46. A third mechanism is also to play. Once a country has managed to copy a technology and to diffuse it internally, imports of the goods embodying this technology will probably decrease. In fact the imitating country may even start exporting the relevant good. Once total factor productivity has increased we would thus expect imports to decrease.

47. To sum up, theoretical considerations suggest that even if transfer of technology take place, this would not necessarily be reflected in a positive correlation between the volume of trade and the importing country's total factor productivity (or its rate of growth).

**D. WHAT IS THE EMPIRICAL EVIDENCE ON THE ROLE OF TRADE FOR INTERNATIONAL TECHNOLOGY DIFFUSION?**

48. The evidence of the impact of trade on technology transfers is mixed. To some extent differences in the results can be explained by the different measures of knowledge and technology transfers used. Patent applications, foreign R&D and productivity, international economic activity, (e.g. the share of foreign-owned employment in total employment in much of the work on FDI spillovers) are all measures of transfer of technology. Only part of each of these measures of technology transfer is however technological spillover (gain derived to the importing country without payment of a price), since some of these measures could pick up royalties payment and licensing fees, for example, or other market-based economic transactions. In this respect, the best measure of technological spillover is probably patent citations. Yet, patent citations do not take into account the transfer of "tacit" knowledge.

49. In order to study the importance of trade for international technology diffusion, a general approach of the empirical literature is to study the effect of foreign technology (as measured by foreign R&D, patents, etc.) on domestic total factor productivity, where the level of technology abroad is weighted by the bilateral import share (international R&D spillover regression). An alternative approach is to test whether the technology developed abroad affects the rate of innovation in the home country and whether this is related to trade.

50. Hereafter is presented the result of the empirical literature on trade and international diffusion of technology, dividing between those studies that support the idea of an import composition effect on technology diffusion by country of origin, by industry, those that use patents as indicator of technology diffusion and those that focus on the analysis of the determinant of a successful international diffusion of technology.

**1. Import composition effect by country of origin**

51. In order to look at the import composition effect, empirical research distinguishes between imports originating from developed countries and those originating from developing countries, and between imports of technology intensive goods and imports of non-technology intensive. The idea is that imports originating from industrial countries have a higher embodied technology content than imports from developing countries. Similarly, imports of capital goods or imports of machinery and equipment have a higher average technological content than total manufacturing; therefore, the former have a higher potential for technology transfer.

52. This literature typically studies the extent of technology spillover using the international R&D spillover regression. This approach explains a country TFP on the basis of domestic and foreign R&D activities. The role that the R&D of each foreign trading partner plays in determining the domestic country level of productivity is weighted by the level of their bilateral imports.

53. A benchmark study in this context is that conducted by Coe and Helpman (1995). They find that technological spillovers are higher when a country imports relatively more from high rather than low-knowledge countries (i.e. there is an import composition effect). Second, they conclude that, for a given composition of imports, technology transferred from abroad is higher the higher the overall level of imports.

54. Doubts about the relevance of trade for technology transfer have been raised by a study by Keller (1998), who managed to obtain similar results to Coe and Helpman, using a "random" import shares as weight rather than the actual import shares. However, Coe and Hoffmaister (1999) contested the randomness of the import shares figure used in the Keller analysis, and confirmed the validity of their results. Moreover, Keller (1997b, 2000) himself, using the same type of analysis on industry-level data for eight industrialized countries, finds that import composition might matter. In particular, this is true, if countries receive a relatively high share of their total imports from one particular country - such as is the case for Canada, for example, which imports about 80% from the United States.

55. More recent study also supports the evidence of a significant role for trade on technology transfers. Providing support to the idea that import composition by country is an important determinant of the size of spillovers, Blyde (2001) finds stronger technology spillovers in Latin America from imports originating from the OECD than from imports originating from Latin America.

## **2. Import composition effect by industry**

56. Evidence of the importance of the sectoral composition of imports in determining technology transfers is also strong. Coe, Helpman and Hoffmaister (1997) study technology diffusion from highly industrialized to 77 developing countries. They show that total factor productivity in developing countries is positively and significantly related to R&D in their industrial country trade partners and to their imports of machinery and equipment from the industrial countries. They estimate that in 1990 the total spillover effects from R&D in the industrial countries may have boosted output in the developing countries by about 22 billion U.S. dollars. To put this figure in perspective, total official development aid from multilateral and bilateral sources in 1990 amounted to about 50 billion U.S. dollars. However, the evidence for North-South spillovers employing all-manufacturing or total goods and services import data rather than machinery and equipment import data (SITC class 7) is weaker.

57. Like Coe, Helpman and Hoffmaister (1997), Xu and Wang (1999) find evidence of trade-related technology spillovers using imports of capital goods but not using trade data for all-manufacturing goods. Similar results are obtained by Meyer (2001), who estimates that a role for the diffusion of technology for machinery imports is twice as large as that of all SITC imports.

58. Some authors have suggested that advances in ICTs might have strong productivity effects in other industries, perhaps even abroad. Gera, Gu, and Lee's (1999) estimates of technology spillovers from the U.S. to Canada suggest that technology spillovers embodied in ICT imports from the U.S. have about four times the effect on labor productivity in Canadian industries as spillovers embodied in non-ICT imports.

## **3. Patent citations as indicator for knowledge flows**

59. Some studies in the empirical economic literature that examine the evidence of international technology diffusion use patent situations (rather than R&D) as a measure of technology transfer.

60. Sjöholm (1996) examines citations in patent applications of Swedish firms to patents owned by inventors in other countries. He finds a positive correlation between Swedish patent citations and bilateral imports, a result consistent with the hypothesis that imports contribute to international knowledge spillovers.

#### 4. Determinants of successful international technology diffusion

61. There are big differences in the degree of success that countries have in adopting foreign technology. Another strand of literature has therefore asked what the major determinants of successful technology diffusion from abroad are. Two determinants of successful technology diffusion that have been emphasized are a certain level of domestic *human capital* (which is proxied by the level of education of the population; Nelson and Phelps, 1966) and of domestic R&D (Cohen and Levinthal, 1989). Both are associated with the notion of *absorptive capacity*, the idea that a firm or country needs to have a certain type of skill in order to be able to successfully adopt foreign technological knowledge.

62. The empirical economic literature that assesses the role of human capital and existing domestic R&D activity in determining technology transfers looks at how human capital interacts with measures of technology transfers. For example, Caselli and Coleman (2001) use data on imports of office, computing, and accounting machinery as a measure of inward technology diffusion. They argue that since many countries do not have a domestic computer industry, imports of computers represent a measure of transfer of computer technology from abroad. They find that computer imports are positively correlated with measures of human capital.

63. Hanushek and Kimko (2000), using standardized science and engineering test scores for around thirty countries, have recently argued that the *quality* dimension of human capital is at least as important as its general level in determining the success of technology transfer.

64. Finally, Griffith, Redding and van Reenen (2000a) use industry-level data from twelve OECD countries for the years 1974 to 1990 to study what are the determinants of productivity dynamics in this sample. Consistently with productivity convergence theory, they find that subsequent TFP growth is negatively related to the initial productivity gap. If the productivity gap variable is interacted with R&D, the tendency of TFP to converge across countries is stronger still. This is consistent with absorptive capacity being empirically important, because it says that catch-up is particularly rapid if there are substantial R&D investments in low-productivity industries.

## IV. FOREIGN DIRECT INVESTMENT AND TECHNOLOGY DIFFUSION

### A. HOW DOES FDI TRANSFER TECHNOLOGY?

65. FDI inflows from a developed to a developing country are likely to have positive effects on the host country productivity. FDI is seen to increase technological knowledge in the developing world by relocating high productivity production into the developing countries. This phenomenon implies a passive and an active knowledge spillover effect. First, investments by MNEs in developing countries tend to increase the productivity level in the developed country *directly*, simply because these foreign affiliates tend to be of greater productivity themselves and their production is included in the national statistics. Like for trade of technology advanced inputs, this is a form of passive technology diffusion, insofar it does not require a process of active learning. Moreover, this increase in productivity is lost if the MNE relocates.

66. Potentially more important (as they would not be lost when the MNE relocates in a different country) are active knowledge spillovers, i.e. the technological know-how that disseminate from

foreign production plants into the domestic economy<sup>6</sup>. In this respect, FDI might be an even more important source of technology diffusion than trade, because it involves not only the entering of goods into the developing country, but also of whole parts of the production chain of MNEs. In particular, FDI leads to imports of factors of production to the developing countries in the form of highly skilled individuals and/or capital goods of high technological content. In addition, FDI brings new management techniques, new production lines, etc..

67. In this respect, FDI fosters knowledge spillovers through the interaction between domestic and foreign firms and person-to-person communication.

## 1. Interactions between domestic and foreign firms

68. FDI favours interaction between domestic and foreign firms by bringing foreign firms geographically close to domestic firms. Three basic effects of the interaction between domestic and foreign firms lead to technology diffusion: (a) backward and forward linkages, (b) demonstration effects, (c) competition effect.

- (a) *Backward linkages* favour technological diffusion, by providing higher incentive to local suppliers to adopt new technologies. The foreign affiliate engages its suppliers in its production chain and requests from them higher quality and faster delivering standards. Technological knowledge spills from foreign more technologically advanced firms to local firms as the former often support their suppliers in their efforts in the form of inventory and quality control methods, standardisation information, etc..

*Forward linkages* favour technological diffusion, as technologically advanced foreign affiliates help the host country firms forward in the production process to raise their quality and service standards. Other firms in the market, not only the foreign affiliate, can then enjoy the higher standards of suppliers and distributors. In this way technology diffuses internally.

FDI favours the diffusion of technological knowledge through its demonstration and competition effects.

- (b) *Demonstration* effect consists in the copying, imitating and reverse engineering of new technologies and the adoption of managerial, marketing and production processes of higher efficiency (one of the most often cited examples is that local firms can learn and benefit from the export performance of foreign affiliates, that often have larger expertise in exporting and a larger portfolio of international contacts).
- (c) *Competition* effects are important because local firms may start to adopt new managerial habits and to imitate new technologies when they feel the pressure of foreign competitors in the market that have an advantage consisting of superior technologies or organisational methods.

## 2. Person-to-person communication

69. FDI also favours person-to-person communication as it brings foreign experts in contact with domestic workers. FDI may enhance human capital formation and knowledge sharing. This may

---

<sup>6</sup> Blömstrom and Kokko (1998) have recently surveyed a number of ways in which FDI can lead to spillovers.



happen in the form of formal training (on-the-job training, schooling, personnel exchange) as well as informal knowledge sharing (informal contacts, academic contacts, technical publications, etc.).

70. Production in these foreign affiliates will also entail a learning effect for the workers engaged in the production process. The learning of employees in foreign affiliates takes the form of learning-by-doing but also involves formal training for workers and management. That foreign affiliates tend to train their employees more than local firms has been documented by Gershenberg (1987) in the case of Kenya (see Box 1) and for Hong Kong by Chen (1983). Learning-by-doing is not amenable to statistical record keeping and thus not as easily empirically verifiable, but has been identified as one of the major channels of productivity growth over time. Learning-by-doing might simply consist in obtaining basic skills required to work machinery, such as sewing machines. But it might also involve domestic managerial employees learning better management and administrative skills. Since the function of managers is to achieve an efficient combination of inputs, the learning effect of managers might be very important for achieving productivity gains.

71. Training and learning-by-doing increase productivity directly, since they represent ways of accumulating human capital (intended as a higher level of expertise) that are not captured by the conventional measures of human capital, which is based on years of schooling. If this type of skill-investment by foreign affiliates in their workforce is large and productive, we can expect an increase in the output of the economy. This increase will occur without a corresponding increase in "measured inputs", thus we can in turn expect to see increases in TFP<sup>7</sup> of the host economy. Given the way we measure productivity and treat it as synonymous to technological knowledge this does represent an increase in the technological level of the economy.<sup>8</sup>

72. Foreign knowledge acquired via learning-by-doing might successively spread throughout the domestic economy, when a worker leave the MNE and starts up his own business or joins a local firm. Labour mobility spreads the gains from learning-by-doing and training in the foreign affiliates to the local economy and as such enables domestic producers to adopt new production techniques. The evidence from Kenya presented in Box 1 addresses the effects of FDI on skill levels in the host economy and the importance of labour mobility to spread acquired knowledge throughout the economy.

73. To sum up, there are four channels of technology diffusion through FDI:

- backward and forward linkages
- demonstration effects
- competition effects
- learning by doing.

---

<sup>7</sup> Recall that TFP is the average output produced per unit of inputs into production. Inputs are generally physical capital, labour and human capital.

<sup>8</sup> It should be emphasized that this process of learning-by-doing represents a form of knowledge spillover, to the extent that foreign affiliates provide some of the training and learning opportunities to their employees free of charge. Indeed, the knowledge and training received by workers in foreign affiliates becomes embodied in the workers receiving them and their property rights over these are well defined. In principle under perfect markets (if there were not liquidity constraints, or it was possible to insure against oneself the risk of uncertainty of future earnings for example) the value of this knowledge could be paid for by the employees (the employee should be able to take into account that this training will provide him with higher future earnings). If this was the case we would not be in presence of knowledge spillover. There would be a transfer of knowledge, but this would not represent an externality (see Acemoglu and Pischke, 1998).

74. The *type of FDI* (as defined by its technological content and potential for technology diffusion) together with the *economic conditions* of the host country, such as its IPR regime, general level of education of the population, degree of labour mobility and entrepreneurial environment, determine how effective these four channels are in transferring technology from abroad and diffusing foreign technology internally in the domestic country.

75. In the following sections are examined first, what types of FDI embody the highest potential for technology diffusion and second, what factors determine what type of FDI a country attract. It is shown how foreign technology acquired through FDI diffuses internally. In particular the role of education, IPR and labour mobility are examined. Finally, a survey of the empirical evidence of the impact of FDI on technology diffusion concludes this section.

## B. WHAT TYPE OF FDI EMBODIES THE HIGHEST POTENTIAL FOR TECHNOLOGY DIFFUSION?

76. The potential for technology diffusion of FDI might depend on the technology content of the FDI itself and on the extent of integration of the MNE with the economy of the host country.

### 1. Technology Content

77. The technology content of FDI can reflect on the level of technology advancement of the good produced by the MNE or on the technology intensity of the activity undertaken by the MNE in the host country. Foreign firms can decide to relocate in the host country the production of a high technology good, such as computers (as for example Intel in Costa Rica) or they can choose to produce low technology goods, such as T-shirts. Also, MNEs can locate in the host country high technology activities such as research and development, or only low technology activities such as assembling.

78. If the intensity of spillovers from FDI varies across industries, then the composition of FDI matters for the evolution of productivity in the developing country. In order to capture the fact that types of FDI characterised by different levels of technology intensity have a different impact on TFP, empirical analysis should study the impact of technology-intensive FDI on the host country TFP separately from low-technology FDI<sup>9</sup>. Unfortunately, the lack of reliable sectoral data on bilateral FDI pose an important limit to this analysis. As a consequence the size of technology transfers through FDI could be largely underestimated.

79. It might seem intuitive that technology spillovers are greater in high-technology industries. However one should be aware that this does not need to be the case. On the contrary, there is some empirical evidence that spillovers are greater in those industries in which the technological gap between developing and developed economies is smaller. One explanation for this is that when the technology gap is small, the domestic producers can build on already acquired knowledge to imitate foreign affiliates. Kokko, Tansini and Zejan (1996) use plant level data for Uruguay over the period 1988-1990 to test the existence of spillovers within industries. They find spillovers only for plants in industries with small technology gaps vis-à-vis foreign firms. They define the technology gap as the difference in labour productivity between domestic and foreign firms and they find a positive impact on labour productivity of the presence of foreign firms only in the sample with low technological gap. They interpret this as meaning that the ability of the domestic economy to generate knowledge spillovers from FDI requires the knowledge in foreign affiliates to be close to the technology frontier of the domestic economy.

---

<sup>9</sup> An alternative could be to estimate the different impact of FDI originated by various countries, each of which is characterised by a different level of technological development (see Girma and Wakelin, 2001). This would however only partially overcome the problem.

## 2. Extent of Integration with the local economy

80. For a given level of technology intensity of FDI, the extent of integration with the local market and with the local labour force also determine FDI's potential to diffuse technology.

81. What determines the extent of integration of FDI with the local market? A crucial distinction in this regard is whether the FDI is intended to use the cheap labour in the local market and then export to developed countries; or to serve the demand in the local market, using intermediate goods produced by local producers and local skilled as well as unskilled work force. In the former case, backward and forward linkages, demonstration effects and competition effects are not used as channels of international diffusion of technology. Technology is in this case transferred from the investor to the local economy only via the training and learning-by-doing of the local labour force employed by the investor. If the main reason for the investor's location in the host country is to exploit cheap labour, it is also likely that the company is engaged in a low-technology intensive activity. Therefore, the technology transfer occurring through learning by doing will also be limited in scale. If the investment is focussed on the domestic market, however FDI acts as a mechanism of technology transfer through all possible channels. As a consequence, the potential for technology spillovers into the local economy is larger.

82. This leads to the differences between vertical and horizontal FDI. The distinction between these two types of FDI is important because they are likely to be characterised by a different degree of integration with the economic network of the host country.

83. *Vertical FDI* characterise, investment decisions of firms from developed countries in developing countries (Maskus 1998). Vertical FDI is typical of those firms that fragment their production chain into stages, matching factor intensities of their activities with factor endowments of host countries.

84. Vertical FDI generally relates to production for export (be it of consumer end products or intermediate goods). It is often concentrated in Export Processing Zones which have very few linkages with the country where they are located (CEPAL, 1998; Buitelaar and Padilla Perez, 2000). Therefore it is likely to present a very low potential for technology transfer.

85. *Horizontal FDI* concerns the foreign production of goods for the foreign market that are similar to those produced at home. In the horizontal-type FDI, multiplant firms produce similar goods in all locations. Horizontal FDI is sometimes referred to as market-seeking FDI, and it is more common in FDI between industrialised countries of similar size and characteristics. In this case the MNE is likely to develop strong backward and forward linkages with the host economy, and is likely to induce a strong competition and demonstration effect together with learning-by-doing.

### C. WHAT FACTORS DETERMINE THE TYPE OF FDI THAT A COUNTRY ATTRACTS?

86. The previous section noted that technology transfers through FDI might depend on the level of technology intensity of the FDI and the extent of integration between the activity of the multinational and the local economy. It is in general believed that vertical FDI is characterised by a lower degree of integration with the local market and a lower level of technology intensity than is horizontal FDI.

87. This section considers what determines the level of technology intensity of FDI that enters a country, and in particular the role of the level of education and the strength of the FDI regime in determining what type of FDI a country will attract.

## **1. What determines the level of technology content of the FDI that enters into a country?**

88. In order to answer this question it is necessary first to define what determines the decision of investment. An early attempt at explaining why firms become multinationals was developed by Dunning's, (1981) O-L-I framework. Dunning identifies three types of advantage that a firm needs to enjoy in order to become international and be able to face the competition of local firms in foreign markets.

- (a) Ownership advantage. The firm has to own tangible or intangible (technology, trademark) assets that confer it a comparative advantage. Intangible assets tend to play a larger role in this case. These are often knowledge-based assets that can easily be transferred within the firm across borders but not between firms.
- (b) Location advantages. It must be advantageous to locate abroad rather than servicing the foreign market through exports. This can occur when high transport costs divide two countries, when the host country has low labour costs or large natural resources of the type used as input in the investing firm, for example.
- (c) Internalisation advantages. Firms must enjoy an advantage in servicing the market locally themselves rather than licensing, or selling their knowledge abroad and letting local firms serve the market. The most obvious reason for internalisation advantages is the inability to design contracts that satisfy both the multinational and the local firm.

89. Firms that enjoy these three advantages will find it more efficient to serve foreign markets via FDI rather than by exports or licensing. Elaborating on this framework, other economists (Markusen and Maskus, 1999a and 1999b) have argued that the most common reason for a firm to become a multinational is that the firm possess a specific knowledge-intensive asset that can be easily (and cheaply) transferred within the firm and used in several plants at minimal extra cost (economies of multiplant production), but cannot be easily transferred across firms. It is the knowledge-intensive nature of MNE activities that makes FDI so important for technology spillovers.

90. It follows that the regime of IPR (ownership advantage) and the availability of skilled labour (location advantage) in the host country are two important factors in determining the location of high-technology firms. These issues are discussed more extensively in the next sections.

## **2. IPR and FDI inflows to developing countries**

### IPR and the volume of FDI to developing countries

91. It is generally argued that a strong IPR regime favours FDI inflows into a country, because it ensures that the inventor can appropriate monopoly profits from innovation. Yet, the empirical evidence on the effects of IPRs on FDI is mixed (see Kondo, 1995, Ferrantino 1993, Mansfield (1995) Lee and Mansfield, 1996; Maskus 2000a)<sup>10</sup>.

92. A plausible explanation of the weak evidence for a positive impact of a stronger IPR regime on the volume of inward FDI is based on three arguments. First, the strength of the IPR regime is likely to affect differently different types of FDI (vertical versus horizontal FDI). Second, the type of FDI that a country attracts largely depends on its level of development. Finally, trade, FDI and

---

<sup>10</sup> Maskus (2000a,b), Mansfield (1995) and Lee and Mansfield (1996) find a positive and significant effect of the strength of IPR and US FDI; Maskus' results hold only for FDI to developing countries. Ferrantino (1993) and Kondo (1995) do not find evidence of a significant effect.

licensing are substitute ways of serving a foreign market. The regime of IPR determines which of these mechanisms is chosen by a foreign firm.

(i) *IPR and vertical versus horizontal FDI*

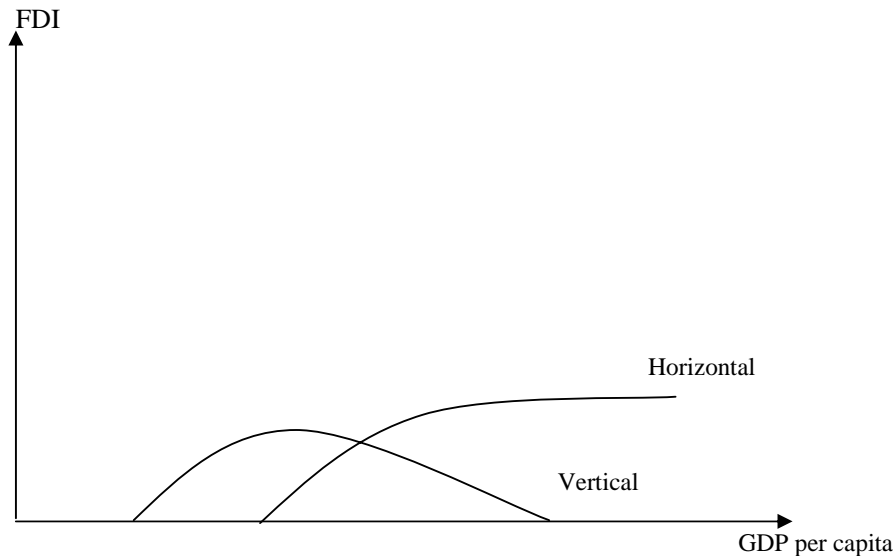
93. In the case of vertical FDI, the firm locates in a specific country to take advantage of lower production costs or natural resources not available elsewhere. The investor is neither interested in the local demand for its products nor in how IPRs in that country affects that demand. Local IPR regimes play a role in the location decision of vertical FDI only to the extent that lack of protection could interfere with the production process, or that local firms could develop into international competitors by imitating technologies. Developing countries have too large a technological disadvantage with respect to developed countries to be able to represent a threat to the MNE in the international market. Therefore a strengthening of the IPR regime is not likely greatly to affect the decision of a firm located in a developed country to invest directly (in the form of vertical FDI) in a developing countries.

94. In the case of horizontal FDI, firms locate in a specific country to serve its market more efficiently. This is more often the case when the reason why a firm directly invests abroad is to take advantage of its ownership of intangible assets (trade mark, patents, copyrights). In these circumstances, the attractiveness of a market (market size, purchasing power of its population) and the strength of the IPR regime play a crucial role in the firm's decision to invest abroad. A weak IPR regime could hinder the offer of IPR-sensitive products – i.e. those that can be easily copied, via FDI as cheaper imitation or copied products could reach the market, preventing the appropriation by the multinational of its reward to innovation. It follows that stronger IPR regimes are likely to be associated with higher horizontal FDI.

(ii) *The type of FDI and the level of development of the host country*

95. In general, the type of FDI that a country attracts is highly correlated with its development stage (Maskus 1998, Figure below). LDCs attract virtually no FDI (except in natural resources), since they lack the necessary infrastructure and human capital. As countries develop, they are increasingly able to attract vertical FDI, mainly attracted by low wages. As countries climb the development ladder, their wage level rises and they become less attractive for vertical FDI. However, rising wages usually mean rising purchasing power of the population, and countries become more attractive for horizontal FDI.

Figure 1: Inward Vertical and Horizontal FDI Flows and the Level of Development of an Economy



Source: Zhang (1996) and Maskus (1998b)

(iii) *IPR and the choice between Exporting, FDI or Licensing*

96. A firm has three ways to supply a foreign market. It can export the product, produce it there or sell the license to another firm. The decision among these different mechanisms to serve the market is in part related to the level of enforcement of IPRs in the foreign market. In particular, economic theory suggests (see Maskus 2000b) that firms first serve markets with exports. As countries improve their IPRs regimes, exports are substituted by FDI and when a certain threshold of protection is reached FDI is substituted by licensing.

97. The results of some of the empirical literature support this theory. For example, Maskus (2000b) finds a negative correlation between US FDI and the strength of IPRs in the country of destination for a sample of both developed and developing countries, but a positive correlation for the sub-sample of developing countries. A plausible explanation is that the negative sign captures the substitution effect of FDI versus licensing for developed countries, whilst the positive sign arises from the fact that few developing countries have reached the IPR threshold yet.

98. To sum up, the weak evidence of a strong relationship between the strength of the IPR regime and the flow of FDI to developing countries can be explained by the fact that most of the FDI flows to developing countries are vertical FDI and that vertical FDI is not very sensitive to the extent of enforcement of IPRs. As far as FDI to developed countries is concerned, the level of IPRs is in general very high so a stronger IPR regime could lead to the choice by firms to serve the market by licensing rather than FDI.

IPR and the technology content of FDI

99. There is only weak evidence of a positive effect of the strength of the IPR regime on FDI inflows. This raises the question whether the IPR regime affects the composition of FDI in terms of its technological content. It is indeed likely that the regime of IPR plays a different role in the investment decisions of a firm engaged in high technology activities (such as R&D) or producing a technology intensive good as compared to a firm producing a low-tech commodity, for example.

100. A survey conducted by Mansfield (1995) on several American, German and Japanese companies shows that, as the technology intensity of the activity of a firm increases -from sales/distribution to R&D activities-, the percentage of firms reporting that the strength of IPRs is an important factor in the decision of whether to locate their direct investment in a country or in another one increases. In another study, Lee and Mansfield (1996) using data of US FDI at the firm level found that IPRs play a larger role in determining the location of FDI for technology intensive activities, and when technology is easily copied.

101. Overall, evidence on the relationship between strength of the IPR regime and FDI flows shows that a strong IPR regime is an important factor in attract of investment by high technology firms.

### **3. Education as a pull factor for FDI: a reason for a sound education policy**

102. There is a two way relationship between education and FDI. FDI raises the overall level of expertise of the workforce in the host country, through training and learning-by doing. As long as multinationals hire local labour, training and learning-by-doing represent a spillover of knowledge generated abroad to the host country.

103. In this section it is seen that a high level of education is also a pull factor for FDI. An economy with a large pool of skilled workers might be able to attract more FDI. In addition, it is possible that education levels affect the composition of FDI by industrial sector.

#### Education and FDI inflows

104. It can be argued that the availability of a cheap workforce is the main reason for multinational enterprises to locate in a developing country. An increase in the relative supply of skilled labour will lead to an increase in the relative wages for unskilled labour and could as such have an adverse effect on total FDI. However, installation of capital and administration of production processes requires skilled labour, so the supply of skilled labour also affects the cost of investing in a country. Foreign affiliates tend to import production processes originating in the developed world and these processes often require a workforce that is relatively skilled compared to the local population. The availability of skilled labour will thus increase the incentive for FDI flows into a country. In addition, since the reliance of foreign investors on skilled labour varies across industrial sectors, the relative supply of skilled versus unskilled labour will influence the sectoral composition of FDI.

105. There is evidence that foreign affiliates hire more skilled labour than their domestic counterparts, thus showing the importance of the local availability of skilled labour for location decisions of MNEs. Aitken, Harrison and Lipsey (1996) provide data for Mexico and Venezuela on the pay structure of foreign affiliates as compared to domestic firms. In the case of Venezuela, wages paid by foreign affiliates were on average 31 per cent higher than those paid by domestic producers. In Mexico this premium reached 38 per cent. These premia are paid, either because the mix of the labour force foreign investors hire contains more high-skilled, high-wage employees or because the workers acquire skills while working for foreign investors that increase their reservation wages. What matters in the context of pulling FDI is to what degree the demand of foreign affiliates is relatively "skill-heavy". Aitken et al. (1996) provide evidence of the fact that foreign firms tend to locate in industries and regions that are skill-intensive relative to the rest of the economy. This indicates that the wage premium is not only due to the skills acquired by employees while working in foreign affiliates, but also that foreign affiliates tend to hire more highly skilled labour to start off with. It can be concluded that an increase in the supply of skilled labour would benefit foreign investors and likely induce FDI flows into the economy.

### Education and the Composition of FDI

106. The question of whether the composition of FDI is affected by the relative skill levels available in different economies is at least from a theoretical point of view easier to answer. Changes in the supply of educated workers can be expected to affect the industrial composition of FDI flows according to how skill-intensive these are, since it directly affects the costs of production in these industries. An example of a transition economy attracting FDI in high technology sectors is Costa Rica, where large FDI flows over recent years occurred in relatively high technology industries. The decision by Intel to locate a significant part of its chip production in Costa Rica in 1998 is a noticeable example. The major reasons given by Intel at the time for this decision have been the high skill level and literacy in English of Costa Rica's workforce, next to stability and respect for the rule of law.

107. The educational mix (the relative supply of a workforce of different types of qualifications) is also very important. It will lead to differences not only in the industries in which FDI takes place, but also in the type of activity MNEs choose to transfer to their foreign affiliates. Consider the car industry as an example. An increase in the supply of skilled labour might induce a MNE to upgrade its production from purely final assembly of the car to include actual construction of complicated components, such as the axle or engine. As the skill supply rises further, part of the firm's R&D activity might also be moved to the foreign affiliate.

108. If FDI is important for the international diffusion of technological knowledge, the evidence that the level and the type of education affect the flow of FDI into a country and the type of FDI that the country attracts stresses the importance of a sound education policy for development. As seen in the next section, a sound education policy is also important for development, insofar as the level and the quality of education in a country is also an important determinant of its "absorptive capacity", i.e. its ability to adopt innovations originated abroad.

#### **D. HOW DOES TECHNOLOGY TRANSFERRED THROUGH FDI DIFFUSE INTERNALLY?**

109. The previous section considered how IPR and education act as pull factors of FDI. It was shown that the strength of the IPR regime and the level and quality mix of the supply of skilled labour force affect not only FDI flows but also their sectoral composition and the type of activity in which MNEs will engage. It was also explained that the volume and the type of FDI that a country attracts are important determinants of the size of international technology transfers.

110. Technology transfer is a two party business. There is a technology provider and a technology recipient. Successful technology transfers require that the host country be able to acquire the technology and that this technology diffuse internally. In this section the focus is on IPRs, education and labour mobility as factors determining how easily foreign technology is acquired and diffuses internally in the host country.

#### **1. IPR and the internal diffusion of technology**

111. It was seen in the previous section (section C.2) that a stronger IPR regime can lead to larger flows of FDI or FDI with higher technology content. This will increase the technology transferred. How will a stronger IPR regime impact on the absorption and internal diffusion of technology in the host country, for a given flow and composition of FDI? The answer requires looking at each of the channels of technology transfers analysed in section A.

112. Technology diffusion through backward and forward linkages is affected in two opposite ways by the strength of the IPR regime. On the one hand, if IPRs are weakly protected, a foreign firm can fear suppliers or distributors as potential competitors, or it can fear losing the advantage over



other competitors deriving from the exclusive access to higher quality inputs or distribution services that a strong IPR regime could guarantee. It will thus tend to develop few backward and forward linkages. On the other hand, if technology is disclosed to all potential suppliers or distributors, the foreign firms can enjoy the benefits of stronger competition among suppliers and distributors. From this view point, weak IPR protection will constitute a disincentive to develop backward and forward linkages.

113. On the other hand, technology diffusion through demonstration and competition effects of FDI may be seriously curtailed by a strong IPR regime. Demonstration and competition effects can only take place if local firms are allowed to copy and imitate the new technologies and managerial skills of the foreign entrant.

114. As far as technology transfers through training and learning-by-doing of local managerial staff are concerned, labour mobility allows the spread within the host country (internal diffusion) of the know-how of foreign affiliates. This occurs when workers trained in multinationals move to local firms. An IPR regime that is too strong may curtail the spread of information, but an IPR regime that is too weak may lead firms to bring most managerial staff from their home country and involve local staff only in the lower ends of the production chain where it does not fear the spread of the know-how learnt. Sherwood (1990) reports findings of surveys in Brazil and Mexico where MNE executives argue that workers' exposure to new technologies is constrained by the infeasibility of protecting proprietary technologies in case the workers were hired away.

115. There is also an indirect positive effect of stronger IPR on the internal diffusion of technology. As previously noted, the strength of the IPR regime may determine what type of activity foreign firms will locate into the host country. For example, a protected IPR regime may favour the location of R&D activity rather than assembling, say. This may have an indirect effect on the capacity of a country to acquire technology and spread it internally, insofar as a strong IPR regime alleviates the brain drain problem for developing countries, by giving high qualified individuals the possibility to work in their home country (McGrath, 1996).

## **2. Education and the host country absorptive capacity**

116. How does the education of the domestic workforce influence the diffusion of knowledge to the local economy? It was earlier noted that the level and the quality mix of the education of the workforce (i.e. the availability of human capital) is an important determinant of the composition of FDI. This composition effect can influence the overall intensity of technological diffusion into the host economy, if certain industries display greater or lower propensity to transfer knowledge (see section B).

117. However, the level and the quality mix of the education of skilled workers, also determine the absorptive capacity of a country. As in the case of trade induced spillovers, the reengineering of knowledge depends on the availability of skilled labour in the developed country. Technology transfers cannot occur, if the host country lacks adequate human capital.

118. A survey of the empirical studies underlying the importance of a country minimum education level in order to be able to benefit from FDI originated in developed countries is provided in the subsequent section E. It can be anticipated that there is in general evidence of a positive and significant effect of education achievements and the magnitude of technology transfers.

## **3. Labour Mobility and Technology Diffusion**

119. The training and the learning-by-doing that MNEs offer to local workers is embodied into the worker. The knowledge accumulated as human capital will diffuse internally into the local market if

this employee leaves MNE to go to work in a local firm or start up a new business. In this context the flexibility of the labour market and the efficiency of the financial market in the host country play a crucial role in determining internal diffusion of knowledge. If the labour market is not flexible local firms cannot match the wage required to attract a trained worker from the multinational. On the other hand, if financial markets are inefficient, the worker may face liquidity problems that would hinder any decision to leave the MNE or start a new business.

120. What are the effects of training on a worker's probability to leave the MNE? It is rational to expect that those individuals who have received the most training are the least likely to move from the MNE, since MNEs will attempt to protect their investment through greater salaries and other benefits. Earning profiles of workers receiving more training should appear to be steeper.

121. On the other hand, it must also be the case that those individuals who have acquired a knowledge that is not available in other firms, are especially attractive to local producers. In particular, the value of skills learned in the foreign affiliates is larger for domestic producers than for other MNEs. Therefore, if a worker of a MNE leaves the current employer, local producers have an incentive to outbid other MNEs in order to be able to benefit from his/her services. Thus conditional on leaving the MNE, individuals will be more likely to switch to domestic producers.

122. To sum up, internal technology diffusion will depend mainly on the flexibility of the labour market. There are two opposing forces that determine the spread of the knowledge accumulated in the form of expertise through the host economy. On the one hand, the MNE will try to reduce the probability that a trained worker leave the firm, by offering higher wages, say. On the other hand, local firms have a higher incentive than other multinationals to hire a worker that has been trained in a MNE. Therefore, if a worker leaves a MNE the probability is high that he will be hired by a local firm. The evidence of Kenya and Bangladesh presented in Box 1 confirms these predictions.

**Box 1: Labour Mobility and FDI - Evidence from Kenya and Bangladesh**

In the OECD, switching between employers has become commonplace for employees, as they attempt to find better matches for their skills, new challenges and simply higher wages and better career opportunities. Is this mobility of workers between firms also present in the developing world and does it contribute to the spread of knowledge between foreign affiliates and domestic producer?

These questions are significant for all types of employment, but managerial employment does deserve special attention because of the central role it plays in achieving efficient production practices. Furthermore domestic managerial personnel are rare in many developing countries. In Kenya, for example, at the time of independence in 1963, 81 per cent of top-level administrators and 55 per cent of all managerial personnel in the private sector were foreigners. Since then the share of Kenyans amongst the managerial employment has increased substantially, so that in 1980 77.5 per cent of managerial personnel were Kenyans. What role did MNEs play in this transformation? Do local employees get additional training and learn modern practices in foreign affiliates of MNEs? Does this knowledge spread to the domestic sector?

Answers to these questions can be obtained from Kenyan detailed survey data of 72 middle to higher level managers working at local firms, affiliates of MNEs or in joint ventures between international firms and public enterprises. All the firms in question employ at least 50 workers.

The first observation this data permits is that local managers in foreign affiliates receive considerably more training than managers at locally owned firms. Figure 2 presents the amounts of training given to managers of different firms and the breakdown of this training into different forms of training. The height of the bars represents total training received, whereas the different patterns show the type of

training. Firms with international connections, especially foreign affiliates of MNEs provide substantially more training to their managers and most of this additional training takes the form of more formal instruction (seminars and schooling), with some additional training taking place outside of Kenya. By contrast, locally owned firms tend to train their managers much less and almost all of this training takes the form of on-the-job training.

The professional mobility of managers, who get trained by foreign affiliates and then fill positions in the domestic sector, contributes to the spread of knowledge throughout the economy. However multi-national firms are interested in recouping the investment made into their managers and thus to reduce turn-over amongst their managerial staff. Managers in MNEs do consequently exhibit much less mobility than those at local producers. Whereas in the whole surveyed sample 39 per cent of managers were working in MNEs, the proportion of employees of MNEs amongst those that never switched employers was 53 per cent. For local managers the proportion in the sample was 22 per cent, but they only represented 11 per cent of the 'loyal' managers. Thus the managers in the MNEs tended to be much more loyal than those in local firms, who received substantially less training. In addition, even among the managers within the different firm categories, the tendency to stay longer in a firm increases in the average training received by the employee. Managers who never switched firms have on average received substantially more training than those that did switch, regardless of whether they worked in local firms, joint ventures or multi-national enterprises. This confirms that firms are keen to reduce turnover in general and even more so amongst those managers that receive the most training.

Managers who received training and learned about advanced technological production processes in the MNEs tend to be especially valuable to domestic producers. The marginal product of those workers after acquiring the training in the MNEs is higher in the domestic firms than in the MNEs, who already possess the knowledge embodied in these managers. This is reflected by the fact that conditional on leaving a MNE, the managers are more likely to start working at a domestic producer than to move to another MNE. Consider the table below. The data shows substantial fluctuation between MNEs and local firms of the pattern described above. Both managers from MNEs and from local firms are more likely to change the type of firm, than the pure employment shares would warrant. A manager coming from an MNE was 16 percentage points less likely to be hired by another MNE than if the hiring was done randomly according to employment shares. Likewise for managers coming from locally owned firms the likelihood to switch to an MNE is also higher than warranted by the employment share of MNEs.

The data from Kenya thus suggests that the presence of multi-national firms increases the amount of managerial training given to indigenous managers and that even though MNEs take steps to reduce turn-over, there is a substantial amount of fluctuation between local firms and the affiliates of MNEs. MNEs do train their employees more than domestic producers and these acquire skills in MNEs that are valuable to domestic producers. One of the main conditions for diffusion, the mobility of factors between local and foreign-owned firms is given. The indirect effect of dispersion of skills through labour turn-over adds to the direct effect of training by foreign affiliates on the productivity levels in the host economy.

The evidence from Kenya for the managerial level is complemented by an interesting study of the emergence of the Bangladeshi textile industry described in the World Investment Report (1992). It describes the technological cooperation of Daewoo with Desh, the first locally established exporter of manufactured textiles in Bangladesh. Of 130 initial workers, 115 eventually left either to work for other new local garment manufacturers or in order to set up their own manufacturing plant for garments. This illustrates the spread of skill and technological knowledge from joint-ventures and FDI through the mechanism of labour mobility.

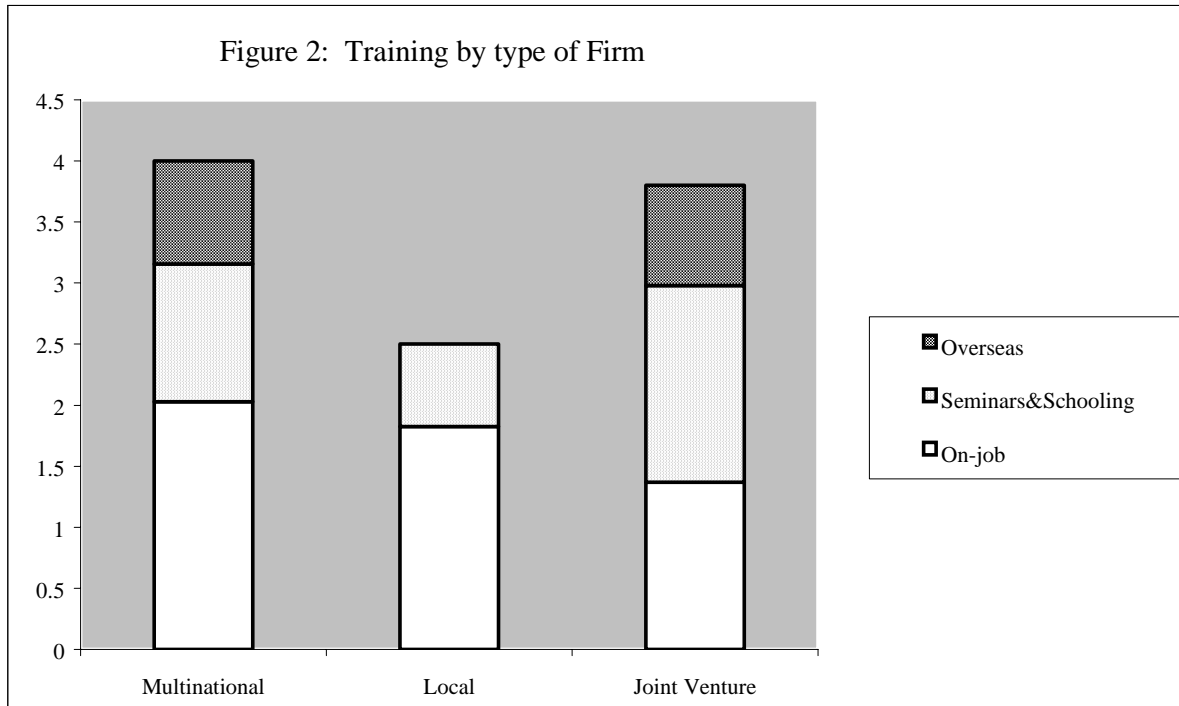


Table 6: Employment Switch for Managers Between MNE and local firms (Kenya)

	To MNE	To Local
From MNE	48%	52%
From Local	75%	25%
Pure Employment shares	64%	36%

Note: The top two rows of the table give the conditional transition probability for a manager of a firm of either type. Thus the top left entry reads: 48% of managers conditional on leaving a MNE and hired by either MNE or local producers were hired by an MNE. The bottom row gives the employment shares for different types of firms in the sample. From this we see that a manager coming from an MNE was 16% less likely to be hired by another MNE than if the hiring was done randomly according to employment shares. Data from Gershenberg (1987).

E. WHAT IS THE EMPIRICAL EVIDENCE ON THE ROLE OF FDI IN INTERNATIONAL TECHNOLOGY DIFFUSION?

123. This section reviews the results of recent empirical economic literature on the importance of FDI as a channel of international technology diffusion. The approach generally used in the literature to estimate the contribution of FDI to domestic productivity consists in explaining domestic productivity levels with domestic and foreign R&D effort (as measured by patent count or R&D expenditure). The contribution of each foreign country R&D on domestic productivity is weighted by

the volume of bilateral FDI or other measures of multinational activities such as subsidiary GDP, sales or its number of employees.

124. A general result is that FDI increases the host country total factor productivity. Yet, this effect is in general not as strong as the estimated technology spillover effect of trade. To some extent, this result can be ascribed to the fact that data on bilateral FDI are not as good as trade data.<sup>11</sup>

# **1. The impact of FDI on productivity: various measures of FDI**

125. Below are reported some of the results of the studies on FDI and productivity. These studies differ mainly in the measures of FDI used net capital flows, share of subsidiaries' value added, their share of employment, number of plants, patents.

126. Using a sample of thirteen OECD countries, Lichtenberg and van Pottelsberghe de la Potterie (1996) find positive knowledge spillovers from outward FDI, but insignificant spillover effects from inward FDI. Using industry level data, Baldwin, Braconier and Forslid (1999) find some indication of positive spillover effects from inward FDI. However, overall, their results are mixed. Both these studies rely on figures for FDI derived by the balance of payment – a quite imprecise measure of FDI, since not all net capital flows are FDI, on the contrary capital flows can be generated in the local capital market.

127. The study conducted by Xu (2000) uses the share of subsidiary value added over the host country GDP as a measure of multinational activity. He finds a positive correlation between US outward FDI and productivity growth in the host country. In addition, he shows that technological spillovers from US multinationals subsidiaries are stronger for rich countries than for poor countries; and provides evidence that this result might be related to the different levels of human capital in the two groups of countries.

128. Other studies use firm-level data. Among these, Aitken and Harrison (1999) find a negative effect of FDI on productivity of Venezuelan plants between 1976 and 1989. Here FDI is measured as the ratio of employment of foreign owned plants to total employment. This measure presents some shortcomings. For example, a lower level of total employment would increase the measure of FDI adopted by Aitken and Harrison, even if the presence of foreign firms has not changed. So, Aitken and Harrison's result it is likely to capture a short term effect, rather than a long term one.

129. The studies conducted by Girma and Wakelin (2001) and Haskel, Pereira and Slaughter (2001) are subject to the same shortcomings as Aitken and Harrison. Girma and Wakelin (2001) study the impact of inward FDI on the UK electronic industry between 1980 and 1992. The level of inward FDI is measured by the ratio of foreign owned plants to all plants. Productivity growth in the electronic sector is explained by three types of technology transfer, intra-industry spillovers (measured by inward FDI in the electronic industry at 4-digit level) divided by foreigner investor country, inter-industry spillovers between industries that are technologically similar (measured as the FDI in the electronic industry at the 2-digit industry) and inter-industry spillovers between industries that are located in the same geographic region within the UK. The data show evidence of positive spillovers from most of the countries but the US, and from plants technologically similar, but not stronger spillovers from plants geographically close.

---

<sup>11</sup> A secondary explanation is that the productivity effect of imports of intermediate goods are overestimated due to the fact that the quality of inputs is not adequately taken into account when the productivity of industries using imported intermediate goods is computed (unavailable or slowly adjusted price indices are two possible reasons for this problem).

130. Haskel et al. extend the sample set used by Girma and Wakelin and repeat their estimation using a different techniques. Their results differ in the finding that US FDI shows positive spillover effects, whilst Japan shows negative effects; but they confirm the finding that there are positive spillovers between plants technologically similar, whilst their geographical proximity is not a significant source of spillovers.

131. Globermann, Kokko and Sjöholm (2000) and Branstetter (2001) examine the correlation between patent citations contained in the applications for a patent (as a measure of domestic innovative performance) and FDI. The former use data on Swedish firms and find that only outward FDI gives access to foreign technology. The latter uses data on patent citations between the US and Japan and finds a significant correlation.

## **2. Simultaneous analysis of multiple channels of technology diffusion**

132. Keller (2001b)'s industry-level analysis of spillovers among the G-7 countries finds significant effects for imports, inward FDI, as well as communication links on productivity. In a breakdown of the total effect, he attributes more than 50 per cent of the total effect to imports, and the remainder to equal parts to FDI and communication links.

## **3. The role of education**

133. As far as the role of education in determining the technology intensity of FDI is concerned, a study by Kokko and Blomström (1995) relates skill levels in the host economy to transfers of technology to foreign affiliates for majority-owned foreign affiliates of US MNEs in 1982. Technology transferred to the foreign affiliate are measured by the licensing and royalty payments and the imported capital goods as fraction of total sales by foreign affiliates in the host economies. They find greater licensing payments per worker in countries with higher skill levels, capital imports however are not systematically related to skill levels in the host economies. These results can be interpreted as weak evidence that greater skill levels in the host economy induce greater technology transfers by MNE into their foreign affiliates. This obviously does not prove that more technology is transferred to the host country.

134. As far as the role of education in determining the absorptive capacity of a country is concerned, Kinoshita (2000) analyses the impact of inward FDI on productivity for the Czech Republic between 1995 and 1998. In his paper productivity growth is the result of the own research of a firm and spillovers from abroad. He finds that in-house expenditure is a significant factor of productivity growth (thus suggesting that R&D is perhaps an important omitted variable in other studies); whilst FDI shows a positive effect only when interacted with the R&D variable. This result suggests that FDI contributes to productivity growth only if there is a sufficient level of technology absorptive capacity.

135. In their study on FDI and education, Borensztein, Gregorio and Lee (1998) relate growth in the 1970s and 1980s to the level of FDI and find that FDI increases the growth rate provided the education level in the economy is sufficiently high, emphasizing the need to evaluate the link between FDI and education.<sup>12</sup>

---

<sup>12</sup> Their result, that a minimum level of education in the economy is needed, relies on an extrapolation from the interaction effect between FDI and education in a linear regression of growth on the latter and should therefore be regarded with suspicion. Furthermore see the sensitivity analysis by Levine and Renelt (1992) concerning the lack of robustness in this type of study. The authors don't report robustness checks and it is therefore hard to judge to what extent their results are spurious.

**4. How can the weak evidence of spillovers through FDI to developing countries be explained?**

136. Overall, the evidence about the technological spillover effects is weak. There are three main reasons for this. First, data on FDI are not as good as data on trade. Second, most of the studies on FDI suffer from omitted variable problems, since data on R&D are not always available. Third, some of the analyses fail to capture FDI's long term effects.

137. In particular, the evidence of positive technological spillovers from inward FDI is stronger for developed countries than for developing countries. This can be due to the fact that FDI directed to developed countries carries a higher learning potential or to the fact that developed countries have a higher absorptive capacity than developing countries. In both cases the higher level of human capital and expenditure in R&D in developed countries seem to be the discriminating factor.

138. Another important possible explanation of the evidence that international diffusion of technology through FDI is stronger between developed countries is the fact that most research takes place in developed countries (about 35 per cent of all R&D takes place in the US and more than 90 per cent in the OECD countries) and is directed towards the needs of the developed countries.

139. R&D performing firms are motivated by the desire to capture the returns from this research. These returns can't be as easily captured in the South as in the North, since property rights are less well protected in the South. This leads R&D performing firms to direct their efforts into research that is most effective in reducing costs in the North. Their research investments center on technologies to complement the production processes and the factors of production mainly employed in the developed countries. Foremost amongst the factors of production mainly employed in these developed countries are skilled workers. The investments into R&D are thus made in projects that promise to complement an educated work force. Therefore, gains from technology innovations developed in the North can be very small for the South.

140. The evidence that there are larger spillovers when the technology gap between foreign and host country is smaller (Kokko et al., 1996) corroborates this explanation.

141. Backward and forward linkages between foreign and domestic firms are a good vehicle for technology diffusion. A similar level of development between the host and investor country makes easier a development of a series of useful interlinkages between firms at different stages of the production process. Moreover, a high technology activity can actually carry a higher level of technology content. Finally, local effort is clearly necessary for successful technology adoption.

142. Among the reasons why the evidence of positive spillover effects of FDI on productivity is weak specially for developing countries is the fact that empirical analysis does not distinguish between vertical and horizontal FDI. Empirical evidence is in accord with the theoretical prediction that developing countries mainly attract vertical FDI, characterised by a low-level of technology intensity and few backward and forward linkages.

**V. PARTNERSHIP AGREEMENTS AND TECHNOLOGY TRANSFERS**

143. Licensing, franchising and joint venture agreements may substitute for FDI as a way to serve a foreign market and act as alternative mechanisms for the transfer of foreign technology. Technology diffuses across countries via partnership agreements in the same way as via FDI. Therefore the same considerations relative to the role of education and the IPR regime in attracting specific types of investments and in determining how effectively technology diffuses also hold for partnership agreements.

144. The focus here is on what factors determine the decision of a firm to enter in a partnership agreement rather than directly invest in the foreign market and what characterises partnership agreements with respect to FDI in terms of technology transfers. A survey of the empirical evidence on the effectiveness of partnership agreements in diffusing technology across countries conclude this section.

A. WHAT DETERMINES THE DECISION BETWEEN FDI AND PARTNERSHIP AGREEMENTS?

145. Four main motives are commonly cited in the economic literature for the formation of partnerships (Hennart, 1988).

- Through a partnership agreement, firms can take advantage of economies of scale in their production process while remaining separate identities, thus diversifying risk;
- Partnership agreements can be used to overcome entry barriers into a new market, such as the presence of high tariffs and quotas for example;
- Research joint ventures, allow the pooling of complementary bits of knowledge, thus favouring productivity of research by increasing knowledge level and reducing duplications;
- Foreign companies may enter into a partnership agreement with a local company to allay xenophobic reactions.

146. Overall, partnership agreements provide scope for reducing the political and economic risks associated with direct investment, and are therefore preferred to FDI when these risks are relevant.

147. However, licensing, franchising and joint ventures present a disadvantage with respect to FDI from the point of view of a technologically advanced foreign firm that enters into a partnership agreement with a local firm. In a partnership agreement, the foreign firm discloses information about the technology to the domestic firm and therefore the extent of the risk from imitation that the originating firm faces is an important factor of decision as between FDI and partnership agreements.

148. An important factor in this regard is the strength of the IPR regime. If enforcement of IPRs increases beyond a certain threshold, foreign firms may be willing to engage in joint ventures, franchising or licensing agreements with local firms. This is because stronger IPRs will reduce the threat of local imitation (imitators have the advantage of not paying the license fee), thus augmenting expected profits on both sides. Likewise, licensing, franchising and joint ventures are also preferred when imitation is very difficult.

149. In other circumstances, licensing, franchising and joint ventures are the only feasible way to serve the market. In many countries FDI is constrained by the government. Sovereignty concerns may be a reason for some governments to prefer foreign firms to engage in licensing agreements rather than FDI.

150. Other studies point to the characteristics of the host countries as an important factor in determining the choice between FDI and partnership agreements. Nogues (1993) argues that the decision to engage in licencing agreements depends both on the legal strength of the licensing agreement and the capacity of licensees to absorb and exploit the technology transferred rather than on the strength of IPRs. In addition, Das (1999) shows the importance of the riskness of the project and the host country political environment in determining the mode chosen by the multinational firm to enter productive activity in a developing country. Das' paper also provides a framework to study the choice between licencing and joint ventures, where licensing typically involves an up-front fee



and royalty payments based on revenues earned by the local firm, while joint ventures pay a share of the profit to the local firm.

151. Mansfield (1994, 1995) and Lee and Mansfield (1996) provide empirical evidence that firms may refrain from engaging in joint ventures and licensing to third parties if the strength of protection is not adequate. A study by Tomlinson (1970) for a sample of British firms in India and Pakistan which formed joint ventures shows that the most cited reasons for choosing the option of a joint venture were. (i) pressures by the host country's government, (ii) spreading of the risk, (iii) need for local facilities or resources, (iv) and local identity.

#### B. WHAT IS THE POTENTIAL FOR TECHNOLOGY TRANSFERS FROM PARTNERSHIP AGREEMENTS?

152. It is commonly believed that, other things being equal, there is a higher potential for technology transfers from licensing, franchising and joint ventures agreements than from FDI. Indeed, all channels through which technology diffuses via FDI (backward and forward linkages, competitive and demonstration effect and learning-by-doing) are also activated by any of these partnership agreements. But in addition, the technology spillover component of these partnership agreements is likely to be larger than from FDI. This is because, first, firms engaging in FDI retain control of their proprietary technologies; they do not disclose their knowledge to third parties. In contrast, in a licensing agreement, the local licensee is provided with full information of the newest technologies.

153. Second, local licensees do not have to spend resources in imitation (recall that technology spillover is the technology gain acquired without paying for it). On the contrary, often licensors acquire a responsibility for the ability of their licensees to absorb and benefit from the technology transferred.

154. It is important, however, to note that this presumption that the technology flow from the licensor to the local licensee might be higher than the technology transferred to the local economy via FDI, may be contradicted by the fact that IPRs are more protected in the country in which the licensing activity takes place, than in other countries. Thus, the potential for international diffusion of foreign technology might actually be lower under licensing than FDI, the chosen mode of serving the market when enforcement of IPRs is weaker.

155. A similar point is raised by Fosfuri (2000). He shows that when IPR protection is not strong, so that the licensor faces the risk of imitation by the licensee, the firm can strategically use the vintage of the technology to deter imitation by the licensee. As a result, transfers to affiliates of MNE might be of a later vintage than technologies sold to outsiders.

156. As far as the relative importance of licensing versus joint ventures in determining technology transfers is concerned, Marjit and Mukherjee (2001) show that technological collaboration together with equity participation improves the quality of the technology transferred relative to the case of a pure technology licensing agreement.

#### C. WHAT IS THE EMPIRICAL EVIDENCE ON THE ROLE OF LICENSING AND JOINT VENTURES FOR TECHNOLOGY TRANSFERS?

##### Licensing

157. Empirical evidence generally points to a positive effect of licensing agreements on technology transfers.

158. Pack (2000) shows that technology transfers through licensing do not play a significant role in the early stage of the development of poor countries. But as industrialisation in more technologically advanced sectors take place, licensing assumes more relevance.

159. The paper by Montalvo and Yafeh (1994) examines investments in foreign technology by Japanese firms. The relationship between the acquisition of a foreign technology and the affiliation with a corporate group is analysed. The results indicate that affiliated firms acquire more foreign technology than independent firms, suggesting that corporate groups have played an important role in Japan's technological progress.

160. Similarly, Dowling (1994) finds that licensing was the method of technology transfer on which Japan, Korean and Taipei, China primarily relied.

161. Yang and Maskus (2001) test empirically whether stronger IPRs foster licensing activities and whether this in turn lead to more technology transfers. They find that the strength of the IPRs regime has a positive impact on several measurements of licensing activity. However, they are not able to conclude that stronger IPRs foster technology diffusion via increased licensing activity.

162. This is because, first, their measurement of licensing activity is the US receipts of affiliated and unaffiliated royalties and licensing fees. It may well be that the increase in licensing activity only means that licensing fees have increased because of the stronger market power of IP owners (stronger IPR protection gives IP owners greater bargaining power with respect to the licensee, who face more difficulties under stronger IPR protection in acquiring the same technology through imitation) whilst the amount of technology transferred is the same.

163. Second, one cannot exclude the possibility that what is being captured by the increased measure of licensing activity is an increase in payments for technology transfers, that were previously being acquired without cost. In this case, the country may be pulling resources away from other forms of technology transfers (like imitation, reverse engineering etc...) so that in fact, although licensing activity increases, technology transfers actually decrease.

#### Joint ventures

164. A common belief is that joint ventures tend to be an efficient mechanism of transfer of technology because characterised by an active participation of the parent organisation, including national research centres, in the development process. Accordingly, empirical evidence shows the presence of positive spillovers from joint venture.

165. A noticeable example is that reported by Campbell and Hand (1998). Their study shows that joint ventures foster transfer of technologies from distant water fishing nations to developing resource-owning countries.

166. For the case of the European semiconductor industry, Hobday (1997) shows that European technological competencies improved with the adoption of pro-active technology activities (joint ventures and technology exchange) as opposed to passive activities such as licensing, thus showing a positive contribution of joint ventures to technology transfers.

167. A study conducted by Katz et al. (1996) examines the transfer of technology over a three-year period in an international joint venture comprising three operating divisions of large multinational chemical companies located in Germany, United States and Japan. A total of 208 technologies are identified as having been transferred between the venture partners.

168. What determines the success of technology transfers through joint ventures? A critical examination of the experiences of the pioneer joint ventures in Shanghai (Martinsons, 1995) points to management skills in bridging cultural differences as a main determinant of success. The result of an empirical study conducted on 50 major international projects put in place by the 36 largest Canadian consulting engineering firms in developing countries point to the investment in training of workers as a major factor of success (Niosi et al. 1995). It also finds that successful transfers occur when the transferees themselves conduct research and development and do not suffer from host government restrictions in the case of technology transferred via trade or FDI, empirical evidence on the effectiveness of technology diffusion seems to suggest the importance of adequate absorptive capacity of the transferee country.

169. How does technology diffuse from firms that have foreign links to those that have not? Using firm level data for the Czech Republic during 1992-96, Djankov and Hoekman (2000) find a negative technology spillover effect of joint ventures and FDI together on firms that do not have foreign partnerships.

170. Part of the literature on joint venture and technology transfers focuses on the role played by national research centres. In a recent study, Steffensen et al. (2000) show that the success of a spin-off company in absorbing technology transfers relies on the degree of support that it receives from its parent organisation<sup>13</sup>. In their investigation, based on the experience of 6 of the 19 spin-offs from the 55 research centres in the University of New Mexico in 1997, they show that university research centres continue to provide laboratory facilities and access to research equipment to the successful spin-offs.

171. This evidence highlights the role that public-private initiatives, national centres for technology and manufacturing, research and development consortia, and university outreach centres can assume in enhancing economic development.

172. Few other studies outline cases of successful experience of technology transfers through partnerships and collaboration. One which does relates to the partnership agreement between Fujitsu and ICL, where the exchange of competencies helped to enhance the technological capabilities of both firms (Lynskey, 1999).

---

<sup>13</sup> A spin-off is a company that is formed by individuals who were former employees of the parent organisation (a research centre or a foreign firm) and a core technology that is transferred from the parent organisation.