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Technology Spillovers from Foreign Direct Investment (FDI): an Exploration of the Active Role of MNC Subsidiaries in the Case of Argentina in the 1990s

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Abstract

The usual perspective on technology spillovers from FDI sees the MNC subsidiary as a passive actor. It presumes that the technological superiority that spreads from subsidiaries to other firms in the host economy is initially created outside it by MNC parent companies, and is delivered to subsidiaries via international technology transfer. The role of subsidiaries is little more than to act as a 'leaky' container lying between the technology transfer pipeline and the absorption of spillovers by domestic firms. This paper suggests a different model in which a substantial part of the potential for spillover is created within local subsidiaries as a result of their own knowledge-creating and accumulating activities in the host economy. We explore empirically the effects of these activities on technology spillovers from FDI using data for industrial firms in Argentina over the period 1992-1996. The analysis suggests that significant results can be obtained incorporating subsidiaries' own technological activities as an explanatory variable of the spillover process.

Key words: *FDI, technology spillovers, absorptive capabilities, multinational enterprises, subsidiaries' technology behaviour*

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1-The Purpose of the Paper

Analyses of the technological spillover impact of FDI on host economies have typically assumed the impact to be the outcome of two linked steps. The first involves multinational corporation (MNC) parent-to-subsidiary international transfer of technology that is superior to the prevailing technology in the host economy. The second involves the subsequent spread of this technology to domestic firms – a technological spillover effect. The latter has been addressed in a growing number of spillover studies in various host economies (Lipsey, 2004; Gorg and Strobl, 2001).

This paper suggests it is important to consider a different model of the process. In this alternative a substantial part of the technological potential for spillover is generated within the local subsidiary by its own knowledge-creating activities, rather than being delivered to it from the parent company. To some degree, therefore, variability in the significance of spillovers would reflect heterogeneity in the intensity of subsidiaries' innovation and other knowledge-creating activities in the host economy. Using data for industrial firms in Argentina over the period 1992-1996 we explore empirically the possible significance of this alternative model.

The structure of the paper is as follows. Section 2 reviews previous approaches to the analysis of FDI-related spillovers and elaborates on the alternative approach used in this paper. Section 3 describes the methods and data used in this study and the empirical results are presented in Section 4.

2. Alternative Perspectives on FDI-related Technology Spillovers in Host Economies [1]

2.1 The centrally driven supply-side origins of spillovers

(a) The original 'pipeline' model

There is now a long history of empirical analysis of FDI-related technological spillovers, running from the early work of Caves and Globerman in the 1970s to the rapidly growing number of such studies in the last ten years – e.g. Aitken and Harrison (1999), Kokko (1994), Blomstrom and Sjoholm (1999) , and Haskel et al. (2002). Since the work of Stephen Hymer in the 1960s (published 1976), a core element in the theoretical framework underlying this work has concerned MNC possession and exploitation of technological assets – an ownership advantage seen as the main reason for the MNC's existence. A second, usually implicit, element is the assumption that the MNC is a tightly integrated organisation, with the behaviour of subsidiaries closely shaped by central strategies and decisions. The combination of centrally accumulated technological assets and tightly

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[1] A more extended discussion of these alternative perspectives on the FDI-related spillover process is provided in Bell and Marin (2004)

integrated organisational behaviour sets the basis for the two-step 'pipeline' that delivers spillovers of superior technology from MNC parents to domestic firms without any significantly active role on the part of the local MNC subsidiaries.[2] They are simply leaky containers at the end of the transfer stage of the process.[3]

Empirical studies have not however indicated the widespread and significant spillover effects one might expect on the basis of this model (Gorg and Greenaway 2004). Instead, much of the evidence is contradictory (Lipsey, 2004; Gorg and Strobl, 2001). Early studies using industry level and cross-sectional designs (e.g. Caves, 1974 or Globerman, 1979) found positive results but were unable to identify the relevant causality.[4] More recent studies have exclusively used firm level designs, typically combined with panel data analysis. Although such studies have found evidence of spillovers in some cases (e.g. Haskel et al., 2002; Keller and Yeaple, 2003), the generally positive results in the earlier research have not been replicated in a wide range of countries.[5]

(b) Mediating variables: limited absorptive capability - a possible demand side constraint
Research attention has shifted to explore whether the limited capabilities of locally owned firms act as a constraint on their ability to absorb the potentially available spillovers from MNCs – a suggested constraint on the demand side of the spillover process. There are, however, two problems with this approach. First, it does not question the centrally-driven supply side model. It merely bolts on the end a postulated demand-side explanation for the inconclusive and negative results from the simpler 'pipeline' models. Second, the evidence from these approaches is still mixed. For instance, Kokko (1994) in the case of Mexico, and Konings (2001) for Poland and Bulgaria have found such

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[2] Such spillovers are usually seen as productivity gains for domestic firms arising in two ways. First, the knowledge initially transferred from the parent diffuses from the subsidiary via various channels and is captured as an externality by domestic firms. Second, the subsidiary's superior performance brings greater competitive pressure to bear on domestic firms, which are induced to respond by generating their own technological change. These, however, are very different mechanisms. The first is about non-market mediated knowledge diffusion from MNE subsidiaries. The second is about domestic firms incurring the costs of generating knowledge by their own efforts or by acquiring it through market channels that have nothing to do with the FDI presence. To some unknown extent, therefore, the second type of productivity gain constitutes a 'pseudo' spillover.

[3] This perspective has been summarised recently by two of the most prolific contributors to the empirical analysis of FDI-related spillovers.
    "It is well known that multinational corporations ... produce ... most of the world's advanced technology. When a MNC sets up a foreign affiliate, the affiliate receives some amount of the proprietary technology that constitutes the parent's firm-specific <u>advantage</u> .... . This leads to a geographical diffusion of technology, but not necessarily to any formal transfer of technology beyond the boundaries of the MNC. ... However, MNC technology may still leak to the surrounding economy through external effects or spillovers that raise the level of human capital in the host country and increase productivity in local firms." (Blomstrom and Kokko, 2003, p. 3)

[4] This is because positive results from this type of research design may result from MNCs locating in what are already relatively high-productivity sectors in the host economy (Aitken and Harrison, 1999).

[5] E.g. In Sweden (Braconier et al., 2001) or the USA (Chung, 2001), as well as in transition or industrialising economies such as Morocco (Haddad and Harrison, 1993), the Czech Republic (Djankov and Hoekman, 2000), Venezuela (Aitken

'demand-side' effects to be significant. But other studies have not found the same results: for example Haskel et al. (2002), Damijan et al. (2003), Patibandla and Sanyal (2005), and Sjoholm (1999).[6]

(c) Mediating variables: industry differences and corporate strategy - supply side constraints
Looking at the other side of the process several recent studies have questioned the assumed homogeneity of MNC behaviour that has underpinned most empirical analyses to date. In particular, two kinds of MNC diversity have been seen as possibly influencing, often in combination, the types of technology that MNCs transfer to subsidiaries, and hence the scale and significance of the knowledge resources in subsidiaries that may subsequently leak to domestic firms.

The first is diversity in the characteristics of the industries in which MNCs operate. 'Advanced' industries such as electronics, are thought to possess greater potential than more 'traditional' industries for generating spillovers because they use more recent vintages of technology, employ greater numbers of skilled workers and undertake more R&D. Also, within a particular type of industry, the intensity of the value-adding activities might provide, it is argued, differing opportunities for technology spillovers (Narula and Dunning, 2000). The structure of world markets in particular industries may also be a source of variability in the content of technology transferred through FDI, and hence in the potential for subsequent spillovers. For example, Dunning and Cantwell (1986) have argued that if a global industry is concentrated amongst only a few MNCs, there will be lower incentives to decentralise more knowledge-intensive activities, and therefore the potential for spillovers will be more limited.

The second type of heterogeneity is about differences in the centrally driven strategies of MNCs. Wang and Blomstrom (1992), for instance, developed a model in which international technology transfer emerges from parent company decisions in the light of expected strategic interaction between their foreign subsidiaries and the technological characteristics of host country firms: the higher the host country firms' investment in learning, the more advanced the technology transferred in order to ensure profitability in the face of more technologically capable competition.[7] Reflecting a more recent direction of work on MNC strategies, Chung (2001) introduced a distinction between

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and Harrison, 1999) or Poland, Bulgaria and Romania (Konings, 2001).

[6] Particularly interesting among these are studies (e.g. Haskel et al., 2002) finding inverse relationships between spillovers and domestic firms' capabilities. This returns to Findlay's earlier (1978) proposition: the wider the technological disparity between foreign and domestic firms the greater the opportunities for domestic firms to improve efficiency.

[7] Thus, as with the absorptive capability model, the technological abilities of local firms are seen as an important influence on spillovers – but in this case via their effect on the international transfer step.

capability-exploiting and augmenting strategies as possible influences on technological spillovers in the USA.

These views about heterogeneity on the supply side have not, for the most part, been empirically evaluated.[8] In addition, they leave intact the centrally driven model of spillover generation via the technology transfer process: variability is seen as arising from MNC decisions about the international transfer step in the process. Subsidiaries continue to be seen as playing a passive role and, if they occur at all, their R&D and other knowledge-creating activities are assumed to be merely reflections of parent company decisions. As emphasised by Frost (2001), we still have a very limited understanding of the processes of technological change in foreign subsidiaries, and consequently even less about whether and how those may contribute to the spillover effects of FDI.

2.2 Subsidiaries' technological activities: Locally Driven Sources of Spillovers?

A body of recent research has addressed issues about FDI from the 'bottom-up' – focusing primarily on the development of subsidiaries as unique and differentiated organisational entities. This research has shown that variation in innovative capabilities across subsidiaries, and over time, depends on much more than the centralised decisions of the parent company – including (a) the decisions and strategies of subsidiaries themselves and (b) aspects of the local environment that create constraints and opportunities for subsidiaries. As emphasised by Birkinshaw and Hood (1998):

> *"... the subsidiary's capabilities are, to some extent, distinct from the capabilities of headquarters operation and its sister subsidiaries. ... the particular geographical setting and history of the subsidiary are responsible for defining a development path that is absolutely unique to that subsidiary, which, in turn, results in a profile of capabilities that is unique." (p. 781)*

One implication is that subsidiaries may themselves affect the potential for generating spillovers into the domestic economy. We are aware of only two studies that have begun to explore this possibility. Braconier et al. (2001) used MNC subsidiaries' R&D expenditure as a better measure of FDI activities in Sweden than the more commonly used measures of total FDI financial flows, though they found no evidence of spillovers using that indicator. Todo and Miyamoto (2002) used two indicators of technological activities in MNC subsidiaries to estimate spillovers in Indonesia: the commonly used R&D-based indicator (R&D expenditures) and what they called a human resources development indicator (measured by the subsidiaries' expenditures on training). They found that

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[8] Chung (2001) is an exception.

only subsidiaries engaged in R&D and training had a positive impact on the productivity of domestic firms.

In the rest of this paper we move further in this direction. We derive a number of indicators with which to characterise the knowledge-creating and accumulating activities of MNC subsidiaries in Argentina, and we examine empirically the importance of heterogeneity in those activities as a source of differences in technology spillovers. In particular we test the following three hypotheses:

(1) *The 'Pipeline' model*: spillover effects arise from FDI independently of both the absorptive capabilities of domestic firms and the knowledge-creating and accumulating activities of subsidiaries in the host country.

(2) *The 'Absorptive Capability' model*: potential spillover effects arise from FDI, but are captured only by domestic firms with high absorptive capabilities.

(3) *The 'Active Subsidiary' model*: spillover effects arise from FDI only when foreign affiliates are technologically active in the host country.

3. Data and Methods

3.1 The Data Source: The Argentine Innovation Survey - 1992-1996

The empirical analysis reported here uses information provided by the Innovation Survey in Argentina, 1992-1996. The sample used in the survey (1533 firms, 283 of which are MNC subsidiaries)[9] is representative of the total population of industrial firms in the country: it includes 50 per cent of all industrial firms, and these account for 53 per cent of total sales, 50 per cent of total employment, and 61 per cent of total exports. The survey provides basic economic information at the firm level for 1992 and 1996 (size, age, added value, exports, imports, sales, employment, etc), and these permit the computation of various performance indicators (e.g. productivity levels and growth rates). In addition, following the broad framework of the Oslo Manual it provides information about a wide range of technological activities at the firm level and this allows the computation of several measures of technological behaviour on the part of both MNC subsidiaries and domestic firms, as explained in Section 3.2.

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[9] A company is defined in this study as a subsidiary in which the proportion of foreign ownership is higher than 10%.

Given macroeconomic changes[10] in the 1990s and a financial crisis that began in 2000, Argentina might seem an idiosyncratic case study. We note however that an important number of industrialising countries introduced similar macroeconomic changes during the 1990s, following the Washington Consensus, and consequently the Argentinean case is more the rule than the exception.[11] Furthermore, the Argentinean financial crisis only started significantly to affect internal economic activity from 2000. The period we analyse (1990-1996) was characterised by sustained growth: on average 6% per annum. Argentina also provides a particularly appropriate and demanding context for examining the possible merits of spillover models for at least two reasons. First, it has a relatively FDI-intensive industrial economy, reflected for example in the fact that FDI via wholly owned MNC subsidiaries accounted for 50% of the largest industrial firms in 2002 (Kulfas et al., 2002). Second, it is a mature industrialising economy with substantial human resources and prior industrial experience, constituting a substantial base of absorptive capacity to 'capture' potentially available spillovers.

3.2 Measuring the Innovation Activity of MNC subsidiaries and the Absorptive Capacities of domestic firms

The Innovation Survey data was used to compute a number of different indicators of the technological activities of MNC subsidiaries and domestic firms.[12] Ten such indicators are used in this analysis, grouped below in three broad categories.[13]

(a) Investment in disembodied knowledge and skills

In principle, investment in disembodied knowledge and skills is potentially the most important source of locally-driven knowledge spillovers from subsidiaries to domestic firms since it covers the kinds of knowledge that are potentially most mobile and most likely to 'leak' from subsidiaries. Four indicators are used:

- **R&D intensity:**
    - reported expenditure on R&D*
- **Skill training intensity:**

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[10] These changes include: trade liberalisation (e.g. all capital goods' tariffs were reduced to zero during 1995-96), capital liberalisation (e.g. no capital controls, no minimum terms, no sectoral restrictions to FDI, no requirements for FDI), privatisation (large role played by MNC), country risk reduction due to debt renegotiation (Brady Plan, finished in 1992)

[11] In addition, as we will see later, we have introduced several measures to control for changes in the levels of competition across industries, and the use of industry dummies should control for the possibility that macroeconomic changes have affected different industries dissimilarly.

[12] Annex 1 describes the dataset and provides further information about the derivation of these indicators, together with descriptive statistics.

- reported expenditure on training*

- **Skill intensity of employment:**
  - the number of engineers, other professionals and technicians employed in production (not in management) as a proportion of total employment

- **Investment in licensed technology:** [14]
  - reported payments for licensed designs, know-how, etc.*

(b) Investment in capital-embodied technology

Investment in capital-embodied technology is likely to be a very important source of productivity growth in the investing firms but it appears less likely to be a significant driver of 'genuine' spillovers to other firms. Although information about the introduction of capital embodied assets in one firm may leak to another, the knowledge actually embodied in those assets is probably much more 'sticky'. Three indicators are used:

- **Investment in information technologies:**
  - reported expenditure specifically on IT facilities and systems*

- **Investment in equipment for innovation:**
  - reported expenditure on equipment required to introduce new products and processes*

- **Investment in imported capital goods:**
  - reported expenditure on imports of capital goods.*

(c) The innovation strategy of the enterprise

The Innovation Survey asked firms about the importance they attached to broad aspects of their innovative activity. Responses to these questions were used to compute three indicators as follows.

- **The importance of 'significant' product innovation:**
  - Firms were classified into two groups: those attaching 'Hi' and 'Lo' importance to significant product innovation, valued 1 and 0 respectively.

- **The importance of 'significant' process innovation:**
  - Firms were classified into two groups: those attaching 'Hi' and 'Lo' importance to significant process innovation, valued 1 and 0 respectively.

- **The importance of innovation in firm strategy:**

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[13] When used as firm-level indicators, all the measures identified with an asterisk are normalised by the firm's total sales.

[14] Only a small number of firms reported any licensing payments. This measure is therefore excluded from the estimates for the individual variables, but is included in the factor analysis to compute a composite index of technological activity.

- Firms were classified into two groups ('Hi' and 'Lo'), distinguishing between those that considered selected innovative activities had been (a) "decisive" or only (b) "significant" or "non-significant" for their business strategy.

In the analysis, the above ten indicators are employed in two ways. First, they are combined in a composite index of absorptive capability and technological behaviour. The index was calculated using factor analysis, and the weights of the different variables are therefore endogenously determined rather than imposed exogenously by ourselves.[15] However, the joint variation of these indicators is limited.[16] Consequently, in a second approach we use the ten indicators separately, reflecting particular kinds of innovative activity undertaken by the firms.

Both the composite and the separate indicators are first computed for domestic firms and used as indicators of their absorptive capabilities when we assess the significance of this factor in explaining spillover effects (see Section 4.1.2). Second, they are computed for local subsidiaries and used to indicate the heterogeneity of their technological behaviour, and also to assess whether that heterogeneity is simply a matter of inter-industry differences or something more specific to individual firms (see Section 4.2).[17]

3.3 Estimating the spillover effects of subsidiaries' technological activities

Two steps are taken.

First, we characterise each of the 157 five-digit industries in the data set according to the technological behaviour of MNC subsidiaries in that industry.[18] We then distinguish between two types of industry: (a) industries characterised by a relatively high intensity of technological activities on the part of subsidiaries and, (b) industries characterised by a relatively low intensity. The distinction is made first using the composite index of technological behaviour and second using each individual indicator separately. Median values of the index and of each indicator are used to

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[15] See Annex II for an explanation of the methodology and the values of the composite indices.

[16] Using only one factor, for instance, the total variance explained for this factor is 26% and 24% respectively for absorptive capabilities and technology behaviour of subsidiaries - see Annex II.

[17] In both these applications, all the measures are computed in 'levels' – either as an average across the four-year period, or by a measure at the end of the period in 1996. The measures are computed as firm-specific indicators and normalised where appropriate.

[18] Industries at the five-digit level are taken as the sphere of knowledge-centred interaction between subsidiaries and domestic firms, and hence as the economic 'spaces' within which spillovers might arise. We therefore estimate only intra-industry spillovers recognising that this will only partially capture 'vertical spillovers, so probably under-estimating positive spillover effects.

distinguish between 'high' and 'low' intensity of technological activity.

Second, spillovers from FDI to domestic firms are then estimated for two different groups of domestic firms: (a) those located in five-digit industries characterised by a relatively high intensity of technological activity on the part of subsidiaries, and (b) those located in five-digit industries characterised by a relatively low intensity.[19]

When spillovers are significant for a particular group of domestic firms, we claim that the particular subsidiaries' technological behaviour (used to distinguish industries and firms) is the supply-side source of this effect.

We model FDI spillovers within the familiar production function framework. Change in FDI participation in industries is treated as an additional 'input' explaining the productivity growth of domestic firms, and its coefficient is taken as evidence of spillover effects from FDI.[20] Variations of the following basic equation[21] were used to investigate spillover effects:

$$\Delta \ln Y^d_{ij} = \lambda \Delta \ln Input^d_{ij} + \delta \Delta FDIpart_j + \eta Z^d_{ij} + G^d_{ij} + I_j + \varepsilon_{ij} \qquad (1)$$

In (1), d denotes domestic firms, subscripts i and j denote plant and industry, Δ represents changes in the variables between 1992 and 1996 (t-4), and λ, δ, and η are parameters to be estimated. Y^d denotes added value of domestic plants, $Input$, their use of normal inputs, $FDIpart$ is a measure of the scale of the FDI presence in each industry. Z is a set of plant and industry level control variables. G and I are dummies for corporate groups and industries respectively.

For $Input$, we use total employment (L) and the ratio of investment to added value (I/Y).

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[19] Annex III shows the distribution of domestic firms relative to the various indicators of subsidiaries' technological behaviour.

[20] We are aware that the use of production functions and the available techniques to estimate spillovers involves a number of well-known problems. We nevertheless use this method for two reasons. First, because we want to be able to compare our results with the bulk of previous work in this area, especially with respect to the estimation of spillovers in industrialising countries for which patent analysis is not relevant. Second, despite all the problems of production function analysis, we concur with the view of Griliches and Mairesse (1998) that "it is hard even to pose the question without embedding it in such a framework".

[21] The derivation of this equation is provided in Annex IV.

FDIpart is the share of total employment in the 5-digit industry *j* that is accounted for by all employment in foreign owned firms in the industry.[22] We use an indicator based on employment rather than capital because labour turnover is likely to be a particularly important channel for spillover effects.

G is a categorical dummy variable that distinguishes independent domestic firms from those that are part of a domestic conglomerate.

I is a dummy variable distinguishing the 22 two-digit industries.

Z includes a set of additional variables that may affect TFP growth in domestic firms:

(a) ΔKC^d = change in knowledge capital, as reflected in R&D expenditures plus changes in the expenditure on new equipment specifically concerned with product or process innovation[23]

(b) $\Delta Skills^d$ = change in the professional/non professional ratio (professionals include engineers and other professionals in production, administration and R&D)

(c) $\Delta Comp^d$ = change in competition.

We expect that the increases in *KC* and *Skills* will positively affect changes in total factor productivity of domestic firms through their effects on their knowledge capital (Griliches, 1992). Their inclusion therefore reduces the possibility of bias due to non-included variables that change across domestic firms and over time.

Variables reflecting changes in competition are also introduced: changes in industry concentration and in import penetration. These are intended to account for what we described earlier (endnote 2) as 'pseudo' spillovers – technological changes generated by domestic firms in response to increased competition from FDI. In addition, these variables should also capture changes in other unobservable variables that affect competition and that might have disciplined the domestic industry to become

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[22] This indicator was constructed on the basis of the information provided by the 50% sample survey because data about FDI penetration at the 5-digit level for the whole economy do not exist. However, the Survey sample included <u>all</u> of the 500 largest industrial firms in Argentina. Since MNC subsidiaries in manufacturing industries in Argentina are typically large, almost all of them are probably included in the sample of 283 subsidiaries.

[23] R&D expenditure is not a good indicator of the technological efforts of firms in developing countries in augmenting their knowledge capital, since such efforts are generally not formalised as explicit R&D activities. We therefore include expenditures on equipment for product or process innovation as an additional indicator of these efforts.

more efficient.[24]

The expanded equation is as follows:

$$\Delta \ln Y^d_i = \alpha_1 \Delta \ln L^d_i + \alpha_2 \frac{I_i}{Y_i} + \alpha_3 \Delta FDIpart_j + \alpha_4 \Delta Skills_i + \alpha_5 \Delta KC_i + \alpha_6 \Delta Concen_j$$

$$+ \alpha_7 \Delta \operatorname{Im} pen_j + G^d_i + I_j + \varepsilon_i \qquad (1')$$

Where:

$\Delta \ln Y_i$	=	The log change in value added
$\Delta \ln L_i$	=	The log change in total employment
I/L_i	=	The ratio of total investment to total output 1992
$\Delta FDIpart_j$	=	The change in FDI participation by industry
$\Delta Skills_i$	=	The change in the ratio professional/non-professional workers
ΔKC_i	=	The log change in R&D expenditures plus the log change in the expenditures in new equipment for product and process innovation
$\Delta Concen_j$	=	The change in Herfindahl index (industry level)
$\Delta Impen_j$	=	The change in import penetration (industry level)
ε_i	=	Δu_i.

Several aspects of the estimation methods merit brief further comment.

First, by using a plant level specification and modelling in first differences - with a time period of 4 years - we control for fixed differences in productivity levels across firms and industries, which might affect the level of foreign investment. In this way, we address the identification problem highlighted by Aitken and Harrison (1999), as noted earlier.[25]

Second, this specification and the inclusion of group and industry dummies (*G* and *I*) also corrects for the omission of other unobservable variables that might undermine the relationship between FDI and productivity growth of domestic firms. In particular:

- by observing changes over time, we remove plant-specific, industry and regional fixed effects such as heterogeneous long-term strategies of the firms, and differences in the regional infrastructure and/or technological opportunity of the industries[26]

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[24] As noted earlier, this is important in Argentina between 1992 and 1996, because important pro-market reforms were introduced and intensified during those years.

[25] Nevertheless we cannot completely rule out the possibility of spurious correlation if there are industry characteristics that change over time and affect the pattern of FDI.

[26] This also removes other factors that even when they are not fixed over time might be roughly constant over a 4-year period, such as the level of education, or regional policies.

- the use of dummy variables removes fixed characteristics of domestic firms that belong to an economic group or that operate within particular sectors.

These controls are important in this analysis because, as discussed earlier, industry effects are often considered likely to affect spillovers from FDI.

Third, there could still be a bias in the estimators if there are important unobserved variables excluded from the model that change across firms and over time (such as the managerial abilities of domestic firms). By introducing the control variables under Z - that change across firms and over time - and by modelling in first differences we expect to minimise this possibility.[27]

Fourth, it has been suggested also that, to estimate the coefficients in a production function, capital and labour inputs should be treated as endogenous (Griliches and Mairesse, 1998). Here the focus, nevertheless, is not on estimating the coefficients on capital and labour, but on estimating δ (the coefficient for FDI). Endogeneity of capital and labour therefore is an issue only if it results in biased estimates of δ. Also, a plant-level specification in a first differences model should correct for this possible bias if the endogeneity is caused by an omitted variable and the variable does not change over time (Griliches and Mairesse, 1998).

Fifth, in principle there might be a problem about representativeness since *FDIpart* is calculated from the sample data. In practice, however, because it is very likely that _all_ MNC subsidiaries are included in our survey (see note 22), it is also very likely that the distribution of foreign affiliates across industries for the sample and the population are very similar.[28]

Finally, a need for caution arises from an element of selection bias because our data do not represent the full population of plants, only the surviving plants present in both 1992 and 1996. Our estimators of the impact of FDI should therefore be interpreted only with respect to surviving firms.[29]

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[27] We will not, therefore, introduce other methods to address this issue (such as those proposed by Olley and Pakes, 1996) because they usually require very restrictive assumptions about, for instance, markets and, therefore, as pointed by Griliches and Mairesse (1998), they may introduce additional bias in the estimations.

[28] We may still be overestimating *FDIpart* because all MNC subsidiaries are probably included in the sample but not all domestic firms. However this is likely to be of limited importance because we are interested in the *changes* rather than the *levels* of FDI participation (our estimations are in first differences).

[29] In principle, a correction should be introduced using information about the domestic firms that exited the industry. However, we do not have information about these firms. Also, because of unpredictable competition effects, it is difficult to anticipate the direction of the possible bias arising from the absence of data about these non-surviving firms.

4. Empirical Results: The Magnitude and Determinants of FDI-related Spillovers:

This section estimates the spillover effects in manufacturing in Argentina using a number of different specifications. It is divided into two parts. In the first (Section 4.1), we follow the historical sequence of methodological approaches used in previous research, testing the first two hypotheses indicated earlier. In Section 4.2 we test the third hypothesis, using a range of estimations incorporating variables reflecting different aspects of locally driven knowledge-creation and accumulation in MNC subsidiaries. We demonstrate the heterogeneity of that technological behaviour in Section 4.2.1, and estimate its significance in generating spillover effects in Section 4.2.2.

4.1 Results with Previous Methodological Approaches

The results of the first estimation (Table 1) are derived from a specification similar to that used in most of the early work on spillovers in which it is assumed that FDI generates spillover effects without differentiating between the technological behaviour of different subsidiaries or domestic firms. In this case, our estimation – using equation 1- provides a non-significant coefficient for the FDI variable. Thus, in common with other studies (especially of industrialising economies) the process of international knowledge diffusion via FDI does not appear to have delivered to Argentina during this period the spillover effects expected by the centrally driven, supply-side ('pipeline') model.

Table 1: Estimates Via the Conventional Model

	Estimation in first differences
TECHNOLOGICAL SPILLOVERS	0.24
	(0.74)
R^2 (adjusted)	46%
Observations	1033

Source: Authors' calculations based on the Argentinean Innovation Survey

Notes: 1 Not significant at the 10 per cent level; standard error in parenthesis

2 For brevity we show only the coefficients and significance levels for the FDI variable in the estimation models. The coefficients and significance levels for all the other variables are available on request from the authors.

We therefore turn to the second hypothesis, examining whether these results arise because we failed to take account of the ability of domestic firms to absorb the subsidiaries' superior technology which, according to the underlying model at least, must have been available to domestic firms. In Table 2 domestic firms are divided into two groups with 'high' and 'low' levels of absorptive capability. These were defined in terms of the distribution of, first, the composite index of absorptive capabilities (Row 1) and second, each of the separate capability indicators (Rows 2.1 to 4.3). FDI-related spillovers were calculated for each group and each capability indicator.

Table 2: FDI Spillovers and the Absorptive Capability of Domestic Firms[1]

When the domestic firms' absorptive capabilities were defined as 'High' and 'Low' with respect to the following:	*Sign and significance of the estimation of FDI spillovers for domestic firms when their absorptive capabilities were:[1]*			
	'High'		**_'Low'_**	
	Co-efficient for FDI and *t* values	R^2 and Number of Observations	Co-efficient for FDI and *t* values	R^2 and Number of Observations
1 COMPOSITE INDEX OF ABSORPTIVE CAPABILITIES[2]	0.064 (0.16)	39% (560)	0.53 (0.72)	34% (559)
2 INVESTMENT IN DISEMBODIED TECHNOLOGY				
2.1 R&D INTENSITY	0.067 (0.13)	48% (342)	0.76 (1.36)	44% (767)
2.2 SKILL TRAINING INTENSITY [3]	0.35 (0.73)	49% (365)	0.72 (1.33)	43% (744)
2.3 SKILL INTENSITY OF EMPLOYMENT	0.77 (1.09)	45% (560)	0.25 (0.79)	43% (539)
3 INVESTMENT IN CAPITAL-EMBODIED TECHNOLOGY				
3.1 INVESTMENT IN INFORMATION TECHNOLOGIES	0.81 (1.75)*	45% (628)	0.39 (0.54)	45% (481)
3.2 INVESTMENT IN EQUIPMENT FOR INNOVATION[4]	0.54 (1.44)	45% (398)	0.48 (0.77)	45% (711)
3.3 INVESTMENT IN IMPORTED CAPITAL GOODS	0.55 (1.74)*	57% (447)	0.5 (0.82)	38% (662)
4 INNOVATION STRATEGY				
4.1 IMPORTANCE OF 'SIGNIFICANT' PRODUCT INNOVATION	0.094 (0.22)	45% (522)	0.84 (1.35)	43% (587)
4.2 IMPORTANCE OF 'SIGNIFICANT' PROCESS INNOVATION	0.32 (0.77)	43% (485)	0.8 (1.22)	43% (624)
4.3 IMPORTANCE OF INNOVATION IN FIRM STRATEGY	0.1(0.22)	48% (350)	0.85 (1.53)	42% (759)

Source: Own calculations based on the Argentinean Innovation Survey 1992-1996

Notes: [1] All standard errors, in brackets, are corrected for heteroskedasticity. *significant at 10% level, **significant at 5% level and *** significant at 1% level.

[2] Using factor analysis, three indexes of absorptive capabilities were obtained. Here we show the results for the first. Results for the second and third were also not significant. The first factor is explained mostly by three variables, investment in equipment for innovation, payments for licences and imports of capital goods (see Annex 2 for more details)

[3] In sensitivity tests a positive and significant coefficient is obtained if we consider only the top 10% (137) of domestic firms

[4] In sensitivity tests a positive and significant coefficient is obtained if we include the top 25% (344) of domestic firms

In this way, the only significant associations between the productivity growth of domestic firms and the growth of FDI arise when domestic firms invest relatively heavily in capital-embodied technology. It is difficult therefore to glean from these results a picture that the diffusion of superior knowledge from MNC subsidiaries in Argentina made a significant contribution to productivity growth in domestic firms when the latter had absorptive capabilities to capture potentially available spillovers. Consequently we now abandon the core assumptions of the centrally driven supply-side model. We will no longer presume that MNC subsidiaries are homogeneous in offering to domestic firms in host economies flows of potentially absorbable, superior technology originally transferred from their parent companies. Instead, we turn to the third hypothesis, examining whether subsidiaries' own knowledge-creating and knowledge-accumulating activities played any role in generating spillover effects.

4.2 A Locally Driven Supply-Side Model

We first examine (Section 4.2.1) subsidiaries' technological activities on their own, demonstrating that they vary significantly between subsidiaries. We also show that this variation is not merely an issue of inter-industry differences. We then estimate the significance of this heterogeneity in explaining spillovers (Section 4.2.2).

4.2.1 The Technological Activities of MNC Subsidiaries

Table 3 shows how subsidiaries behaved with respect to investment in disembodied and capital-embodied technologies. The wide heterogeneity of behaviour is striking. With respect to R&D expenditure, for instance, one quartile of the subsidiaries spent the equivalent of 13.5 per cent of their total sales on R&D but, at the other extreme, the first quartile did not invest anything at all in R&D. Similarly, the top quartile increased their R&D expenditure by 0.55 per unit increase in total sales, but the bottom quartile decreased their investment by a larger amount with similar growth in sales. The same heterogeneity can also be observed with respect to the other investments in disembodied technologies and the subsidiaries' investment in different categories of capital embodied technology.[30]

The wide diversity in subsidiaries' technological behaviour suggests there is at least an issue here to examine. It seems highly unlikely that the potential for generating spillover effects is similar across all these different types of behaviour.

Table 3:   Subsidiaries' Technological Behaviour

Indicators of Local Technological Behaviour	Subsidiary Quartiles			
	First	**Second**	**Third**	**Fourth**
1-Investment in disembodied technology				
R&D intensity				
- Level (Expenditure as a proportion of total sales)	0%	0.1%	1.1%	13.5%
- Change (increase in R&D per unit increase in sales)	-0.65	0	0.01	0.55
Training intensity				
- Level (Expenditures as a proportion of total sales)	0.1%	0.2%	0.5%	17.9%
Professional workers in production				
- Level (Number as a proportion of total employment)	1%	5%	10%	41%
- Change (Increase in number per unit increase in employment)	-2	0.11	0.36	0.67
2-Investment in capital-embodied technology				
Investment in Information Technologies				
- Level (Expenditure as a proportion of total sales)	0%	0.1%	0.2%	1.2%
Investment in Equipment for Innovation				
- Level (Expenditure as a proportion of total sales)	0%	0%	1.1%	17.6%
- Change (Increase in expenditure per unit increase in sales)	1.88	0	0.02	0.62
Investment in Imported Capital Goods				
- Level (Expenditure as a proportion of total sales)	0.2%	0.9%	1.8%	18.3%
- Change (Increase in expenditure per unit increase in sales)	-0.38	0	0.03	1.1

Source: Authors' calculations based on the Argentinean Innovation Survey.

As some studies have suggested (see Section 2.1c), however, it is possible that this heterogeneity merely reflects inherent differences in the technology-intensity of industries, rather than intra-industry differences in the technological behaviour of subsidiaries. We therefore examine in two ways whether the technological intensity of industries determines subsidiaries' behaviour. First, we regress each indicator of the subsidiaries' investment in disembodied and capital embodied technology against a classification of the technological intensity of industries in Latin America,[31] controlling for the scale of the subsidiaries in terms of sales or employment. Second we used a chi square test to analyse whether the indicators of various aspects of the subsidiaries' innovation strategy were independent of the technological intensity of industries.

The results (Table 4) suggest that industries are not the primary source of variability for the local technology behaviour of subsidiaries. Indeed, the technological intensity of industries only affects significantly (and in the expected direction) subsidiaries' expenditures on training. For all the other variables the effect is either non-significant or operates in the opposite direction - as with the

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[30] And also, with respect to the emphasis on innovation in their strategy, although we do not show the data here.

[31] This classification, developed by Ferraz et al. (1997), allocates all the 4-digit manufacturing industries (SIC codes) into five broad categories. The taxonomy is similar in principle to the OECD and other classifications of industries in terms of their technology-intensity. However, recognising that the same industry codes may incorporate very different technological characteristics in different economic contexts, it was developed to differentiate industries in the particular context of Latin America. The categories and example industries are shown in Annex V.

indicators of investments in capital embodied technology. We conclude therefore that variation on subsidiaries' technological behaviour should be more extensively explored as a supply-side source of spillovers.

Table 4: The Technological Intensity of Industries and the Technological Behaviour of Subsidiaries

Aspects of the Technological Behaviour of Subsidiaries[a]	Significance of the Technological Intensity of Industries in Explaining Differences in Aspects of Subsidiaries' Technology Behaviour	
Investment in Disembodied Technology		
R&D Intensity: Level	Not significant	
R&D Intensity: Change	Not significant	
Training Intensity: Level		Significant (+)
Employment of professional workers: Level	Not significant	
Employment of professional workers: Change	Not significant	
R&D employees: Level	Not significant	
R&D employees: Change	Not significant	
Investment in Capital-Embodied Technology		
Investment in information technologies: Level	Not Significant	
Investment in Equipment for innovation: Level	Significant (-)	
Investment in Equipment for innovation: Change	Significant (-)	
Investment in imported capital goods: Level	Significant (-)	
Investment in imported capital goods: Change	Significant (-)	
Innovation Strategy[b]		
Importance of 'Significant' product innovation	Independent	
Importance of 'Significant' process innovation	Independent	
Importance of innovation in overall strategy	Independent	

Source: Authors' calculations based on the Argentinean Innovation Survey
Notes: (a) All variables in levels are introduced in their natural logs
   (b) The Ferraz categories were re-ordered into two groups (1+2+3 and 4+5+6) and three (1+2; 3; and 4+5+6) in order to test for independence. In both cases all tests do not reject the hypothesis of independence.

4.2.2 Locally-Driven Supply-Side Influences on Spillovers

Table 5 shows the sign and significance of technology spillovers for two types of domestic firms: (a) those located in 5-digit industries where foreign subsidiaries are 'technologically active' with respect to the indicators in the rows, and (b) those located in industries where subsidiaries are 'technologically passive' with respect to the same indicators.[32] It is striking that there are significant results with appropriate signs for a large number of the indicators, including the composite index.

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[32] It is important to note that subsidiaries that are technologically 'active' with respect to one indicator (e.g. R&D intensity) will not necessarily be active with respect to others. Therefore the sectors included in each group, and consequently the domestic firms introduced, may differ between the indicators.

Table 5: FDI Spillovers and MNC Subsidiaries' Local Knowledge-Creation and Accumulation

	Sign and significance of the estimation of FDI spillovers for domestic firms in sectors where subsidiaries are:[1]			
	Technologically Active		*Technologically Passive*	
When the sectors are classified as technologically 'active' or 'passive' with respect to the following aspects of the technological behaviour of subsidiaries:	Co-efficient for FDI and *t* values	R^2 and number of Observations	Co-efficient for FDI and *t* values	R^2 and number of Observations
1 COMPOSITE INDEX OF TECHNOLOGICAL BEHAVIOUR [2]	1.65 (2.01)**	37% (567)	-0.76 (-1.95)	38% (542)
2 INVESTMENT IN DISEMBODIED TECHNOLOGY				
2.1 R&D INTENSITY [3]	0.86 (1.48)	45% (493)	-0.09 (-0.17)	46% (616)
2.2 SKILL TRAINING INTENSITY	1.58 (2.23)**	54% (236)	-0.65 (-1.12)	49% (617)
2.3 THE SKILL INTENSITY OF EMPLOYMENT [4]	1.22 (2)**	45% (492)	-0.71 (-0.74)*	51% (604)
3 INVESTMENT IN CAPITAL-EMBODIED TECHNOLOGY				
3.1 INVESTMENT IN INFORMATION TECHNOLOGIES	1.22 (1.88)*	46% (474)	-0.17 (0.38)	46% (635)
3.2 INVESTMENT IN EQUIPMENT FOR INNOVATION	1.16 (1.71)*	44% (456)	-0.16 (-0.33)	47% (653)
3.3 INVESTMENT IN IMPORTED CAPITAL GOODS	1.06 (1.91)**	45% (507)	-1.14 (-1.69)*	46% (602)
4 INNOVATION STRATEGY				
4.1 IMPORTANCE OF 'SIGNIFICANT' PRODUCT INNOVATION	0.81 (1.65)*	44% (706)	-0.36 (-0.35)	52% (403)
4.2 IMPORTANCE OF 'SIGNIFICANT' PROCESS INNOVATION	0.79 (1.59)	44% (706)	-1.18 (-0.23)	51% (403)
4.3 IMPORTANCE OF INNOVATION IN FIRM STRATEGY	0.92 (1.71)*	46% (598)	0.02 (0.04)	46% (511)

Source: Authors' calculations based on the Argentinean Innovation Survey 1992-1996

Notes: [1] All standard errors, in parenthesis, are corrected for heteroskedasticity. *significant at 10% level, **significant at 5% level and *** significant at 1% level.

[2] Using factor analysis three indexes of technological behaviour were used. Here we show the results for the first. The second and third provided non-significant results. This first factor is explained mostly by four variables, R&D expenditures, skills, investments in equipment for innovations, and imports of capital goods (for more details see Annex 2)

[3] In sensitivity tests a positive and significant coefficient for *FDIpart* (5% level) is obtained if only the top quartile of domestic firms (227) is selected.

[4] In sensitivity tests a positive and very significant coefficient for *FDIpart* (1% level) is obtained if only 10% of domestic firms is selected.

For instance, training activities carried out by subsidiaries seem to be an important local driver for technology spillovers. The 236 domestic firms located in industries where subsidiaries have relatively high expenditure on training experienced positive and significant spillovers. In contrast, the other group of domestic firms, located in industries where subsidiaries spent little on training, experienced falling productivity ('negative spillovers'),[33] though this result is not significant. The same relationships hold with respect to the skill-intensity of employment. When foreign firms employ high proportions of professional and skilled workers, spillovers to domestic firms are positive and significant; but when this proportion is low there is again a fall in domestic firms' productivity, and the relationship is significant. It is of interest to note that, among the indicators of investment in disembodied technology, it is only subsidiaries' expenditure on R&D that seems to have no influence on the transmission of spillovers – though a positive and significant effect is found if only the top quartile of the distribution of domestic firms is selected.

With respect to all three indicators of investment in capital-embodied technology, high levels of subsidiary investment are positively and significantly associated with spillovers to domestic firms. It also seems clear that the strategic importance attached to innovation by subsidiaries influences the extent to which spillovers are transmitted.

In summary, there is a sharp contrast between the two types of approach we have taken to the estimation of spillovers. The methods we used in Section 4.1, based on underlying models of a process that is centrally driven by the transfer of technology from parent firms yielded no evidence of spillover effects – i.e. we did not confirm Hypothesis 1. This changed very little when that model was augmented by consideration of the absorptive capability of domestic firms – i.e. we did not confirm Hypothesis 2. On the other hand, when we tested in this section a battery of models incorporating measures of *localised* knowledge-creation and knowledge accumulation by MNC subsidiaries (Hypothesis 3) an array of strong, positive and significant results was generated.

5. Conclusions

One broad conclusion to be drawn from these results is about the role of absorptive capabilities. Having failed to identify spillovers delivered automatically by FDI, we explored whether absorptive capabilities were an important influence on the extent of spillovers. The analysis suggested that, on their own, they were not, so adding to the body of similar results from other studies in industrialising

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[33] Since 'real' spillovers cannot be negative, this inverse relationship between FDI expansion and domestic firms' productivity probably reflects some form of negative effect of increased competition from FDI.

countries. However, the detail is also interesting in suggesting differences between the apparent absorption effects of different types of technological behaviour. Investment by domestic firms in capital embodied technology and, to a lesser extent, in skill training were associated with spillover effects.[34] In contrast, investment in R&D appeared unimportant. This last finding raises questions about the relevance of commonly used R&D-based measures of absorptive capability in the context of industrialising countries.

A second broad conclusion is about the conventional 'pipeline' model of spillovers that is driven by the knowledge-assets of multinational corporations. In the experience examined here, it was not simply the *existence* of MNC subsidiaries, linked to the superior knowledge resources of the parent, that generated spillovers. Instead, the subsidiaries' own knowledge creation and accumulation seems to have been a significant source of the spillover potential. This suggests that the knowledge asset model, with its smoothly operating technology transfer 'pipeline' to subsidiaries, is not an appropriate framework for analysing the significance of technology spillovers from FDI to domestic firms. Instead, we argue that an alternative approach to analysis is likely to more useful. This still takes account of the 'supply side', but focuses on the role of subsidiaries' own technological behaviour. However, it is important to recall the specific Argentine context of our case-study – relative to many other industrialising countries, an economy with a long-established industrial base, relatively mature MNC subsidiaries, and a substantial endowment of human capital. In other contexts the emphasis we have given to the technologically active role of subsidiaries may be less appropriate. Indeed, it might be productive if the field of spillover studies in general was to give much more attention to the relevance of different models in different circumstances.

Our conclusions about the importance of technologically active subsidiaries leave open, however, several important questions. One is about whether subsidiaries' knowledge-creating activities are simply reflections of inter-industry technological differences. Our conclusion is that this is not the case in this study. More specifically, the technological intensity of industries did not provide a significant explanation for the technology behaviour of subsidiaries, and hence for spillovers. This contrasts with arguments in several recent studies noted in Section 2.1(c).

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[34] See note 3 under Table 2.

A more important question is about the explanation of the behaviour of the subsidiaries. Our study throws little light on this, but the literature offers two perspectives. One, typically drawn on in spillover studies, attaches most importance to centrally determined corporate strategies and motives in the light of global and local competitive conditions. The other, while recognising the role of centrally driven strategy, gives more emphasis to the autonomy and localised strategy of subsidiaries within the overall corporate system. The former tends to see the subsidiary as playing a relatively passive role in the process leading to spillover generation. The latter would ascribe a much more active role to the subsidiary's strategic discretion. Our results point in the direction of the second, subsidiary-driven explanation. However, it is possible that the technologically active behaviour of subsidiaries that seems to have generated spillovers in the case examined here might still have reflected subsidiaries' conformity to central corporate strategy much more than their own initiatives in, and responses to, local contexts. Further work to clarify this issue would be important because of its implications for host country policy with respect to FDI.

The generation of spillovers (and other externalities) provides the welfare justification for policy intervention in connection with FDI. However, if as we suggest, the mere *existence* of MNC subsidiaries in host economies is not a sufficient condition for such spillovers, policy measures that simply seek to attract FDI along with its presumed inflow of superior technology would be inefficient. Instead, the results of this study suggest that policy measures should focus on what MNC affiliates actually do in the host country. More precisely it should focus on the two areas that seem to be important in generating spillover effects: (a) the knowledge-creating and knowledge accumulating activities of subsidiaries; (b) their embeddedness in linkages with the domestic economy through which those knowledge assets might flow. But the effectiveness of such a focus, and how it might best be developed, would depend on the extent of subsidiaries' autonomy in shaping their own technological behaviour within the structure and strategy of the corporation as a whole.

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ANNEXES

ANNEX 1:   THE INNOVATION SURVEY IN ARGENTINA

The Innovation Survey was carried out in 1996, but the firms provided four types of information:

1) For the single year 1996 (e.g. 'participation of foreign capital' refers to 1996),

2) For 5 points in time, annually from 1992 to 1996 (e.g. 'R&D employees' is provided for each of the 5 years),

3) For two points in time: 1992 and 1996 (e.g. sales, exports, and investments),

4) For the whole period (e.g. improvements in products and processes relate to the whole period)

The rest of this annex has two parts.

Part 1 describes the types of information covered by the Innovation Survey, and comments on our construction of indicators based on this information

Part 2 describes the relative participation of MNC subsidiaries and domestic firms as shown by the Innovation Survey and provides background descriptive statistics based on the different indicators constructed.

Part 1 The Information reported by the Survey and the indicators

The information covered by the database may be classified into 4 main areas: firm-level indicators of performance and productivity, investments and efforts carried out in order to acquire external technologies, internal technological efforts and capabilities, and innovative output and strategy. Specifically, each area includes:

1.   Performance, productivity
(a) Total sales, (1992-1996).[35]
(b) Total exports and composition (goods, services, technology and technical assistance).
(c) Total number of employees between 1992 and 1996 by activity and qualification.

2.   Availability and acquisition of externally developed technologies
(a) Composition of investments in fixed assets.
(b) Characteristics of the main investments in fixed assets.
(c) Automation and control, value of PCs in administrative, technical and other applications, quantity and value of control systems and automation.
(d) Acquisition of information technologies.
(e) Total import values and composition.
(f) Total imports of capital goods and composition.
(g) Main reasons to import capital goods.
(h) Payments to national and foreign private enterprises for licences and technology transfer.
(i) Type of consulting hired.
(j) Characteristics of the consulting about production, organisation of the productive system, products, commercialisation, organisation and business management.
(k) Type of agreements with other firms or institutions (1992/96).
(l) Linkages and contacts with Argentinean Institutions of Science and Technology.

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[35] The added value by firm for 1996 was obtained from other sources

3. Internal technological efforts and capabilities

(a) Number of employees between 1992 and 1996 by activity and level of qualification.

(b) Organisational structure of the R&D activities.

(c) Expenditures in personnel (staff) devoted temporarily or permanently to innovation activities and main activities of the personnel: basic research, applied research, development of products or process adaptation of products or processes, technical assistance to production, engineering of projects, administrative reorganisation, general organisation, commercialisation of new products, total.

(d) Other expenditures in innovation activities (basic research, applied research, development of products or process, adaptation of products or processes, technical assistance to production, engineering of projects, administrative reorganisation, general organisation, commercialisation of new products).

(e) Sources of information for innovation (experimental own R&D, production, linked firms, headquarters or other subsidiaries, competence, reverse engineering, customers, enterprises of consulting, suppliers of equipment and materials, universities, public institutions of research, private institutions of research, licences and patents, conferences, seminars, fairs and expositions, journals, publications and other bibliography, centres of technological information and data bases).

(f) R&D joint ventures with other enterprises or institutions (with local or external enterprises from the same group, customers, suppliers, competitors, other enterprises, experts and consulting firms, private institutions of research, public institutions of research, universities).

(g) Activities of training during the period 1992-1996 (Modes, costs and total hours).

(h) Motivations for training.

(i) Productive, commercial and business agreements 1992/1996.

(j) Implementation of organisational techniques.

3. Innovative output

(a) Activities of technological innovation, 1992/1996 (innovation of product, innovation of process, design, development, automation and control, renewal of machinery and equipment, work re-organisation, reorganisation of productive flows, execution of continuous improvements, costs rationalisation, training of human resources).

(b) Improvements in products between 1992 and 1996 (technological improvement of current products, new products due to advances in the technological and scientific base, new products due to new productive process, new products due to novel inputs, differentiation of products).

(c) Improvements obtained in processes between 1992 and 1996 (technological improvement of current processes for equal products, machinery and equipment linked to new processes, new processes for new products, new process based on advances in the scientific and technological base).

(d) Patents granted between 1992 and 1996 (quantity), (granted in Argentina, granted abroad).

(e) Innovation's objectives (total or partial replacement of current products, extend the range of products, development of products that do not affect the environment, improve the quality of products, introduction of new materials, development of new equipment, Improve the flexibility of the processes, reduction of the costs of production, improvements in work conditions, adoption of less polluting productive process, development of innovations based on scientific innovations, adaptation of products to the national market, adaptation of products to the external markets).

(f) Main factors hindering innovation.

The following 10 indicators were derived from this information:

A) Investment in disembodied technologies
  1 R&D intensity
  2 Skill training intensity
  3 Skill intensity of employment

    4   Investment in licensed technology

B) Investment in capital embodied technologies
    5   Investment in information technologies
    6   Investment in equipment for innovation
    7   Investment in imported capital goods

C) Innovation strategy
    8   Importance of significant product innovation
    9   Importance of significant process innovation
    10   Importance of innovation in firm strategy

R&D intensity, skill training intensity and the three investments in embodied technologies are ratios between the absolute value for this indicator and total sales per firm. The skill intensity of employment is calculated as the ratio between professional workers and non-professional workers for each firm.

Finally, the innovation strategy is calculated on the bases of the information provided by the questions a), b) and c), included in the item 'innovative output' above. The responses to these questions were used to compute the indicators as follows:

- **The importance of 'significant' product innovation:**
  - Firms were classified into two groups: those attaching 'Hi' and 'Lo' importance to significant product innovation, valued 1 and 0 respectively. The former were defined as those that introduced new products: (a) as a result of improvements in the scientific and technological base, (b) in association with new production processes, and/or (c) in association with the employment of novel inputs. The second group was classified as attaching 'Lo' importance to significant product innovation when firms only introduced improvements to existing products, and/or when they differentiated existing products.

- **The importance of 'significant' process innovation:**
  - Firms were classified into two groups: those attaching 'Hi' and 'Lo' importance to significant process innovation, valued 1 and 0 respectively. They were classified as the former when they: (a) introduced new processes because of improvements in the scientific/technological base, and/or (b) improved processes in association with the introduction of new machinery and equipment. The second group were classified as attaching 'Lo' importance to significant process innovation when they only improved processes for the same products, and/or introduced changes in processes only to implement product changes.

- **The importance of innovation in firm strategy:**
  - The survey asked firms whether they considered each of a range of activities "decisive", "significant" or "non-significant" for their business strategy. We classified firms as attaching 'Hi' importance to innovation in their strategy when they classified the following activities as decisive: (a) product/process innovation, (b) the incorporation of new equipment for innovations, (c) changes in work organisation, and (d) re-organisation of the production line/flow. Firms classified as attaching 'Lo' significance to innovation were those that described these activities as "significant" or "non-significant".

Part 2 Firms and Ownership, and Descriptive Statistics

A. Firms and ownership

The survey covered 283 MNC subsidiaries and 1250 domestic firms. A company is defined in this study as a subsidiary when the proportion of foreign ownership is higher than 10%. The Survey sample included all of the 500 largest industrial firms in Argentina.

Table 1 shows the distribution of firms, sales and employment according to ownership.

Table 1: Subsidiaries and Domestic Firms in the Survey: Their Sales and Employment (1996)

Type of firm		Number of firms	Total sales (in thousands)	Total employment
Subsidiaries	Total	283	24,600	132,630
		(18%)	(52%)	(41%)
Domestic firms	Total	1,250	22,500	192,325
		(82%)	(48%)	(59%)
Total	Total	1,533	47,100	394,955
		(100%)	(100%)	(100%)

Source: Authors' calculations based on the Argentinean Innovation Survey

Table 2 describes the participation of subsidiaries in 2-digit manufacturing industries, with respect to employment, sales and the number of firms.

Table 2:   The Participation of MNC Subsidiaries in Argentine Manufacturing Industries (2-digit level, 1996)

Sectors	Share of foreign firms, 1996 (%)		
	Total employment	Total sales	Number of firms
Tobacco Industries	100	100	100
Petroleum refining and related industries	79	89	46
Electronics	65	78	19
Stone clay glass and concrete products	55	68	27
Chemicals and allied products	57	66	44
Rubber and miscellaneous plastic products	56	66	22
Primary metal industries	62	62	22
Paper and allied products	43	55	18
Motor vehicles and equipment	54	54	34
Communication equipment	50	49	29
Machinery and equipment	46	46	15
Food and kindred products	31	42	13
Precision, photographic medical optical	22	38	20
Lumber and wood products except furniture	25	29	7
Textile mill products	28	28	8
Leather and leather products	23	26	11
Miscellaneous manufacturing industries	17	25	6
Fabricated metal products	22	20	15
Printing publishing and allied products	14	14	13
Transportation equipment	1	1	5
Apparel and other finished products	0	0	0
Computer and office equipment	0	0	0

Source: Authors' calculations based on the Argentinean Innovation Survey

Subsidiaries dominate mature process industries such as petroleum (89% of sales and 79% of total employment), chemicals (66% of total sales and 57% of employment) and rubber and plastic products (66% of total sales and 56% of total employment). They are also similarly important in other industries such as electronics (78% of sales and 65% of total employment), communication equipment (49% of sales and 50% of total employment) and machinery and equipment (46% of sales and employment).

B. Descriptive statistics

Table 3 shows descriptive statistics for nine indicators derived from the survey, distinguishing between domestic firms and MNC subsidiaries.

Table 3:   MNC Subsidiaries and Domestic Firms: Selected Indicators of Economic Performance and Technological Behaviour
(Average levels 1992-96)

	Number of Firms	Mean Values	Quartiles			
			First	Second	Third	Fourth
1. Economic performance						
Added value per worker						
MNC subsidiaries	256	96,381	-6,234	31,831	59,462	398,005
Domestic firms	1,173	38,877	2,513	18,916	33,179	147,433
Export intensity						
MNC subsidiaries	241	15%	0.2%	4%	12%	73%
Domestic firms	621	15%	0.1%	3%	12%	73%
Investment per employee						
MNC subsidiaries	270	13.0	0.21	3.2	8.5	75
Domestic firms	987	13.1	0.08	1.67	5.0	76
2. Investment in disembodied technology						
R&D intensity						
MNC subsidiaries	166	3%	0.0%	0.1%	1%	14%
Domestic firms	377	5%	0.0%	0.0%	0.1%	13%
Training intensity						
MNC subsidiaries	187	1%	0.1%	0.2%	0.5%	18%
Domestic firms	406	4%	0.0%	0.1%	0.3%	24%
Skill intensity						
MNC subsidiaries	282	11%	1%	5%	10%	41%
Domestic firms	1,531	6%	0%	2%	5%	30%
3. Investment in capital-embodied technology						
In Information Technologies						
MNC subsidiaries	283	0.2%	0.0%	0.1%	0.2%	1%
Domestic firms	1,245	4%	0.0%	0.01%	0.09%	24%
In Equipment for Innovation						
MNC subsidiaries	143	4%	0.0%	0.0%	1%	18%
Domestic firms	404	6%	0.1%	2%	4%	46%
In Imported Capital Goods						
MNC subsidiaries	192	4%	0.2%	0.9%	2%	18%
Domestic firms	407	5%	0.1%	1%	3%	26%

ANNEX II: **THE COMPOSITE INDEXES OF ABSORPTIVE CAPACITY AND TECHNOLOGICAL BEHAVIOUR**

We use Principal Factor Component Method – PFC - (to extract factors) rather than Maximum Likelihood (which is more sensitive to departure from normality). The PFC method is justified here because we want to explain the total variance of some subsets of variables with all of them being *grouping* variables of some more disaggregated features.

A) For the evaluation of the absorptive capabilities of domestic firms

The use of only one index/factor provides the following weights for each variable

Indicators	*Weights*
R&D expenditures	0.07415
Training	0.06415
Skills intensity	0.01840
Acquisitions of IT	0.02888
Payments for the use of licences	0.30950
Investments in equipment for innovations	0.34173
Imports of capital goods	0.32577
Importance given to product innovation	0.11752
Importance given to process innovation	0.13137
Importance of innovation in firm strategy	0.12574

The proportion of the total variance explained in this way is very low however, 26%.

B) For the evaluation of the local technology behaviour of subsidiaries

A similar procedure was followed for the case of the subsidiaries.
Retaining only one factor the following weights were obtained for each indicator

Indicators	*Weights*
R&D expenditures	0.26622
Training	0.13708
Skills intensity	0.27746
Acquisitions of IT	0.10999
Payments for the use of licences	0.12113
Investments in equipment for innovations	0.23545
Imports of capital goods	0.28392
Importance given to product innovation	0.18050
Importance given to process innovation	0.16723
Importance of innovation in firm strategy	0.16344

The proportion of the total variance explained in this way is very low again, 24%.

ANNEX III: LINKING DIFFERENT SUBSIDIARIES' TECHNOLOGICAL BEHAVIOUR TO SPILLOVERS

In this annex we present the distribution of domestic firms relative to the various indicators of subsidiaries' technological behaviour.

Table 1: Distribution of Domestic Firms According to Subsidiaries' Investments in Disembodied Knowledge and Skills within 5-digit Activities (Levels)

Percentage of Domestic Firms	R&D expenditures[a]	Training expenditures[b]	Skills[d]
10%	0	0	0
25%	0	0	0
Median	39	94	41
75%	885	950	210
90%	3,514	3,936	788
Mean	1,259	2,925	225
Std Dev	2,821	10,265	414
Observations	2,490	2,490	2,490

Source: Authors' calculation based on the Argentinean Innovation Survey
[a, b, and c]: In thousands of dollars, [d]: Number of professionals (engineers and others) in production tasks

Table 2: Distribution of Domestic Firms According to Subsidiaries' Investments in Capital-Embodied Technology within 5-digit Activities

Percentage of Domestic Firms	Acquisition of IT technologies	Investments in equipment for innovations	Imports of capital goods
10%	0	0	0
25%	0	0	0
Median	336	403	772
75%	350	6,127	6,044
90%	943	23,575	14,595
Mean	331	7,361	4,978
Std Dev	807	17,400	9,361
Observations	2,490	2,490	2,490

Source: Authors' calculation based on the Argentinean Innovation Survey. All values in thousand dollars

Table 3: Distribution of Domestic Firms According to Subsidiaries' Innovation Strategy within 5-digit Activities

Percentage of Domestic Firms	Product Innovation	Process Innovation	Importance of innovation
10%	0.00	0.00	0.00
25%	0.00	0.00	0.00
Median	0.02	2.00	2.00
75%	0.04	6.00	4.00
90%	0.08	8.00	8.00
Mean	4.09	4.17	3.24
Std Dev	6.93	7.41	5.65
Observations	2,490	2,490	2,490

Source: Authors' calculation based on the Argentinean Innovation Survey. All values in thousands dollars

All these variables are categorical, 0 for less innovative subsidiaries and 1 for more innovative. So, the values in columns are number of more innovative subsidiaries by activity

ANNEX IV: THE MODEL AND VARIABLES

Estimation in first differences

$$\Delta \ln Y^d{}_{ij} = \lambda \Delta \ln Input^d{}_{ij} + \delta \Delta FDIpart_j + \eta Z^d{}_{ij} + G^d{}_{ij} + I_j + \varepsilon_{ij} \qquad (1)$$

Equation (1) is derived from a Cob-Douglas production function of the form:

$$Y_{it} = A_{it} L^\alpha{}_{it} K^\beta{}_{it} \qquad (2)$$

Where Y is added value, L labour, K capital, A, together with α and β (the elasticities of output with respect to each input) are fixed parameters and the sub indexes $i\,t$ indicate variation across firms and time.

This function is linear in the logarithms of the variables, so after taking logarithms, and adding two terms:
a) a term b_i that captures all unobserved time-constant factors that might affect Y_i,
b) a stochastic disturbance term u_{it} to account for variations in the technical or productive capabilities of the ith firm at the time $_t$,

we can write this relationship for $_t$=1996 and $_{t-4}$=1992 as follows:

$$\ln Y_{it} = a_{it} + \beta \ln K_{it} + \alpha \ln L_{it} + b_i + u_{it} \ (a = \ln A) \qquad (3)$$
$$\ln Y_{it-4} = a_{it-4} + \beta \ln K_{it-4} + \alpha \ln L_{it-4} + b_i + u_{it-4} \qquad (4)$$

Then, differentiating (3-4) the change in added value for domestic firms between 1996 and 1992 can be expressed as follows:

$$\Delta \ln Y_i = \Delta a_i + \beta \Delta \ln K_i + \alpha \Delta \ln L_i + \Delta u_i \qquad (5)$$

Where α and β are the participation of capital and labour in value-added, and the unobserved effect b_i has been differenced away.

We do not have capital stock, so instead of β we estimate the marginal product of capital by using I/Y in 1996.

In effect $\Delta \ln Y_i = \Delta a_i + \beta \Delta \ln K_i + \alpha \Delta \ln L_i$ (5) can be written also as:

$$\Delta \ln Y_{ij} = \Delta a_{ij} + \frac{\Delta Y}{\Delta K} \frac{K}{Y} \frac{\Delta K}{K} + \alpha \Delta \ln L_i \ (5`), \qquad (5')$$

where $\dfrac{\Delta Y}{\Delta K} \dfrac{K}{Y} = \beta$.

So, after cancelling K in equation (5`), and given that $\dfrac{\Delta Y}{\Delta K} = \rho$ and $\quad \Delta K = I$ , equation 5` can be

written as (6).

$$\Delta \ln Y_i = \Delta a_i + \rho \frac{I_{it}}{Y_{it}} + \alpha \Delta \ln L_i + \varepsilon_i \qquad (6)$$

Where $\varepsilon_i = \Delta u_i$

The hypothesis that the changes in FDI participation by sector affect productivity growth of domestic firms is investigated by modelling the changes in a_i as:

$$\Delta a_i = \delta \Delta FDIpart_i + \eta Z^d{}_i + I + G^d + \varepsilon_i \qquad (7)$$

where the changes in a - or TFP growth - are assumed to vary across sectors, group, Z, and also following changes in FDI in penetration by sector.

Finally, combining (6) and (7) we arrive at equation (1) in the text

$$\Delta \ln Y^d{}_{ij} = \lambda \Delta \ln Input^d{}_{ij} + \delta \Delta FDIpart_j + \eta Z^d{}_{ij} + G^d{}_{ij} + I_j + \varepsilon_i$$

Where: $\Delta Input$ includes changes in L (labour) and the level of I/Y (investment over product 1992) and ΔZ, the changes in skills, knowledge capital and competition

ANNEX V: DIFFERENTIATING INDUSTRIES - FOLLOWING THE CLASSIFICATION OF FERRAZ et al. (1997)

Table 1 illustrates some of the industries included in each category, Table 2 shows all the 4-digit SIC codes included in each category and Table 3 the distribution of domestic firms and subsidiaries by sectors aggregated following the classification of Ferraz et al.

Table 1: The Classification of Industries

Ferraz Categories	Illustrative 4-digit SIC Industries	
INDUSTRIAL COMMODITIES	Dyeing and Finishing Textiles Paperboard Containers Industrial Inorganic Chemicals Iron And Steel Foundries	**Less Technology-Intensive**
AGRO-BASED COMMODITIES	Canned, and Preserved Fruits Animal Fats And Oils Grain Mill Products Sugar	
TRADITIONAL SECTORS	Meat products Bakery products Apparel Soap, Detergents and Cleaning Preparations	
DURABLE GOODS	Household Appliances Watches Motorcycles Bicycles and Parts	
THE AUTOMOTIVE SECTOR	Motor Vehicles Passenger Car Bodies Motor Vehicle Equipment	
DIFFUSERS OF TECHNICAL PROGRESS	Pesticides and Agricultural Chemicals Drugs Farm Machines Machine Tools Communication Equipment Electrical Industrial Apparatus Aircraft and Space Vehicles	**More Technology-Intensive**

When used to differentiate the industries of MNE subsidiaries, the underlying principle is the same as noted earlier in the discussion in Section 2: less knowledge-intensive firms in the more traditional and commodity industries towards the top of the table are likely to offer more limited spillover potential than more knowledge-intensive firms in the industry categories towards the foot of the Table.

Table 2: SIC Codes Included in the Classification Categories Following Ferraz et al.

Ferraz Categories	SIC code
INDUSTRIAL COMMODITIES	(1711) (1712) (1911) (2010) (2021) (2101) (2102) (2109) (2310) (2320) (2411) (2412) (2413) (2694) (2696) (2710) (2720) (3130) (3150)
AGRO-BASED COMMODITIES	(1513) (1514) (1531) (1532) (1533) (1542)
TRADITIONAL SECTORS	(1511) (1512) (1520) (1541) (1543) (1544) (1549) (1551) (1552) (1553) (1554) (1600) (1721) (1722) (1723) (1729) (1730) (1810) (1820) (1912) (1920) (2022) (2023) (2029) (2211) (2212) (2213) (2219) (2221) (2222) (2230) (2424) (2429) (2430) (2519) (2520) (2610) (2691) (2692) (2693) (2695) (2699) (2731) (2732) (2811) (2812) (2813) (2891) (2893) (2899) (3140) (3190) (3610) (3691) (3692) (3693) (3694) (3699)
DURABLE GOODS	(2930) (3230) (3320) (3330) (3512) (3591) (3592) (3599)
AUTOMOTIVE SECTOR	(3410) (3420) (3430)
DIFFUSERS OF TECHNICAL PROGRESS	(2421) (2423) (2911) (2912) (2913) (2914) (2915) (2919) (2921) (2922) (2923) (2924) (2925) (2926) (2927) (2929) (2930) (3000) (3110) (3120) (3210) (3220) (3311) (3312) (3313) (3511) (3520) (3530)

The distribution of the sample firms in the Survey across these categories is shown in Table 3. This shows two important broad patterns. First, the total sample of MNE subsidiaries is spread fairly evenly across the different categories and not heavily concentrated in the more knowledge-intensive categories. Indeed, a surprisingly large proportion of subsidiaries (70%) is located in traditional and commodity industries. Second, in most of the categories MNE subsidiaries are not a dominant presence (at least by number of firms). However, they do constitute quite a large proportion of all the firms in the knowledge-intensive automotive sector (34% of all firms).

Table 3: Distribution of Domestic Firms and Subsidiaries Aggregated by Categories Following the Classification of Ferraz et al.

Ferraz Categories	Domestic Firms	Subsidiaries	Total
INDUSTRIAL COMMODITIES	**190**	**57**	**247**
Row (%)	77%	23%	100%
Column (%)	15%	20%	16%
AGRO-BASED COMMODITIES	**76**	**13**	**89**
Row (%)	85%	15%	100%
Column (%)	6%	5%	6%
TRADITIONAL SECTORS	**704**	**126**	**830**
Row (%)	85%	15%	100%
Column (%)	57%	45%	54%
DURABLE GOODS	**56**	**8**	**64**
Row (%)	87%	13%	100%
Column (%)	4.%%	3%	4%
AUTOMOTIVE SECTOR	**47**	**24**	**71**
Row (%)	66%	34%	100%
Column (%)	4%	9%	5%
DIFFUSERS OF TECHNICAL PROGRESS	**172**	**54**	**226**
Row (%)	76%	24%	100%
Column (%)	14%	19%	15%

Source: Authors' calculations based on the Argentinean Innovation Survey