Technological spillovers from multinational presence : Towards a conceptual framework

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TECHNOLOGICAL SPILLOVERS FROM MULTINATIONAL PRESENCE TOWARDS A CONCEPTUAL FRAMEWORK*

Geoffrey Gachino

Abstract
This paper undertakes a critical review of existing spillover analyses and proposes a unique analytical framework for examining technological spillovers in a manufacturing industry setting. The proposed framework overlaps three different literature strands; cluster and network dynamics, technological innovations; and spillover literature. It enables determination of the extent to which multinational presence in a host country stimulates spillover occurrence to local firms as well as their nature. Using this framework, the kind and the channels through which spillovers occur most can be equally determined – this is particularly relevant for policy intervention in a technically backward country. Lastly, it allows determination of factors and conditions under which spillovers from multinationals occur.

Keywords: Multinational presence, spillover index, learning, network dynamics, capability building and innovation.
JEL Classification: C4, F2, L1, L2, L6, O1, O3.

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1. Introduction

One of the significant global features in the last two decades is the steady rise in foreign direct investment (FDI) in tandem with globalisation largely facilitated by rapid advancement in technological change. For instance, between 1990 and 2005 the share of FDI inflows (in current terms) in world gross domestic product (GDP) rose from 1% to 3% while the ratio of FDI inflows in global gross domestic capital formation (GDCF)[1] rose from 4% to 14%. Strikingly, such a rise in trend has several consequences. First, an increasing share of countries' output is accounted for by multinational (MNC) subsidiaries. Second, FDI can spur industrial development by playing a supportive or complementary role to local investment through direct and indirect effects such as investment in production units and positive spillover occurrence respectively. The proponents of new growth theory – endogenous technological change, accumulation of human capital and openness to international trade and investment – particularly emphasise on the importance of indirect effects (spillovers) in long run economic growth and development [Lucas, 1988; Romer, 1990; Aghion and Howitt, 1990; Coe and Helpman, 1995; Grossman and Helpman, 1995].

Indirect effects comprise all those aspects resulting from the presence of subsidiaries of MNCs on the national economy that may increase the productive efficiency of domestic firms (Caves, 1974). Caves referred to them as productivity spillovers and classified them into allocative efficiency, technical efficiency and technology transfers. Allocative efficiency occur when MNCs introduce competition by breaking existing monopolies while technical efficiency come about when competitive pressure and demonstration effects by MNCs induce technical efficiency to local firms in a host country. Lastly, technology transfer occurs due to the fact that MNCs may speed up their technology transfer and innovation processes more than local firms, thus causing some of them to disseminate faster, than would have been the case, in the host country. Several case studies have shown that indirect effects from the activities of MNCs to local firms occur through channels/mechanisms such as competition, human capital – labour turnover, linkages and demonstration effects.

However, the latter consequence is hypothetical, contentious and has remained a subject

[1] Computed based on figures obtained from UNCTAD.

of research debate for a long time. As such, it forms the major thrust of this paper where we argue that on the basis of the new levels of FDI achieved coupled with the observed sophistication in MNC operations, due to their ownership advantages, existing theoretical and methodological approaches are inappropriate and a new analytical approach is needed.

Despite the voluminous literature on FDI and productivity spillovers, the findings have largely remained inconclusive in terms of spillover process – occurrence, mechanisms and determinants. While most of the existing works report positive spillovers, a few studies have reported contradicting results. However, analysis based on a few selected studies below, shows that due to scope and methodologies used, all these studies failed to provide an accurate extent of spillover occurrence. This notwithstanding, the methods employed also hindered an appropriate examination of conditions under which spillovers occur since more attention was paid to MNC presence with little or no consideration for mechanisms through which spillovers occurred.

The paper is organised as follows. Section 2 presents a brief literature review and a summary of the emerging issues from the spillover review undertaken. Section 3 introduces an alternative theoretical framework while section 4 presents the analytical framework proposed for measuring spillovers. In section 5 we look at the determinants of spillovers occurrence and finally, section 6 presents the summary and conclusion.

2.0 A Brief Review of Pertinent Issues

In this section, we examine a few selected studies on FDI and spillovers for two main reasons. First to understand the methodological approach employed in the studies. The second reason is to demonstrate inherent weaknesses in spillover analysis. We start by examining a few of the early studies pioneered by (Caves, 1974). Employing production function, Caves 1974 used aggregate data to examine spillover occurrence in the Australian Manufacturing. Foreign presence was characterised by positive spillovers which enhanced local firms' technical efficiency. Similar findings were obtained by Globerman (1979) who investigated spillover benefits to Canadian manufacturing industries employing the same methodology and specification as in (Caves, 1974). Following the same approach, Blomstrom and Pearson (1983) used industry level data to

investigate whether technical efficiency of Mexican plants derived from spillover efficiency associated with FDI. Employing ordinary least squares (OLS) they found positive relationship between foreign presence and labour productivity which according to them implied that foreign presence had a positive influence on domestic labour productivity.

Similar results were obtained for Indonesia by Blomstrom and Sjoholm (1999) who conducted an empirical analysis based on Indonesian establishment data to determine whether the type of foreign ownership had any effect on productivity and the degree of spillover occurrence. Their analysis was based on the assumption that local participation with foreign firms may reveal some of their proprietary knowledge, which would occur through various trainings in foreign firms or by gathering experience at work. The study proceeded by conducting linear regression estimations taking labour productivity as the proxy for technical efficiency of the local firms. The results showed that foreign establishments had a comparatively high level of labour productivity and that intra-industry spillovers from foreign investment existed in the Indonesian manufacturing sector. Labour productivity in domestically owned establishments varied with the degree of foreign presence. Sjoholm (1997) and Takii (2001) are additional studies on Indonesian manufacturing industry which employed a similar approach and obtained similar findings – that foreign presence stimulates spillovers.

Nevertheless, findings of spillover occurrence obtained in the above studies can be challenged in that spillovers could result following disappearance of weak and inefficient local firms. None of these studies made any effort to examine that aspect. Also, in-depth investigation showed that data used in most of the studies was limited to a very short time span while at the same time it was used in an aggregate format treating industries and sectors homogenously, which is hardly the case. Industries, sectors and even firms are characterised by high levels of heterogeneity with significant differences in technological capabilities and capacities to learn and innovate.

The technologies used by foreign firms in various industries also differ widely in terms of complexity, which imply that technology gap between foreign firms and locally owned firms ought to be considered. The study failed as well to consider the selectivity bias problem where foreign firms are likely to choose sectors which are dynamic, innovative

and presumably operating in such sectors would be viewed profitable. Lastly Caves study did not explicitly examine the mechanisms of spillover occurrence and diffusion to local firms. Learning and technological changes were thus treated as 'black boxes'. In light of these discussions, Caves finding of technical efficiency is not convincing and would thus be naive to make solid deductions of how local firms benefit in their technological development effort from MNC presence.

Contrary to the above studies, some studies did not find spillovers despite being based on productivity approach suggesting that such effects of foreign presence are not always beneficial [Aitken and Harrison, 1992; Haddad and Harrison, 1993; Aitken, Hanson and Harrison, 1997; Aitken and Harrison, 1999]. All these studies attempted to advance the analytical frontier by extending productivity approach by incorporating factors not considered earlier such as industry and regional dynamics, systemic coordination and support infrastructure, and general firm-level specificities.

We examine a few of such studies beginning with Haddad and Harrison (1993) whose study differed from those examined above on two fronts. First, their study employed a comprehensive data set of firm level manufacturing firms in Morocco over several years. Secondly the study used detailed information on the level of quota and tariff protection to investigate whether lack of spillovers stemmed from a tendency of foreign firms to gravitate towards protected sectors. Their hypothesis was that when knowledge or new technology embodied in foreign firms is transmitted to local firms, it would result in higher productivity levels and growth rates for local firms in sectors with a large foreign presence. Using productivity dispersion technique, they found dispersion to be smaller in sectors with many foreign firms. According to them this could be explained by competition which is induced by the foreign firms, causing firms that cannot approach the best-practice frontier to exit the industry. Their results further showed that foreign investment as an output growth determinant in the sector level was negative. Hence, the hypothesis that foreign presence accelerated productivity growth in domestic firms was thus rejected.

Aitken and Harrison (1999) used annual census data on over 4000 Venezuelan firms to measure the productivity effects of foreign ownership. The study was unique in its attempt to overcome the identification problem – where foreign investment is likely to

be attracted to more productive sectors of the economy. In such cases the productivity of the domestic firms would overstate the positive impact of foreign investment. To avoid this problem inherent in all past sectoral level studies the behaviour of each firm was observed over a period of time to control for fixed differences in productivity levels across industries which might affect the level of foreign investment.

Aitken and Harrison (1999) estimated log-linear production functions to investigate two basic propositions: whether foreign equity participation could be associated with an increase in the plant's productivity and whether foreign ownership in an industry affected the productivity of domestically owned firms in the same industry. Productivity in both the plants and the sectors was estimated by their outputs, which was taken as the dependent variable and regressed on the two measures of foreign ownership alongside other input variables. The study showed that domestic firms in sectors with high foreign presence were significantly less productive than those in sectors with low foreign presence. In other words, they found evidence of negative spillovers from FDI and suggested that such negative spillovers could result from a market stealing effect: foreign competition may have forced domestic firms to lower output and thereby forego economies of scale. Nevertheless, adding up the positive own-plant effect and the negative spillovers, on balance, the study found that the overall effect of FDI on productivity of the entire industry was positive though quite small.

In the Czech Republic, Djankov and Hoekman (1998) investigated the impact of foreign investment on the productivity performance of firms using information on Czech enterprises. They estimated a production function using total factor productivity as a proxy for technology transfer. Their assumption was that adoption of new technologies would, with some lag in time, lead to an improvement in productivity. They found a negative spillover effect. Greater foreign presence in an industry had a statistically significant negative effect on the performance of firms without foreign linkage (pure firms).

A quick observation on all studies which reported no spillovers is that despite the noted evolution on estimation techniques, the basic productivity principals were maintained. As will be shown in the summary below this was problematic and it actually made the studies reflect similar caveats to the studies done before following Caves. These caveats

are discussed below as emerging issues.

2.1 Emerging Issues: A Recapitulation

The above review has demonstrated existing divergence in spillover analysis which is likely to have stemmed from the way spillovers were conceptualised as well as variations in methodologies used in examining extent of spillover occurence and their economic impact. We discuss a few notable weaknesses starting with what we refer to as tendency towards *single factor exponentiation* where foreign presence was considered to be the only major factor in determining occurrence and effect of spillovers in a host country. Foreign presence in a host country was easily perceived to generate efficiency enhancing productivity spillovers to local firms. Hence, empirical estimations of spillovers were done using total factor productivity; examined simply as a linear function of foreign presence.

The second weakness is *automaticity* or *exogeneity problem* where spillovers and their effect were thought to occur automatically, making the process of spillover occurrence quasi-inevitable. The assumption of automaticity, implied in productivity techniques, ignored the entire process of endogenous technological change placing learning, and the actual mechanism of spillover occurrence to the background. As a consequence, the studies failed to provide rigorous examination of such mechanisms through which spillovers brought about inevitable technological changes, in terms of skills, knowledge and learning acquired.

The third problem relates to the *narrow conceptualisation of spillovers* phenomenon. Where as indicated above MNCs were the only firms taken into consideration while analysing spillovers disregarding the role and effort of local firms together with a host of other supportive factors within the local systems of innovation in host countries. No attention was paid to the supportive and systemic infrastructure in which firms were embedded. Firms are sometimes situated in regions with varying or no infrastructural or institutional support systems with possible implications for spillover occurence.

On the basis of issues raised, this paper emphasises that an alternative approach is required. An approach which would enable an appropriate assessment of what the influence of interactions, learning and capability development is in the spillover

occurrence process. Such an undertaking requires a deep understanding of local support system and its role in the spillover process. It would also require a deep understanding of the network dynamics involved including existing corroborative linkages in an industry or economy wide systems. The role of supportive infrastructure and institutions would have to be examined. The role of social capital, which entails social trust, norms and networks of civic engagement would also have to be taken into consideration. Social capital is considered here to refer to a set of horizontal associations between people, consisting of social networks and associated norms that have an effect on community productivity and well being (Brusco and Sabel, 1981; Piore and Sabel, 1984). They facilitate co-ordination and co-operation and thus increase productivity by reducing the transactions costs of doing business.

In sum, we conclude this section by stating that in the context of vast development in the endogenous, technological change and evolutionary literature, traditional linear argument is definitely flawed if taken to explain spillover occurrence as it tends to reduce spillovers to the presence of foreign firms or even foreign capital, without exposing the actual effect or real occurrence mechanisms. The process can better be understood from the lenses of evolutionary and institutionalist perspective, which views firms not as isolated, static and pure economic agents, but rather as members of changing economic and social-institutional networks. The proposed alternative framework is developed in the next section.

3. Spillover Occurrence: Towards an Alternative Theoretical Framework

Given the weaknesses identified, it is clear that occurrence and impact of MNC spillovers on local enterprises cannot be appropriately explained using simple linear aggregate analysis particularly in the case of non-pecuniary (technological) spillovers. Unlike pecuniary spillovers, non-pecuniary spillovers are exceptionally difficult to deduce from aggregate macro economic data [see Hirschman, 1958; Rasiah, 1995]. Such spillovers include knowledge flows that are invisible, imperfectly understood, determined by multiple factors, and difficult to track hence difficult to investigate.

This explains why high aggregate analysis fails to capture and explain effects of many other factors such as influence of the government policies and/or a variety of social-institutional factors such as cooperation, coordination and trust among entrepreneurs.

Other aspects neglected include importance of networks and linkages to support structures such as productive centres, financial institutions, research and academic institutions; all of which are important factors to consider when investigating spillovers. Transaction costs also become important for the promotion and further development of networks and linkages through contractual enforcement. It is garmane to argue here that only firm level analysis is capable of offering a well-grounded understanding of relationship among firms, including MNC influences on local firms. In addition to the spillover literature the two alternative literature strands combined to develop an analytical framework for examining spillovers are clustering and network dynamics and technological innovations.

3.1 Cluster and Network Dynamics

The first theoretical framework proposed is cluster and network dynamics founded on the industrial district concept pioneered by Marshall (1890) who posited that an economy stood to gain from greater division of labour and collective efficiency, when enterprises within a particular industry clustered in close proximity to each other. Existence of a pool of specialised knowledge in the cluster, reinforced through a common set of culture and social values created an industrial atmosphere for driving differentiation and division of labour (Young, 1928).

The framework on cluster and network dynamics benefits from a multidisciplinary niche of approaches in social sciences which combines a wide range of aspects ranging from industrial organisation to social capital. Here we only discuss a few of these starting with transactions costs and institutional economics founded in the industrial organisation theory with pioneering works by Coase (1937), Chandler (1977) and Williamson (1985) among others. According to Chandler (1977) the evolution and development of modern corporations depends on what he refers to as the visible hand of the hierarchy, which differs substantially from the invisible hand of the market in terms of resource allocation. His argument is that the visible hand of hierarchical coordination and control carried out internally through direction out-competes the invisible hand of market coordination. Chandler argues in favour of being big and mainly vertically integrated as one condition for a successful performance; by making it possible to stimulate efficient throughput, innovation and development capabilities.

This notwithstanding the notion of vertical integration has been criticised for its failure to explain some observed phenomena e.g. growth or decline of most industries. In the face of current international competition, there is increased pressure of rapidly changing product designs and technologies, companies including big corporations (including MNCs) have resulted heavily on outsourcing/selling various components to other firms including (small and medium enterprises). Such companies are left performing only key aspects of the production like initial design, final assembly and final testing. This implies that in an environment that demands rapid new product introductions and continual technological change, no single firm can complete the design and production of most products on their own. That way, firms then gain flexibility to introduce increasingly sophisticated products faster by relying on networks of suppliers.

The transaction cost theory by Coase's (1937) and later by William's (1985) emphasises that; markets and hierarchies play important roles in coordinating production. According to the transaction theory, the choice between long-term contracts and a standard market transaction for the exchange of goods will depend on the costs and benefits of the former relative to the latter. Put simply, a firm decides to contract when it gets to a point where the costs of organising an extra transaction within the firm are equal to the costs involved in carrying out the transaction in the open market, or, to the costs of organising by another entrepreneur. If the market for intermediate goods is prone to failure, because of small number problems, asymmetric information, asset specificity, uncertainty and irreversible commitment, then incentives for opportunistic behaviour can be reduced by internalising or partially internalising the transaction. Thus transaction cost theory becomes important in explaining inter-firm relationships.

However, when such contractual relationships emerge among firms, cooperation and market forces are necessary to facilitate production coordination (see Richardson, 1972: 883-96). Richardson viewed an industry as a system of dense and integrated activities. Such activities included discovery and estimation of future wants, research and development, execution and co-ordination of processes of physical transformation and marketing of goods. These activities had to be carried out by firms with appropriate capabilities in terms of knowledge, experience and skills. This seemed to extend Smith's specialisation principle where enterprises specialise in activities which use a particular

capability and collaborate with other enterprises specialising in complementary activities, hence stimulating network activities as a means of production co-ordination.

The above process of stimulated networks of interdependent producers increases the opportunity to innovate in the firms by encouraging specialisation based on a combination of existing internal capabilities and external knowledge in the form of externalities. These externalities are from the existing institutions and other firms e.g. competing firms or subcontractors in the existing network of linkages and collaborations. However, being innovative can increase the probability of spillover occurrence into a firm as this depends on the absorptive capacity of a firm, which tends to increase with the degree of innovativeness in the firm. Industrial technological innovation do not take place as a result of individual firms lone technological effort, if this happens it's only to a limited extent. Many innovations and their causes exist outside individual firms and only a tiny fraction of innovations at a given moment do take place in firms compared to external innovations[2].

The framework on clusters and network dynamics attempts to go beyond transaction cost framework, which placed markets and hierarchies as the prime coordinators of production. The literature on clusters and network dynamic posits that while transaction cost framework is useful in explaining inter firm collaborations, the importance of "social capital" e.g. trust-based relationship, which is sometimes nurtured with proximity, is hardly given attention. The main critique here is that, though the contractual relationships bind suppliers/purchaser and trainers to firms, firms have to build trust relationships to obtain commitment and loyalty [Brusco, 1982; Brusco and Sabel, 1981; Piore and Sabel, 1984; Nadvi, 1999]. This is to say that trust arises to overcome problems of reliability, information access and uncertainty hence helping to strengthen long-term efficiency. Trust therefore plays an important complementary role, in shaping the inter-firm networks that arise in the process of overcoming coordination problems which emanate from imperfect market. This is to mean that given this role played by trust in

[2] Schumpeter acknowledged this point when he wrote: "capitalist economy is not and cannot be stationary. Nor is it merely expanding in a steady manner. It is incessantly being revolutionalised from within by new enterprises, i.e. by the intrusion of new commodities or new methods of production or new commercial opportunities into the industrial structure as it exists at any moment. Any existing structures and all the conditions of doing business are always in a process of change" (Schumpeter, 1934).

augmenting outsourcing relationships, it should then be included as part of transaction costs framework.

Several works exist which show the influence of cooperation and market forces in the growth of collaborative relationships. Such relationships between agents within clusters and networks, through the sharing of vital information, resources, skill, knowledge and technical expertise, and other forms of joint action reduce transaction costs and further enhance competitiveness as well as accelerate learning and technical innovation [See Brusco and Sabel, 1981; Brusco, 1982; Piore and Sabel, 1984; Saxenian, 1991; Rasiah, 1995]. Cluster and network dynamics framework will therefore be expanded by incorporating the literature on technological innovation which has led to the development of national systems of innovation (NSI).

3.2 Technological Innovation: National Systems of Innovation and Evolutionary Perspectives

The national system of innovation emphasises the ways in which technology, social-economic agents, organisations, institutions and policies interact with each other for the purpose of fostering knowledge, learning, capability building and innovation. According to Freeman (1987), NSI can be viewed as *"…the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies"*. It is thus characterised by agents engaged in formal government and education institutions, network of physical, scientific, economic and technology infrastructure. The flow of technological information, knowledge and skills within the NSI is regarded as the most important thing for the purpose of learning and capability accumulation in the local, national and global context. Flow of technological information and knowledge with the NSI is highly dynamic and non-linear. As a result, interactions among agents are crucial to facilitate flow of information, skills and knowledge for the purpose of learning and capability building. These attributes of involving all actors dynamically and interactively for social-economic benefit, led to the formulation of NSI [Freeman, 1995; Lundvall, 1992; Nelson, 1993]. The NSI has largely been motivated by evolutionary economics theory expounded by Nelson and Winter (1982), Rosenberg (1982) and Stoneman (1983) among others.

The concept of NSI fits most analysis dealing with technological change, learning and innovation in developing countries, where technological change and learning does not

have to emanate from formal R&D institutions. Precisely, the science-push school of thought, tended to reduce innovation into a well-defined sequence of activities depicting a unidirectional flow of causation, from fundamental discoveries in science leading eventually to technological inventions, innovations, and diffusion of new products and production techniques. This model, referred elsewhere by David 1992 as "Simplest Linear Model – SLIM" influenced economic thinking and policy analysis to a wide extent and for a long time. Its attributes were however misleading in their postulate that innovations required specialised scientific and technological skill. This tended to reduce innovation(s) to a preserve of serious scientific research whose source could only be R&D laboratories which was totally naive as many innovations do not necessarily require basic research not even applied research, but just occur in the process or as an end result of many trials and errors. Accordingly, this was a narrow scope of visualisation accorded to the innovation process. Innovations occur everywhere at all times even on the shop floors and one need not limit himself to the scientific R&D laboratories looking for innovations, local artisans and craftsmen in the least of the developing countries do have their own innovations as does the support and maintenance engineers in production processes or even local traders and merchants.

3.3 Spillover Occurrence and Host Country's Technological Innovation Development: Stimulating Learning and Capability Building

Contrary to the traditional technique where spillovers were conceptualised in terms of productivity gains, we re-conceptualise spillovers in terms of learning and capability building. Firm's productivity largely depends on the accumulated technological capabilities over time where constant and continuous learning leads to a dynamic process of technological accumulation. We shall therefore assume that foreign presence through knowledge spillovers and other factors are likely to lead to learning in domestic firms either by providing raw materials, resources or specific stimuli which triggers various form of technological change. However, this should not be taken to imply that spillovers are the only determinants of capability building since a whole range of factors are involved stemming from incentive framework (demand); supply factors (access to skills, finance and information) to institutional factors (rules of the game).

Firm level capabilities can be categorised in several ways particularly drawing from the main proponets who include Lall (1992), Bell and Pavitt (1993); Ernst, Mytelka and Ganiatsos (1998) and Rasiah (2005). Useful categorisation of technological capabilities

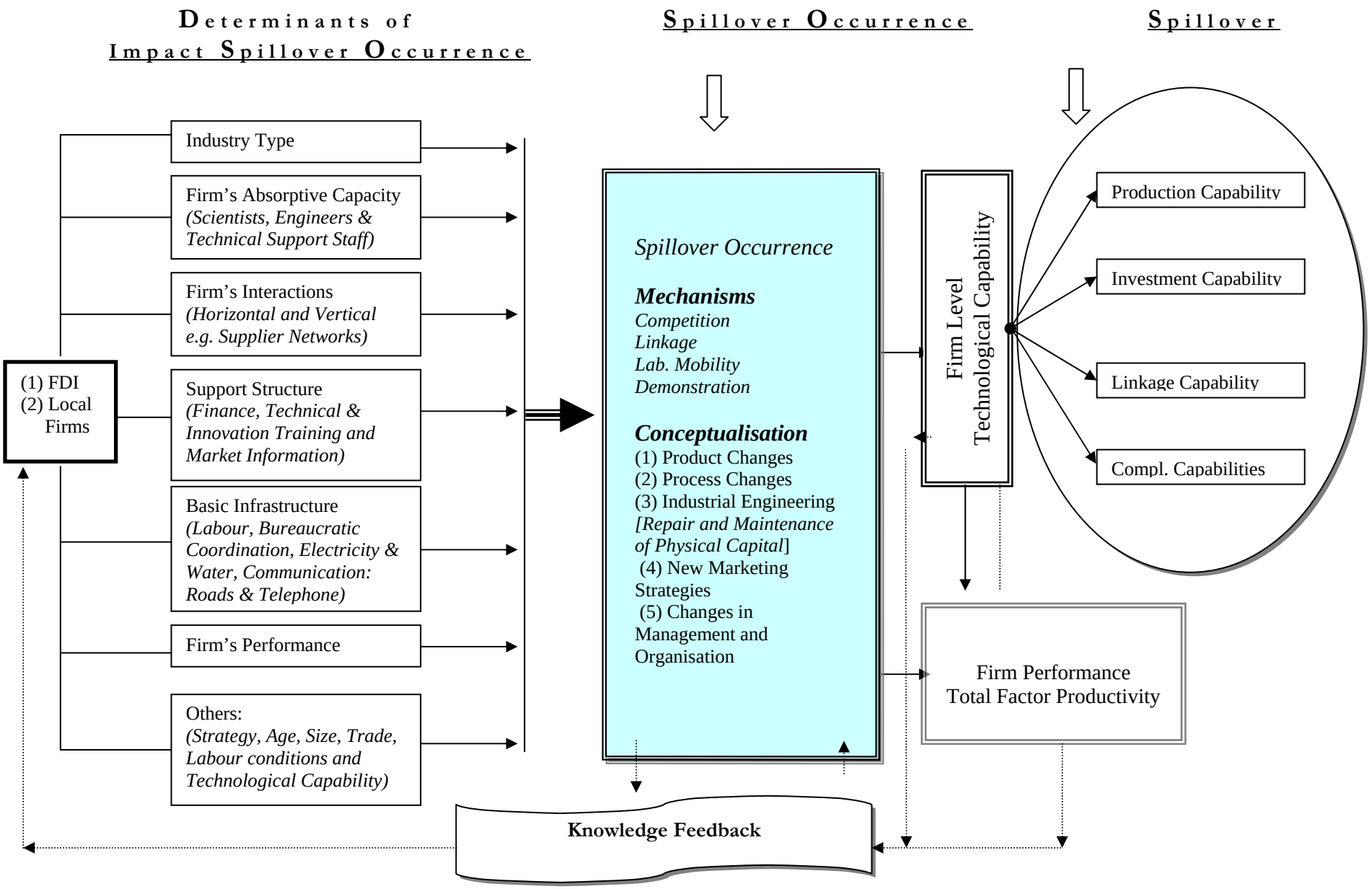
considers the functions they perform and the degree of complexity as the two classificatory principles. Figure 1 shows technological capability categorised into investment, production, linkage and complimentary capabilities (such as innovation and organisation and marketing capabilities). Investment capability includes skills and knowledge used in the project identification, feasibility studies, preparation, design, setting up and commissioning of a new industrial project or the expansion and/or modernisation of existing ones. These capabilities can be broadly divided into two; 'pre-investment' capabilities and the rest required for carrying out the investment itself 'project execution'. The former cover a variety of activities, ranging from pre-feasibility and feasibility studies, site selection and the scheduling of investment, to the search for sources of technology, negotiation of contracts and bargaining for suitable transfer conditions. The later involves several project execution activities to establish or expand facilities.

Linkage capability has also become important due to the learning aspects involved when firms form forward and backward linkages. It refers to skills, knowledge and organisational competence needed to transfer information, skills and technology to, and receive them from, component or raw material suppliers, subcontractors, consultants, service firms, and technology institutions. Such linkages affect not only the productive efficiency on the enterprise but also the diffusion of technology through the economy and deepening of the industrial structure, both essential to industrial development. Under complementary capabilities examples include organisation and marketing capabilities. The former consists of skills that are required to relate and co-ordinate the necessary functions so as to utilise effectively various existing capacities both in the firm and outside the firms. Marketing capabilities includes the knowledge and skills required for collecting market intelligence, the development of new markets, the establishment of distribution channels and the provision of customer services.

Due to the magnitude and scope of work involved, this paper will focus only on production capability and then identify the associated learning and technological changes. Production capability range from basic skills such as quality control, operation, and maintenance, to more advanced ones such as adaptation, improvement or equipment 'stretching to the most demanding ones of research, design, and innovation. The skills involved determine not only how well technologies are operated and improved, but also

how well in-house efforts are utilised to absorb technologies bought or imitated from other firms.

Figure 1: A Framework Model for Spillover Analysis: Determinants, Mechanism and Effect on Technological Learning and Capability Building



4.0 Analytical Framework for Measuring Spillovers Based on Technological Changes, Learning and Capability Building

Flowing from above, occurrence of spillovers is likely to place domestic enterprises on a learning function, thus increasing their potential to learn, and to accumulate experiential tacit knowledge. We therefore re-conceptualise spillovers broadly in terms of learning and capability building. Further, four channels of spillover occurrence identified from the spillover literature – which include competition, linkage, labour mobility and demonstration effects – will be considered (Figure 1). To be precise, spillovers taking place through each of these channels will then be conceptualised in terms of learning and dynamic technological changes taking place in a firm. According to the literature on technological innovations the process of undertaking technological changes is fully embraced as an important procedure in the process of capability accumulation [Stoneman, (1983: 1995); Metcalfe, 1989; Rosenberg, 1982; Nelson and Winter, 1982; Freeman and Soete, 1997]. It provides diverse forms of learning such as learning by doing, by watching or by experimenting all of which result in explicit, experience and experiential knowledge accumulation. This helps increase firms' endowment of tacit knowledge and skill base and subsequently their ability to innovate [Fransman, 1984; Kim, 1999]. A study by Mytelka (1985) presented a candid illustration of how changes in consumption, production, organisational and marketing could promote technological capability within firms. The implication of this discussion is that spillover occurence can indeed stimulate allocative, technical and technology transfer into the local firms in a host country.

For each of the spillover occurrence channel considered, five types of technological changes associated with production capability are identified (Figure 1). Production capability is considered for simplicity since it is not possible to consider all forms of capability here. Consequently, under production capability the following technological changes are considered as proxies for spillover occurrence; production changes, process changes, industrial engineering, new marketing strategies, management and organisation changes. The degree to which each change takes place would be determined subjectively in the firms on a continuous gradual ordinal scale ranging from a minimum score of 0 representing *"nothing happening"* to a maximum score of N representing *"very much"*. On the basis of this scale, an

index is computed which is then used in the quantitative determination of spillover occurrence as well as spillover determinants. It should however be acknowledged that the index inevitably suffers some potential drawbacks especially due to the fact that it would largely be based on firms' own subjective assessment.

We provide one example based on competition mode of spillover occurrence just for demonstration purposes. Due to competition pressure from competing firms, a firm is bound to react by undertaking changes which can range from production to organisational (see Table 1). The changes can be classified under five components involving production capability mentioned above including two more changes that could result in accumulation of complementary capabilities such as marketing, organisation and management changes. For each of the five changes, a firm would have to indicate subjectively what the perceived degree of change was due to competition on the basis of scale provided.

For instance, consider the first case depicted in the second row of Table 1, a score between 0 and N would be chosen for changes in products due to competition pressure. As an example, changes in products would include development of completely new products or improvement of old products. Assume a particular firm introduced new products in response to competition pressure and that this firm rates this change as *"a score of 2"* on the score range provided. Then the score awarded, *"a score of 2"*, is taken as $\mathbf{Pd}_c$ as shown in Table 1 and 2. It is important to emphasise that the respondents should be able to identify who their competitors are whether locally owned or foreign firms.

Table 1: Reaction to Competition Pressure Ranked by Order of Importance

Reaction to Competitive Pressure	**Ranking by Importance**
Improving our products, develop new ones or copy/imitate their products	0 1 2 ..... N
Improve processing techniques, raw material and quality control, upgrade our technology & equipment to save energy or raise productivity etc.	0 1 2 ..... N
Repair and Maintenance of physical capital, inventory control etc.	0 1 2 ..... N
Improve and strengthen our marketing department by new ideas skills and knowledge in domestic or foreign markets (exporting) etc.	0 1 2 ..... N
Undertake organisational changes for better management and implementation of production & other routine activities that enhance the firm's efficiency.	0 1 2 ..... N
Others *(please specify).*	0 1 2 ..... N

Source: Gachino 2006.

Similarly, using the scores for all other channels, a technological spillover index (SPO INDEX) can be developed. The idea of employing an index to evaluate firm level processes and activities is now widely embraced particularly when dealing with complex technological capability issues in developing countries. This can be traced to the works of Lall (1992); Bell and Pavitt (1993); Ernst, Ganiatsos and Mytelka (1998); Wignaraja (2001) and Rasiah (2002: 2005). The present spillover index is however different and attempts to quantify firm level technological behaviour with particular emphasis on qualitative information from survey interviews. On the basis of five scores awarded; $\mathbf{Pd_c}$, $\mathbf{Pr_c}$, $\mathbf{Rm_c}$, $\mathbf{Ms_c}$ and $\mathbf{Mo_c}$ an average, **C**, is then computed as shown at the bottom of the competition column, see Table 2. This process is repeated for all the other channels, for linkage the average is **L**, mobility is **M** and demonstration is **D**. Eventually, the composite spillover index, is computed as a simple arithmetic average of all the four channels as shown by the following expression:

$$SPO \quad INDEX = Composite \quad Average(C, L, M, D) \qquad 1$$

Table 2: Computation of Spillover Index, SPO INDEX

Spillover Conceptualisation	Competition **(c)**	Linkage **(l)**	Labour Mobility **(m)**	Demonstration **(d)**	**Average Score**
Product Changes **(Pd)**	Pd_c	Pd_l	Pd_m	Pd_d	**PD**
Process Changes **(Pr)**	Pr_c	Pr_l	Pr_m	Pr_d	**PR**
Repair & Maintenance **(Rm)**	Rm_c	Rm_l	Rm_c	Rm_d	**RM**
Marketing Strategy **(Ms)**	Ms_c	Ms_l	Ms_m	Ms_d	**MS**
Management & Organisation **(Mo)**	Mo_c	Mo_l	Mo_m	Mo_d	**MO**
Average Score	**C**	**L**	**M**	**D**	**SPO INDEX**

Source: Gachino 2006

Similarly, the SPO INDEX can be computed by column average. A score for product change under each chanel would be taken and averaged to give **PD;** the row average in Table

2. This is done for the four other rows – **Pr, Rm, Ms** and **Mo**. In the end, the average for the last column is computed as follows:

$$SPO \quad INDEX_{firm} = Composite \qquad Average(PD, PR, RM, MS, MO) \; 2.$$

The two procedures; average by column or average by row yield the same results, a composite spillover index, SPO INDEX, a proxy for spillover occurrence. The average spillover occurrence for a manufacturing industry can be obtained by computing the average for all the firms on the same range 0 *'None"* to N *"Highest"*.

5.0 Determinants of Spillover Occurrence

Following the discussion held, spillover occurence is a function of individual firm's resource endowment and their interactions with socio-economic agents, it can be assumed that spillover occurrence is determined by a number of factors encapsulated in the structure–conduct–performance framework [Bain, 1968; Scherer, (1973: 1980)]. According to this framework various elements of market structure determine firm conduct, and that structure and conduct together interacted determine market performance. The major elements of structure include organisational structure of firms; whether they are vertically or horizontally integrated. Firm orientation; whether they operate to serve domestic market or external market (export oriented). Others include buyer and seller sizes, product differentiation, and entry and exit conditions. The major elements of conduct were human capital development strategy, product development strategy, co-ordination with other firms and existing supporting institutions. Although R&D is also identified in this category, very few firms in developing countries undertake it. Lastly, performance includes firm revenue in terms of output sales and value added, market share, unit cost of production, total factor productivity or partial productivity levels as in case of labour and capital productivity.

An institutional environment is incorporated into this framework since its influence on firms' structure and conduct can in turn have an influence on firm performance, all of which again affect each other interactively and dynamically. This is inspired by the works of institutional economists such as Williamson (1985), Richardson (1972) and North (1992). In the words of Douglas North (1992), "… institutions and the way they evolve shape

economic performance." Under the institutional environment, several factors are identifiable which directly or indirectly impinge on firms' performance. They include basic infrastructure, labour force characteristics, prevailing government policies and political climate, degree of accountability and transparency level, ethnicity background and cultural practices, existing market structure of competing firms, firm ownership structure, trade orientation, inter-firm and institutional links etc.

Similarly, from technological innovations debate alluded to above, many socio-economic and technological factors are involved in the spillover process. Thus determinants of spillover occurrence, their mode of occurrence and impact on firms' activities can also be traced and identified within the NSI but from the lenses of firms and partly of support institutions.

From the alternative analytical framework designed and presented in Figure 1, determinants of spillover occurrence can be outlined in a broad proposition. That in a technically underdeveloped country, the occurrence of spillovers does not only depend on the presence of MNCs, but also on absorptive capacity, presence of support structures and institutions, presence of interactions and trade orientation. Others include firm size, age, ownership structure, performance, labour market conditions, firm strategy and industry structure). We discuss each one of them separately.

5.1 Absorptive Capacity

For spillovers to occur there must be high absorptive capacity. Knowledge spillovers depend on the ability and effort of the recipient parts to exploit new knowledge and technology [Cohen and Levinthal, 1990; Grossman and Helpman, 1991ab; Benhabib and Spiegel, 1994]. Firm R&D become important in keeping pace with and absorbing the knowledge spillovers. A firm with a strong R&D base would therefore be efficient in the diffusion of spillovers. A firm's internal absorptive capacity can be viewed as accumulated technological knowledge over time sometimes reflected by age of a firm.

However, most firms in developing countries might not be in a position to accumulate knowledge due to lack of resources and knowledge cannot therefore be taken as a simple function of firm age. Similarly, R&D measures might not be very applicable as most firms hardly undertake it due to lack of either human or technical resources. In such cases, other

indicators like share of technical personnel and the existing level of capital investment become useful. Absorptive capacity depends on the level of technological knowledge in human resources and physical capital investment both important for their complementary role.

5.2 Systemic Infrastructural and Institutional Support Structure

Occurrence and impact of technological spillovers is not an automatic process and cannot be analysed using a handful of selected factors and employing narrowly conceived frameworks. Given the dynamic, uncertain and tacit nature of technology and knowledge, spillover occurrence is an extremely dynamic process largely influenced by a multivariate of factors either internal or exogenous to the firms and sometimes to the country. The implication is that spillovers are beyond the control of the firm as well as the country. Hence a systemic approach would be important for knowledge generation, its exploitation in firm's production, its utilisation for learning to learn and to innovate, and further its diffusion through a dynamic and interactive process. As the literature emphasises, systemic interactions among agents arise from networks and linkages created in the form of sub-contracting relationships or supplier-client linkages that serve to demonstrate technological innovations or serve as stimuli for learning and innovation.

Also emphasised in the same literature is the importance of infrastructural and institutional support structures. Examples include institutions like productivity centres, technology transfer bodies, training programmes and investment promotion councils. Similarly, institutions such as those providing financing play a very active role towards facilitation of innovation based on knowledge acquired in the spillover process. Doner (2001) and Aoki (2001) articulated the role of such institutions as intermediary organisations which coordinate demand-supply relations between firms, government and institutions. They play an important role in strengthening network cohesion. Even those that enforce contractual arrangements play an important role – since as Williamson (1985) demonstrated lack of commitment through long-term contracts leads to under-investment in relationship-specific assets.

5.3 Systemic Embeddedness: Importance of Firm Interactions

The conceptual framework developed regards spillover process as an extremely interactive and dynamic, largely influenced by a multitude of socio-economic agents as well as existing policies which operate in a systemic manner. A strong network cohesion which supports generation and diffusion of knowledge is emphasised [Freeman, 1991; Lundvall, 1992]. Interactions are regarded as important means through which interactive learning, information and technology can be exchanged or jointly exploited for the purpose of productive activities. This implies that interactions among firms, institutions, and government and business associations are likely to stimulate the process of spillover occurrence. Firms embedded in such systems would thus benefit exploitation of spillovers of knowledge, accumulation of capability through learning from demonstration effects.

In light of this discussion, we hypothesise that firms' systemic interactions are important for spillovers to occur. Systemic interactions among agents arise from networks and linkages created – with common ones being vertical and horizontal linkages. Other forms of networks and linkages include informal contracts, membership in formal and informal associations and collaborations. Mytelka and Farinelli (2000) and Saxeniaan (1991) offered detailed discussions on the importance of clustering and networking in promoting new product development, spurring diffusion of new technologies by facilitating information exchange and joint problem solving between firms in an industry and sometimes in different industries.

5.4 Firm Size–Scale Factor

There exists a long debate in industrial organisation on importance of size on firms' competitiveness and now on spillover occurrence. Studies conducted argue that firms achieve competitiveness once they attain a certain minimum efficiency scale (MES). MES is the lowest level of output where the minimum average cost (MAC) is required to exhaust scale economies in manufacturing [Scherer, (1973: 1980); Pratten, 1971]. MES tends to vary with industries. Large and heavy industries, such as steel and metal industry, manufacturing things like trains and locomotion, aeroplanes, automobiles or ship building are characterised by high scale economies. In such cases, a high MSE unit production is required if low unit costs are to be achieved.

To a large extent, big firms may be at an advantageous position in terms of spillover occurrence primarily on account of their ability to mobilise productive resources and other services that are either external or internal to a firm. As an example, there might exist some kind of market segmentation that favours large firms in that only firms above a certain size are able to have access to certain skills, information and credit facilities needed to be competent. Due to their large size, large firms can have more specialised manpower obtained from sustained training while on-the-job or externally including abroad. Large firms often have formal information gathering systems, spend much time and resources to identify and use important external sources of scientific and technological expertise. Large firms usually have more networks with individuals and institutions that provide training, technical information and technical services, which are important inputs in the technological capability acquisition process. The networks enable exchange and diffusion of useful information, skill and technologies. When it comes to financing for capability development, capital market imperfections confer an advantage on large firms in securing finance for technological activities. Availability of capital means more resources to engage in systemic research, labour training and a greater need for structured information gathering. It could also be due to sectoral distribution of activities that due to economies of specialisation only large firms could reach efficient levels of technological capability.

To the contrary, not all industries require high MES unit production. In many cases scope rather than scale is important. For instance, in industries dealing with plastic components or small-batch machine tools, it is scope that is important but not the scale (Piore and Sabel, 1984; Rasiah, 1995). It should also be emphasised that information technology has continued to play a contributory role in making small size very efficient following the increased decomposition and dispersal of production. Several empirical studies now exist which dispel arguments supporting the significance of large size in efficiency and innovative activities [Audretsch and Zoltan, 1991; Audretsh, 2002]. Nonetheless, when small firms make no effort to improve their technological capabilities due to over reliance on labour intensive technologies, the result is weak absorptive capacity, low spillover occurrence, reduced learning and innovation. This point is further supported by the fact that small firms are sometimes characterised by low levels of output sales, which might be inadequate to spread

over the costs of learning and capability building e.g. R&D. They lack resources to identify and exploit important external sources of scientific and technical expertise.

5.5 Age of the Firm

To a large extent, the influence of age on the spillover occurrence is similar to that of size from the perspective of those who associate spillover occurrence with firm size as discussed above. We hypothesise that firms with longer experience are considered to enjoy greater experiential and tacit knowledge than the older a firm is, the more the spillovers are likely to occur. In a period of time, large firms are expected to improve their technical capacity and efficiency than the small firms as large firms enjoy economies of scale with ample resources to spread over learning, capability building and innovation initiatives. In a recent study on Kenyan manufacturing industry, Lundvall and Battese (2000) investigated whether technical efficiency was systematically related to the size and age of firms. Firm size had a positive and significant effect in the wood and textile sectors while the age effect was less systematic, but was significant in all sectors, except textiles.

Linking the size and age of a firm, Jovanovic (1982) argued that firms increase in size as a result of a selection process, in which efficient firms grow and survive, while inefficient firms stagnate or exit the industry. He noted that since the process takes time, larger firms are therefore expected to be older which would imply a positive age spillover relationship. This would be expected based on a firm's accumulated stock of knowledge and experience over time, emanating from various kinds of learning processes undertaken in the firms as they imitate their competitors and MNCs, as they do R&D and search for information or simply as they make incremental innovations. The accumulated stock of knowledge and experience over time amounts to absorptive capacity necessary to recognise external knowledge, absorb it and utilise it for productive purposes.

5.6 Industrial Specificity

Industrial specificity has a strong bearing on spillover occurrence, learning and technological capability building since industries are different. A high level of heterogeneity with significant differences in technological capabilities and capacities to undertake technological learning and absorption exist among industries. This is more so to the extent that even technologies used by MNCs within industrial sectors often differ widely in complexity.

There is a wide array of literature in support of this fact. Take for instance the garments and automobile industries. According to Gereffi (1994: 2002) framework of producer-buyer driven value chains, garments are categorised in terms of buyer-driven chains, while automobiles are characterised by producer-driven chains. In both industries there is increased use of technology and tacit knowledge. While garments have become high technology users, the auto parts have equally become more knowledge intensive. The auto parts industry is closely related to machinery and engineering industries and electronics assembly. This is a tremendous transformation from being labour intensive to knowledge intensive since 1980s (Ernst, 2000; Kraemer and Diedrick, 2003).

Another notable characteristic is that changes in national and international policies over time have significant influences in different industries. In auto parts industry the nature of liberalisation measures pursued seem to erode technological capabilities developed through the import-substitution period. As a result, specialised suppliers of auto parts in some host countries have reduced significantly. Countries like South Africa, Mexico, Brazil, Philippines and Taiwan are typical examples [Barnes and Lorenzen, 2003; Quadros, 2003; Ofreneo, 2003]. With regard to other industries like food processing and beverages, differences arise depending on the nature and characteristics of products processed. Products can vary from small-scale confectionery manufacture to high volume resource-dependent such as fruit and juice packaging by MNC firms such as Del Monte and Chiquita. In these industries too, there is increased use of knowledge and technology. Detailed case studies by Mytelka (1999) and Mytelka and Farinelli (2000) have demonstrated that even traditional industries such as wine producing have become knowledge-intensive.

5.7 Firm Performance

Another determinant of spillover occurence is the level of firm performance. A firm is able to performance well if it has developed a substantial amount of technological capability. Such a firm is characterised by high capacity utilisation, high output performance in terms of sales and profits. Such a firm would be in a position to undertake dynamic strategies; perform basic R&D, recruit well-trained professionals like scientists and engineers, undertake human resource development and other enrichment programmes. These arguments are articulated in industrial organisation, which postulates that a firm's performance is a function of its own endowments, conduct and the systemic environment

characterised by interactions among socio-economic agents [Bain, 1968; Scherer, (1973, 1980)]. This has a direct implication that a firm with high performance offers more room for learning, acquisition of tacit and experiential knowledge all of which enhance firm's absorptive capacity. A high performing firm is also deemed competitive; another important aspect which influences spillover occurrence. When local firms have the capacity to offer strong competition to MNCs, this prompts the MNCs to constantly change their techniques by transferring more of their recent technologies which are in turn imitated by the domestic firms.

5.8 Firm Strategy

Another factor likely to influence spillover occurrence is firm strategy. Examples of firm strategies include process modernisation to enhance efficiency and flexibility of the firm, diversification into new products, capturing new markets including exports. Others include lowering of overhead costs, scale expansion and quality improvement. A firm may also have a strong strategy to broaden its knowledge base through conducting R&D or human resources development by adopting a training strategy in vocational, technical or professional education aimed at improving skills to the technicians, equipment maintenance and other skilled workers. The direct implication of this is that a firm with a demonstrated strong path dependence leading towards absorption capacity accumulation would result in spillover occurrence to the local firms.

5.9 Trade Orientation –Exports and Imports

Trade orientation is another factor believed to have an influence on the spillover process. For instance, exports are likely to result in spillovers in two ways. First, when MNCs in a host country export, and second when local firms begin exporting. To a local firm producing for domestic market, participation in export market would imply adding sunk costs looking for new global markets, establishing international distribution linkages and networks as well as establishing overseas transport infrastructure. Alot of time and effort is required to understand the global regulatory framework and continuously learn the constantly changing consumers' tastes and preferences globally. We hypothesise that local firms are likely to benefit from MNCs existing stock of knowledge on international market and hence enable them to become exporters. This shortens their process, which would have inadvertently

been longer for the local firms. This would take place if the MNCs in the host country produce for export market.

In such cases, MNCs will already have an existing export networks abroad supported by established transport infrastructure internationally. Local firms can benefit from the 'export information externalities' through collaboration or demonstration and penetrate the export markets. The MNCs' knowledge of international market could spill over to the local firms through the MNCs' export activity. Through demonstration effects, the domestic firms can learn or imitate techniques (processing, production, marketing, networks, managerial or organisational) from MNCs, which would in turn enable them participate in the international export market. The arguments are supported by the assimilation literature based on the East Asian miracle. That exports contributed tremendously to development of technology capability building as a result of international spillovers occurring from interactions with MNCs as well as foreign clients abroad [Westphal, Kim and Dahlman, (1985); Westphal, 1990; Rasiah, 2005)].

In the second case, participation in the export market is anticipated to stimulate a dynamic learning process in several ways. First, by introducing pressure to compete in international markets the local firms are made to pay attention to the global tastes and preferences. We can refer to this as learning by exporting. Secondly, participation in the export market forces local firms to increase their technological effort in order to learn continuously and master techniques required in maintaining international competitiveness at the world market. As a result of the two factors, a local firm learns and accumulates technological and absorptive capacity. Even at the local level, the competition for foreign market based on the host country's available resources by the MNCs and local firms stimulates learning and thus improvement on export performance. Export orientation is believed to relax the market size constraint, which means more MNCs and new local firms can enter. The larger the number of firms, the larger will be the spillover effects be as argued by the postulates of agglomeration economies.

Importation by a firm is also believed to have a positive relationship with spillover occurrence. A firm is likely to increase dramatically its level of technological knowledge

particularly when imports are sourced from countries with frontier R&D and innovative capabilities. Imports of new capital and intermediate goods are viewed as some of the main channels for international transfer of knowledge, technology and innovation. In this regard countries that participate in imports benefit the foreign technologies (Coe, Helpman and Hoffmaister, 1997). The proponents of international trade have elaborated this in detail (see Posner, 1961; Vernon, 1966; Romer, 1990; Grossman and Helpman, 1995). By importing, the firm learns through imitation, becomes innovative and at the same time builds absorptive capacity necessary to absorb spillovers.

5.10 Labour Market Conditions

Labour market conditions often influence spillovers occurrence, learning and capability building and innovation. When analysing labour market conditions, the most common factors examined include wages and affiliation to trade unions. Related studies examining the role of labour market conditions indicate that good labour conditions can positively contribute towards industrialisation by stimulating competitiveness [Piore and Sabel, 1984; Zeitlin, 1989; Wilkinson and You, 1995]. The same studies have shown the converse to be also true involving low road to industrialisation when good labour market conditions are not observed. In the current context, we argue that when a firm observes good labour market conditions it is bound to pay high salaries and wages, offers fridge benefits, provides staff with human resources training opportunities including enrichment programmes etc. In such cases, however, the workers morale is motivated reducing their willingness to leave their jobs. Hence the premium paid involving professionals, skilled and technical workers translates into reduced spillover occurrence, which would inadvertently occur through mobility of such workers[3]. Contrary to the above, if the labour market conditions are just fair, uncertain or even bad, then the mobility of workers is bound to be high and so would be the accompanying technology spillovers.

6.0 Summary and Conclusion

The purpose of this paper was to provide an analysis of FDI and spillover literature and propose a theoretical framework which would guide future analytical work in spillover analysis appropriately. A critical assessment of both theoretical and empirical literature on

[3] Note that good labour conditions could also imply positive impact of spillovers on firms' capabilities.

spillovers from MNCs revealed that most of the existing work relied heavily on theories of production function. It also emerged that although estimation techniques had evolved significantly since the pioneering work, the results of spillover occurrence including their economic impact remained largely inconclusive. While on one side the productivity approach produced evidence supporting spillover occurrence, the other side produced contradictory evidence showing lack of spillovers from FDI. This paper argued that, differences in the results obtained could be attributed to many things ranging from use of different methodologies, firm and industry variations to country specificities all of which were largely ignored.

On the basis of the emerging issues and following developments in the endogenous and evolutionary literature, an alternative framework was suggested. Technological spillovers were viewed as complex in nature, uncertain, imperfectly understood and as something which required a more complex analytical approach. An endogenous, evolutionary and institutional approach that views enterprises as embedded in dynamically changing economic and social-economic-institutional networks would be required. For this reason, in addition to the spillover literature, two strands of theoretical literature were adopted; cluster and network dynamics and technological innovation.

The literature on FDI spillovers was pioneered by Caves (1974: 1982) applying production function framework. This was latter followed by a plethora of related works employing a similar framework [Globerman, 1979; Blomstrom and Pearson, 1983; Blomstrom, 1986; Blomstrom and Sjoholm, 1999]. This literature has been advanced by recent studies which have introduced new methodologies taking into consideration new dimensions, instruments and dynamics such as time variations, industry type, locational and other spatial variables (Haddad and Harrison, 1993 and Aitken, Hanson and Harrison 1997). The spillover literature has also been advanced by the proponents of new growth theory whose emphasis is on endogenous technological change, accumulation of human capital and openness to international trade and investment [Lucas, 1988; Romer, 1990; Aghion and Howitt, 1990; Coe and Helpman, 1995; Grossman and Helpman, 1995]. They all emphasise the importance of spillovers in long run economic growth and development.

The literature on clustering and network dynamics is founded under the theory of industrial organisation and begins with the pioneering work by Coase (1937), Chandler (1977), Richardson (1972) and Williamson (1985). It extracts elements of transaction costs and institutions economics. Voluminous work now exist that support examples of effective industrial networks, where cooperation, market forces and social capital such as trust have been cited as important elements in the formation of production relationships (Brusco and Sabel, 1981; Brusco, 1982; Piore and Sabel, 1984; Saxenian, 1991). Industrial networks of individual enterprises help to reveal various kinds of spillovers that occur – whether pecuniary or non-pecuniary – and investigate their impact on technological learning, capability building and innovation.

The third strand of literature adopted relates to economics of technological innovation, which emphasises the importance of firm technological learning and capability in incurring technological change and innovation. This literature is founded under the broad framework of evolutionary economics recently advanced by Nelson and Winter (1982), Rosenberg (1982), Freeman (1985), Stoneman (1983), Metcalfe (1989), Freeman and Soete, 1997 among others. This has in addition motivated the development of national system of innovation framework [Freeman, 1991: 1995; Lundvall, 1992; Nelson, 1993].

This paper drew insight from the three theoretical strands overlapped. For illustrative purposes the paper considered production spillovers. The framework incorporated four spillover channel identified – competition, linkage, labour mobility and demonstration effects. Technological spillovers occurring through each of these channels are further conceptualised in the same way – technological changes, learning and capability building. It was shown that firms respond to external stimuli, skills, knowledge or technology transferred by implementing dynamic technological changes. Such technological changes include modifications, improvements and extensions meant to improve efficiency and increase firm productivity. As emphasized in the technological innovations literature, introduction of technological changes is important in learning and capability building as it provides learning in firms – learning by doing, by watching or by experimenting – resulting in explicit, experience and experiential knowledge accumulation. This helps increase firms' endowment

of technical and tacit knowledge, skill base and capability and subsequently their ability to innovate.

For each of the spillover occurrence channels considered, five kinds of technological changes associated with production capability building were identified; production changes, process changes, industrial engineering, new marketing strategies, management and organisation changes. The degree to which each technological change takes place was determined subjectively in the firms on a continuous gradual ordinal scale. On the basis of this scale an index (spillover index) was computed which we considered as the proxy for spillover occurrence.

The computed index would enable determination of the extent to which spillovers occur, their kind as well as the channels through which they occur most. It was further shown how use of such an index enabled quantitative analysis of spillovers including mechanisms (competition, linkages, labour mobility and demonstration effects). Further, an empirical examination of spillover determinants (necessary conditions for occurrence) can also be investigated using the same index. As a conclusion the use of alternative framework enables a suitable analysis particularly relevant for FDI spillover policy intervention in a technically backward country.

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