National systems of innovation and the international technology strategies of multinationals

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Abstract

The paper first introduces typologies of the production subsidiaries and R & D laboratories through which MNEs activate global competitive and creative strategies. These are used to describe, and assess the implications of, the diverse ways in which MNEs participate in the national system of innovation (NSI) of individual countries. Such NSIs are seen as increasingly the drivers of national competitive progress. The analytical concern is then with whether MNEs' involvement increases or lessens the ability of an NSI to propel the sustained development of an economy. It is argued that the requirement is for policy to address the need for a balanced NSI and to comprehend the implications of the selective nature of MNEs' involvement.

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Introduction

This paper seeks to evaluate the implications of the ways in which multinational enterprises (MNEs) approach and utilise the two key drivers of contemporary economic progress; technology and globalisation. By definition we can consider the MNE to be the most natural and fully-developed user of the opportunities offered by a *global* economic system. But much recent research on the strategic postures of MNEs suggests that the most effective of them are the ones that can see globalisation as an opportunity to leverage freedom of exchange between economically and competitively diverse sub-units (nations; regional groupings; dynamic sub-regions or clusters) into a coherent, differentiated, integrated network (Ghoshal and Nohria, 1989; Malnight, 1996). Deeply embedded in the understanding of the MNE has been the view that its ability to utilise dispersed potentials (markets or productive resources) has derived from its possession of, and ability to transfer, superior technologies. However, most recent perspectives on MNEs' technology strategies (befitting the more complete view of decentralisation concomitant with more profound understanding of a differentiated globalisation) move away from a hierarchical characterisation of centrally-generated knowledge transferred to peripheral usage, to the heterarchical viewpoint (Hedlund, 1986; Birkinshaw, 1994) where these companies are potentially willing to learn from (i.e. generate new technologies and competences in) any economy in which they operate. Effective MNEs have globalised their learning processes. Flows of technology are multidirectional as new knowledge is generated in many locations in many ways, and understanding and synthesising differentiated learning potentials has become a key skill in globalised competitiveness.

It is, of course, a central premise of new growth theory that broadly-defined technology (i.e. including the tacit knowledge encompassed in human capital) is a key determinant of levels of economic development and of evolving growth potential. Also detailed analysis of patent data has indicated that as countries become more developed and as, therefore, dynamic comparative advantage increasingly determines their competitiveness, the technologies that define their specialisation become increasingly focused around a limited range of scientific disciplines and associated commercial competences (Cantwell, 1991, 1995; Cantwell and Janne, 1999). Thus as countries develop we can see MNEs' involvement with them moving from use of routine cost-effective inputs (static comparative advantage), or even supply of local markets, towards greater concern with involvement in the generation of technology-based created comparative advantage (Papanastassiou, 1995, 1999). Whereas early analysis of the effects of MNEs (or foreign direct investment) focused on how their ability to *transfer* their extant technological advantages could benefit host-country activation of sources of static comparative advantages, the most appropriate contemporary concern needs to be an understanding of their involvement with the *generation* and *application* (innovation) of new technology (i.e. with separate national systems of innovation).[1]

The ability of countries to generate new scientific knowledge, turn this into potential commercial technology and to create successful new goods and services from it, varies across a number of dimensions. Fundamentally, of course, the general level of capability encompassed in a national system of innovation (NSI) is likely to be closely related to its overall level of economic development. Secondly, the balance between different facets of the NSI will differ between countries and over time. For example, many of the formerly centrally-planned economies of Central and Eastern Europe inherited very unbalanced NSIs in which a strong commitment to basic scientific research contrasted with great weaknesses in applying the output of this into successful commercial activity (new goods and services).[2] Alternatively some countries (notably Japan) obtained reputations for an ability to acquire technologies externally (by licensing) and greatly improve their commercial application, thereby manifesting a NSI biased significantly towards product development but capable of compensating for weakness in precompetitive research. To some degree we argue here that MNEs are often the inheritors of the latter scenario, using their globalised perspectives on product development and marketing along with various nationally distinctive capacities in scientific research, to build balanced global systems of innovation. Thus, the third distinguishing characteristic of NSIs is likely to be a distinctive technological heritage, providing specialised programmes of current scientific research that possess world leadership potentials based on the evolution of existing bodies of experience and knowledge.

It is then crucial in understanding how MNEs address the opportunities and implications of globalisation to understand how they react to individual countries NSIs, differentiated in the ways discerned above. For instance, where a country has a generally very weak NSI, reflecting very limited individualised technological or industrial capability, MNEs (in a now traditional 'gap filling' [Pearce, 2001, p.52] mode of analysis and behaviour) supply those attributes (market access; tacit knowledge [skills]; as well as technology) that activate unrealised potential sources of competitiveness (labour and other low-cost standardised inputs). Where MNEs provide the initial impetus to a country's growth and development in this way, it is then important to ask how they can contribute to its sustainability seen, *inter alia*, as involving the generation, broadening and deepening over time of a genuine *national* system of innovation. The MNEs' ability to respond, interactively, to a country's increasingly technology-based development processes then resides in its ability to address, selectively, *differential* aspects of the NSI noted above. In some countries the MNE may focus mainly on product development and market-oriented creative activity, in others mainly on pre-competitive scientific research. Whatever part of the NSI the MNE addresses the *content* of its activity is likely to increasingly reflect distinctive areas of the country's technological heritage or tacit knowledge and expertise.

The paper develops in the following manner. The next three sections supply the building blocks for the main analysis by outlining, the particular structure of the NSI to be adopted here; a typology of subsidiary roles reflecting MNEs' strategic heterogeneity; a typology of roles played by decentralised R & D units in MNEs. Then the core of the paper uses these categorisations to generate speculations on the ways in which MNEs involve themselves with the scientific and creative scopes of individual host countries and how their operations can strengthen, weaken or alter the direction and scope of, host economies' competitive development. The ideas offered in the core of the paper have two origins. Firstly, from the innate logic generated by the differentiated modes of operation that are defined within the characterisation of the subsidiary and laboratory typologies. Secondly, from interpretation of evidence derived from a detailed survey analysis (Papanastassiou and Pearce, 1999; Pearce, 1999a,b; Pearce and Papanastassiou, 1999)[3] of MNEs' operations in the UK.[4]

National System of Innovation

For the purposes of this analysis we adopt a highly simplified four stage NSI (Fig.1). Referring to the separate facets as 'stages' does not imply an immutable sequential behaviour, however, merely that the intuitive logic is for the defined activity of, for example, applied research to follow basic research or product development to follow applied research. This does not presume that successful product adaptation (stage four) must be predicated on knowledge that has evolved through all three previous stages. It also does not preclude reversal of 'stages' where, for example, product development operations request extra applied research to resolve, scientifically, a gap in their knowledge. Most crucially, for our purposes, we have suggested that MNEs approach NSIs selectively and may then focus different stages of a coherent *global* approach to innovation in different countries. Whether this selective MNE intervention increases or diminishes the value of a country's NSI to its wider developmental concerns is the theme of our questioning here.[5] We now introduce the four stages of our NSI.

Basic research is carried out purely to resolve scientific issues, defined by scientists whose commitment is entirely to the enhancement of the body of knowledge delineating their discipline. There is no predetermined perception in the articulation or implementation of basic research projects of any specific commercial application, or of the work as being an attempt to resolve a question defined by a particular problem within a firm's current product development or engineering operations. To commercial enterprise basic research is a purely speculative scientific abstraction. However, private companies will in some way support basic research, in the view that ultimately the longer-term perspectives of competitive development will need to be fuelled by radical new perceptions driven by new dimensions of scientific understanding. Unique, or favoured, access to results of a major scientific breakthrough can then be the crucial factor enhancing an enterprise's competitive revitalisation and underpinning scope for long-term survival. Similarly, countries see basic research as an important element of a balanced and sustainable NSI, as a central driver of the wider economic aims of technologically-oriented competitive progress. The particular projects implemented in a country's basic research programmes will be predominantly evolutionary, with a current generation of research scientists deriving the impetus to their ongoing investigative agendas from their background in the body of knowledge currently defining distinctive scopes of that country's science base.

Horizontally, in our schematisation of the NSI, currently successful enterprises will be, to some degree, based on use of scientific knowledge that is now part of the country's technological heritage and, therefore, will be willing to support further speculative research aiming to deepen understanding of those disciplines (now defining the country's internationally-perceived areas of scientific leadership). We can consider a particular piece of investigation to have reached the end of its basic research stage when it starts to be perceived as embodying potentials of specific commercial value.

Applied research then continues to be based around the investigation of specific *scientific* questions. Now, however, these questions are defined in the light of potential practical applications (e.g. in radical new generations of products, or the substantial qualitative enrichment of existing ones), that have been discerned within the results of basic research. Whilst applied research is still *done* by scientists the articulation of the problems, and the full comprehension and evaluation of results, now depends on inputs from the more creative elements in other functions (market researchers, engineers, strategic planners). Thus an enterprise with a strong innovative culture is one with well-developed and mutually-creative inter-functional communications, in which research scientists can achieve valuable and uncompromised originality with this ultimately able to support competitive commercial progress. Governments with the commitment to a full NSI, that includes basic research, would then support such complementary applied research, not by downgrading or isolating the basic work (two alternative perceived threats to such purist investigation), but by generating mechanisms for the detection and activation of its potential applications.

The end of the applied research stage is reached when a much clearer view of the commercial potential is available and, crucially, all the essentially scientific issues are resolved. We have suggested that what is available at this stage is a 'new product concept' (Papanastassiou and Pearce, 1999, pp. 93-95; Pearce and Papanastassiou, 1996, pp. 38-40; Pearce, 1997, pp. 17-19). This concept fully defines the nature of the new good or service, and makes available all the core scientific knowledge necessary to achieve its creation. What is not yet resolved are the precise forms in which the good or service will be offered to consumers and the precise engineering of its production/supply processes. It is, in fact, an important argument of our view of innovation in globally-competing enterprises that the precise commercial formulation taken by the new product concept may vary considerably in a number of separate market situations.

Product development addresses the need to turn the potentials emerging from applied research into fully-realised commercial attributes. Thus, in our terms, it uses talented marketing personnel to define the most viable commercialised form of the broad product concept and creative engineers to generate the most cost-effective supply technology in the relevant production location. Scientists remain central to the product development stage of the NSI, both in communicating the new technology to its users and, perhaps, through more applied research to resolve any unexpected residual issues. But the balance within the multifunctional product development stage had changed, with the impetus now deriving from marketing and engineering under an increasingly involved strategic management. These groups now address competitive responsiveness in specific environments, with new goods and services, defined to meet needs of particular customers, supplied in a way to optimise cost-efficiency under given impact constraints.

Adaptation of products and production processes represents the last of the creative, competitiveness-enhancing, activities encompassed in our categorisation of an NSI. Over time, within a national context, a successful mature product may benefit from competitive refinement (adaptation of details and peripheral characteristics) as income levels rise and other influences provoke changes in tastes. Also, as development proceeds, changing costs and qualities of inputs (notably labour) may lead to adjustments of production techniques. Similarly, and notably relevant to our concerns here, when a firm seeks to interject production of a successful established good into a new geographical market area a suitable concern for competitive responsiveness may again lead to adaptation of the detail of product characteristics, packaging and marketing techniques, and to the way in which the good or service is produced. Again this element of global strategy does not assume homogeneity, and creative activity (responding to diversity) becomes part of the process of competitive spread.

Typology of Subsidiary Roles.

Here we introduce briefly the three-part version of the scope typology of subsidiary roles, that was used in the study of foreign-firms' operations in the UK.[6]

(i) *truncated miniature replica (TMR)*.

The strategic role of a TMR subsidiary is to supply already well-established parts of a MNE's product range in a new national (or otherwise narrowly-defined) market space. In terms of the dimensions of the scope typology it, therefore, has a relatively wide product scope and a distinctively narrow (geographical) market scope.[7] For our purposes the key facet of the TMR is the truncated nature of its functional (or value-added) scope. Its limitation to securing the competitiveness of *existing* products in a new market thereby precludes all of the high-value-added innovation scopes (science-enhancing R & D; pathbreaking market research and new market creation; risk-taking entrepreneurial management). An effective TMR, though, should have some allowance for individualised creativity, since effective localised (host-country) competitiveness may require some adaptation of the product (in response to local tastes, or income differences) and/or production process (reflecting input costs and availabilities). This is certainly likely to encompass localised marketing activity, provide some scope for ambition in local management decision making and, perhaps, require the support of some limited in-house R & D work. The understandings generated by work on subsidiary dynamics in the evolution of MNE networks (Birkinshaw and Hood, 1997, 1998, a,b; Tavares, 2001, a,b, Pearce and Tavares, 2002) would suggest that TMRs can often seek to leverage these initially limited creative scopes towards more ambitious roles.

(ii) Rationalised Product Subsidiaries (RPS).

The priority that the competitive pressures of globalisation increasingly place on cost-effective supply have tended to expose the potential inefficiency inherent to TMR-type operations (Papanastassiou and Pearce, 1999, pp. 25-27; Pearce, 2001, p. 156). Thus the activity of many subsidiaries has moved towards the efficiency-seeking aims of the RPS. A much more limited product scope rationalises a subsidiary's supply responsibilities around goods that it is capable of producing at competitive levels of unit cost (by the standards of the MNE's integrated international supply network). Securing this position in the wider MNE network then greatly enhances the effective market scope of the subsidiary. However, the powerfully cost-based motivation and network-determined responsibilities of the RPS preclude even the limited creative initiatives available to the TMR, giving the narrowest possible subsidiary functional scope.

(iii) Product Mandates (PM).

A PM subsidiary secures from its MNE parent the full responsibility[8] for the development, supply, marketing and sustained further competitive evolution of a new part of the group's product range. To fulfil this mandate it is likely to pursue in-house (or through subcontracted arrangements) significant R & D, highly creative marketing activity, entrepreneurial management initiative and innovative engineering of production technology. The ability of a PM, or kindred subsidiary form,[9] to secure such an individualised creative responsibility reflects characteristics of the host-country economy, notably its technology heritage and R & D base, education and skill levels, distinctive market characteristics and ability to leverage them through talented marketing personnel, and a cadre of ambitious risk-oriented managers. To secure coherence of activity, and in the interest of network balance, the permitted product-scope of a given mandate subsidiary is likely to be limited. However, to cover the high overhead expenditures of its creative functions, and reflecting the expectation of distinctively original goods, PMs usually target a wide international market scope.

Typology of R & D Laboratories

As with subsidiaries we outline here the typology of R & D laboratory roles adopted in the study of MNEs' UK-based operations.[10]

(i) Support laboratories (SL).

The essential role of the SL is to facilitate the successful intra-group transfer of an MNE's established, commercially-effective, technologies. We can then distinguish two variants of the role. In the first the SL1-type facility operates in the recipient subsidiary (probably a TMR) and supports its ability to assimilate, adapt and operationalise the technologies relating to these existing products whose localised production it is to implement.

The second (SL2) variant usually supports an outward flow of technology by offering assistance to a subsidiary (TMR or RPS) in another country that seeks to operationalise an established technology. We can indicate two circumstances in the competitive evolution of a MNE that could benefit from SL2-type support. Firstly, in the network building process of subsidiary rationalisation noted above, a TMR may lose responsibility for supply of some products whose technologies it had fully mastered. Where an RPS elsewhere is newly undertaking the production of these goods the earlier TMR may play a SL2 role, by using its residual knowledge of the relevant technologies to assist the new RPS in building up its operational capabilities. Secondly, the international supply of a good innovated by a successful PM may eventually involve delegation of some production to cost-efficient RPS operations in other countries. The transfer of the relevant technologies to these new production facilities can devolve to SL2-type operations within the 'parent' PM.

(ii) Locally integrated laboratories (LIL).

Whilst SLs are concerned with the refinement, transfer and application of established technologies relating to the existing product range, LILs are central to the generation of new technologies and their embodiment in successful innovation processes. Thus the natural habitat for an LIL is within a PM subsidiary. There it provides the scientific inputs into the innovation process by working in a closely-integrated fashion with the other creative functions.

(iii) Internationally interdependent laboratories (IIL)

The defining characteristics of IILs are that they work on precompetitive scientific problems in total isolation from the current commercial concerns of their MNE and that, therefore, they have no logical ongoing association with any producing operations of the parent group in the same country.[11] Thus an IIL in a particular country researches issues in a scientific discipline which is accepted as one of those most likely to provide new knowledge relevant to the MNE's current industry,[12] and in which the local science-base (part of the host-country's NSI) has a reputation for international leadership in extent of current technology stock and strength of ongoing research agendas. An MNE committed to the long-term regeneration of its core technology through precompetitive solving of scientific problems is likely to have this type of lab in several countries. This seeks to provide a portfolio of research agendas in those separate, but potentially complementary, areas of science that are perceived to underpin the likely technology trajectory of the firm. It then also reflects the heterogeneity of NSIs, with each IIL tapping into the specialised research heritage and current leadership areas of different countries. Though the strength of each IIL is then its localised specialist focus, its value to the group is likely to emerge through synergies and complementarities of its results with those of other similar facilities. The MNE will then, perhaps through a central ‘parent’ laboratory, inculcate a culture of communication to establish and nurture interdependencies and information exchange within their set of IILs. A flexible nexus of fluctuating collaborations and joint projects between IILs then helps move isolated research results towards viable group-level knowledge.

MNEs’ participation in NSIs

This section uses the typologies outlined above to interpret evidence on how MNEs participate in individual NSIs. For each stage of an NSI we indicate the institutions (subsidiaries and/or laboratories) through which MNEs operate, what they interject into the NSI through such units, and the ways in which they coopt and utilise the relevant outputs.

(i) *Basic research*

We can indicate two institutional arrangements through which MNEs enter the basic research component of an NSI; IILs and collaborative projects. These are then seen to provide two types of inputs into the NSI; funding and new dimensions of technology.

(a) *IIL:* As we have defined it an IIL is a wholly-owned and fully-controlled research facility of an MNE operating within another country’s NSI. The aim is to generate new research results whose value is likely to be perceived in a manner that is synergistic with other results (or supportive of ongoing research agendas) elsewhere in the group. A MNE’s financial commitment to an IIL is likely

to be manifest, firstly, in expanded scientific infrastructure, through the building of new labs or the extensive refurbishment and re-equipment of existing ones.

The second funding component of an IIL will take the form of salaries to locally-trained scientists. Thus the distinctive research capacity that emerges in an IIL is expected to derive from the recruitment of a balanced team of local scientists, who possess specialist capabilities that reflect their education, training and previous research work within the country's science base. This immediately raises the crucial point that these are potentially scientists (experienced and successful researchers and, perhaps, their emerging 'star' protégées) with a very high opportunity cost to those local institutions that fail to retain their services. MNE funding through salaries may, therefore, be merely crowding-out some of the higher-quality possibilities in local labs.[13] This must be acknowledged as an important factor, albeit one that is hard to evaluate practically since it invokes a particularly complex version of the counterfactual situation. Two positive possibilities of the IIL can be suggested, though.

Firstly, the work the scientists do in the IIL may be more productive (in terms of strengthening local technology scope and then, perhaps, feeding through to better performance of the wider local economy) than they could have achieved in a host-country institution. How this might eventuate is a key element in the analysis here. Secondly, the top local scientists recruited by IILs might *not* have perceived the continued development of their careers in the research units of the firms and Universities of their country of origin. They may have been candidates for the international migration that is increasingly common in high-quality human capital, with the improved funding (their salaries and project support) and/or the renewed and extended research stimulus of an IIL instead retaining their local commitment. This is likely to have positive externalities, or spillovers, into the local scientific community beyond their direct benefits to the (admittedly 'foreign') lab they now work for. This may include charismatic stimulus (through public lectures, University visits, contributions to broader controversies and intellectual debates, etc.) to younger scientists outside their own institution (the IIL), or inputs to the formulation of wider scientific policies and programmes (serving on government advisory boards, funding bodies, committees of enquiry, etc.)

The second input into an NSI deriving from the operation of an IIL can be seen as technology itself, in the sense of new research options emerging from access to an additional, but essentially complementary, body of scientific knowledge and competence (i.e. that of the parent MNE). Thus *where* an IIL is located is determined by the ability of the host-country's technological heritage and current research capacity to support the type of investigation required. But *what* that research is is determined by the MNE's own technology trajectory (Papanastassiou and Pearce, 1999, pp. 91-92). This trajectory can be seen to comprise the MNE's current stock of core technology and its embodiment in a product range, and a broadly understood view of the directions in which these are expected to evolve through basic research (IILs) and product innovation (LILs). Thus the perceived needs of extending and enriching the technological trajectory will determine the range of scientific disciplines to be researched in IILs. The essentially evolutionary nature of this will also indicate that particular IIL projects, whilst clearly seeking to benefit distinctively from the specific strengths of the host-country inputs, are likely to also be defined in the light of existing MNE technologies (those seen as potential bases for valuable progress) and indeed, to some degree, will use these technologies amongst the building blocks from which research programmes are generated.

An idealised interpretation of the effects of IILs on the basic research component of an NSI is that they can both deepen and widen the scope of the work undertaken. Access to improved funding, and to a body of complementary technologies, can reinforce the scope for the NSI to further pursue those lines of basic investigation that are dictated by its own technological heritage and established specialisms. Here the IIL supports the processes of agglomeration that deepen the focus on particular areas of science for which it already has an established reputation of world research leadership. But IIL's agendas may, to some degree, also work against these agglomerative forces, without necessarily weakening the ability of distinctive basic research to benefit the rest of an NSI (and economy). Thus research issues and current technologies of MNEs may ask somewhat different questions of the NSI's strengths than would have been articulated by purely local scientific and commercial interests. If the symbiotic process between the two scientific communities (MNE and NSI) works effectively the IIL research agenda will then differ from that which is purely locally driven, but be no less logical as an evolution of the research programmes. Compared to what would have happened in their absence, IILs may widen the basic research agenda of the host country, but in ways which remain coherent and cohesive with the balanced and logical progress of the NSI. Ideally IILs carry out projects that would not otherwise have been undertaken but which, nevertheless, make distinctive use of the defining strengths of the local science base and research community.

(b) *Collaborative research*: whilst IILs internalise (for their in-house work) elements of the host-country science base, MNEs can also utilise a contractual means of accessing local basic research capacity, through collaborative projects (Papanastassiou and Pearce, 1999, pp. 189-207; Pearce and Singh, 1992, pp. 177-79).

These are most likely to involve research that is substantially carried out in local University labs, but with MNEs providing, at a minimum, financial support and thereby claiming exclusive or privileged access to results. The MNE's contractual involvement with an otherwise independent host-country lab may be articulated and activated by an IIL in the same country, by a local production subsidiary not otherwise involved with basic research, or by parts of the group outside the country (e.g. an IIL elsewhere or the parent R & D unit in the home country). Whatever the specific form of the MNE's participation, the generalised expectation is that such collaborations will play some role within a broadly-defined programme of basic research targeting the types of science-based breakthroughs that can underpin the group's competitive progress and survival. To some degree they become networked into the MNE's science programmes.

The decisive initial input of MNEs into such basic research collaborations is likely to be finance. The original attractiveness of a University lab to an MNE will probably derive from its recent achievements and the apparent quality and content of its ongoing research. The early aim will thus be to tap into the University lab's established research strengths and programmes and, by supplementing its budget, to facilitate the extension of its agenda into further projects. Once the MNE's involvement has secured good communications and shared confidence it is likely to want to go beyond 'arms-length' access to results and to influence, hopefully in a supportive and constructive fashion, the development of the local lab's agenda. Increasingly jointly-developed projects may emerge. At this stage the MNE's own technology will start to be interjected into the research and the aims of projects influenced more proactively by the firm's perceived needs. The MNE's involvement again (as with the IIL) endorses the distinctive qualities of the NSI, but pursues a participation that ultimately seeks to tailor parts of the basic research agenda towards its own concerns.

Within the concept of a purely *national* innovation system the justification for support (financial and institutional) for *pre*competitive basic research is that ultimately some of the output *will* fuel commercial progress and supply part of the basis for the competitive evolution of the economy. However, whilst the networked position of MNEs' participation may bring in resources that enrich and stimulate the basic research component of an NSI, these interdependencies may also influence the future application of their results in ways that diminish the contribution to the rest of the NSI. The international linkages and aims of MNE technology programmes may mean that the innate tendency is to see the output of IILs more in terms of potential 'lateral' flows to other elements of the group than 'horizontal' to another phase of the NSI.[14]

There is, of course, a very real potential for MNE basic research output to move into applied research in the same NSI (indeed, almost inevitably, in the same unit). Thus the perception of possible eventual commercial use for particular basic research results may emerge in the IIL that carried out the project, and this may secure for it the permission to accede to the appropriate applied research. A strong IIL can internalise the crucial basic/applied research transition. Thus fig.2 provides an arrow indicating the horizontal transfer of IIL (or perhaps collaborative) output within the same NSI.

But the scope for leakage out of the NSI is, as observed, also very strong. Basic research results of an IIL may be transferred to another part of the MNE science community in two forms. In the first possible commercial applications may, again, have been perceived in the basic researching IIL, but permission for further applied research may this time be denied. Here a group-level decision determines that another IIL, in another country, is better equipped to perform the type of applied research that appears necessary.

In the second case the basic results have *not* yet acquired any obvious commercial resonances but are, instead, seen as inputs to further basic work in other parts of the network. The most developed form of that scenario can see a central (parent) R & D lab coordinating a group of IIL projects with intuitive *a priori* overlaps or synergies, and then collating the outputs of these separate units. One responsibility of this central lab may be to nurture and facilitate the interdependencies between IILs by encouraging the sharing of results and by inculcating a non-defensive culture in which it is normal for one IIL to see its work taken up by another.[15] Crucially it may also be such a central lab that is most naturally committed to discerning applied research potentials in the basic research output. Thus the commercial potentials of precompetitive work may often not be perceived from individual isolated basic research projects, but only when various results are brought together and evaluated dialectically in terms of their resonances (consistencies, inconsistencies, overlaps and interdependencies). The central lab may then allocate responsibilities for the perceived applied research needed to those IILs that seem best equipped to address the diverse facets of the programme.

(ii) Applied research

MNEs' applied research in a particular NSI still takes place mainly within an IIL-type facility and still targets the solution of an essentially scientific problem. From the point of view of the enterprise, however, the investigation is now less purely speculative, in the sense that the need to answer a more specifically-defined scientific question *is* perceived in terms of an emerging commercial possibility. The applied research problems posed here are now likely to derive extensively from a new body of knowledge, and thus be positioned within a complementary range of questions, that resulted from antecedent basic research in the MNE and the perception of possible competitive uses for it.

Additional funding clearly remains a routinely significant input of MNEs to the applied research component of an NSI. However, it is the ability to ask very specific and potentially highly-rewarding questions, that are defined within a complementary body of supportive new research, that becomes relatively more important. Thus fig.3 designates 'basic results' as a key MNE input. This, it is suggested, can arrive in two ways. Firstly, as described in the previous section, as part of a wider group-defined programme. Secondly, in a more self-contained (horizontal) fashion, where the IIL is able to carry through to an applied research context the investigation of issues deriving from its own basic work. We can also suggest that, due to the increasingly commercially-sensitive nature of this type of research, its internalisation in an IIL may become relatively more common than the types of collaborative arrangements that often were considered feasible for basic investigation.

In ways that closely resemble those indicated earlier for basic research the MNE inputs can both enrich generally, and refocus the content of, the applied research component of an NSI. However, the latter element may have particularly significant consequences here. Whilst MNEs' involvement may well increase the amount and scientific quality of the applied research done in an NSI it will mean that an increased proportion of output is likely to be diverted away from support of the local economy towards the global technological and innovation programmes of the sponsoring companies.

Of course it remains possible that an MNE's important applied research results could feed forward into product development operations in the same NSI. Two factors endemic to the global aims and options of MNEs can mitigate against this, however. Firstly, even if an IIL has resolved all the scientific questions relating to an innovation (or, at least, has access to all the needed technology) it may still be that the MNE's operations in the same country do not provide the ideal context for the fulfilment of the commercial innovation process. Thus the other functional inputs that complement science in the process of innovation may be perceived as better equipped to take forward the commercial activation of the applied work in another location. Even where an innovation is self-contained around a small body of new science from one precompetitive research location the parent group's evaluation of its range of options in other functional inputs may provoke the outward leakage of the new knowledge to the benefit of other NSIs. Secondly, the applied research done in an IIL may in fact be far from self-contained, and it is then innate to its role that the results will flow from the NSI to feed into a broader programme that is coordinated elsewhere. Though the results may ultimately be a significant component in building the technological base of a new product concept this cannot influence the country's participation in the eventual commercialisation process. Thus fig.3 indicates a significant outward flow of applied results from a NSI into the dispersed technological and innovation processes of the group.

(iii) Product development.

MNEs' involvement in the product development facet of an NSI is operationalised through two institutions; a product mandate (PM) subsidiary and an associated locally integrated laboratory (LIL). The PM, we recall, takes full responsibility for the innovation, initial production, marketing and subsequent competitive evolution of a product. To do this it builds a strong functional scope, including R & D, market research and assertive marketing, creative engineering and an impetus from an ambitious management that is committed to the unit's individualised competitive status in the MNE. The LIL is a central element in the PM's creativity, and essentially mediates the new science emerging from applied research to the other functions involved in the innovation process. Thus it will not itself carry out any further pure scientific investigation (all scientific issues assumed to be closed off in applied research) but will assimilate (learn) the core new technology from precompetitive work, interpret it to associated functions (marketers, engineers) and play a key role in its practical manifestation in new goods, services and production techniques. The framework envisages two scenarios through which new technology enters an MNE's operations in the product development stage of an NSI.

Firstly, the PM's innovation process may be predominantly driven by the results of applied research secured through the internalised (horizontal) transfer of scientific output from precompetitive IIL-type work in the same country. This independent and self-contained subsidiary-level approach to innovation will also need, and be partly defined by, top-quality marketing inputs, since it will derive locally the broad new product concept (NPC) as well as then fill in the precise details of its commercialised form. Although the scientists recruited for the LIL will embody less distinctive capacities than the basic researchers of IILs, they will still need the talent to comprehend, articulate and apply new results and often, therefore, represent a significant opportunity cost in terms of their non-availability to indigenous enterprise. As suggested, the PM's market researchers are certainly also likely to be amongst the most creative available and their recruitment, again, represent a significant opportunity cost to local firms.

Against this (and subject to the usual counterfactual uncertainties) this scenario has powerful potential to enrich the product innovation phase of an NSI. Notably it means that where an MNE's involvement in the previous stages has generated distinctive outputs in precompetitive science these are co-opted to secure equally distinctive outcomes in market competitiveness. Also it means that a product innovation secured in a PM can have greater competitive impact than would a comparable one in a local enterprise, since its markets may be determined by the MNE's wider global perspectives. Thus, we can suggest, if a new good is derived essentially within one NSI it is likely to represent a unique addition to the group's product range and potentially have access to all the world's markets. We can thus designate the subsidiary activating this self-contained scenario as a *world* product mandate (WPM).

The second scenario determining the role of the PM/LIL nexus in innovation involves it in the completion of a process begun elsewhere in the MNE group, by picking up an outline NPC and its associated science and generating from it a fully market-responsive and efficiently-produced good. In some cases the PM may do this on a unique basis; i.e. be the only site involved in the completion of a group-derived NPC potential. Alternatively, in a fully-developed global innovation strategy, the MNE may mandate a subsidiary in *each* of several regional markets to generate a distinctive variant of the NPC that responds to all the idiosyncratic tastes and needs of its regional customer base and optimises the production technology in its use of the input environment (availability and price of factors) of the host country. A subsidiary operating in this manner can be designated as having a *regional* product mandate (RPM).

Where a subsidiary wins the mandate to fill in the competitive detail of an NPC it is likely to do so by asserting the capacity of its host NSI to supply the necessary creative inputs (scientists, marketing, engineering), rather than potentials for low-cost production possessed by the wider local economy.[16] To do this, we have noted, it will be seeking to recruit top quality local personnel with potentially high opportunity cost to indigenous firms' innovation activity.[17] Against this, potential external benefits or spillovers may also be discerned in an enhanced learning scope available to local personnel that are recruited for the PM/LIL's operations. Thus the process of assimilating the technology and ideas underpinning the NPC will involve these personnel in interaction with the high-level creative activity of the MNE group, which may inculcate valuable new attitudes and perceptions on the organisational procedures of efficient innovation. This will immediately strengthen the NSI by deepening the in-house ability to retain and enhance its position in its group's innovation network. Beyond this the increased experience of these personnel in the formulation and operationalisation of innovation processes (additional to an enhanced competence in their specialised functional area) may be of immense value if they decide to move back into indigenous enterprise.[18]

Overall there are realistic reasons for an expectation that MNEs' use of the PM/LIL nexus in a globalised approach to innovation can interject knowledge and resources into individual NSIs in a manner that can result in enhanced competitiveness of the local economy. The sources of this competitiveness in technology and creative personnel imputes to these MNE operations a role in generating a country's dynamic comparative advantage. Within the host economy the immediate benefits of this competitiveness may take the form of new and higher-quality products available to consumers and an upgraded employment structure encompassing higher-value jobs. However, the innate involvement of PM/LIL operations in MNEs' global strategies also implies the benefit of improved *international* competitiveness. In fig.4 we indicate the key manifestation of success for the MNE taking the form of significant exports from the host country, as the PM fulfils its responsibility to supply new goods to, at least, parts of the company's global markets. The origins of this in successful innovation characterises this as technology gap trade.

But as the product matures an increased need to sharpen the cost-efficiency of its production may emerge. At this point some supply may be relocated to cost-based RPS-type units elsewhere in the group. This involves the transfer of the PM's technology to other locations in the MNE supply network and, therefore, fig 4 shows the possible presence of a SL2 operation to secure this. This, in turn, emphasises the vulnerability of any innovation-based unit to product-life-cycle forces. In the case of PM/LIL operations the question of the ability to sustain its dynamic creativity is enhanced where this is dependent on access to group technology and new product ideas (the NPC). Thus the persistence of PM/LIL units often depends (externally) on the parent MNE group's ability to generate new innovation potentials, and (internally) on the host-country's ability to support those aspects of its NSI that enable the facility to continue to attract elements of the group's creative programmes.

(iv) *Adaptation*.

Whilst the previous stage of our NSI involved the generation of the original competitive use of an initially disembodied new source of technology, here the final stage addresses the frequent need to adapt technologies that are already successfully embodied in established competitive goods in order to sharpen their value in the specific context of a particular national economy. Our modelling of the global competition strategies of MNEs suggests that production of an existing good may commence in a new country for two possible reasons.

Firstly, a TMR pursues the market-seeking objective of increasing the returns from supply of the good to local consumers. Traditionally a dominant factor provoking this was avoidance of restraints on trade, leading to the interpretation (Kojima, 1978) of such a relocation of production as sub-optimal, trade-destroying, behaviour. In more recent perspectives of competitive strategy this localisation of supply may, instead, acknowledge the distinctiveness of certain important markets and the advantage to then be obtained from individualised responsiveness to their idiosyncratic needs. Thus the TMR, working with an SL1 lab and a strong marketing group, will adapt the goods (and perhaps, as a result, also the production technology) to enhance their competitiveness in the perception of local consumers. The core benefit to the host economy is then manifest in greater consumer satisfaction. To the extent that this then results in greater demand, successful TMR/SL1 activity can also expand employment and tax revenues.

The second motivation for starting production of an established good in a new location is the efficiency-seeking one of securing an additional low-cost source of supply to an increasingly price-competitive international market.[19] Thus an RPS is expected to realise economies of scale and utilise the host-country's most abundant inputs, in order to assert itself as a specialised low-cost location in an MNE's supply network for successful mature products. The importance, in an MNE's supply network rationalisation process, of locating manufacture of mature goods in countries where the abundant inputs fit the existing production techniques underpins a tradeorientation that helps activate these countries' sources of static comparative advantage (Pearce, 2001). Thus it is construed (Kojima, 1978) as a welfare-enhancing trade-creating mode of behaviour. In some cases MNEs may feel the need to optimise this process by adapting the production technique to further sharpen its match with available local inputs. This may be done locally (in-house) through an SL1 or externally through advice from an SL2 that is already familiar with the process technology.

Conclusions.

The key theme of this paper, and of the empirical investigation that underpins it, is that contemporary MNEs address globalisation as a strengthening of the context in which they can leverage *difference* between economic areas[20] in terms of tastes, production capacities and technological and research scope. Paralleling this is the view that as countries' development proceeds the strength and distinctiveness of their NSIs increasingly defines the extent and form of their international competitiveness. The scenarios reviewed here indicate the generalised way in which the interjection of MNEs' global programmes for technological and competitive enrichment can strengthen individual NSIs, but also that a tendency to do this on a selective basis can alter the balance of an NSI (between stages) and its content (what is done in a particular stage). It is the need to understand the qualitative detail of MNEs' participation, rather than quantitative extent of attraction, that is the basic policy recommendation here. This can take the form of two, complementary, warnings.

The first is a warning against a short-termist overemphasis on attracting PM/LIL operations as a key element in a country's product development activities. Though this can strengthen the immediate scope for innovation-based trade success it often does so in a way that diminishes the depths of the roots of such competitiveness in the host economy's wider capabilities. Thus basing localised innovation on technology and product concepts already generated by the MNE can shortcut aspects of the development sequence, but also makes it extremely dependent and with a diminished reflection of distinctive localised science and competences. Sacrificing 'backward' roots in the NSI's precompetitive activity increases the dependency of the country's competitive development (innovation) on both the ability of MNEs' wider global operations to generate new product concepts, and the ability of the economy to supply the types of skills needed to *play a role* within a mainly externally-driven creative process. Lack of real roots could make MNEs' product development activity in a country almost as potentially 'footloose' as cost-based supply operations.

The second warning is the corollary of the above, suggesting that governments should normally also welcome MNE participation in basic and applied research activity. Three factors in our analysis could lead governments to display reluctance in attracting IIL-type operations. Firstly, that the results of successful IIL research may leak from the NSI (to fuel MNEs' operations elsewhere). Secondly, that precompetitive work is *per se* expensive, unpredictable and high-risk. Thirdly, and opportunistically, that the product development stage can now depend on MNEs' global operations as sources for key scientific inputs.[21] As observed above, allowing the emergence of an inbalance in an NSI (towards product development) has innate short-termist risks by diminishing potential sources of creative sustainability. With explicit regard to IILs we have suggested that, even where the next *use* of powerful research results may be elsewhere in the MNE's network, these units can still strengthen an NSI in significant ways.

Firstly, it is often reasonable to treat new basic/applied results as a public good. Thus, even when utilised outside the NSI by an MNE, such results do not become lost or forgotten, and can still represent a useable part of the technology stock of the country's science-base. Secondly, the NSI may be strengthened through its human capital (scientists). At an extreme MNEs' IIL operations may retain the local participation of top-quality scientists, who might otherwise migrate. More generally, MNE involvement with precompetitive science may benefit the motivation and performance of local researchers by (in addition to salary improvements) setting them more interesting challenges. This can stem from placing their work at the creative interface of two science communities, that of the MNE and that of the host NSI.

Overall, then, the plea is for a policy based on a careful and detailed understanding of heterogeneity and distinctiveness; both in the interdependencies between elements of an NSI and in the range of technological needs and strategic motivations in MNEs.

Figure 1 National System of Innovation

BASIC RESEARCH	APPLIED RESEARCH	PRODUCT DEVELOPMENT (Including market research)	ADAPTATION AND MARKETING

Figure 2 Basic Research

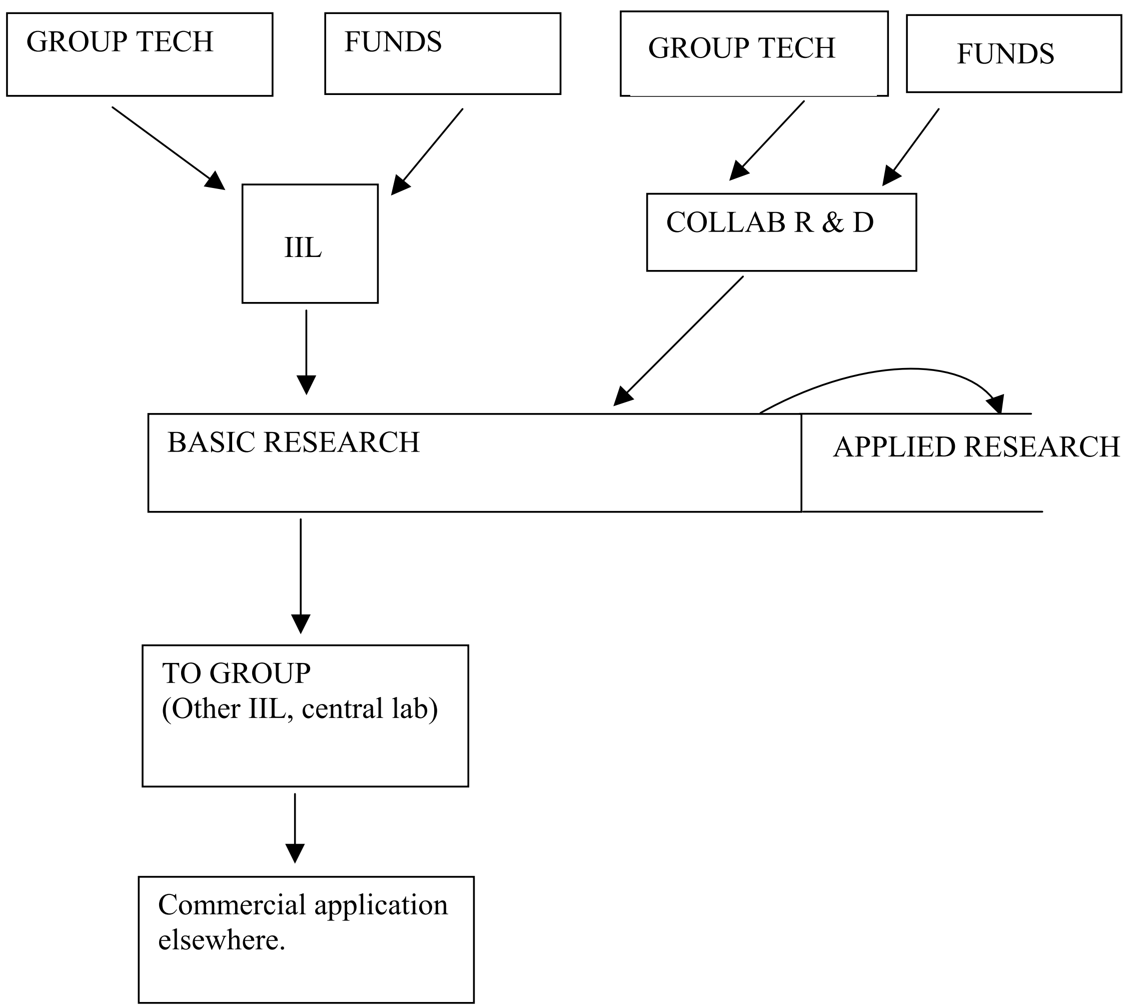


Figure 3 Applied Research

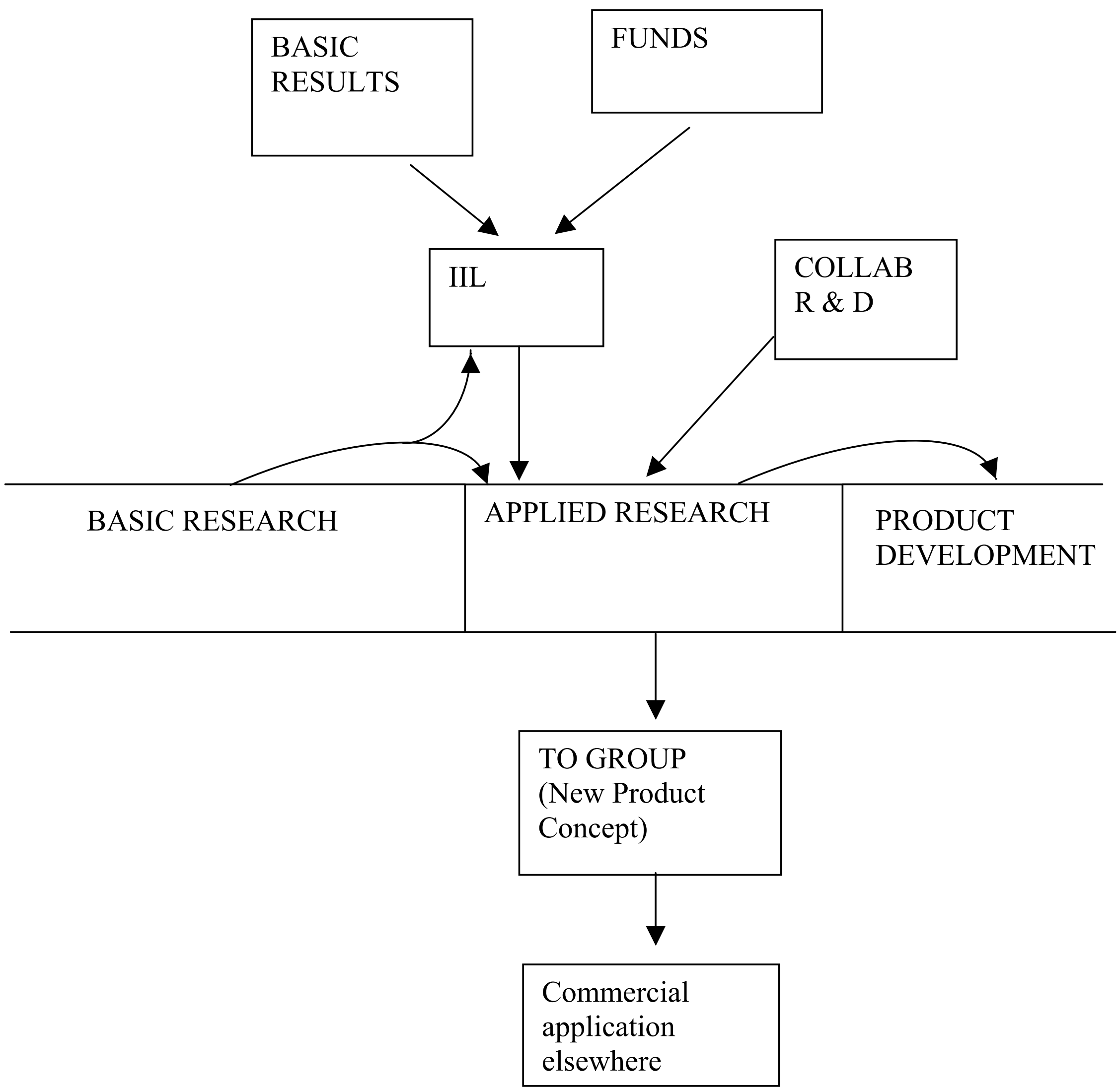


Figure 4: Product Development

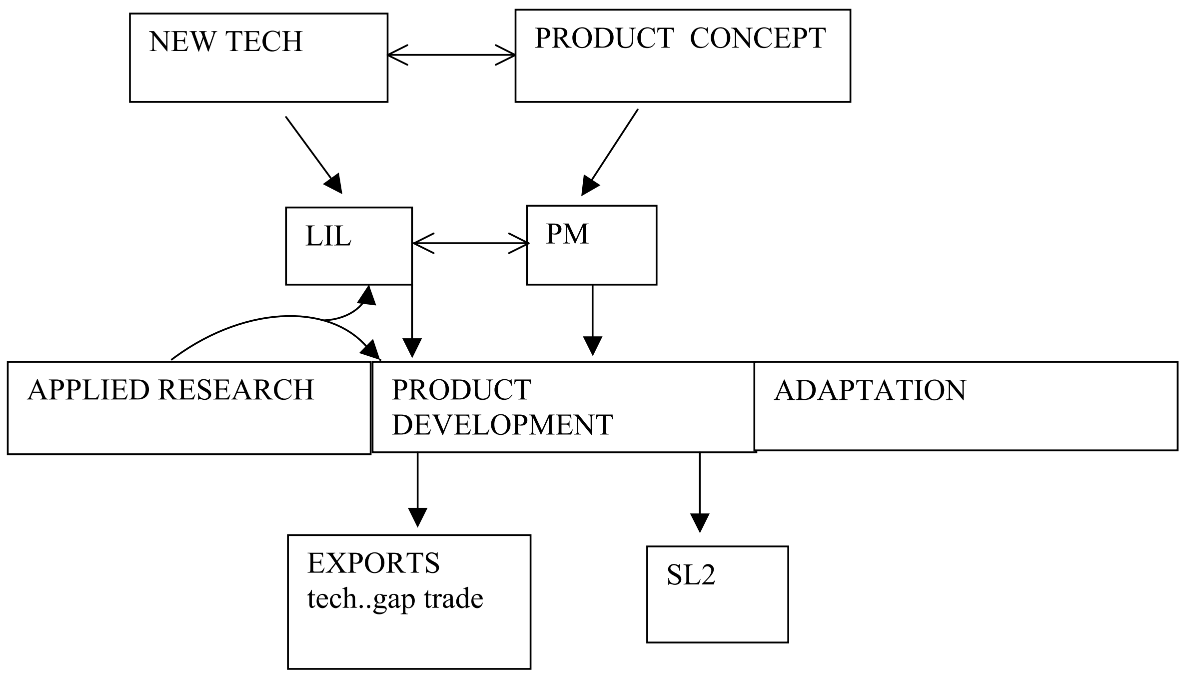
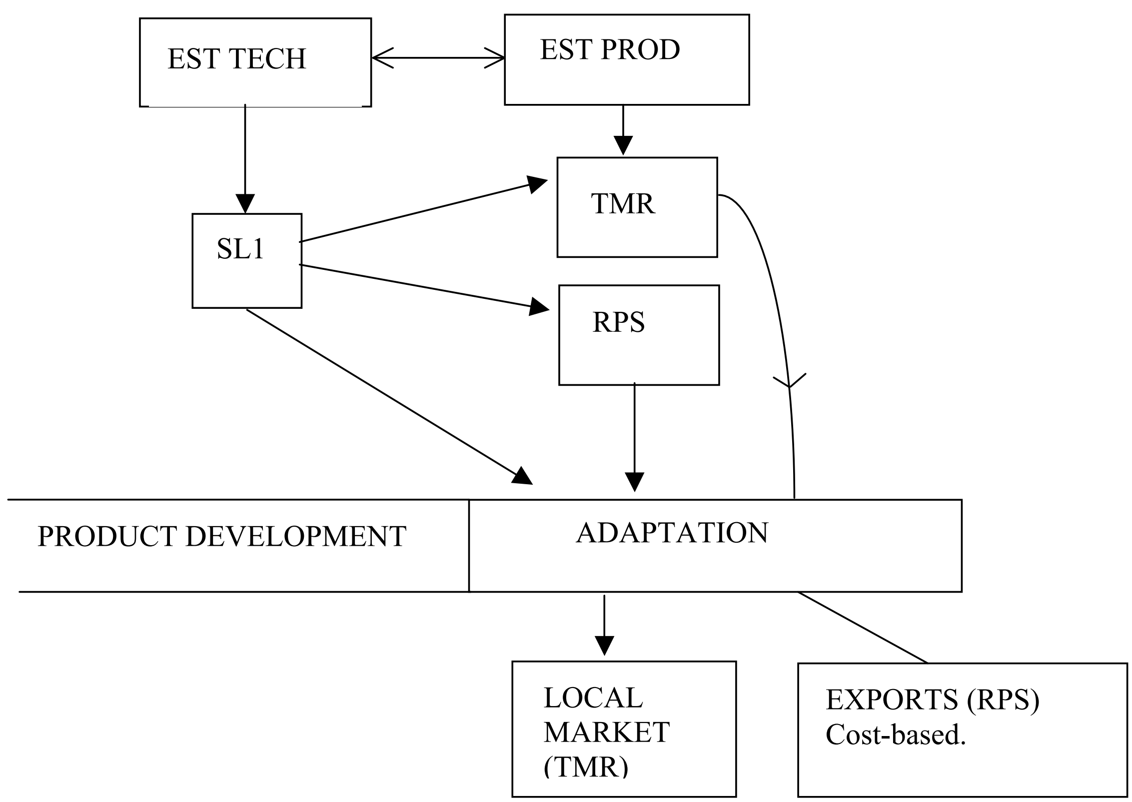


Figure 5 Adaptation



Notes:

[1] As will be seen below we use here a very simplified format of a national system of innovation tailored to the immediate concerns of this exposition. For a useful positioning of the concept in the wider concerns of technology and competitiveness see Freeman and Soete (1997, pp. 291-315) and for detailed analysis of specific systems contributions to Lundvall (1992) and Nelson (1993).

[2] It can then be argued (Manea, 2002; Manea and Pearce, 2001) that intervention of MNEs at the mainly product development stages of these countries' activity can help activate such underutilised knowledge potentials. This can be interpreted as providing an improved balance of the NSI.

[3] The survey was carried out in collaboration with Marina Papanastassiou whose contribution to the ideas discussed here is fully and happily acknowledged.

[4] For reasons of space and time no attempt is made here to systematically annotate the lines of argument generated with specific evidence from the survey. Subsequent development of the paper will seek to do this and to fully access the work of other scholars that reflects on (supportively or in contradiction) the themes and issues addressed here.

[5] Of course the detail of fully-developed analyses of NSIs focuses on the social institutions, competitive organisations and collaborative arrangements whose interdependencies comprise the activity at the different stages. However, we can then present our analysis as, in essence, focusing on the activity and effects of one subset of these institutions and systems, in the form of those involved in the technology strategies of MNEs.

[6] The origins of the scope typology are in the work of White and Poynter (1984) and D'Cruz (1986). For a review of this and detailed description of the version used here see Papanastassiou and Pearce (1999, pp. 21-32).

[7] This attempt to reproduce significant parts of the parent MNE's existing activity in its local contexts earns the TMR its description as a 'miniature replica' (of the wider group operations).

[8] It can be emphasised (Pearce, 1989, 1992, 1999a) that taking *responsibility* for different facets of the mandated activity does not inevitably imply complete performance in-house. Thus, at its discretion, a PM can secure some inputs to its creative or supply activities through collaborative or subcontracting arrangements. These may be with other parts of its MNE group or with independent agents.

[9] Other categorisations of decentralised units with distinctive strategic leadership responsibilities in MNEs include Centres of Excellence (Forsgren and Pedersen, 1998; Fratocchi and Holm, 1998) and the Flagship Firm (D'Cruz and Rugman, 1992, 1994).

[10] The classic pioneering work distinguishing distinctive roles for overseas R & D in MNEs is that of Ronstadt (1977, 1978). The origins of the typology used here are the work of Haug, Hood and Young (1983) and Hood and Young (1982). The first systematic attempt to relate extent and nature of overseas R & D to MNEs' wider strategic motivations is that of Behrman and Fischer (1980).

[11] Often IILs are located within producing facilities, for reasons of institutional and administrative convenience. This is often a source of tension as IIL management fears diversion to 'troubleshooting' on the factory floor. In addition to disruption of their work they may not be equipped to solve shopfloor problems whose technological basis derives from a different stage of the group's knowledge.

[12] The more radical results of IIL research may sometimes drive new opportunities which move the very industrial basis of the enterprise.

[13] Though an element of crowding out may also apply to the physical capital (infrastructure), it is likely to be more precise for human capital (scientists). Thus for infrastructure (laboratory capacity) net expansion is clearly feasible. The host-country stock of the quality of researchers sought by MNEs is, however, fixed at a particular point in time.

[14] For discussion of project mobility in MNEs' science and innovation programmes see Pearce and Singh (1992, pp. 73-75, 144-5). The associated ideas of 'reverse transfer' of technology in MNEs has been analysed by Hakanson and Nobel (2000, 2001) and Yamin (1999).

[15] Thus part of the central laboratory's responsibility can be seen as the generation of a sense of the operation of procedural justice (Kim and Mauborgne, 1991, 1993; Taggart, 1997, 1999) within the collaborative R & D network.

[16] In fact this does not imply *inefficient* production of the new goods because the innovation process can seek to engineer production technologies that are oriented to use of the available input mix and competences.

[17] The demands on local marketing personnel will be less than in the first scenario, however, since they do not create the truly pathbreaking aspects of an NPC but only focus on its locally-responsive refinement.

[18] Indeed a certain frustration with the somewhat dependent position of an MNE's PM/LIL activity could encourage such personnel to pursue more indeividualised creative scope in a local enterprise once they have acquired the confidence to do so.

[19] Just as the localised innovation processes of the previous stage encompassed elements of the behaviour of the first stage of Vernon's (1966) original product cycle model, this cost-related relocation of standardised product supply is very much that envisaged by his final stage.

[20] Discussed for convenience during the exposition as national economies, but also applicable to wider (integrated) areas or subregions (clusters).

[21] In fact if all, or most, developed industrial economies adopted the same opportunist approach and lowered support for basic/applied research the ultimate result would be a slowing of technology-driven economic progress worldwide. It could then be MNEs that perceive this first and most clearly. A response could then be an attempt to reinvigorate precompetitive investigation through commitment to IIL networks.

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