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CHINA'S TRANSITION TO A KNOWLEDGE ECONOMY

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Introduction

The Coastal regions of China have benefited more from reform policies associated with China's research and educational sectors. These reforms were put in place to ensure that the results of knowledge creation activities from universities and research institutes 'spilled over' into the entrepreneurial economy. Human Capital is important to any knowledge activity whether creation or transfer. The development of Human Capital is through education .This factor may ultimately be responsible for long term growth by technological innovation .In this context it is necessary to discuss the two dominant schools of thought regarding economic growth before considering other aspects of knowledge spillovers.

Neoclassical and Endogenous Economic Growth

The traditional model of neoclassical growth is represented by the Solow model[1] which links the production of goods in an economy, with factors of production such as labour and capital, using a black-box production function. Often associated with the neoclassical production function is the economic concept of constant returns to scale .The implication of the latter with regards to the output of the production process is that if factors of production are increased by a factor X, then output will also increase by the same factor X. Moreover, because the amount of capital increases the extra amount of good produced begins to decrease. This is to say that there are diminishing returns associated with capital. Furthermore, demand for goods is dependent on consumption and investment. In this respect consumers save a fraction of their income and do not spend all their income. The level of capital stock is determined both by investment and the rate at which capital stock depreciates. When the amount of investment in the economy equals the amount of depreciation of capital stock, the economy is at a steady state representing long run economic growth. If the level of saving in the economy is high, the economy will maintain a large capital stock and subsequently a high level of output in the steady state. However, the economy cannot maintain a high level of output in the long run. Sustained economic growth is explained by population growth; and technological progress is outside the model and is independent of the use of economic resources.

The other school of thought with regards to economic growth is the so called Endogenous growth theory. Endogenous models of economic growth take the form: $\mathbf{Y} = \mathbf{K}^{\alpha}.\mathbf{A}(\mathbf{L})^{1-\alpha}$. Technological progress is endogenised and is represented by A. Unlike the Neoclassical production function

[1] Solow, R (1956),'A Contribution to the Theory of Economic Growth', The Quarterly Journal of Economics,Vol.70,No.1 (Feb 1956) PP 65-94.

represented by the Solow Model[2], the production function does not exhibit diminishing returns to capital. Human capital is introduced into the model has a component of capital in order to counteract the diminishing returns phenomenon often associated with the non-human form of capital. Furthermore, knowledge is assumed to be a form of capital; and as it is less likely to exhibit diminishing returns to capital, the production function is assumed to exhibit constant returns to capital. The latter is, therefore, assumed to explain long run economic growth. Moreover, Endogenous growth theory focuses on two aspects of growth with regards to technology. Firstly, the marginal cost of use of the technology by an additional worker is negligible .This feature distinguishes technology from other factors of production such as physical capital and labour. For the latter two factors of production the marginal cost of using an additional factor of production can be infinite[3].Secondly, the return on technological investments can be separated into a public return and a private return. The implication of this is that the innovator/inventor gets a return which is a sufficient to act as an incentive to innovate / invent; while the public return is the benefit gained by the user of the newly developed technology – the so called knowledge spill over effect. Neoclassical growth theory limits the extent of economic growth due to government fiscal policy to a short-term effect. Long-term economic growth is due to exogenous technological innovation. It maybe intuitive to suggest that neoclassical growth theory is more relevant to economies which are already functioning at their Production Possibility Frontier. On the other hand, Endogenous Growth theories attempt to explain cases where underdeveloped economies catch up with developed ones. The implication is that government fiscal policy has long term effects on economic growth. Therefore, in any analysis of the Chinese economy, an Econometric model which treats knowledge creation and technological innovation as endogenous to the model is more relevant than the traditional neoclassical framework. Moreover, an Econometric model founded on Endogenous Growth theory is more relevant for the purposes of analysis and estimation of economic growth in China because China is a developing country which has not yet reached its Production Possibility Frontier. However, an Econometric

[2] Ibid.

[3] Jones, C.I (1995),'R&D Based Models of Economic Growth', The Journal of Political Economy, Vol.103, No.4

analysis which makes use of data such as length of roads, telephone density, school enrolments and other policy related variables in an attempt to analyse China's economic growth will be meaningless because the part of the country which makes the most significant contribution to that growth is the Coastal regions. Furthermore, a major problem with the so-called R&D models is what Jones (1995) defines as 'scale effects'.

R&D Models

Most, if not all R&D models in the literature forecast that if the resources earmarked for research were to be doubled then the growth rate of output would also increase proportionately.[4]This effect is a scale effect and is not borne out by rigorous empirical studies using time series data from industrialised countries. Jones (1995) suggests that if the scale inducing effects of contemporary R&D growth models are removed then the models will produce Solow growth model effects. He postulates that the scale effects are due to the R&D equation implicit in standard R&D models of endogenous growth:

$$\frac{\dot{A}}{A} = \delta . L_A \quad (1)$$ A = Productivity or knowledge, L_A = Labour involved in R&D activity.

As can be seen from equation (1) above the scale effects are due to the fact that the TFP term $\frac{\dot{A}}{A}$ is directly proportional to the units employed in research activity, L_A. Scale effects are negated by changing the variable on the right side of equation from the units of labour employed in R&D activity to the proportion of all labour employed in R&D activity. However, the problems with this formulation of the R&D model are twofold.[5]Firstly, there is the implication that one unit of labour can generate as many innovations as ten units of labour .Secondly, empirical results suggest that increases in TFP are not equalled by the increase in the proportion of labour devoted to R&D activity. Due to the inconsistencies associated with the proportion approach to labour R&D, Jones (1995) constructs a 'semi-endogenous' R&D model derived from these models, by redefining the growth equation in two

[4] Ibid.

[5]Clark, D (1996),"Urban World/Global City", Routledge, New York.

ways. Firstly, the change in knowledge in an economy is equal to the number of researchers multiplied by the rate of innovation. Secondly, the level of knowledge creation is inversely proportional to the stock of existing knowledge. The less the stock of existing knowledge than the higher will be the level of knowledge creation. Therefore, knowledge creation can be defined by the function $\ell = \sigma.A^{\beta}$; and if $\beta > 1$ then knowledge creation generates increasing returns to scale. Finally, the total innovations produced by X units of labour will decrease at a point in time because of duplication and overlap by competing researchers in various institutions. Consequently, Jones (1995) constructs a decentralised R&D model based on Romer (1990). The framework of analysis is the three-sector structure including the final goods sector, the Intermediate goods sector; and the R&D sector. The flow is assumed to be bottom up. In his analysis Jones (1995) focuses on the steady state growth rate of the economy; and the proportion of labour in the R&D sector. Scale effects are replaced by the growth rate of the labour force rather than its level. In this case Jones (1995) relaxes the assumption of increasing returns to scale, assumes growth of the labour force; and the growth path of the economy is balanced. The implication of the latter is that the creation of knowledge is at a constant rate. A growing labour force (researchers) carries with it the implication that the rate of knowledge creation and thus productivity will also grow over time. In this way diminishing returns to productive output in the economy are impeded by the innovative creativity of researchers formulating new inputs. In addition, in deriving a semi-endogenous R&D growth model, Jones (1995) finds that tax incentives and subsidies do not influence steady state growth whereas in the R&D models by Romer (1990) and his contemporaries such effects are endogenised. The main implication of Jones (1995) work is that individuals are the key to the creation of knowledge and therefore productivity growth is directly related to the growth in the number of active researchers then with the growth rate of the population as a whole. The semi-endogenous model endogenises economic growth due to the economic activities of rational profit maximising agents; and differs from the Solow model in this respect. Moreover, the effects of government R&D subsidies have no direct effect on economic growth but only serve to transition the economy from one steady state to another. With regards to this thesis the implication of the work by Jones (1995) is twofold .Firstly, education plays a key role with regards to knowledge creation .And secondly, diminishing returns to output can be mitigated by the increasing returns due to the role of active researchers. It will be shown that the numbers of the latter are greatest in China's Coastal / Coastal regions.

Human Capital

Human capital was introduced by Endogenous growth theory into the production function because the capital component of the typical Neoclassical production function exhibited diminishing returns to capital. It was felt that by introducing a human capital element then the production process could exhibit constant returns to scale .Nevertheless, while Endogenous growth theory counters the diminishing returns effects displayed by Neoclassical production functions, it does not account for the increasing returns effects which some production processes actually display .There are two forms of human capital and both influence economic growth in different ways. Firstly, the highly educated form of human capital which participates in knowledge creation leading to economic growth through innovative technological progress. This form of labour can be defined as skilled labour, L^s .Secondly; human capital is also a factor into the production process contributing directly to GDP growth. This can be treated as unskilled labour, L^{us} .Although there are two distinguishable forms of labour the standard production function treats both as one, acting as perfect substitutes for each other. Furthermore, labour in this form of production function is denoted by h, where $y = k^{\alpha}(A.h)^{1-\alpha}$ .A standard production function which distinguishes labour into its constituent forms; and which has been empirically tested in the literature is shown below:[6]

$$y = k^{\alpha}[(A_u.L_u)^{\sigma} + (A_s.L_s)^{\sigma}]^{\frac{(1-\alpha)}{\sigma}}$$

By distinguishing between unskilled and skilled labour, there is now an implicit assumption that each of the forms of labour will use a level of technology associated with it. In carrying out their empirical analysis on the viability of the altered production function, Caselli and Coleman (2006) have carried out a cross-country study for differences in the production function whilst controlling for cross-country quality of education as well as capital-skill complementarities. As part of their findings they propose that developed countries use skilled labour more efficiently then unskilled labour .The reason

[6] Caselli, F and Coleman, W.J (2006),'The World Technology Frontier', American Economic Review, June 2006.

they give for this is that developed countries use a level of technology suited to skilled labour; while developing countries use a level of technology suited to an unskilled workforce. However, although they account for inter-country differences in skill levels and the use of associated technologies; Caselli and Coleman (2006) do not account for the use appropriate types of technology when intra-country differences in labour skill levels exist, as inevitably they must do. In the case of China there is an abundance of unskilled workers who are employed in manufacturing export driven industries, while skilled educated workers are employed in managerial posts in industry, service industries and otherwise engaged in research. The work of Jones (1995) has indicated the importance of education; and Caselli and Coleman (2006) have made the distinction between skilled and unskilled labour .The New Economic Geography can be extended by suggesting that in China's case, a combination of knowledge creation/transfer and manufacturing agglomeration economies are responsible for long run economic growth. Thus, it is possible to introduce knowledge creation has the increasing returns component of an additive production function whose other component produces constant returns to scale due to manufacturing. In this way the Production Possibility Frontier of an economy such as China's will grow continually due to the effects of education. However, at a theoretical level increasing returns to scale is ruled out.

The literature on the overall impact of human capital on economic growth is split. At a micro level there is a strong correlation between educational attainment and returns on an individual basis. Nevertheless, studies at the macro level have produced contradicting results. Cross-country studies have shown a positive correlation between school enrolment rates and economic growth. However, studies focusing on the stocks of human capital producing a negligible correlation with economic growth, if not a negative one. A new set of empirical investigations into this contradiction, while supporting the positive impact of human capital on economic growth has formulated an analytical framework involving three methodological considerations which any study of correlations between human capital and economic growth should be aware.[7] Firstly, education rather than imparting skills to individuals may act as a catalyst to awaken an underlying characteristic of economic agents.

[7] Fedderke, (2005),'Technology, Human Capital and Growth', Journal of Economic Literature, July 2005.

Therefore, the rates of return to education at the aggregate macro level may not coincide to returns at the micro level. Secondly, the impact of education on economic growth is negatively impacted by the failure to distinguish between the quality of human capital and its quantity. Finally, educational standards, provision and attainment vary between countries. Therefore, any cross country empirical analysis that fails to take this into account will produce results which are erroneous showing that education has an insignificant impact on economic growth at the macro level.

In traditional production functions, both neoclassical and endogenous, human capital is indistinguishable between skilled and unskilled and is merely represented by labour. Furthermore, while allowing the effects of technological change to be attributed to productive activity, the traditional production functions do not identify the source of technological change.[8]However, it may be possible to intuitively link the source of technological change in an economy such as China with a number of factors. For example, the level of government funding of R&D activity; and the implications for educational attainment due to changes in government policy with regards to education. It is also important to consider government policy regarding the establishment of centres of innovation, such as Science & Technology research parks, in combination with policies facilitating the spillover of research results from centres of innovation to commercial enterprises. Furthermore, there is also a need for the resources, institutions and levels of attainment necessary to facilitate the development of the quality of human capital necessary to take part in innovative activities. Fedderke (2005) gives a simple mathematical elucidation of the link between the generation of ideas and the resources devoted to it:

$$\frac{\partial A}{\partial t} = \sigma.\alpha.(t).X(t) - \beta.A.(t)$$

Where σ = a research success coefficient (commercialisation of research),

X = Resources for R&D

α = Proportion of resources devoted to R&D

β = The rate of decay of technology.

[8] Ibid

Thus, technological change is dependent on the proportion of resources devoted to R&D.The greater is the latter (size of α), then the greater will the rate of knowledge creation; and the ultimate rate of technological advance will depend on how effectively research results are commercialised (size of σ). According to Fedderke (2005) the analytical framework represented by the above equation begs the question as to the true source of the advances in knowledge .The answer is that there can only be two sources of advances in knowledge. These include the creation of knowledge and subsequent technological advancement. Nevertheless; these factors are dependent on the stock of accumulated knowledge or the overall command over productive resources.

Learning by doing can improve efficiency in the production process, as hypothesised by Romer (1986).The implication is that when firms undertake investment in fixed capital this aids the learning by doing knowledge creation process .If investing firms are unable to internalise the improvements in the production process then a knowledge spillover occurs .As a result the improvements in the production process applied by one firm allows for the 'learning by doing' of other firms. This process assists in the formation of agglomeration economies at a point in fixed space. It is also implicit in this argument that the learning by doing occurs through on the job learning and innovativeness of individual workers; and that it occurs as a by-product of the individual firm's decision to invest in human capital and the resulting production process. However, the problem with the learning by doing argument to technical change and knowledge creation is that there is a lack of 'intent' in allocation resources purely for the sake of technological advancement; and an incentive on the part of human capital purely for knowledge creation. Knowledge creation occurs purely due to normal work routines on the production line; and while backward and forward linkages may arise, these are often difficult to measure. The difference between R&D led knowledge creation and that which results from production driven learning by doing is that in the former the incentive is for a commercial rate of return while the latter occurs as a by product of the R&D spending by one firm. Knowledge creation through the learning by doing process essentially treats knowledge has a public good. In order to factor in to economic theory the concept that individuals may intently engage in R&D activity; and internalise the benefits resulting from R&D activity it is necessary to give knowledge the characteristics of a private good.[9] Romer (1990) has developed a class of RGHAH models which are evolutionary to the Schumpeterian tradition but which treat knowledge has a mixed good. In this formulation human capital is treated as a rival and excludable good; and accumulated knowledge is treated as non-rival and excludable. In Romer's formulation of knowledge creation activity, knowledge creation is driven purely by technology and human-capital. The reliance of knowledge creation on capital and unskilled human capital is removed. Furthermore, the greater the population engaged in innovative activity the greater the increase in FDI.The is due to the so-called scale effects associated with the RGHAH models. However, as discussed above, Jones (1995) dismisses the scale effects associated with the RGHAH class of models as there are not supported by empirical evidence. A further feature of the Romer (1990) RGHAH analytical framework is that opportunities for knowledge creation never die out. Both Romer (1990) and Romer (1986) follow the endogenous approach to innovation sponsored growth. Fedderke (2005) suggests that the human capital attributable to the creation of knowledge can also be analysed using the neoclassical approach by treating this form of human capital as an additional factor of production, alongside labour, capital and technology. In this way a distinction can be clearly drawn between the purely physical form of human capital and the intellectually innovative form of human capital both of which drive economic growth in different ways.

The results of empirical analysis into the relationship between human capital and economic growth provides contradicting results some of which support the relationship and some which do not support the relationship. However all of the results neatly fall into one of four categories.[10]The first category concerns cross country studies, which using school enrolment rates as a proxy for human capital show a strong link between education and economic growth. However, cross-country studies have been criticised for the lack of robustness of the results they produce which may be due to cross-country variations in quality of education and levels of educational attainment. The second category of macro level studies suggests a negligible effect of education on economic growth, whereas micro level

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[9] Fedderke, J. (2005),'Technology, Human Capital and Growth', Journal of Economic Literature, July 2005.

[10] Ibid

studies point to a strong relationship between the two. The third category of studies models institutions as the long term determinants of the efficiency and productivity of human capital and one study indicates the importance of government policies and institutions. [11] Within this context government policies and institutions play a key role in motivating firms to accumulate capital and individuals to accumulate skills and thus develop the quality of human capital. Moreover, variations in social infrastructure account for productivity differences between countries. In essence, the level of social infrastructure in a country may itself depend on the level and development of human capital. The fourth category of studies focus on identifying the specific determinants of economic growth as well as attempting to explain the paradox between the relationship of economic growth and education at the macro and micro level. One study in this category found that primary school attendance to be the second most important determinant of economic growth. Another study in attempting to explain the macro-micro paradox seeks a resolution to it by assuming that a divergence in the private and social returns to education; and a difference in cross-country educational quality. However, the impact of educational quality on economic growth dissipates once the quality of government institutions is controlled for; suggesting that the quality of education may simply be a proxy for the quality of government institutions.

Endogenous growth theory supports the notion that efficiency gains in an economy take place through technological innovation which itself is driven by human capital. Efficiency gains are typically measured by changes to total factor productivity (TFP). Fedderke (2005) analyses the growth in TFP due to infrastructure in South Africa. He uses sector specific data, in order to focus on the impact on TFP growth of the quality and quantity of human capital; and aggregate data in order to analyse the interaction between social infrastructure and human capital. The results of the regression analysis were twofold. Firstly, human capital as a direct effect on output, with the weight of the impact depending on the quality rather than the quantity of human capital. Secondly, human capital formation is itself dependent on social infrastructure.

Knowledge Diffusion and Growth

[11] Hall, R.E & Jones, C.I (1999),'Why Do Some Countries Produce So Much More Output Per Worker Than Others?' Quarterly Journal of Economics, 114(1).

Berliant et al (2005) have modelled uncompensated knowledge spillovers with a microfoundation. The main argument in their paper is that agglomeration of economic activity, i.e. urbanisation, leads to the efficient transmission of information and knowledge because of the lower costs of communication. The Berliant et al argument is supported by empirical evidence from Jaffe et al (1993) that there is a positive correlation between the employment density in metropolitan areas and patents per capita. Furthermore, the greater the heterogeneity in the knowledge held and information known by individual agents are factors critical to the exchange of knowledge. This is because in the model, agent's trade off a fewer number of meetings with other agents with a probability of greater knowledge exchange against a greater number of meetings. The alternative view offered in this thesis is that transportation and communications infrastructure lowers the cost of knowledge and information exchange. In so doing these types of infrastructures act as a substitute for urbanisation by increasing the economic density of space. Thus, by investing in transportation and telecommunications infrastructure in rural areas low population densities can be magnified, facilitating a reduction in income disparities between the booming Coastal provinces of China and its interior hinterland. The results of the work by Berliant et al (2005) can easily be contradicted by suggesting that access to the Internet facilitates knowledge creation and the Internet is a spatial independent entity.

Knowledge spillovers depend not only how much knowledge individuals possess but also on the differences in the knowledge possessed by each individual[12] .The process of learning depends on differences in the knowledge possessed by each individual; and as Jovanovic & Rafael (1989) point out 'if all of us know the same thing, we cannot learn from each other'. In their paper, Jovanovic & Rafael (1989) consider the relationship between growth and inequality; and the effects of improvements in communications technology on growth. They argue that the build up of knowledge is not a static process but a dynamic one. According to this interpretation 'today's state-of-the-art technology is the outcome of many building blocks, and it embodies many ideas'[13]. Furthermore, they

[12] Jovanovic, B & Rafael, R (1989),"The Growth & Diffusion of Knowledge", Review of Economic Studies 56

[13] Ibid.

argue that the process of knowledge building and exchange involves the interaction of people, a process facilitated by the presence of transportation and telecommunications infrastructure. Therefore, the diffusion of knowledge and its growth are inseparable concepts. Spence (1984) and Arrow (1962) also investigated the process of learning. The former assumed that knowledge spillovers were proportional to the rate of knowledge acquisition. However, the latter assert that it is through the process of learning by doing that the essence of knowledge growth and diffusion are captured because the current knowledge base grows as the number of people using the newly acquired knowledge increases. Nevertheless, as pointed out by Jovanovic & Rafael (1989), both Spence and Arrow did not directly consider the differences in knowledge amongst agents. Knowledge heterogeneity exists because different people have different ideas and innovation takes place because of the differences in ideas[14]. Furthermore, knowledge heterogeneity leads to adverse selection problems in Akerlof's used car market leading to inefficiency and disequilibrium in the market. Jovanovic & Rafael (1989) clearly establish that adverse selection problems become a serious issue when the growth and diffusion of knowledge takes place through imitation rather than by invention. Therefore, in the case of China this is a strong argument for intellectual property law, its enforcement and the protection of patents.

Kuznets (1955) observed that middle developed countries experienced greater inequality than least or most developed countries. Jovanovic & Rafael (1989) observe that while cross-sectional and time-series data agree that income inequality is least in a developed economy, they do not agree on the reasons for rising income inequality in a least developed economy as the economy grows. The explanation offered by Jovanovic & Rafael (1989) for this anomaly between the cross sectional and time series data is that as an economy grows income inequality rises due to the fact that at the early stages of development there are a large number of unimplemented ideas in the economy. This is in contrast to an advanced economy where economic growth takes place as the PPF is extended or grows due to innovation and there are fewer unimplemented ideas in the economy. In the case of a developing economy, ideas tend to integrate markets; and in developed countries which already are

[14] Ibid.

operating at the possible level of technical efficiency, new ideas tend to move the PPF outward .This concept has been illustrated in Figure 1.6 [Page 26].The Jovanovic & Rafael (1989) model of growth and diffusion of knowledge explains the shape of the Kuznets Curve with regards to ideas rather than factor markets. The shift of the Kuznets Curve can be explained by a shift from the exploitation of bad ideas to good ideas and the evolution of knowledge. The essence of the work done by Jovanovic & Rafael (1989) is that,

"An increase in technological opportunity and a decrease in the costs of acquiring knowledge have the predictable effect of raising the economy's output in all future periods".

Clearly, the greater the level of invention and innovation; and the greater the stock of transportation and communications infrastructure in the Chinese economy, then the greater will be Chinese economic growth.

Knowledge Spillovers & Technology Diffusion

Differences in productivity explain differences in income across countries[15]; and in the case of China, within the country. Moreover, institutions, technology and government policies determine productivity. According to Keller (2004) rich countries have the financial resources to invest in R&D.Thus, the developed countries are responsible for the creation of technology. This technology then 'diffuses' to developing countries through technological imports; and outward bound FDI. The mechanism for this knowledge transfer in China's case has been FDI ,SEZ's and HTDZ's.Keller (2004) analyses the factors which are responsible for determining the degree of technological diffusion between countries; and the factors determining the means by which technology diffusion takes place. From case study literature and micro-Econometric findings it is apparent that there are two major channels facilitating the diffusion of technology from developed countries to developing countries. These include technology imports from developed to developing country knowledge diffusion; and outward bound FDI.

[15] Keller, W (2004),"International Technology Diffusion", Journal of Economic Literature, Vol XLII, Sept 2004

Technology may diffuse from one country to another through the trade in intermediate goods[16]. Furthermore, he asserts that the diffusion of technology can be expected to be geographically localised 'because of the well-documented fact that trade falls with geographic distance'. Multinational corporations operating within a country will bring into the country of production all the fixed assets and technology required to ensure that it becomes possible to ensure high productivity at a new factory. Thus, low labour costs and high profits are sufficient justification to shareholders for localising manufacturing operations in China. Moreover, it is the interactions of multinationals which have formed joint ventures with Chinese firms which leads to the process of domestic technological innovation and spilllover effects from international R&D.The process of innovation stemming from contact with foreign MNE's has four stages.[17]The first stage involves the use of the technology in the domestic Chinese market. In the second stage there is a process of becoming familiar with the new technology. Thirdly, it becomes possible to reproduce domestic versions of the technology .In the final stage improved versions of the domestically produced technology is produced .There are a number of ways to measure technology effects. These include R&D expenditure, increased Total Factor Productivity; and the number of patents registered.[18]

The problem with using R&D expenditure has a measure of technology is that there is no global standard.[19] Whereas, rich countries define R&D expenditure has that which leads to innovation, other countries may include in R&D expenditure which leads to product imitation and technology adoption. Patents on the other hand give the innovator/inventor a short-tem monopoly over returns generated by others using the patented technology on licence. An agreed royalty accrues to the inventor if the technology is licensed to a third party. Furthermore, Patent data has been collected for a long time in developed countries, although the legal protection of inventions/innovations has only become a featured practice in developing countries like India and China over the last few years. Nevertheless, Keller (2004) identifies a number of problems in using patents has a measure of technological innovation/invention. Firstly, a small number of patents accounts for a large share of the value of the

[16] Ibid
[17] Ibid.
[18] Ibid.
[19] Ibid

fiscal value of all patents. Secondly, not all inventions/innovations are patented. Thirdly, technology may in part be non-codifiable and a patent will not be able to capture this fully. The final measure of technology, defined by Keller (2004) is Total Factor Productivity (TFP).The TFP is the incremental increase in production experienced as a result of using the technology. TFP is a measure derived from inputs and outputs and as such is vulnerable to measurement errors and biases. Furthermore, TFP is a residual measure and as such maybe contaminated by spurious influences from other sources[20]. In order to overcome these problems, it is suggested that researchers have developed two strategies[21]. Firstly, rather then analysing changes in TFP levels as a result of the use of new technology, changes in TFP are considered .Secondly, TFP measures are combined with data on R&D.By establishing causation between TFP and R&D the chances of inappropriately measuring the changes in technology are greatly reduced. Keller (2004) also explores the question, and with particular relevance to China, whether exporting helps domestic firms in learning and applying new technology. He cites that the literature provides abundant evidence for exporters to be more productive than non-exporters on a cross-sectional basis. However, Keller (2004) while making this observation suggests that in itself the productivity of exporters over non-exporters does not suggest causality with learning about technology. Furthermore, Keller (2004) reveals from a survey of the literature that Econometric analysis does not provide strong support for 'learning by exporting'. However, this is at odds with case study evidence. Keller (2004) suggests that 'learning by exporting' may not happen in all industries and in this way 'learning by exporting' may be a heterogeneous phenomena especially when 'learning by exporting' takes place with regards to advanced technology. Finally, Keller (2004) points out that any analysis of 'learning by exporting' would be more meaningful if the destination of exports could be traced and if at firm level the importer of the exporter's goods is actually engaged in any kind of R&D.

Technology transfer also takes place via higher education and research institutions links to industry. Although much research has been conducted on this phenomena in a developed country not much research has been conducted from a developing country perspective. However, this has been to

[20] Keller, W (2004),"International Technology Diffusion", Journal of Economic Literature, Vol XLII, Sept 2004

[21] Ibid.

an extent remedied by Liu and Jiang (2001) .In developed countries at least six types of technology transfer between centres of research and industry can be identified.[22]These include spin-offs, buyer-seller transactions, published research papers, networking amongst researchers and entrepreneurs, real estate developments; and graduate students gaining employment in industry. However, there are a number of obstacles associated with the transfer of technology from centres of research to industry. Firstly, there is the risk associated with the successful commercialisation of results by industry, of a research project which has incurred costs. Secondly, there is a question about the practicability of the research project. Thirdly, there is a reluctance of business leaders in industry to grasp technological research and innovation as a necessary strategy to expand the business and engage in competition with other companies; as well as an inability to distinguish between technology development and product development. This can also take the shape of the introduction of poorly or incompletely developed technological innovations into the production project. Finally, there may only be a purely academic approach to research without any business sense on the part of researchers. This would result in the fact that successful research is not commercialised.

Government policy has also played a big role in facilitating the transfer of technological innovation from centres of research such as universities and research institutes to industry and the subsequent commercialisation of research results. This is specifically with regards to the development of Science and Technology research parks; and reform policies focused on the commercialisation of R&D activities in China. The development of research parks began in Japan; and its use spread to Taiwan, Singapore, South Korea and finally China. The key feature of the Science and Technology research parks in all five countries is that the agents who facilitate technological innovation and its subsequent commercialisation –SME's, LME's, universities and key government institutions are all brought under 'one roof'.[23] This is also a key way in which agglomeration economies due to knowledge linkages caused by knowledge externalities arise in the spatial plain.

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[22] Liu, H and Jiang, Y (2001),'Technology transfer from higher education institutions to industry in China: nature and Implications,'Technovation 21,175-188.

[23] Ibid

Until 1979 the Chinese economy was Centrally planned with strong vertical linkages with each Ministry having a devoted research base with universities and institutions carrying out research activity for that Ministry .Research benefits went to the associated Ministry, assisting it in meeting its Central plan targets. Horizontal linkages between various research institutions and between research institutions and firms were non-existent as there was no need for the commercialisation of product innovation in a centrally planned economy. Nevertheless, there was a need for technological innovation of the production process; and technological innovation to support the military-industrial complex. Moreover, China's economic reforms can be characterised by the fact that there was a move from a centrally planned economy to a 'socialist market' economy. In conjunction with other reforms this transformation involved the reform of the research sector. This process occurred in two stages. In stage 1, which started in 1986, the formation of horizontal linkages were encouraged so that research institutions could develop links with SME's and LME's.This reform removed the vertical linkages which allowed for the duplication of research across sectors and the wasted funding of research. Moreover, research institutions became responsible for their own profits and losses. Consequently, SME's and LME's were to increase their R&D budgets in order to fund the research carried out by the research institutions which had become attached to them as a result of the reforms. Stage 2 of the reform of R&D in China took place in 1995 with measures introduced to optimise the reforms of 1986.In addition to further weakening the vertical linkages of research institutions, which had formed during the Central plan era, the two step reform process also facilitated the focus of research projects to move from technological innovation geared towards development of the production process to product innovation. Before 1980 government policy towards S&T had been to train S&T personnel and narrow the disparity between the numbers of S&T personnel produced by China and other developed countries. After 1980 government policy again shifted to make use of all available S&T personnel for technological innovation associated with product innovation, free market competition and the consumer. However, research results which could have been converted into commercially viable products as remained low.[24] Nevertheless, the endogenous knowledge creation process in China

[24] Liu, H and Jiang, Y (2001),'Technology transfer from higher education institutions to industry in China: nature and implications,'Technovation 21,175-188.

is beginning to bear fruits. For example ZTE of Shenzhen has just launched a new model of mobile phone which is 'capable of displaying streaming video at broadband internet speeds'.[25]ZTE has launched its new F230 model in direct competition to Nokia, which is the world's foremost mobile phone manufacturer.

SME's and LME's are the agents who ultimately make commercial use of the results of R&D activity in China's case. Nevertheless, Liu and Jiang (2001) note that there are a number of reasons why SME's and LME's are not grasping the benefits of technology. Firstly, management not grasping technological innovation as a tool for strategic development. Secondly, there may be insufficient resources for R&D activity due to firm size; and insufficient R&D facilities to actively participate in and benefit from technology transfer. Thirdly, ineffective communication between SME's, LME's and centres of innovation may hinder the collaboration and technology transfer process. From a centre of innovation point of view there are also obstacles to the collaboration with SME's and LME's in research projects; and the successful transfer of results from one to the other.[26]In universities the number of academic papers measures the performance of researchers. More often then not publication is a key requirement to holding academic posts. Research may, therefore, not be linked to market demand.[27]Furthermore, whereas research in universities is considered as primary research much more developmental research is required to 'practically enable' the results of primary research to be brought to market. It is more often not the case that some companies may lack the resources to carry out the practical secondary research. In addition, universities receive funding from enterprises for specific research projects and this brings in revenue. However, the long-term economic benefits of the commercialisation of the result of the research project accrue to the enterprise. This, therefore, creates a tangency in the incentives for researchers in universities to carry out market orientated research; and firms to fund research projects. Nevertheless, despite the tangency in financial benefits for researchers and enterprises if a discovery becomes a commercial success, the

[25] International Herald Tribune, February 13th 2008.

[26] Corsten, H (1987),'Technology transfer from universities to small and medium-sized enterprises-an empirical survey from the standpoint of such enterprises', Technovation 6.

[27] Liu, H and Jiang, Y (2001),'Technology transfer from higher education institutions to industry in China: nature and implications,'Technovation 21,175-188.

researcher who made the discovery may not receive the recognition he/she desires. However, if the researcher retains some degree of control over his/her discovery he/she may create a 'spin-off' as a vehicle to commercialise the invention. In order to protect the results of research intellectual property legislation was introduced in China only in 1979.While the discoveries of technological innovations are enshrined in intellectual property legislation in China; piracy is still prevalent .Nevertheless, in SEZ's and high technology zones the legal framework is much stronger than in other parts of the country. However, in the event of legal disputes, universities lack the resources to mount legal action against the copyright infringer. Thus, university researchers may instead of transferring technology prefer to go it alone and find ways to commercialise discoveries. Universities have faced a conflict between their dual roles of academic teaching and academic research, while some universities only fulfil the former role and some conducting both roles. Since the mid-1980's, the government implemented a reform plan specifically aimed at universities with specific purposes in mind.[28]Firstly, to enhance horizontal linkages of universities with each other, with SME's and LME's. Secondly, in order to engage university research, teaching and the research application to the real world. Thirdly, to reform the way in which S&T funds are allocated. And finally to set up specialised research labs. Due to the impact of these reforms universities in China have been playing a greater role in technological innovation and the transfer of those technological innovations to SME's and LME's. In China the transfer of technology is facilitated through two modes. Firstly, there are the informal relationships of researchers based at universities and staff working in enterprises. Secondly, there are the more formal networks setup between universities and enterprises. [29]The latter maybe facilitated by the Ministry of Education, specifically for the purpose of technology transfer.

Liu and Jiang (2001) use Tsinghua University has a model Chinese university engaged in cutting edge technology transfer. They note that it has characteristics, which make it especially suited for the purpose of technological transfer. Firstly, personnel engaged in research at the university are of the highest academic calibre. Secondly, the provision of facilities for research in speciality fields at

[28] Ibid

[29] Ibid

universities in China is good. Thirdly, Tsinghua has attracted a number of high profile research projects which it undertakes in collaboration with government and enterprises. Tsinghua actively participates in technology transfer through a number of mechanisms.[30]The key mechanism was the formation of a committee, which acts as an active catalyst for engagement of the university's research power with MNC's as well as indigenous companies. The committee features the establishment of excellent communication between Tsinghua and companies through the use of liaison officers. Other mechanisms include collaboration with local governments, the establishing of spin offs with enterprises, active research collaboration with enterprises; and the formation of S&T networks with other Chinese universities. Liu and Jiang (2001) provide an impressive analytical framework for the study of technology transfer through universities to enterprises. However, universities are but one mechanism by which the transfer of knowledge can take place. Another mechanism is Foreign Direct Investment.

Foreign Direct Investment (FDI)

The analytical framework behind FDI can be defined under three theoretical frameworks. These include Dependency theory, Industrialisation theory; and New Growth Theory. Industrialisation theory stresses that FDI facilitates spillover effects as it constitutes the transfer of a set of business activities by an MNC to a host country rather than just a simple financial transfer. New Growth Theory focuses on the creation of knowledge and its transfer through such activities as R&D, externalities and human capital accumulation.

It has long been accepted that FDI plays an important role in the transfer of technology across national frontiers as a result of multinational corporations setting up operations in foreign countries such as China offering incentives based on reduced or no taxation on domestically generated profits, repatriation of such profits back to the home country of the multinational corporation; and the low cost of labour. Furthermore, in order to set up operations in China multinational corporations would have had to transfer the type of technology used in operations in the MNC's country in order to fully take advantage of the low factor costs and to ensure consistency in its standards of manufacture and production globally. However, as Keller (2004) points out, at least two studies by Hanson (2001) &

[30] Ibid.

Gorg & Greenaway (2002) suggest no evidence for technological spillovers from FDI. Nevertheless, Keller (2004) dismisses these micro-level productivity studies as being too pessimistic, suggesting that more recent micro-level productivity analyses and case studies such as the one undertaken by Larrain, Lopez-Calva and Rodriguez-Clare (2000) on Intel's FDI in Costa Rica suggest that FDI does have a positive spillover effect. The entry of foreign companies into the Chinese market puts pressure on domestic Chinese companies to work more efficiently by introducing new technologies into their production processes. The gains in efficiency accruing to local firms cannot be absorbed by the foreign companies and are referred to as spillover effects. Spillover effects are a mechanism by which FDI promotes growth in an economy by technological innovation. It is important to note that in China the activities of foreign MNC's are concentrated within Special Economic Zones, High Technology Development Zones and Science and Technology Parks .These activities are in the form of joint ventures with Chinese counterparts. Therefore, due to locational concentration, locational dependence and superior infrastructural facilities it is easy for physical and knowledge agglomeration economies to form. There have also been a number of Econometric studies examining whether multinational corporations facilitate international technology transfer as measured by patent citations. However, Keller (2004) points out that the results of these Econometric studies are less conclusive as to whether FDI does facilitate spillover effects because it is not clear whether the subsidiaries of the multinational corporations transfer technology to the firms of the host country or vice versa. The literature suggests that the latter effect is stronger. [31] This result may arise because the MNC subsidiary maybe technologically intensive but poor at sourcing resources. Furthermore, the MNC subsidiary may have been set up in the host country with the specific purpose of soaking knowledge from host country firms.

Chuang and Lin (1999) suggest that local firms R&D capabilities in Taipei, Taiwan were in the initial stages of economic development substituted by inward and outward FDI and the buying of technology. The study indicated that there was a limit to which inward bound FDI could transfer technology and facilitate spillovers. Once this limit had been reached further technological change

[31] Singh, J (2003),"Knowledge Diffusion and Multinational Firms: Evidence Using Patent Citation Data ", Working Paper, Graduate School Business Administration and Economics Department, Harvard University.

could only be facilitated by a government policy dedicated to fostering a R&D culture and horizontal linkages by domestic firms. This has been happening at an evolutionary pace in China with reforms in 1986 and 1995.Nevertheless, Keller (2004) suggests that FDI spillovers are much stronger in technologically intensive sectors then in other sectors; and that FDI is an important conduit for technology transfer but only in a limited number of sectors. In the case of China, FDI has played a significant role in fuelling the economic growth of the country especially in the 1990's.Studies of FDI flowing into China since 1979 can be classed under three categories. These include the pattern of FDI flow, the determinants of FDI; and the effects of FDI.[32]One prominent study formed the conclusion that the government's policy with regards to FDI was to facilitate the enhancement of the technological and industrial capabilities of the Chinese economy.[33]Another study revealed that Gross Regional Product was an important determinant of locational choice of MNC's for inward bound FDI.[34]However, these studies do not give credit to the reform policies which have encouraged high GRP in some provinces than in others. With regards to the effects of FDI on the Chinese economy, studies[35] have found that FDI has enhanced the indigenous resources available to facilitate the formation of capital; and to increase export earnings. These two factors have encouraged economic growth in China. Furthermore, a two-way causality between FDI and growth has also been established. However, the literature indicates a non-consensus on the issue of the level of technology, which has been transferred by FDI into China. Some researchers indicate that a high level of technology has been transferred while others suggest that low level non-productive technology has been introduced. Indeed, Fan (2003) suggests that the precise spillover effects of FDI on the Chinese economy are far from clear, that 'research needs to identify the specific conditions under which spillover effects occur'; and that government policies focusing on improving basic infrastructure,

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[32] Fan, X.E (2003),'Technological Spillovers from Foreign Direct Investment – A Survey', Asian Development Review, vol.20, no.1

[33] Hayter, R and Han, S.S (1998) ,'Reflections on China's Open Policy toward Foreign Direct Investment', Regional Studies 32(1).

[34] Broadman, H.G and Sun, X (1997),'The Distribution of FDI in China,' World Economy 20(3).

[35] Fan, X.E (2003),'Technological Spillovers from Foreign Direct Investment – A Survey', Asian Development Review, vol.20, no.1

better opportunities to enhance human capital; and policies aimed at helping local firms to acquire technological capability and development will help enhance the effects of inward bound FDI.

Technology Transfer

It has already been ascertained that the transfer of technology has two distinct channels[36]. The first channel is through the transfer of technology from an MNC to its subsidiary in the host country. The second channel takes the form of an externality when technology is transferred from the MNC's subsidiary to a local firm. FDI and foreign companies play a key role in the transfer of advanced technology to China by three methods.[37]These include increased innovation due to competition, interpersonal communication; and the diffusion of technology. Historically, all of the foreign investment into the Chinese economy since 1949 and up to 1978 has been by the former Soviet Union. However, in 1978 the Chinese government instituted a set of ongoing reforms to attract investment into the Chinese economy by foreign companies. The reforms were driven by a number of factors, which included the following. Firstly, a non-existent Chinese capital market. The implication of this is that investment in China's economy could not be funded through domestic capital markets. Secondly, a commitment by Central government to join the WTO. And, finally a desire by Central government for the Chinese economy to become recognised as a market economy, with the implication that if that recognition was achieved then quotas could not be put up by foreign countries to Chinese exports.

In the Chinese context, when considering agglomeration economies arising from FDI it must be remembered that these economies arise from knowledge transfer rather than knowledge creation. In 1997 foreign MNC's began to establish R&D institutes in China. These foreign MNC's included IBM, SUN, Ericsson, DuPont, Unilever, Rhone-Poulenc and Bayer.[38] The location of research facilities in China by MNC's can also be seen as a vote of confidence in the availability and abundance of highly skilled and educated local personnel. Jiang (2003) points out that the investment

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[36] Ibid.

[37] Jiang, Y (2003),"FDI and Technology Transfer in China" in "Conference on China's New Knowledge Systems and Their Global Interaction", (Ed) Sigurdson, J, VINNOVA.

[38] Ibid.

by MNC's in opening R&D facilities in China is a cause for resentment by Chinese research facilities. Nevertheless, according to Jiang (2003) there are a number of externalities relating to the flow of FDI in R&D in to China beneficial to the Chinese economy. These beneficial externalities relate to the restructuring of Chinese industry due to increased levels of labour specialisation, advanced technology imports, transfer of Chinese R&D into the domestic economy and increased foreign trade. Moreover, FDI ensures that domestic firms become more competitive with foreign firms; and domestic firms become engaged in R&D activity.

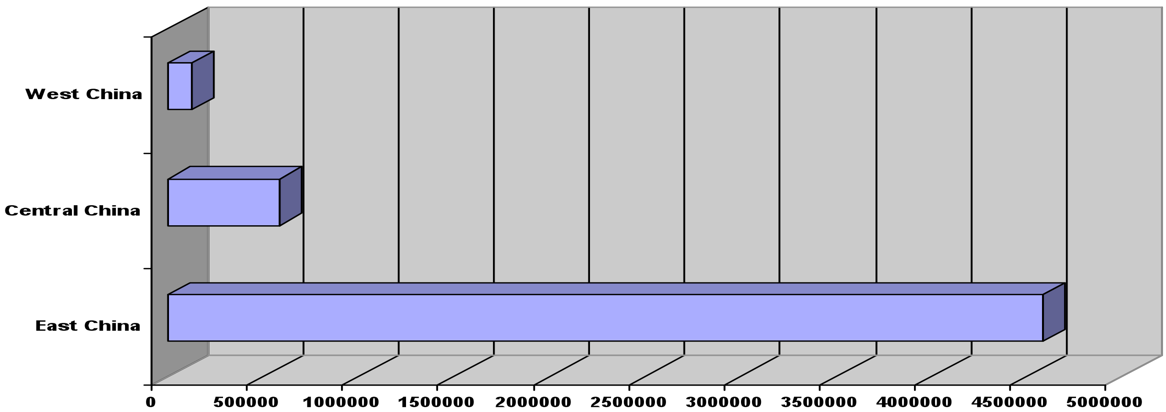

Figure 1: Regional Distribution of FDI 2003

Source: China Statistical Yearbook 2005, Chapter 18, Table 18.6

Figure 1 shows that even in 2003, 71% of the regional total of FDI into China was received by the Coastal provinces of Jiangsu, Shandong, Guangdong and Coastal municipality of Shanghai .The Western provinces of Sichuan, Yunnan, Xinjiang, Qinghai, Gansu and the Central provinces of Hunan, Hubei and Henan are amongst the other provinces of China which received the balance of FDI into China. It is often citied that FDI is responsible for the prosperity of the Coastal provinces .However, FDI has merely served has a vehicle for the transfer of knowledge; and the mechanism by which resources of production have been allocated. The attractiveness of FDI to the Coastal provinces; and its repulsion from China's interior is a significant contributor to China's unbalanced development in the reform years. From this perspective it is clear that the lack of a dual track development policy in 1978 encompassing pro-poor policies for China's Western and Central provinces with the opening up of China's Coastal regions has resulted in the deepening income disparities between China's Coastal and Western and Central regions.

Innovation and Intellectual Property Rights

Innovation and the transfer of technology are similar in the respect that the gaining of new technology will put the acquirer of that technology on a growth pattern based on knowledge. However, knowledge accumulation by diffusion is an important part of the innovative process in developing countries. Bascavusoglu (2007) seeks to account for the underestimation of the innovativeness of developing countries in the empirical literature, by using panel data to evaluate the determinants of the factors of innovation in developing countries. The main feature of the analysis is that a number of methods of analysis are combined ,including patent citations ,self-citations ;and the role of institutions in innovation as determined by a national innovation system .The latter is deemed to be important for long run economic growth.[39]The effective use of technology with in the framework of a national innovative system depends upon two factors .These include the flexibility of labour to adapt to new technology and intellectual property rights.[40]While intellectual property rights and financing issues are factors which hinder the innovation process, international trade plays a key role in the technology spillover process.[41] The main fault with the methodology used by Bascavusoglu (2007) is that while the literature recognises R&D expenditure has the measure by which developing countries benefit from foreign knowledge ,due to a lack of data they use a pattern of 'self-citations' as a surrogate. However, the study is also one which considers geographical proximity. In this regard, a key result was that the impact of technology spillovers on a country's economy varied with its relative distance from the technology source. Secondly, more innovative countries benefit from technological spillovers .Thirdly, low labour costs induce low levels of innovation because technology is relatively more expensive compared to labour. Fourthly, countries benefit from their own R&D activities, thus implying a role for government. Finally, intellectual property rights legislation is more effective when

[39] Furman, J.L et al (2002),'The determinants of national innovative capacity'. Research Policy 31.

[40] Bascavusoglu, E.(2007),'Innovation and Knowledge Spillovers in Developing Countries', Open Discussion Papers in Economics, Number 62, The Open University.

[41] Ibid

a country has surpassed its knowledge imitation stage; and moved onto endogenous knowledge creation.

Conclusion

A distinction has been drawn between Neoclassical growth theory and Endogenous growth theory .The latter seems sufficient to describe how economic growth in China may occur .In this regard Endogenous growth theory allows for an explanation of the importance of human capital to economic growth through innovation. Nevertheless, how the latter occurs through knowledge creation is not explained within the NEG .However ,a role for human capital in endogenous growth draws into the argument, the roles of research and development (R&D) and education in endearing economic growth. It has also been established that as part of the economic reforms, the Chinese government initiated specific reforms to horizontally integrate R&D related activities in two stages; and thus facilitate the commercialisation of knowledge creation. These reforms are an addition to the knowledge spillovers ,which have occurred as a result of the activities of foreign MNC's as a direct result of inward bound FDI into the Chinese economy ;and the setting up of SEZ's and High Technology Development Zones (NHTIDZ's).It is in these specifically designated zones that there has been a concentration of infrastructure investment .In the following chapter a closer look will be taken at knowledge creation and the concept of innovation systems in the Chinese economy.

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