Firms' technological trajectories and the creation of foreign subsidiaries*

Davide Castellani§
ISE-Università di Urbino

First Draft: October 2000
This Version: July 2001

Abstract

Multinational firms are traditionally considered as firms possessing some technological lead and exploiting this proprietary advantage in international markets, but a growing literature has been arguing that multinational firms set up foreign subsidiaries not only as a means to exploit their own technology but also to enrich it. This paper provides some empirical evidence in this line of analysis. The aim of the paper is to assess the effects of the creation of foreign subsidiaries on firm's technological trajectory. The idea is that by setting up subsidiaries in foreign countries multinational firms can achieve some form of reverse technology transfer which can be expected to affect their technological trajectory. The empirical investigation has been carried out using data from 1992 to 1996 on a sample of 1,814 Italian manufacturing firms. Results support the view that the creation of manufacturing subsidiaries have a positive impact on firm's productivity trajectory and, more interestingly, this positive impact is greater when subsidiaries are created in regions where knowledge spillovers are expected to be relatively higher, such as the U.S

JEL: C23, D24, F23
Keywords: foreign direct investments, total factor productivity, dynamic panel data

* This paper is a contribution to the TSER project on "Assessing the Impact of Technological Innovation and Globalization: the effects on growth and employment" (AITEG), whose financial support is gratefully acknowledged. The author wishes to thank Giorgio Barba Navaretti and Antonello Zanfei for supervision, Roberto Simonetti for providing some of the data used, Massi Bratti, Erich Battistin, Grazia Ietto-Gillies, Alfonso Rosolia and participants at the AITEG Meetings for comments on a earlier draft. Data preparation has been carried out with the excellent research assistantship of Elisabetta Andreani and Elvio Ciccardini. The usual disclaimer applies.
§ Correspondence: ISE-Università di Urbino, Via Saffi, 2 - 61029 Urbino - Italy. E-mail: dcastell@guest.net

1. Introduction

The interplay between foreign direct investments and technology is not new to scholars of innovation and internationalisation. Multinational firms are traditionally considered as firms possessing some technological lead and exploiting this proprietary advantage in international markets (Dunning, 1993). In this view firm's core technology is developed by the parent company in the home country and knowledge flows mainly from centre to periphery, i.e. from the headquarters to foreign affiliates. In recent years, the evolution of markets and technologies have cast doubts on this view. The process of globalisation of technology is calling attention on the role of multinational firms as key players in the process of worldwide generation and exploitation of knowledge (Archibugi and Michie, 1995; Cantwell, 1995). A growing literature argues that multinational firms set up foreign subsidiaries not only as a means to exploit their own technology but also to enrich it (Cantwell and Narula, 2001; Fosfuri and Motta, 1999).

This paper provides some empirical evidence in this line of analysis. The aim of the paper is to assess the effects of the creation of foreign subsidiaries on firm's technological trajectory. The idea is that by setting up subsidiaries in foreign countries multinational firms can learn foreign technologiers, grasp new uses and applications for their own products and technologies, adapt products and processes to specific needs, improve their organisational processes as well as their commercial and distribution strategies. In sum, one can expect that through foreign subsidiaries multinationals achieve some form of reverse technology transfer which can be expected to affect their technological trajectory. The empirical strategy followed in this paper is to model firm's technological trajectory as an autoregressive process of total factor productivity (TFP) and to control if this process is influenced by the event of the creation of new foreign subsidiaries. Unlike most existing works in this field, which rely on samples of multinational firms, the empirical investigation in this paper is based upon a sample of both multinational firms and domestic firms which do not set-up foreign activities. The latter sample can be thought as the counterfactual and the key question will be: "Do investing firms have better productivity trajectories than non-investing firms?, or, in other words, "What would have happened, if the firm had not invested abroad?".

The empirical investigation has been carried out using data from 1992 to 1996 on a sample of 1,814 Italian manufacturing firms. Results support the view that the creation of manufacturing subsidiaries have a positive impact on firm's productivity trajectory and, more interestingly, this positive impact is greater when subsidiaries are created in regions where knowledge spillovers are expected to be relatively higher, such as the U.S.

The rest of the paper is organized as follows. Sections 2 and 3 provide the theoretical and empirical background. Sections 4 and 5 define the empirical strategy and the data used. Section 6 illustrates the econometric results and section 7 concludes the paper.

2. Firm's technology and the creation of foreign subsdiaries: a two way causality

The theory of foreign direct investment (FDI) tends to consider the multinational enterprise (MNE) as a firm possessing some proprietary (or ownership) advantage (Dunning, 1993; Markusen, 1995), which engages in international production to exploit it in international markets. In this perspective foreign subsidiaries are the most efficient way to control firm's international activities when some intangible assets, such as technology or "knowledge capital" (Markusen and Maskus, 1999), have to be transferred across borders (Buckley and Casson, 1976). Some authors, referring more specifically to investments in R&D activities, have termed this type of foreign direct investments as "asset-exploiting" (Dunning and Narula, 1995) or "home base exploiting" (Kuemmerle, 1999). In sum, the idea was that core technology developed in the parent company is the driver of the creation of new foreign subsidiaries, which in turn had to contribute to the exploitation of that technology in a foreign market.

Other recent contributions have challenged this view and recognized learning as another important rationale for foreign production. It has been argued that MNE are increasingly involved in foreign investments not only to exploit their ownership assets, but to acquire knowledge and technology localized in host countries (Fosfuri and Motta, 1999; Cantwell, 1995; Zanfei, 2000)[1]. The basic idea is that by localizing subsidiaries close to innovative firms and users[2], or in high-tech clusters (such as the Silicon Valley) multinational firms can have access to localized knowledge spillovers (Fosfuri and Motta, 1999). In other words, foreign subsidiaries contribute to reducing geographic distance, which is often crucial for the exploitation of knowledge spillovers (Jaffe, 1993). In turn, technology acquired in specific foreign contexts can be de-contextualized within the MNE and applied in combination with proprietary technology in all the markets where the multinational firm sells (Zanfei, 2000). Linked to this new way of conceptualising foreign direct investments is a different rationale for the creation of foreign subsidiaries, which increasingly become a means to enrich knowledge and technology of the firm. This type of investments have been termed as "asset-augmenting" or "home-base augmenting". While in the traditional literature technology is a driver of internationalisation, in these recent contributions foreign direct investments cause a reverse technology transfer (Criscuolo and Narula, 2001). It is worth mentioning that learning from international operations is to be interpreted as technological in a rather broad sense. In fact, foreign subsidiaries allow different forms of learning, deriving from contact with different user needs which stimulate new product and process development or adaptation existing ones, or from different commercial and

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[1] Dunning (1993) introduces the notion of strategic assets seeking investments and ownership advantages stemming from multinationality to indicate that firms are increasingly involved in foreign investments with the objective of complementing their proprietary technology with assets acquired in foreign markets. In this regard, firms having wide a network of foreign subsidiaries worldwide are in a better position to access more diversified and geographically dispersed knowledge (see also Ietto-Gillies, 1999 and Kogut, 1983).

[2] The role of user-producer interaction in the innovation process has been widely recognized in the literature since Rosenberg (1986). In particular it has been noted that users can contribute to the solution of problems in the introduction of a new technology or can help to find new applications for general purpose technologies.

distribution strategies observed or required in a new market, or from organisational practices learnt through contacts with foreign firms and institutions. Broadly speaking, all of this feedback knowledge contribute to firm's technology since it improves the process through which inputs are converted into outputs.

However, as noted by Cantwell and Narula (2001) it is rather facile to counter the traditional to the more recent view. It seems more fruitful to stress the relevant "complementarities between initial ownership advantage of the firm and its ability to consolidate and extend these advantages through an internal network of competence creating subsidiaries" (Cantwell and Narula, 2001). Indeed, it is a problem of causality running in both directions, which reinforces the technology-subsidiaries relation and poses relevant problems for identification of empirical findings. Due to this two way causality, one is very likely to find a positive association between foreign investments and firms' technology. As we will show below, this amounts to a problem of endogeneity of an independent variable in a regression. In a related literature, addressing the question of learning effects of export behaviour, it has been noted that there tends to be a self-selection process of more productive firms into the export market, therefore extreme caution is required in order to attribute a causal interpretation to a positive correlation between export and productivity. In particular, it has been stressed that the appropriate empirical methodology must be applied in order to disentangle the two directions of causality. Since the problem addressed here is analogous, I will borrow the empirical methodology used there, to extend the analyses to the impact of a more involved form of internationalisation, such as foreign direct investments, on technological trajectories. The aim of the present paper is to assess whether the newer stream of literature have some empirical relevance, and I will test it in the case of Italian manufacturing firms. At this stage I will not purse the issue of technology as a determinant of subsidiary creation any farther, although investigation in this line of analysis is undergoing. Rather, the main focus of the paper will be on the effects of subsidiary creation on firm's technology. In section 4 I will spell out the empirical methodology in more details, but let me just mention here that the basic idea is that multinational firm's technology evolves over time as a path-dependent learning process following distinct corporate trajectories (Dosi, 1982; Cantwell, 1989; Cantwell and Narula, 2001). The idea that foreign investments could cause technology gains can be tested by looking at how firm's technological trajectory changes after the creation of a new subsidiary, controlling for the fact that this latter event is endogenous, i.e. depends on the technological trajectory itself.

3. Empirical background

Empirical research on the impact of foreign direct investments on firm's technology is rather scattered. The most cited example of the technology acquisition rationale for foreign investments are Japanese investments in the U.S., which appear to be driven by U.S. R&D intensity. In particular, the number of entries of Japanese firms in the U.S. by joint venture were positively related to the industry R&D expenditure gap between the two countries, with sectors where Japan was investing relatively less than the U.S. registering a higher number of entries (Kogut and Chang, 1991). More recently, still focussing on Japanese FDIs in the US, Branstetter (2000) finds that Japanese parent firms having a higher number of subsidiaries in the U.S. experienced an increasing tendency to cite U.S. patents. Branstetter claims that this result shows some form of knowledge spillovers from U.S. firms to Japanese parent, via FDI. More general examples which are consistent with the idea of worldwide technology sourcing through foreign direct investments come from the increasing dispersion of multinational R&D activities worldwide. Although to a large extent the core technology of the firm still builds upon research and technology developed at home, it has been shown that a process of globalisation of technology is taking place and MNEs are increasingly setting up global networks of affiliates which tap into different scientific and technological basis (Cantwell, 1995, Pearce, 1999).

As far as firm's productivity is concerned Braconier et al. (2000) test whether, in a sample of 84 Swedish firms, labour productivity is affected by the degree of penetration of outward investments or by R&D performed in foreign countries, weighted by the share of outward FDI directed towards each country. They conclude that outward investments do not work as a channel to transmit R&D spillovers to Swedish MNEs. On the contrary, at a more aggregated level, Van Pottelsberghe de la Potterie and Lichtenberg (2001) testing for the impact of outward investments on home country's productivity in thirteen industrialised countries find that a country's productivity is increased when it home to outward investments directed towards R&D intensive countries. At the sectoral level, Driffield and Love (2001) investigate whether the increase in the stock of knowledge in domestic firms, as measured by the change in domestic capital, represents a technological externality to foreign firms production in the UK manufacturing industries. Results show that such externalities exists and are appropriated by foreign firms but only in R&D intensive sectors.

A stream of empirical work very closely related to the present one addresses the question of learning-by-exporting, that is the impact of export behaviour on firm's productivity. The basic result of most of these studies is that the export status, i.e. the fact that a firm is in the export market in a given year, does not affect the firm's productivity trajectory and holds for a number of countries as different as the U.S. (Bernard and Jensen, 1999), Colombia, Mexico and Morocco (Clerides et al., 1998), Germany (Bernard and Wagner, 1997), Italy (Castellani, 2001). Nevertheless, Kraay (1999) and Castellani (2001) provide evidence that the share of export on total sales affects significantly firm's productivity in China and Italy. Overall, these results suggest that learning from international operations might be related to the degree of commitment towards foreign markets. Such a commitment is minimum for a firm exporting a small fraction of its output and is expected to increase with export intensity and should be even higher for foreign direct investors.

The brief review of the empirical literature highlights that results are far from homogenous due to different methodologies, data sources and level of analysis, but provide some indirect support to the hypothesis that the creation of subsidiaries could cause parent company's technological evolution. In the following I will try to tackle this question more directly.

4. Econometric specification and identification problems

As anticipated above, the basic idea of the following empirical investigation is that firm's technology follow a path dependent process and that the creation of foreign subsidiaries might shift this trajectory upwards. This path dependent process is specified as a first-order autoregressive process of firms' total factor productivity (TFP). In other words I specify a dynamic equation for TFP of the following form:

$$y_{it} = a \ y_{i,t-1} + u_{it} \qquad (1)$$
$$u_{it} = h_i + u_{it} \qquad i=1,\ldots N;\ t=1,\ldots T$$

where y_{it} measures firm *i* TFP at time *t*, h_i is a fixed effect term and u_{it} is zero mean disturbance term. The parameter a measures the degree of persistence of producitivity, i.e. captures exactly the importance of cumulativeness and path dependence in firm's technological trajectory. The hypothesis that the creation of foreign subsidiaries affect the stochastic process governing firm's technological trajectory, is modelled introducing a proxy of current and lagged foreign investments as right-hand side variables $x_{i,t}$, which boils down the following dynamic panel equation:

$$y_{it} = a \ y_{i,t-1} + b_0 x_{i,t} + b_1 x_{i,t-1} + h_i + u_{it} \qquad (2)$$

It is well know from standard econometric theory that this specification has two identification problems: the first regards the lagged dependent variable $y_{i,t-1}$ which is, by construction, correlated with the fixed effect h_i, and would lead to correlation between regressors and the error term. Estimation by standard fixed-effect estimators is biased unless T is very large, which is not the case in most panels using micro-data, such as the one used in this paper. The proposed solution to this problem is to take first differences to wipe out the fixed effect[3]. In other words the transformation yields the following equation:

$$Dy_{it} = y_{it} - y_{it-1} = a_1 Dy_{i,t-1} + b_0 Dx_{i,t} + b_1 Dx_{i,t-1} + Du_{it} \qquad (3)$$

This transformation wipes out the fixed effect, but makes evident the second identification problem. Now both $Dy_{i,t-1}$ and $Dx_{i,t}$ are correlated with Du_{it}. In particular, $y_{i,t-1}$ is correlated with

[3] See Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998). For a textbook version, see Arellano and Honorè (2000).

$u_{i,t-1}$ by construction and x_{it} is correlated with $u_{i,t-1}$ because it is endogenous, i.e. it likely that only the more efficient firms will engage in foreign investments, then past positive shocks to productivity, u_{it-1}, will determine higher propensity to engage in FDIs today[4]. Estimation of this equation requires finding appropriate instruments. It has been noted that past values of *y* and *x* (from *t*-2 backwards) can be good instruments in the estimation of (3)[5]. The idea is that both *y* and *x* can be treated as predetermined variables, since past values can be assumed to be uncorrelated with current errors or, symmetrically, current realizations of *y* and *x* do not depend on future unpredictable productivity shocks. Efficient estimation requires GMM, since for higher *t* the number of available instruments (i.e. of past realizations of *y* and *x*) increases (Arellano and Bond, 1991)[6]. Back from econometrics technicalities to economics, the whole issue is the above mentioned problem of two way causality, from productivity to the creation of subsidiaries and from foreign subsidiaries to productivity gain. Looking at this latter direction of causality requires at least to take care of the first part, because the current decision to set up a foreign subsidiary depends *(i)* on the average level of firm's productivity (fixed effect), i.e. firms which have a "structurally" better technology, which for example might depend on the sector(s) where they operate, will be more likely to create foreign subsidiaries; and *(ii)* on past positive shocks to productivity, i.e. an innovation in a different sector complementary to firm's technology, which increases firm's productivity and its propensity to internationalise.

5. Data

As anticipated in the introduction, one distinctive feature of this paper is the use of a counterfactual, i.e. of a control group with firms non-investing abroad which can be compared with investing firms. In fact, the sample is composed by all the Italian manufacturing firms, both investing and non-investing abroad, in the intersection of Amadeus (henceforth AMA) and Who Owns Whom (WOW). The final sample have 1,817 firms for which we have from a minimum of 3 to a maximum of 5 years of data. A chi-squared test allowed to reject that the sectoral distribution of the sample firms is significantly different from the population of Italian manufacturing firms with more than 50 employees. As regards data sources, AMA is a database of more than 250,000 European firms with either a minimum turnover of 8 million US$, or assets greater than 16 millions US$, or more than 100 employees. For each of these firms, name, address and industry information is provided together with balance sheet and profit/loss data over a time span of 5 years. Data from AMA will be used to build

[4] One way to look at the problem is to think that (1) is one of two simultaneous equation model of productivity and FDI. Here I do not consider the equation for FDI. Clerides et al. (1998) develop a framework for a complicated FIML estimation of both equations in a context of learning-by-exporting.

[5] With the assumption of no serial correlation. Lack of serial correlation is required to avoid that $y_{i,t-1}$ ends up being correlated with u_{it} by means of $u_{i,t-1}$.

the TFP measure, which is obtained as the residual from the estimation of a log linearised Cobb-Douglas production function with fixed effects. WOW[7] provides information on 1,200,000 companies worldwide (of which 800,000 are in Europe), among which the more useful to the purpose of this paper are the name, the year and country of establishment, the 4-digit Standard Industrial Classification (SIC) codes of each affiliate together with the name and country of the ultimate parent[8]. With this information it is possible to estimate the number of foreign subsidiaries for each parent[9] at any year, in any 4-digit SIC code and in any country. Similarly, one can build a measure of new subsidiaries created in every year-SIC-country by the sample firms. Since the number of subsidiaries provides only a very rough measure of foreign investment which does not properly account for the size of investment, I preferred to turn it into an indicator variable, which takes value 1 when a firm sets up a new foreign subsidiary and zero otherwise (FDI_TOT). Firms setting up at least one new subsidiary in year t are defined as foreign investors, while firms setting up no subsidiary in year t are defined as non-investing firms and constitute the control group. Such an indicator may still underestimate foreign investors, as it may take value zero also for firms that are expanding their activities in existing foreign subsidiaries and may fail to capture acquisitions, but for sure firms that are defined as foreign investors cannot be purely domestic firms. Due to lack of reliable data on subsidiaries in LDC, I will focus only on investments in industrialised countries.

Making use of the information on the SIC code and country of establishment of each affiliate, I build proxies of different types of foreign investors. In particular, I define the indicator for "mercantile" investors (FDI_MER) which takes value 1 if a firm set at least one new foreign subsidiary in year t involved in wholesales and retail trade activities (SIC codes from 5011 to 5999), the indicator for manufacturing investors (FDI_MAN), which takes value 1 if a firm set at least one new subsidiary in year t in manufacturing activities (SIC codes from 2011 to 3999). Furthermore, investors have been distinguished according to region where they set up foreign subsidiaries. FDI_EU takes value 1 is firm *i* sets up subsidiaries in EU countries at time *t*, while FDI_US takes value 1 when subsidiaries are created in U.S[10].

Table 1 and Table 2 offer a first look into the data. In particular, Table 1 shows that in our sample, 283 firms out of a total of 1,817 had foreign subsidiaries prior to our period of investigation

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6 Further details on identification can be found in Appendix 1.

7 More precisely the commercial product is named D&B Linkages (1998 ed.).

8 Matching the two sources is relatively easy, given that, for many countries, the two datasets use the same company identification number. For Italy, this code is the Chamber of Commerce registration number.

9 In particular, it is possible to determine the stock of subsidiaries at the end of 1998. Using the year of establishment of each subsidiary, one can infer the number of foreign subsidiaries at any year. Main limitations of this method are that (i) it does not account for disinvestments; (ii) it may not capture acquisitions in the year they occur, if acquired businesses are not started as new companies; (iii) it may consider a new investment the simple reorganization with name change of one company. The latter two points depends on the fact that what is relevant to define the stock of subsidiaries is the year of establishment of a company, which may not correspond to the year of investment, in the case of acquisitions or renaming of companies.

10 It is worth mentioning that the different indicators are not mutually exclusive. In other words, nothing prevent FDI_MER, FDI_MAN, FDI_EU, FDI_US, from taking value 1 for firm *i* at time *t*.

(1992-1996) and the total number of subsidiaries was 619. Furthermore, it suggests that the period under investigation is one of considerable dynamism of Italian firms as regards the creation of new foreign subsidiaries, since the number of newborn affiliates reaches 30% of the existing stock (183). Interestingly it seems that in a very large fraction of total subsidiaries, 450 out of 619, no relevant manufacturing activity is carried out, more than a half of firms having foreign subsidiaries does not have any subsidiary in manufacturing, and this figure raises to two thirds when we focus on newborn affiliates. Most of these subsidiaries are involved exclusively in sales and retail activities. This figure raises one important point regarding the degree of internationalisation of production of Italian firms. To a large extent internationalisation of Italian firms is still mercantile, and do not involve substantial foreign production. One might say that such sales subsidiaries play an intermediate role in the process of integration of Italian firms in the international production system. They represent a step further with respect to simple exporting, but still do not involve the degree of commitment and integration of Italian firms in host countries. In this respect, it must be noted that all the theory developed so far implies some international production. Nevertheless, in the following I will keep on looking also on these commercial subsidiaries, in order to evaluate whether such a type of investment entails some degree of learning. In fact, through contact with foreign customers these type of subsidiaries might provide valuable information on product and process adaptation for specific needs, or might suggest organisational changes to better serve the foreign market, as well as modifications in distribution and commercial strategies. Nevertheless, purely sales subsidiaries might lack the necessary competences to absorb and transmit such learning to the parent company, while production subsidiaries, which often times are coupled with research labs have more technical capabilities which might enable them to leverage local learning. Finally, Table 1 suggests that virtually every firm having a foreign subsidiary (existing at 1991 or new) has a facility in one EU country, while a rather limited number of affiliates are set in the U.S. To conclude this section, let me just mention the insights from Table 2. Non-investing firms exhibit productivity lower than firms creating new subsidiaries. In particular, the gap is wider in the case of firms setting up manufacturing subsidiaries and firms setting up subsidiaries in the U.S. Interestingly, despite the low number of cases (17), investors in the U.S. have remarkably different characteristics. The last column of Table 2 shows rather clearly that the 17 firms setting up new subsidiaries in the U.S. have an average TFP which is two thirds higher than productivity of non investing firms (1.61 versus 1.07) and have twice the number of foreign subsidiaries of the firm investing in the EU. As anticipated several times before, this correlation might be the result a self reinforcing process: more productive firms set up new subsidiaries which raises firm’s productivity and stimulates more complex investments, such as investments at a long distance, such as the creation of a network of subsidiaries in the U.S. Alternatively, this numbers might suggest that the U.S. is the rich market, where new ideas and technologies are developed first, thus the supply of knowledge externality is potentially higher and a subsidiary might have more to learn and to transfer back to enrich the knowledge base of the MNE. In the next section I will try test whether this result is robust to a control for the endogeneity of productivity levels.

6. Discussion of results

In Table 3 a dynamic equation for firm's total factor productivity as a function of the investing status, is estimated on a sample of 1,817 Italian manufacturing firms using the GMM-DPD estimator proposed in Arellano and Bond (1991) (see Appendix 1), which allows to control for fixed effects and the endogeneity of productivity and the investing status. The model seems to be well specified and the underlying assumption cannot be rejected from the test statistics. In particular, first-order negative autocorrelation in the equation in first-differences is strongly supported by the negative and significant *m1* statistic and by non-significant *m2*. Furthermore, the Sargan test of overidentification does not reject the validity of instruments. The autoregressive specification is strongly supported, with a persistence parameter remarkably significant and stable across specifications. This result confirms the hypothesis that technology is cumulative and path-dependent. The hypothesis that the creation of foreign subsidiaries have an effect on parent company's productivity seems to be broadly confirmed. Overall, FDI_TOT is not having an impact significantly different from zero on TFP, but when the foreign investment indicator is broken down into the different types, "mercantile" investments do not seem to produce significant positive effects on TFP, while firms setting up new subsidiaries in manufacturing exhibit a positive shift in the productivity trajectory. In particular, firms setting up new manufacturing subsidiaries seem to have a jump in TFP by 7% the next year. Indeed this is an interesting result, since most of the literature have focussed on this latter type of investments, and all the arguments which have been put forward in favour of the causality from subsidiary creation to shift in technological trajectories mainly refer to production or research subsidiaries. Columns (6) to (11) look in more details into an issue raised by the descriptive statistics. In Table 2 we noticed that firms investing in the U.S. have significantly higher productivity. It was claimed that that results did not proved that subsidiaries in the U.S. brought significant shift in firm's technological trajectory, because we did not control for the fact that investors in the U.S. might have self-selected, i.e. only more productive firms choose to establish subsidiaries overseas. In columns (6) to (11) this self-selection problem is properly accounted for, thus a positive impact of FDI_US on TFP should be interpreted as evidence of the fact that setting up subsidiaries in the U.S. provide a channel for reverse technology transfer. Indeed, results support the idea that setting up a new subsidiary in the U.S. causes a shift in TFP trajectory of 6% and when the attention is limited to manufacturing subsidiaries this impact triplicate to 18%. The same does not hold for the EU, where the induced productivity gain is not significant for total investments (FDI_EU) and is much smaller (8%) for manufacturing investments (FDI_MAN-EU).

7. Conclusions

This paper is a preliminary attempt to identify the relation between foreign direct investments and multinational firm's technological learning. In the existing literature it has been noticed that the creation of foreign subsidiaries can affect a firm's economic performances by allowing access to localized knowledge spillovers. Using data on a sample of Italian manufacturing firms it can be concluded that firms investing in manufacturing activities abroad obtain significant productivity gains relative to domestics firms which do not set international facilities up. Interestingly, the more significant shift in TFP trajectory is observed in firms setting up foreign subsidiaries in the U.S. This result is consistent with the idea that the richer is the destination market in terms of technological dynamism, high standards of user's needs and of organisational practices, the higher will be the potential for knowledge spillovers and reverse technology transfer.

Several issues remain still open. First is the home country or firm's specificities. Does Italy's internationalisation system have characteristics which could induce higher degrees of learning? Comparing Italian data with data from other countries will be one possible avenue for detecting such country specificities, to assess what are the home country conditions which could increase the likelihood of learning from foreign subsidiaries. A related question refers to firm's characteristics which determine the degree of learning. In the present study, individual effects which determine inter-firm differences in productivity trajectories are controlled for by estimating the model in first differences, but a more careful investigation on how the possible interactions of some individual characteristics, such as firm size, sector, foreign ownership and localisation with subsidiary creation impact on technological trajectories will help better understand under what conditions this positive impact is likely to occur. Second, the mechanisms through which foreign subsidiaries have access to localised learning, which form this learning takes, how and at what conditions it is transferred within the MNE, are largely unexplained. Third, this paper has supported the hypothesis that firms investing in the creation of foreign subsidiaries have better productivity trajectories relative to firms which do not internationalise their production. From this result a number of policy implications could be drawn (Fosfuri and Motta, 1999; Criscuolo and Narula, 2001). In fact, a policy maker is temped to think that incentives to firms investing abroad, for example in the form of subsidies to cover part of the fixed cost incurred in such complex forms of internationalisation would help to improve a country's competitiveness. However, careful policy intervention should consider at least two important aspects. On the one hand, governments face a policy trade-off on how to utilise FDI for the purpose of economic development. A rather established tradition, although still controversial and debated, tends to encourage foreign firms to establish local subsidiaries. The promotion of inward investments brings about benefits to the local economy, related to labour mobility from the multinationals to domestic firms, to inter-firm linkages and to knowledge spillovers, but may also result in anti-competitive and market stealing effects (see Castellani and Zanfei, 2001). Results in this paper would provide an alternative route which, has noted above, reaches the objective of improving productivity of domestic firms by encouraging the internationalisation of production. A nice analogy in Van Pottelsberghe de la Potterie and Lichtenberg (2001) puts this trade-off into the right context. They say that it is pretty much like choosing what is the best way to understand a foreign language, either talking with foreigners living in my home country (inward FDI) or by choosing to live in a foreign country (outward FDI). The latter seems to be more appropriate for a "full immersion" learning strategy, considering also the fact that the former strategy have the problem that to a great extent foreigners cannot be chosen, and in particular it is very hard to select the amount and quality of technology they are willing to transfer (Criscuolo and Narula, 2001). But this latter option have other drawbacks. In particular a policy which subsidises the creation of a network of subsidiaries abroad needs to assess to what extent productivity gains induced by foreign investments can be internalised by investing firms or spill-over to other domestic firms, generating positive externalities for the local economy, and the extent to which the growth of internationalising firms crowds out other domestic firms though a competition effect. A complex dynamic analysis is required to understand both what are the effects in the short run and in the medium-long run for the domestic economy.

Table 1 – Number of firms having foreign subsidiaries at 1991 and over the 1992-1996 period

	Total	in Manuf.	in EU	in U.S.
Firms having subsidiaries at 1991	283	114	236	73
	(619)	(169)	(504)	(85)
Firms having new subsidiaries, 1992-1996	136	41	119	17
	(183)	(45)	(149)	(19)

In brackets are the total number of subsidiaries

Table 2 – Descriptive statistics by investing status

	No new subs	New subs	New subs in manuf.	New subs in EU	New subs in US
Number of firms	1681	136	41	119	17
Average number of subs. at 1991	.19	2.10	2.97	2.04	5.52
Average number of new subs. 1992-1996	-	1.34	1.65	1.36	2.58
Average number of subs. 1992-1996 in manuf.	-	.33	1.09	.34	.58
Average number of subs. 1992-1996 in EU	-	1.09	1.31	1.25	1.00
Average number of subs. 1992-1996 in U.S.	-	.13	.24	.06	1.11
Average TFP	1.07	1.14	1.29	1.13	1.61

Table 3 - The impact of foreign subsidiary creation on TFP in Italian manufacturing firms, 1992-1996 (GMM-DPD estimates)

Dependent variable: $\log(TFP)_t$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$\log(TFP)_{t-1}$	.37**	.36**	.36**	.34**	.36**	.36**	.26**	.34**	.39**	.35**	.35**
	(4.22)	(4.11)	(4.32)	(3.80)	(4.29)	(4.24)	(2.43)	(3.97)	(4.64)	(3.71)	(3.61)
FDI_TOT_t		.15									
		(1.12)									
FDI_TOT_{t-1}		.009									
		(.66)									
FDI_MAN_t			.58*		.30						
			(1.74)		(1.37)						
FDI_MAN_{t-1}			.10**		.07**						
			(2.64)		(2.33)						
FDI_MER_t				.38	.02						
				(.96)	(.15)						
FDI_MER_{t-1}				-.008	.01						
				(-.23)	(.91)						
FDI_EU_t						.16		.007			
						(1.39)		(.07)			
FDI_EU_{t-1}						.01		.005			
						(1.04)		(.24)			
FDI_US_t							1.45	.28			
							(1.19)	(.57)			
FDI_US_{t-1}							.06**	.06			
							(1.94)	(1.57)			
$FDI\_MAN\text{-}EU_t$									.75		.74
									(1.52)		(1.56)
$FDI\_MAN\text{-}EU_{t-1}$									.08**		.08**
									(1.96)		(2.00)
$FDI\_MAN\text{-}US_t$										.55	1.11
										(.45)	(.99)
$FDI\_MAN\text{-}US_{t-1}$										.18**	.55**
										(3.48)	(1.75)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. obs.	3894	3894	3894	3894	3894	3894	3894	3894	3894	3894	3894
N. firms	1624	1624	1624	1624	1624	1624	1624	1624	1624	1624	1624
m1	-5.76**	-5.97**	-5.86**	-5.43**	-5.86**	-5.92**	-4.62**	-5.38**	-4.97**	-4.85**	-5.07**
m2	.74	.33	-.25	.55	.16	.42	-.30	.57	-.27	.61	-.38
Sargan test	7.10	9.07	9.83	8.66	12.86	8.18	11.47	17.28	9.35	6.39	9.07
(df)	5	13	9	6	13	9	9	13	9	9	13

Notes:

Coefficients are first-step estimates. T-statistics based on asymptotic standard errors robust to heteroschedasticity are reported in parenthesis.

Significance levels: **: $p<0.05$; *: $p<0.1$

m1 and m2 are tests for first and second order serial correlation in the first-differenced residual. They are asymptotically distributed as N(0,1) under the null of no serial correlation.

Sargan is the test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of instrument validity, with degree of freedom below the statistic.

Instruments used are the variables on the RHS from t-2 back to first available year for the equations in first-differences.

Appendix 1 - Details on identification

In section 4 I discuss some of the identification problems descending from a partial adjustment process with fixed effects of the following form:

$$y_{it} = a_1 y_{i,t-1} + b_0 x_{i,t} + b_1 x_{i,t-1} + h_i + u_{it} \qquad \text{(A.1)}$$

This specification has two identification problems: the first regards the lagged dependent variable $y_{i,t-1}$ which is, by construction, correlated with the fixed effect h_i, and would lead to correlation between regressors and the error term; the second is the endogeneity of $y_{i,t-1}$ and x_{it}. The proposed solution to the first problem is to take first differences to wipe out the fixed effect[11]. In other words the transformation yields the following equation:

$$Dy_{it} = y_{it} - y_{it-1} = a_1 Dy_{i,t-1} + b_0 Dx_{i,t} + b_1 Dx_{i,t-1} + Du_{it} \qquad \text{(A.2)}$$

This transformation wipes out the fixed effect, but make the second identification problem even more stringent because now both $Dy_{i,t-1}$ and $Dx_{i,t}$ are correlated with Du_{it}. In particular, $E(y_{it-1}u_{it-1})\ ^{1}\ 0$ by construction and $E(x_{it}u_{it-1})\ ^{1}\ 0$ because of the endogeneity of x_{it}. Estimation of this equation requires finding appropriate instruments. It has been noted that past values of *y* and *x* (from *t*-2 backwards) can be good instruments in the estimation of Eq. 3, provided that u_{it} are not serially dependent. Lack of serial correlation is required to avoid that $y_{i,t-1}$ ends up being correlated with u_{it} by means of $u_{i,t-1}$. The idea is that both *y* and *x* can be treated as predetermined variables, since past values can be assumed to be uncorrelated with current errors or, symmetrically, current realizations of *y* and *x* do not depend on future unpredictable productivity shocks.

$$E\left(u_{it} \middle| x_{i,t-1}, x_{i,t-2} \ldots x_{i,T-1}, y_{i,t-1}, y_{i,t-2}, \ldots y_{i,T-1}\right) = 0 \qquad t=2, \ldots T \qquad \text{(A.3)}$$

This implies that past values of *y* and *x* (from *t*-2 backwards) can be used as instruments in the estimation of Eq. 3, with the assumption of no serial correlation in the errors in levels, $E(u_{it}u_{i,t-j}) = 0$. Notice that this last assumption implies that errors in first differences exhibit negative first-order autocorrelation, and no serial dependence at higher lags[12],

$$\begin{cases} E(\Delta u_{it} \Delta u_{i,t-j}) < 0 & \text{for j} = 1 \\ E(\Delta u_{it} \Delta u_{i,t-j}) = 0 & \text{for j} > 1 \end{cases} \qquad \text{(A.4)}$$

With this assumption, the model in Eq. 3 is identified with T≥3. With T=3, a_1, b_0 and b_1 are just identified from three orthogonality conditions[13]:

[11] See Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998). For a textbook version, see Arellano and Honorè (2000).

[12] In the estimation test for first and second order autocorrelation in the first differenced equation are presented. Identification requires negative and significant first-order serial correlation and non-significant autocorrelation at higher lags.

[13] Notice that if we allow lags up to t-2 (t-3), the model can be identified only with T≥4 (T≥5).

$$E\left[\begin{pmatrix} y_{i1} \\ x_{i1} \\ x_{i2} \end{pmatrix}(\Delta u_{i3})\right] = E\left[\begin{pmatrix} y_{i1} \\ x_{i1} \\ x_{i2} \end{pmatrix}(\Delta y_{i3} - \alpha_1 \Delta y_{i2} - \beta_0 \Delta x_{i1} + \beta_1 \Delta x_{i2})\right] = 0 \qquad \text{(A.5)}$$

This model can be estimated by GMM as a system of *T*-1-*max*(*L,P*) equations with N observations, where each equation has a different number of instruments, with higher *t* having more instruments, since the time series of past values of *y* and *x* is longer.

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