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Divergence and Convergence: An Exploration

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Divergence and Convergence: An Exploration[1]

Abstract

Literature in economic development shows how countries diverge and converge in economic growth owing to technological change and capital accumulation. In this paper, I examine micro level divergence and convergence of best practices of firms within a broadly defined industry. Multinational investment in developing economies is one of the means of technology flows globally. If local firms have a critical level of capabilities and are able to compete with multinational firms this can lead to technological convergence and consequent economic growth. I have reviewed pertinent literature. I have empirically tested some of the underlying propositions with the case of rivalry between a local firm and a multinational firm in India's two-wheeler industry. The statistical exercise shows a process of convergence of practices of the two firms over a period of 15 years.

Keywords: Competitive Rivalry, Best Practices, Divergence, Convergence, Multinational firms, Local Firms

1. Introduction

In the Schumpeterian world of 'creative destruction' when a firm innovates, it gains an advantage over rivals and generates turbulence in the market structure. Imitation efforts of other firms determine the process of convergence. Innovation and imitation are basically the cycles of divergence and convergence. This process takes place at both micro level of firms and macro level of economies.

In a recent book, Michael Spence (2011) discusses the new dynamics of convergence in economic development between developed and developing economies. In the historical context, around 1820 China and India accounted for 50 percent of the world income. Industrial revolution took place in England around 200 years ago and it spread within Europe, and to North America, Japan, Australia and New Zealand. However, it did not spread to countries such as China, India, African and Latin American countries. As a consequence, the West diverged in economic development while countries in the East declined economically except for Japan. As a matter of fact, Indian economy declined under the British rule (Clark and Wolcot, 2001). Spence shows convergence of economic development between the developed and developing world for the last 40 years citing examples of China, India and Brazil. He attributes this to globalization and rapid flow of technological change across the globe. One of the ways of technological flow is through multinational investment. If a developing economy has some critical endowment of capabilities of skill labor, industrial endowments and growing markets, multinational firms (MNCs) enter to take advantage of low cost skills for global markets as in the case of India's software industry (Patibandla and Petersen, 2002) and also to cater to growing local markets as in the case of two-wheeler and automobile and electronics industries in India. In response to competition from MNCs, if local firms make efforts improve upon their technology and organization, there will be a process of convergence of best practices between MNCs and local firms. This micro-level process reflects in aggregate growth of an economy. I have considered micro level firm level practices in terms of strategic behavior, technology, organization and product differentiation. In Section 2, I have reviewed the pertinent literature. In Section 3, I test some of the underlying propositions with the case of competition between a multinational giant Honda and an Indian firm Bajaj in India's two-wheeler industry.

2. A Brief Review of Literature

I review literature on issues related to strategic behavior and product differentiation, technology and organization to understand the process of convergence of best practices.

2,a. Strategic Behavior

In the industrial organization literature, strategic behavior of firms is examined through applied game theory. In management literature, the focus is on how firms derive competitive advantage and sustain it (Porter, 1980) which could be based on cost and differentiation strategies.

The basic foundation of applied game theory is Nash games and equilibrium. If we consider the symmetric case, two agents play a one shot game by taking other's action as given and each agent does what is best for himself/herself without knowing other agent is doing the same. Pay offs are equal in equilibrium and there is no unilateral incentive for the agents to move from the equilibrium. Introduction of asymmetries such as time, one agent knowing the other's strategy and differences in costs are the basis of firm level relative advantages through strategic play (Dixit and Nalebuff ,2010; Brandenburger and Nalebuff, 1996). When we consider, Cournot-Nash competition in quantities, firms with different market shares can coexist in equilibrium. The differences in market shares are a result of relative advantages of firms in terms of their ability to internalize other firm's reaction function (Stackelberg), first mover advantages, and possessing superior technology.

 If one starts from an equilibrium in which firms with different market shares exist, convergence of a smaller firm to a larger firm depends on its ability to neutralize the relative advantage of the firm with higher market share. The theory helps in identifying the possible strategic choices for firms to convergence with the dominant firm. For example, if the dominant (larger) firm has its advantage in being the first mover, the later mover can neutralize the advantage with superior technology and product differentiation. [2]
On the other hand, large markets bring out forces for both divergence and convergence. For example, a large market with consumers with diverse preferences can give opportunities for firms to differentiate their products both on horizontal and vertical lines similar to microeconomics textbook case of monopolistic competition. An example of a rational divergence strategy is that a potential new entrant into a market is in a position to observe the choices already made by an incumbent and can seek to find a market entry by differentiating himself or herself from the incumbent by assessing the distribution of diverse preferences and abilities of buyers. However, when firms compete for consumers with diverse preferences there could be pressures to convergence in product characteristics similar to Hotelling location model. A simple example of this is how one differentiates Pepsi from Coca-Cola in soft drinks industry.

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[2] The case of Wal-Mart shows the competitive advantage was created by strategic moves into markets untapped by rivals. In the beginning, Wal-Mart identified small towns as potential market. By moving into small towns and investing in capacities for economies of scale, it has been able to prevent new entry as the market size of small towns can support only a single firm with economies of scale similar to a natural monopoly.

Nash games show that maximization of self-interest of players could result in prisoner's dilemma. Cooperation or collusion is better than competition between the players. Cooperation is seen to arise out of learning through repeated games. It is conceivable that such a repeated process could lead to competitors adopting similar strategic positions and controlling similar bundles of resources. However, the collusion between oligopoly players is welfare-inferior in the term the market structure becomes a monopoly at the cost of consumers. This is where the regulatory institutions such as the Anti-trust in the US and competition policy commission in India have to play an important role in restraining this outcome.

Strategic groups framework (Porter, 1985) in management literature posits the existence of mobility barriers within an industry which are the raison d'être for the formation of strategic groups in the first place. These mobility barriers offer some degree of protection against competitive imitation and some insurance against the leakage of the resource and capabilities on which competitive advantages are built. Mobility barriers may be thought of as resource-based advantages enjoyed by firms that allow them to preserve some level of distinctiveness. Firms located in different strategic groups may confront mobility barriers in the short run that prevent them from imitating the strategies of their more successful rivals. Head on competition is thus reduced to competition with a smaller set of firms that occupy the same strategic group as the focal firm. For example, when Japanese firms entered the international markets for electronics and automobiles in 1950s and 1960s, they entered the strategic group of low-quality goods where there were low-entry barriers and later moved up on to the top level strategic groups which implies breaking-up of mobility barriers and converging with the best practices in an industry. Similar was the case of the South Korean firms since the1960s.

2.b Technological Evolution and Convergence

As mentioned, in the Schumpeterian world of 'creative destruction', when a firm innovates in technology, products and practices, it generates turbulence in the market by taking away markets share from rivals. The optimal response of the rivals is either to imitate or innovate. Incentives for innovation emanate from the market and institutional conditions to internalize the rents. Larger is the imitation lag, higher are the rents.

The neo-classical growth theory (Solow, 1988) shows that economic growth is a function of technological change and capital accumulation. Technological change is taken as exogenously given. As physical capital is subject to diminishing returns, economies should converge in the economic growth which did not take place between the West and East for quite some time. The new-growth theory (Romer, 1990; Lucas, 1988) takes technological change as endogenous emanating from the private and public agents investments in

human capital and R&D in response to incentives of markets and intellectual property protection. Investment in human capital is subject to increasing returns owing to learning economies. New technologies can be characterised by non-rivalrious and non-excludability conditions. Non-excludability implies new technologies have some public property characteristics and spill-overs (externalities) to other firms. Non-rivalry implies that use of a new technology or a blueprint (or a new idea) does not preclude others from its' use- there can be a simultaneous use by large number of agents.[3] The larger the number of users, the larger is its' aggregate value. International trade and investment increases the number of users. Most of the innovations take place in the developed economies with vibrant National Innovation Systems (Patibandla, 2006). Innovating firms enter growing developing economies as MNCs to realize economies of scale and increase their profit volumes. This is where the issue of convergence of technology becomes relevant. The optimal competitive response of local firms in a developing economy is to expropriate the public goods nature of new technology from the presence of MNCs and make efforts to imitate the best technology practices by importing from developed countries, buying licenses and adopt them to local conditions by dealing with codified and tacit elements of new technologies. If local firms are successful at this, there will be a process of convergence.

2.1 Vertical Integration and Diversification

Coase (1937) argued that a firm as an organization comes into existence to economize on transaction costs of markets. The firm internalizes economic activity until marginal internal bureaucratic costs of hierarchy are equal to the marginal transaction costs of the market (boundaries of the firm). Williamson (1985) conceptualizes differential transaction costs through the lens of contracts. They differ in three critical dimensions; frequency, uncertainty and asset specificity. All contracts are incomplete. It is not possible to incorporate all possible contingencies into a contract. The behavioral assumptions are bounded rationality and opportunism. Bounded rationality (Simon, 1957) refers to behavior intendedly rational, but limitedly so owing to informational imperfections and cognitive abilities. Opportunistic behavior is conceptualized in terms of self-interest with guile. In the *ex ante* stage of a contract, the market is competitive. Once two agents get into a contract, it becomes a bilateral monopoly. Guile implies that when contracts are incomplete, agents renege on their promises when the environment changes or when one realizes that the other party has invested in assets specific to the contract (locked-in). Given the differential dimensions of

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[3] As shown by Romer (1990) nonrivalry has two important implications for the theory of growth. First, nonrival goods can be accumulated without bound on a per capita basis, whereas a piece of human capital such as the ability to add cannot. Each person has only a finite number of years that can be spent acquiring skills. Secondly, a nonrival good besets knowledge spillovers which implies incomplete excludability. These two features of knowledge- unbounded growth and incomplete appropriability- cause long run sustained growth.

transaction costs, agents choose different governance structures; markets, hierarchy (integration), hybrids (such as franchisees, to some extent joint ventures) and public bureaus. For investments with high degree of asset specificity, the preferable governance is integration.

Following question is why not one large company does the economic activity instead of numerous companies in an industry. An explanation for this can be seen in terms of differential abilities of entrepreneurs and managers in managing a large company. The bureaucratic costs of one large single company are higher than the sum of bureaucratic costs of *N* number of companies in an industry.

When a company becomes large, one way it can reduce its internal bureaucratic costs are by decentralization of *M-form* organization to reduce informational overload at the top. In many industries, one observes both decentralized *M-form* and also centralized *L-form* firms. The question is, if *M-form* is better at internal coordination, why do all large firms not adopt *M-form* instead of *L-form*? Stylized empirics show that *L-form* firms tends to be family-owned and *M-forms* tend to be professionally run companies- the examples are Ford Motors and GM in the US automobile industry. The objectives of the two forms could be different with the professional companies driven by short-term profits and shareholder interests, while family-owned firms focus on long-term ownership objectives.

Chandler (1977) showed that large integrated firms dominated most sectors in the US since the early part of the twentieth century. Large corporations enjoyed economies of scale and scope and an extensive brand image, and gave formidable competition to new entrants. The firms were vertically integrated because they were set up when the industry was young and very few suppliers of intermediate goods existed. As in Williamson's thesis, the suppliers could not be persuaded to set up units because all they could see for the forceable future was a monopolist buyer and investments with a high degree of asset specific investments. In the 1980s and 1990s, the organization of large corporations went through drastic changes with a process of vertical disintegration. One can argue that it was result of development of capital and intermediate input markets and also induced by the entry of Japanese business groups in the global markets.

The Japanese firms adopted the lean production practices and developed the concept of outsourcing and supplier firms. Cost and quality advantage arising out of these practices made the Japanese auto-mobile and electronic companies shake up the world markets in the 1980s and 1990s forcing companies in the US and Europe to adopt some of the Japanese practices. Consequently, most companies in the US and Western Europe have become focused companies. However, the Japanese and South Korean companies still remain diversified- a part of the explanation can be drawn from the organization of their capital markets.

There is no systematic theory to explain un-related diversification. Penrose (1959) shows that an entrepreneur or a manager acquires different resources and capabilities at different stages of a firm. In starting a firm, he/she needs project-implementation skills. Once the firm is established and starts to function, project implementation skills are no more needed. The manager can sell these resources or if he/she acquires strong advantage in these resources, he/she can use them to diversify into other areas. An example of this in India is the large diversified business of the Reliance Corporation (Patibandla, 2006). Khanna and Palepu (2000) extend the transaction cost logic to rationalize that diversification into unrelated areas in developing countries takes place for economizing on transaction costs of capital and labor markets.

One could argue the other way round that capital market imperfections of better access and low cost of capital to the family businesses compared to new entrants and smaller firms, and ability to procure contracts and licenses; help family businesses to increase diversification (Patibandla, 2006a). The diversified business groups can undertake cross-subsidization to compete in those areas where focused companies are highly competitive. If the transaction costs of the markets and capital market imperfections decline overtime, the diversified business groups lose their competitive advantage to focused companies. In other words, convergence of business organization may take place.

3. Empirical Exercise

After following years of closed and protectionist policies since 1950, India started to open up some of its industries such as two-wheelers and electronics to multinationals in the mid 1980's. Until then, the two wheeler industry was dominated by an Indian firm, Bajaj. The Japanese Honda Corporation entered the industry in the mid-1980s with a joint venture with an Indian firm Hero whose earlier business was bicycle production. The competition process between these firms since then is an interesting case for the issue of convergences.

One can approach the issue by looking at: (1) exogenously given asset position of local firms prior to the economic reforms of institutional change, and (2) given the differences between local and multinationals after the reforms, how do MNCs and local firms differ in acquisition of different assets and changing internal processes in response to competition between each other. The are pre-existing differences in capabilities between MNCs and local firms because MNCs enter the local market having acquired assets and processes in relation to their home and global market operations, and local firms have acquired their firm- specific assets and processes in relation to the market institutional environment in the local market

prior to the policy shocks. The prevailing institutional conditions in the post-reforms period provide certain relative advantages and disadvantages to incumbent local firms in relation to new entrant MNCs.

In sequential entry oligopoly models, given all other things equal, a first entrant will always have an advantage over a late entrant. First entrant will be a Stackelberg leader and the late entrant the follower firm. Furthermore, a first entrant can have advantages in lower cost of production because of internalization of learning economies. A new entrant can dislodge an incumbent firm by superior technology.

One can simplify the relative advantage of a MNC over local firms its superior technology, which provides them with a production cost advantage. Local firms' relative advantage can be simplified into their country-specific related institutional experience being the incumbents (first entrants). This aspect is germane to developing economies where markets are subject to complex and diverse institutional conditions. The different sources of relative advantages of MNCs and local firms determine the qualitative behavior of local firms and new entrants in the post-reform period.

Relative production inefficiency of local firms was a result of operating in a highly protected Indian market with a high degree of market power for long in the pre-reforms period. The response for an incumbent to the entry of more efficient MNCs in the post-reforms period is to sever itself from the past investments and adopt more efficient technologies and organisational practices.

On the technology front, most Indian firms were observed to have made minimal investment in R&D assets in the pre-reforms period (Patibandla, 2002). Generally, older vintage technologies were imported and minimal efforts were made in adapting them and building technological dynamism. Consequently, most Indian firms were far below the international technology frontiers. Most Indian firms have been family-run businesses with a highly centralised organisational structure. In the pre-reforms period, economising principle of designing organisational structure was not a major concern for Indian firms as they had access to a highly protected and non-contested home market. Indian firms appeared to have fondness for creating too many hierarchies- a part of the explanation can be drawn from the cultural factors. In a typical large Indian firm, hierarchy levels range between 15 and 20 categories and within six or five broad categories, there were three or four sub-categories (Patibandla, 1998).

In response to competition from new entrant MNCs in the post-reforms period, local firms in India appear to replace technological assets with less difficulty than organisational assets. Local firms adopted more

efficient technologies through imports and increased expenditure on R&D. However, organisational change among Indian firms is subject to path dependency and inertia. The inertia and other institutional factors such as India's labor laws and trade unions constrain firms in firing or replacing employees, and make organisational change a difficult process. A few local firms while starting new plants in the post-reforms period were able to adopt more efficient organisational practices but the employees in older plants resisted the change.

Low cost is necessary but not sufficient for a new entrant MNC to penetrate the Indian market when one brings in the institutional elements. New entrants' knowledge of or experience in dealing with Indian market institutions is negligible in the beginning of entry into the Indian market. This implies it takes time for a new entrant to penetrate Indian market irrespective of its superior technology and organisation. For example, replicating a local distribution network and building long-term relationship with vendor firms may take years for a new entrant. Local firms have an advantage over new entrant MNCs in their experience in dealing with Indian institutional conditions that still cause high market transaction costs. Local firms also cultivated long-term contract relations with dealers and vendor firms.

These (exogenously given) relative advantages and disadvantages of incumbents and new entrants at the time of the policy reforms determine their behavioral response in the post-reforms period. Local firms increase their investment in technology up-gradation by importing vintage technologies and adapting them to local conditions through research and development. As MNCs bring in advanced technologies developed and market tested in the international markets; they do not have to invest in R&D in their Indian subsidiaries. MNCs have to invest significant resources on distribution, marketing and advertising.

In the long-run, the process of convergence is local firms improving upon their technological and organizational efficiency and MNCs acquiring local distribution and institutional knowledge. Local firms' ability to improve production efficiency is a result of the competitive rivalry and also spillover process (externalities) of the MNCs' operations in India. Property rights of intangible assets of MNCs are underdeveloped and as a result they are partially public goods. Others can use assets developed by one firm at a small cost. This convergence process is illustrated by a simple model in Appendix 1.

3.a. Methodology of Observing Convergence

I have undertaken a simple statistical exercise in examining the proposition of convergence, which is presented in Table 1. The conceptual methodology is given in Appendix 1. As mentioned before, I have

considered the case of two firms, one a local firm and a MNC in the two-wheeler industry, Bajaj and Hero-Honda, as the samples. These companies have been competing intensely for a long period ever since 1985 when Honda entered the industry in response to the reforms. Detailed firm- level time series data for these firms is collected from the Center for Managing Indian Economy (CMIE) for the period 1989 to 2003. I measure a set of variables for the two firms.

Variables:

TE: Technical efficiency of production. The methodology of estimating *TE* is shown in Appendix 2.

*MS: M*arket shares of firms. Sales of a firm/Total industry sales

DIS: Distribution expenditure/Sales

ADS: Direct advertising expenditure/Sales

RDS: R&D expenditure/Sales

PLS: Plant and machinery /Sales

VI: Vertical integration (Value-added/Sales)

EXS: Exports/ Sales

IMS Imports/ Sales

AMS: Administrative expenditure/ Sales

For each variable, the differences between each observation of the two firms is taken and squared (to eliminate minus values) for 15 years. The time period is segregated into three segments each one consisting of five time observations. I have measured the means (averages) of differences (squared) of each observation of the variables of the two firms for each of the time period. If there is a convergence, the values of the means of the variables should decline over the three periods. As shown in Table 1, there had been a significant decline in the differences in relative efficiency of production (*TE*) and corresponding market shares. In the case of the response variables of distribution, advertising and R&D to sales variables, there is an increase in the differences from period 1 to period 2, but there is no noticeable decline from period 2 to period 3. Similar is the case with respect to plant and machinery to sales, administrative expenditure and the organizational choice of vertical integration. Overall statistics show there had been a noticeable degree of convergence of the basic characteristics of the competing local firm and the MNC.

Table 1: Convergence

Bajaj and Hero-Honda: Two-wheeler Industry

Time	*TE*	*MS*	*DIS*	*ADS*	*RDS*
1.1989-93	48.93	17.68	0.0016	0.0067	0.0002
	(6.22)	(4.25)	(0.0008)	(0.0063)	(0.0002)
2.1994-98	40.19	14.18	0.003	0.005	0.0005
	(6.72)	(3.6)	(0.001)	(0.005)	(0.0005)
3.1999-03	17.71	7.35	0.002	0.0059	0.0004
	(19.46)	(5.92)	(0.001)	(0.0004)	(0.0001)

	PLS	*VI*	*EXS*	*IMS*	*AMS*
1 1989-93	1.48	7.43	0.046	0.998	0.009
	(1.71)	(1.51)	(0.046)	(1.72)	(0.012)
2 1994-98	2.83	8.02	0.013	0.579	0.019
	(1.73)	(2.75)	(0.012)	(0.423)	(0.012)
3 1999-03	2.09	4.09	0.024	0.91	0.014
	(0.64)	(3.46)	(0.019)	(0.71)	(0.003)

Figures in the parentheses are standard deviations

I briefly discuss the response process of the local firm Bajaj in improving technological and organizational efficiency in response to competition from Hero-Honda. Bajaj sourced technology and licences from Austria, Italy and Japan. It augmented in-house investment in R&D. In order to deal with the tacit elements of technology transfer, it took a group of its engineers to plants abroad to get first-hand learning of the new advanced technologies. It undertook organizational restructuring for adaptation of the technology and achieving operational efficiency. The new organizational approach is shifting from a top-down approach, typical of a family- run highly centralized organization, to a bottom-up approach. On the shop floor, workmen and section managers are grouped into cells and the members are guided by the self-management approach. All the cells were interlinked for a smooth information flow and coordination system. Nearly five thousand workers were given voluntary retirement. Manpower productivity in terms of the number of

vehicles produced per man-year improved by 88 per cent between 1988 and 1998 (Bhudiraja et al 2003). The company developed selective vendor firms for the supply of specific components with long-term contracts and facilitated joint ventures with overseas firms for technology development. In the late 1990s, when consumer preferences shifted away from scooters to motorcycles, the company was able to adjust by developing motorcycle models. By the early 2000s, Bajaj, which had almost lost out to Hero-Honda, was able to derive a relative advantage over the MNC owing to its focus on cost efficiency and its responsiveness to market trends. On the other hand, Hero-Honda depended on the home R&D base in Japan for technology, which hampered quick response to market trends. Bajaj was able to respond swiftly to market trends, able to introduce an entire range of two-wheeler models. In the process, it was able to launch innovative product developments such as two-wheeler model hybrids between motorcycles and scooters to cater to the consumer preferences in India.

There is evidence on convergence of product differentiation strategies of the two firms. Prior to the reforms, scooters, manufactured by the Indian firm, Bajaj were predominant in the market. In the post-reforms period, Honda introduced motorcycles using Japanese technology. As mentioned before, Hero-Honda grew rapidly taking away the market share from Bajaj. In the middle of the 1990s, consumer preferences shifted away from scooters to motorcycles, giving an advantage to Hero-Honda with 4-stroke motorcycles. Bajaj invested in R&D and developed 4-strokes engines imitating Hero-Honda. Bajaj Pulsar motorcycle models were able to gain market share at the expense of Honda's Splendor. Honda on the other hand was able to break the Bajaj stranglehold over the economy segment. Honda's CD Dawn took the market share from the Bajaj's Boxer. By the year 2004, the model sold by both the firms looked quite similar in characteristics and features with close range pricing.

4. Conclusion

A recent book of Michael Spence (2011) shows dynamics of convergence of economic development between developed and developing countries that is taking place through globalization and technological change. MNCs investment in developing countries is one the ways of technology flows. If a developing economy has a critical industrial, skill and technology endowments and local firms are able to compete with MNCs, this results in micro-level convergence of best practices. This reflects in aggregate economic growth rate of developing countries. In this paper, I review pertinent literature of micro-level competition between firms to understand whether the institutional change and competitive rivalry between firms lead to a process of convergence of best practices. Some of the underlying propositions from this review are empirically tested with a simple statistical methodology. The sample takes the case of competitive rivalry

between a local firm (Bajaj) and a multinational firm (Hero-Honda) in India's two-wheeler industry over a period of 15 years. It measures a set of variables and tests degrees of their convergence for the two firms. Results show there is a process of convergence of the practices between firms over the time period. The statistical exercise is simple and the sample consists of two firms. More sophisticated empirical exercises with larger data sets could throw interesting insights on the issue of whether convergence of best practices takes place between firms in developed and developing countries.

Appendix 1: A Conceptual Methodology of Convergence

Suppose S_t and s_t respectively denote a vector of state variables for a MNC and a local firm in period t, and R_t and r_t the vector of response variables. Assume that the choice of response variables depends only on the state variable of the firm given that of its competitor.

Then the response vector for the MNC is:

$$R_t = g\ (S_t;\ s_t),\ \text{and} \tag{1}$$

Likewise, that for the local firm is:

$$r_t = \ g\ \ (s_t;\ S_t) \tag{2}$$

The hypothesis of catching up by the local firm implies a process:

$$s_{t+1} - s_t = f\ (S_t - s_t),\ \text{with } f' > 0$$

I augment this latter hypothesis by assuming $f' \geq 0$, to include the possibility that there may not be any catching-up during the sample period, e.g. if the local firm chooses to compete entirely using its response variables. The augmented equation can be written as:

$$s_{t+1} - s_t = f\ (S_t - s_t),\ \text{with } f' \geq 0 \tag{3}$$

Note that if $f' > 0$, not only the gap $(S_t - s_t)$, but also $(R_t - r_t)$ narrows down over time. Initialize time by setting the period of entry of the MNC as 0. If $S_0 > s_0$, then from equations (1), (2) and (3) one of two possibilities is expected over the sample period:

(i) If $f' = 0$, then $S_t > s_t$, and $R_t \neq r_t$ for all t.

(ii) If $f' > 0$, then s_t increases with t over the sample period. In this case, $(S_t - s_t)$ and $|(R_t - r_t)|$ fall over time. This may lead to a situation where they may become statistically insignificant, and then $S_t > s_t$, and $R_t \neq r_t$ may or may not hold in a statistically significant sense over the sample period.

For the empirical exercises, S and s are scalars, and will stand for variables such as *TE*, Distribution to Sales Ratio, Administrative expenditures for capturing internal organizational efficiency of the MNC and the local firm respectively.

(1) Regarding the first part of the proposition, i.e., MNCs, at the time of entry, are superior to local firms in some attributes; I can have the following cases:

(i) If $S_t > s_t$, and $R_t \neq r_t$, the proposition is not rejected.

(ii) If $(S_t - s_t)$ and $|(R_t - r_t)|$ are not significantly different from zero, but s_t increases over the sample period, I cannot reject the possibility of initial differences among MNCs and local firms.

(iii) If $S_t < s_t$, the proposition is rejected.

(iv) If S_t and s_t are not significantly different, while $R_t \neq r_t$, I infer that difference exists between MNCs and local firms, but cannot establish the superiority of either. This is because while a difference in *TE* results in different responses, I cannot have unambiguous prior expectation about the significance of the difference.

(2) Regarding the second part of the proposition, i.e. there is a convergence process; I can have the following relevant cases:

(i) If $S_t > s_t$, and/or $R_t \neq r_t$; and s_t increases in time, I may infer that there is a convergence process.

(ii) If $S_t > s_t$ does not hold but s_t increases over time, I cannot reject the possibility of a convergence process. In this case the initial superiority of MNCs can be argued to have been eroded through spillover, and thus absent in the sample.

(iii) If $S_t < s_t$ and s_t increases through time, the increase cannot be attributed to spillover. It is however possible to suggest (or rather not reject) that the increase of s_t is the result of competition with MNCs rather than a spillover process.

(iv) If $S_t > s_t$, while s_t is invariant in time I conclude that MNCs have superiority but it has not spilled over during the sample period.

(v) If s_t decreases over time, there is no case for a convergence.

Appendix 2: Measurement of *TE*

Firm-level efficiency indices are measured on the basis of Farrell's (1957) production frontier approach. Developments in the efficiency frontiers literature show the derivation of plant-specific time-variant technical efficiency indices by using panel data. The production function defines the maximum possible output a firm can realize for a given level of inputs employed and the technology level. Farrell's method shows relative technical efficiency as the extent of deviation of output realized by a firm (for a given level of inputs employed) from the best practice in an industry.

The panel data techniques of measuring efficiency overcome several well-known shortcomings of the estimates based on cross-sectional data (see Pitt and Lee, 1981). The panel data capture cross-sectional information of firms in an industry and also repeated observations over time for a given firm. This, in turn, overcomes the shortcomings of strong distributional assumptions about composed error terms. Furthermore, this method does not impose the assumption that technical efficiency is independent of factor inputs.

By taking the Cobb-Douglas functional form, I can represent the technology as follows;

$Y_{it} = \alpha + \beta X_{it} + v_{it} - u_i$

where Y_{it} is the observed output, X_{it} is a vector of K inputs: i index firm ($i=1....N$): t index time ($1....t$). a and β are the unknown parameters to be estimated. v_{it} represents random errors. u_i ($u_i \geq 0$) represents technical inefficiency with one-sided distribution which means that output must lie on or below the frontier. The random error v_{it} is assumed to be identically and independently distributed across firms and time with identical zero mean and constant variance. It is also assumed to be un-correlated with factor inputs. The other error component, u_i, is assumed to be independently and identically distributed across plants with mean m and variance s_m^2. I can rewrite the above equation as

$Y_{it} = (\alpha - u_i) + \beta X_{it} + v_{it}$

Cornwell et al (1990) introduce a parametric function of time into the production function to replace the coefficient of plant-specific technical efficiency. The functional form is

$Y_{it} = X_{it}\beta + \alpha_{it} + v_{it}$

Where $a_{it} = w'_{it} 0_i$, $w' = (1, t, t^2)$, $0_i = (0_{i1}, 0_{i2}, 0_{i3})$; and other variables are as defined before.

The model allows the rate of productivity to vary over time and firms. The production function can be estimated by OLS, which is referred to as the `within estimator' in the literature. The residuals of the

estimated function are used in deriving the efficiency indices. OLS estimation of the production function can be justified in terms of the Zellner-Kmenta-Dreze proposition that, under the assumption of maximization of expected profits, the explanatory variables and the disturbance term are un-correlated. However, α'_{it} is not consistent as T goes to infinity if factor inputs are correlated with firm and time specific effects. Under these conditions, the consistent estimators of α'_{it}, as time goes to infinity, can be derived by estimating the equation using OLS directly. The production function is estimated by the two input Cobb-Douglas production functional form with value-added as output, and L (salaries and wages) and K (rental value) as inputs normalized by appropriate prices.

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