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Book review: **The Development of the Software Industry in Postreform India: Comparative Regional Experiences in Tamil Nadu, Andhra Pradesh, and Kerala**

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Correction

In the June 2009 issue (vol. 16, No. 1), the paper entitled "The impact of international and internal remittances on household welfare: evidence from Viet Nam" by Nguyen Viet Cuong, a misreporting was identified on the second to last sentence above table 1 on page 63. The sentence reads "In 2004, the proportion of households receiving international remittances was 13.8 per cent and 7.1 per cent in urban and rural areas, respectively." The sentence should be corrected to read as follows: "In 2004, the proportion of households receiving international remittances was 13.8 per cent and 4.7 per cent in urban and rural areas, respectively" to be consistent with figures reported under table 1.

Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

References to “tons” are to metric tons, unless otherwise specified.

A solidus (/) between dates (e.g. 1980/81) indicates a financial year, a crop year or an academic year.

Use of a hyphen between dates (e.g. 1980-1985) indicates the full period involved, including the beginning and end years.

The following symbols have been used in the tables throughout the journal:

An em-dash (—) indicates that the amount is nil or negligible.

A hyphen (-) indicates that the item is not applicable.

A point (.) is used to indicate decimals.

A space is used to distinguish thousands and millions.

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STATE EFFECTIVENESS AND STRUCTURAL TRAPS: SOME COLONIAL EXPERIENCES

*Richard Grabowski**

A multiple equilibriums poverty trap model is developed to analyse the effectiveness of State policy in developing and applying policies aimed at reducing poverty, i.e. pro-poor policies. The implication of this model is that, if poverty is concentrated in agriculture, then a necessary key to breaking out of the low level trap situation (where the State is ineffective in carrying out pro-poor policy) is the creation of a backlog of agricultural technology. However, for this technology to be activated and applied by the State requires that the ruling elite feel themselves to be vulnerable in terms of controlling the institutions of the State. The workings of the model are illustrated by examining the colonial experiences of Taiwan Province of China and the Republic of Korea and comparing it to that of South-East Asia.

I. INTRODUCTION

Conventional neoclassical economics takes a particular view of the world. It presumes the world is characterized by a single, stable equilibrium. For example, markets have single, stable equilibriums determined by supply and demand. If there is a shock to the system, countervailing forces come into effect to restore equilibrium. Neoclassical growth theory, for example, implies that there is a steady state equilibrium which can be determined once certain fundamental variables are known (population growth rate, savings, rate of technological change). At this steady state, the rates of growth of capital, augmented (by technical innovation) labour, and output grow at the same rate. If an economy should be below the steady state, it will converge to the steady state (absolute convergence). Of course, if the fundamental factors vary from country to country (savings rates differ, population growth rates differ, and or rates of technological change differ), then

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each economy will have its own steady state and each country will converge to its own steady state (conditional convergence).

The last possibility indicates that there may be many equilibriums, conditional on the values of the key variables. However, if labour, capital, and knowledge are free to move from nation to nation, then steady states for all countries should converge to a common value and absolute convergence once again emerges. Under some conditions, free trade in goods may achieve the same results. Thus, multiple equilibriums would emerge only if there are impediments to the flow of capital, labour, and/or technology. These impediments are often attributed to policy barriers imposed by national Governments, such as barriers to foreign investment, the flow of technology, migration, and free trade. Thus, poorer countries fail to catch up in this scenario as a result of bad policy. Once the policy is corrected, economic convergence occurs.

However, the above perspective presumes that markets exist and are efficient. When this is not true, then another perspective on the world emerges. There may be multiple equilibriums, some stable, some not stable. Stable high-income and low-income equilibriums imply that convergence, of either the conditional or absolute variety, will not occur. Due to accidents of history, a country can be caught in a low-level trap and thus be unable, on its own, to obtain a high-income level equilibrium.

There are a variety of trap type models, some of which will be reviewed in the next section of the paper. In this paper, the focus will be on developing a poverty trap model, a multiple equilibriums model, in which the level of State effectiveness in reducing poverty will be the key variable. That is, there are multiple equilibriums in the sense that there is a high-level equilibrium at which the State is effective in promoting pro-poor policies which enhance or empower the poor. There is also a low-level equilibrium at which the State is ineffective at promoting pro-poor policies which enhance the position of the poor. The focus will then be on how to alter the structural characteristics of the model so as to make the low-level equilibrium unstable. It will be argued that the existence or lack of existence of a pool or backlog of agricultural technology will be a key structural factor. The role of agriculture in reducing poverty will be discussed in the second section of the paper, along with a brief literature review of multiple equilibriums models.

The actual model will be developed in section III. Section IV will illustrate the workings of the model by examining the policies carried out by the Japanese in Taiwan Province of China and the Republic of Korea (both were colonies of Japan prior to the Second World War). The experiences of these countries will be

compared to that of South-East Asia. Finally, section V gives a summary of the paper and draws policy implications for today's developing nations.

II. AGRICULTURE, POVERTY AND MULTIPLE EQUILIBRIUMS

Rapid economic development has become a characteristic of much of East Asia. Specifically, China, Japan, the Republic of Korea and Taiwan Province of China have all experienced very rapid rates of overall economic growth. After the Second World War, Japan experienced rates of growth that, by historical standards, seemed miraculous in nature, and poverty fell very rapidly. The Republic of Korea and Taiwan Province of China had, in many ways, very similar experiences. Both achieved rapid rates of growth and dramatic reductions in poverty. China seems an extension of the process with overall growth rates exceeding that achieved by the other three during their period of high growth, again accompanied by rapid reductions (especially in the early years of the growth process) in poverty.

A common factor in the convergence of these countries involves the rapid growth of labour-intensive manufactured goods, oriented towards foreign markets via rapid export growth. What is less commonly acknowledged is the role which agriculture has played. In Japan, rapid agricultural growth was achieved during the latter part of the Tokugawa period (1600-1863) and the early part of the pre-war period (1869-1939). This rapid agricultural growth provided the income stimulus leading to rapid expansion of labour-intensive, rural based manufacturing. In terms of agricultural growth, from 1876 to 1938 agricultural output grew at an average rate of 1.6 per cent and total productivity at a rate of 1.2 per cent annually (Yamada and Hayami, 1979). Achieving these rates of growth involved significant investment in agriculture. After the Second World War, rapid growth in agriculture was once again achieved via investment in agriculture. Output grew at 3.2 per cent and productivity at 3.6 per cent from 1955 to 1965 (Yamada and Hayami, 1979).

This pattern was maintained in the experiences of both the Republic of Korea and Taiwan Province of China. Prior to the Second World War, both were colonies of Japan, which used them as a source of primary products, both rice and sugar, for the homeland. Thus, the Japanese made significant investments involving the creation of research and extension systems, rapid expansion of irrigation, and the creation of an extensive system of roads and other forms of public infrastructure in the countryside. These programmes to raise overall agricultural productivity were indeed very successful, although much more so in Taiwan Province of China than in the Republic of Korea. In Taiwan Province of

China from 1923 to 1937, agricultural growth rose to an annual rate of 4.1 per cent, with approximately 41 per cent of that output growth due to increases in productivity (Lee and Chen, 1979). In the Republic of Korea, the growth in agricultural production reached 1.62 per cent per year for the period 1930 to 1939 (Ban, 1979), with all of the growth due to input accumulation. After the Second World War, both regions continued to invest significant resources into agriculture, at least in the early part of the time period, which resulted in continued rapid agricultural growth. From 1946 to 1970, output in Taiwan Province of China grew at an annual rate of 5.6 per cent, while productivity grew at 3.9 per cent annually (Lee and Chen, 1979). In the Republic of Korea from 1953 to 1969, output grew at an annual rate of 4.36 per cent while productivity grew by about 2 per cent (Ban, 1979).

The rapid rate of agricultural growth achieved in all three regions is thought to have been critical in the rapid growth of the area. Thorbecke and Wan (2004) argue that rapid agricultural growth provided the critical initial factor in overall rapid economic growth. The agricultural sector provided relatively cheap food to the modern sector while at the same time serving as a source of surplus, which was, in turn, available for investment. Ultimately, it also served as a source of labour for the expansion of the modern sector. However, the expansion of modern sector manufacturing did not necessarily imply rapid urbanization. For at least two of the regions (Japan and Taiwan Province of China), the rapid agricultural growth was accompanied by rapid growth in small-scale labour-intensive manufacturing based in rural areas (Headey, Bezemer and Hazell, 2008). This provided opportunities for farm families to become more broadly entrepreneurial in the sense that they could invest their growing agricultural surplus in small-scale manufacturing activities. Thus, farmers became increasingly connected with manufacturing.

The ultimate result of this rural-based growth was a process in which absolute poverty fell very rapidly and the relative distribution of income did not deteriorate. In fact, Campos and Root (1996) argued that East Asia's success in terms of long-term growth was indeed due to the fact that the benefits of growth were widely shared across groups within each country.

The recent growth experience of China seems to be a process very similar, at least in part, to that which occurred in East Asia. Rapid growth began in China with the reforms of the late 1970s. This created the foundations for a growth process which led to a dramatic reduction in poverty. Specifically, in 1981 two out of three mainland Chinese lived in poverty, but, by 2004, less than one in ten was poor. The rate of poverty reduction from 1981 to 2004 was about 1.9 per cent per year (Ravallion, 2009).

Many have argued that it was through trade and foreign investment that China was able to achieve such a rapid reduction in poverty. However, this does not seem to be the case. Ravallion (2009) argues that two thirds of the decline in the number of people living under $1/day for the whole time period occurred between 1981 and 1987. The rapid growth in foreign investment in China and the growth of exports occurred later.

Ravallion (2009) argues that "the 'heavy lifting' in reducing the numbers of poor in the early stages of China's reform process was done by the rural economy" (Ravallion, 2009, p. 305). These reforms involved the development of the household responsibility system. Prior to the late 1970s, agriculture was organized into large communal or collective farms. Markets were not utilized, and material incentives to stimulate intensity of effort were quite limited. The household responsibility system basically restored family farming and allowed these new family farms to sell an increasing proportion of its output through markets. The rapid growth in agricultural income that followed stimulated the development of small-scale, labour-intensive manufacturing firms (TVE, township and village enterprises) located in rural areas. These two developments resulted in a dramatic reduction in absolute poverty.

Ravallion and Chen (2007) found that the pattern of growth influenced inequality. Inequality fell as a result of agricultural growth, inequality in both rural and urban areas. However, since the 1980s the agricultural sectors rate of growth has declined dramatically. As a result, the degree of inequality has subsequently increased. However, the moral of the story remains, dramatic reductions in poverty in East Asia and China have been the result of a growth process based on rapid productivity growth in agriculture. The growth "miracles" in these regions seem to have an agricultural base to them.

Within this context, one would think multiple equilibriums, poverty trap models would be very useful in explaining sudden explosions of growth. Indeed, such theories have been used to analyse these experiences, especially that of East Asia. However, most of these models completely ignore the agricultural sector and are focused on explaining growth, not poverty reduction. While the latter generally follows from the former, this is not always the case.

Poverty trap models are not recent theoretical developments. After the Second World War, the initial theorizing about the development process was usually in the form of some sort of trap analysis. The work of Rosenstein-Rodan (1943) comes to mind. He argued that, in economically isolated, poor regions, it was unlikely that economic development could occur. One firm contemplating constructing a new factory would find the market quite limited implying that it

would not likely be profitable. However, if a number of individual firms producing different things could be established simultaneously, then each could serve as a market for the others. The likelihood of the firms being profitable is much higher. An external coordinating force would be necessary to bring about the integrated expansion. Thus, two equilibriums would exist, one a low-level trap in which no single firm would invest and the other a high-income equilibrium in which coordinated simultaneous investment would occur. This approach presumes that trade (exporting) is not an option and capital market failure occurs. A modern, formalized version of this type of model has been provided in the work of Murphy, Shleifer and Vishny (1989).

Ragnar Nurkse (1953) argued that there is a vicious circle of poverty. In a market where incomes are low, there are few profitable opportunities for investment, while in a market where incomes are high, there are many such opportunities. In the former equilibrium, there will be little investment, and in the latter significant accumulation of capital. Thus, there are two equilibriums, with the low-income equilibrium representing accidents of history and geography.

A modern version of the Nurkse model is provided by the work of Rodrik (1996). He assumes two types of final goods: simple and complex. The simple good is produced without the use of intermediate goods and with the use of lots of labour and land. The complex good uses lots of intermediate goods. Further, it is assumed that the greater the variety of intermediate goods utilized, the higher is the overall productivity in the complex good industry (increasing returns). Finally, he assumes that intermediate goods are produced under conditions of increasing returns or falling costs.

In this context, two equilibriums emerge. An economy that finds itself in an equilibrium producing the simple final good will utilize few intermediate goods, intermediate goods will be very expensive to produce, thus firms will not find it profitable to try to establish production of complex final goods, since these are intensive in the use of intermediate goods. However, the economy that, for reasons of history, finds itself producing the technologically complex final good will utilize many intermediate goods, they will be cheap, and thus firms will find it profitable to become increasingly complex. Thus, shallowness in the markets for intermediate goods (assuming they cannot be costlessly imported) implies that a country can become locked into the production of simple, manufactured goods.

There are many other examples of growth or development trap models in the literature. However, almost all of these models focus on growth and development equilibriums and these models do not incorporate agriculture in a meaningful way. The next section will develop a simple model focused on poverty

reduction emphasizing the key role that agriculture and agricultural technology can play.

III. A SIMPLE MODEL

Ravallion (2009) has developed a very simple threshold model of State effectiveness in reducing poverty. He assumes that the extent to which a country adopts pro-poor policies is dependent upon the extent of the empowerment of the poor, with the effect subject to diminishing returns. The empowerment of the poor is the extent to which the poor can influence policymaking. One could argue that this is a mainly political relationship represented by a production function that could be written as:

(1) Pro-Poor Policy Choice = f(Empowerment of Poor).

As the political empowerment of the poor increases, policies are likely to be more pro-poor in nature. Technological innovation in this context would be represented by the development or evolution of institutions which enhance the effectiveness of the poor in influencing policy choice so that, for any given level of empowerment for the poor, greater pro-poor policy choice emerges. One can think that a shift from authoritarian political institutions to democratic institutions will, in a poor country, increase the effectiveness of creating pro-poor policies from any given level of poor empowerment. This represents political or institutional innovation.

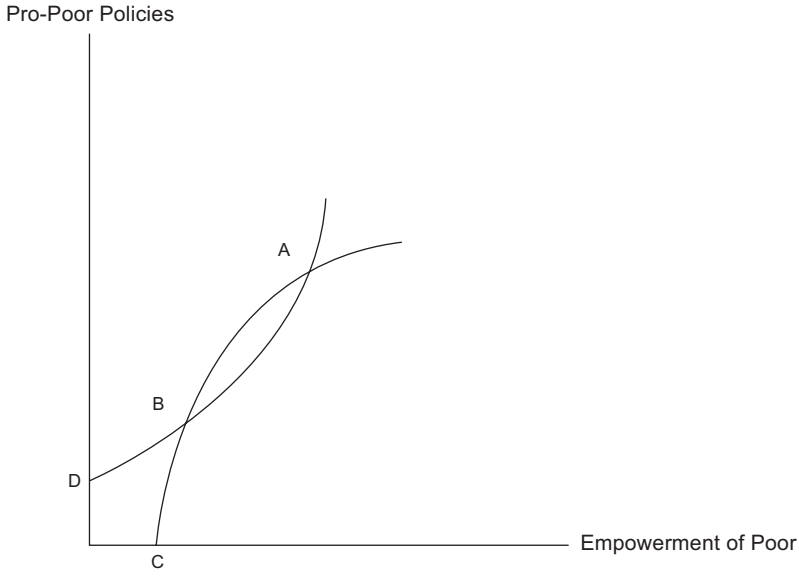
Alternatively, one can imagine a production/function type of relationship between pro-poor policies and empowerment, subject to diminishing returns. One would write the relationship as:

(2) Empowerment of Poor = f(Pro-Poor Policies)

The greater the number of pro-poor policies, leading to greater economic productivity and wealth for the poor, the greater the empowerment of the poor. In this case, technological innovation would increase the amount of pro-poor empowerment that results from any given level of pro-poor policies. One can think of this as representing technological as opposed to political innovation. If most of the poor earn their living in agriculture, then broad-based, labour-using (-intensive) technologies will dramatically increase the productivity (and income) of the poor, thus, empowering them. These ideas are illustrated in figure 1.

The political relationship between empowerment and pro-poor policies is represented by the curve CBA. The technological relationship between pro-poor

Figure 1. Threshold model



Source: Ravallion (2009)

policies and the empowerment of the poor is represented by the curve DBA. As one can see, there are three potential equilibriums, two of which are stable and the third unstable. The two stable equilibriums are the origin 0 and point A, while B represents the unstable equilibrium. At a point to the south-west of B, the level of empowerment of the poor is too low to generate any pro-poor policies, and any existing pro-poor policies cannot sustain political empowerment of the poor. Both fall to the origin. This is the ineffective State, which cannot design or carry out effectively any policy aimed at enhancing the wealth of the poor. At point B, a small increase in either empowerment of the poor or pro-poor policies causes a sustained increase of both to point A. This is an effective State where the poor are empowered and pro-poor policies are achieved. Thus, ineffective States are States trapped in the low level equilibrium, effective States are in the high level equilibrium.

How does a nation escape from the ineffective, low-level equilibrium? In these types of models a big push in terms of pro-poor policies and/or empowerment of the poor can get a nation to point A. But where are the resources for such a big push to come from?

An alternative would be to change the underlying structure of the model. One avenue to do so would be via political reform, usually including the establishment of democracy and creating institutions of accountability and trust. This would represent political or institutional innovation shifting the curve CBA up and to the left. As a result, point B would move in a south-westerly direction until the low-level, ineffective State equilibrium disappears. Any level of political empowerment for the poor or any small increase in such empowerment (from zero) will set off a cumulative causation process of rising empowerment and increasingly pro-poor policies: the development of an effective State. Thus, political reform can change the underlying structure of the model.

Political reform is a process which has been pushed by international agencies. Much economic literature has been devoted to showing that such institutional reform can result in an effective State. However, in practice, achieving such institutional reform has proven very difficult. There is information as to what sorts of institutions promote the interests of the poor, but it is very difficult to create such institutions. Economics has not shed much light on this subject.

There is an alternative path to the establishment of an effective State. That would be technical innovation that shifts DBA down and to the right. Thus, point B would move down until the stable, low-level trap disappears. Such a shift would mean that any pro-poor policy would become better or more effective at producing poor empowerment and vice versa. Let's flesh this idea out a bit.

The literature concerning East Asia and China reviewed earlier focused on the idea that investment in infrastructure and technological development in agriculture yielded pro-poor type growth. The experiences of East Asia and China, at least initially, indicate that growth in agriculture is important for an equitable development process. In the context of the model developed in this section, pro-poor policies (the vertical axis in figure 1) represent policies focused on promoting agricultural growth. Thus, as one moves up the vertical axis, increasing amounts of resources are devoted to enhancing agricultural investment. As agricultural growth occurs, this enhances the incomes of individuals in this sector via direct growth in crop production and the expansion of rural-based manufacturing activity. Since the bulk of the poor reside in the rural sector, rising income in this sector increases the ability of the poor to influence policy. The argument is that growth in the income of the poor increases their ability to promote additional pro-poor policies, empowerment of the poor occurs (movement from left to right along the horizontal axis in figure 1).

Of course, the structure of land ownership influences the ability of pro-poor (pro-agriculture) policies to empower the poor. For example, land reform

which reduces the inequality in the distribution of land will shift the curve DBA down and to the right. This institutional innovation increases the productivity of any pro-poor (pro-agriculture) policies. That is, an equitable distribution of land implies greater empowerment of the poor through agricultural investment. For any given level of pro-poor policy, there would be greater empowerment of the poor.

The conclusion is that significant land reform could provide the foundation for a shift from an ineffective State equilibrium to an effective State equilibrium (point A). However, land reforms are extremely difficult to carry out. So this is likely to be possible only after a significant amount of empowerment of the poor has already occurred, further enhancing the possibility of State effectiveness.

Are there other ways to shift the DBA curves outward? Remember, one can think of this as a kind of production function. Empowerment of the poor is produced via pro-poor investment. Technological innovation would increase the productivity of pro-poor (pro-agriculture) investment. More clearly, the development of new broad-based, labour-intensive agricultural technologies will shift DBA outward and down. With such new agricultural technologies, the incomes of the poor would be significantly increased, resulting in a significant increase in their empowerment.

Let's contrast two different situations: first, a nation in which the trap situation exists and there is no potential for technical innovation in agriculture. In this case, the State will be stuck in the ineffective equilibrium (original figure 1). Contrast this with a country or region in which there is a large backlog of agricultural technology with the potential to dramatically raise agricultural productivity and thus significantly empower the poor. In this case, the ineffective State equilibrium would cease to exist. Thus, any small increase in pro-poor policy or poor empowerment will set off a cumulative causation process in which the State will increasingly become effective at reducing poverty. Thus, the key factor is whether or not a significant backlog of potential technology exists.

However, this is only part of the story. One must ask what incentive does the State have to become effective at reducing poverty? In other words, what is it about a backlog of agricultural technology that drives the State to become more effective? Investments in agriculture will enhance the wealth and influence of the poor, *ceteris paribus*. But what does the State gain in this process? Figure 1 shows the macroeconomics of the trap model, but now one must also understand the microeconomics of such a model.

How does increased productivity in agriculture cause the ruling elite of the State to seek to incorporate the interests of the poor into policymaking and how

does the ruling elite benefit from this? Answers to these questions are presented by the recent work of Bromley (2008). In analysing the weakness of African States, he takes a novel approach. He argues that the ruling elite will seek to enhance the power of the State only if it pays to do so. In much of sub-Saharan Africa, it does not benefit the ruling elite to extend its institutional infrastructure into the hinterland to strengthen its links to the countryside. Thus the State's influence is mainly limited to urban areas and thus, from the outside, the State appears to be weak.

What is the benefit to the State of extending its institutional structure into the countryside? It would seem that revenue—or potential revenue—is the key. States and ruling elites need revenue in order to maintain their grip on society. If there is little potential to extract revenue from rural areas (where the poor live), then there will be little incentive to incorporate the rural population into the State. Thus, the rural poor will not be empowered.

Alternatively, the State may very well be interested in extending its institutions into the countryside if there is the potential to earn tax revenue. This potential will exist if there is a significant backlog of technology available for immediate use. This increased productivity would generate not only a rise in farm incomes, but it would also stimulate the growth in incomes generated by rural manufacturing. The possible extraction of some of this revenue would require that the State establish an institutional structure for diffusing the technology and collecting the revenue. However, in order to extract the revenue, the State will, in turn, have to create quasi-voluntary compliance, in the words of Levi (1989). In order for the State be able to collect revenue, the potential source of that revenue must be willing to comply in return for other things (services). One might at this point argue that the State could just use coercion to extract revenue from the countryside, and, indeed, history provides many such examples. However, two considerations make coercion a very inefficient mechanism for collecting revenue unless it is accompanied by quasi-voluntary compliance: first, coercion without the provision of services in return will lead farmers to reduce their efforts at production, leading to a reduction in tax revenue possibilities over time; second, applying coercion to a large number of small producers is a very time-consuming and costly process. For these reasons, quasi-voluntary compliance is necessary for efficient revenue collection.

The simple logic of the above is as follows. The existence of a significant backlog of agricultural technology implies that, in figure 1, the potential DBA curve is shifted dramatically to the right and downward. The motivation to transform this from potential to actual is provided by the incentives facing the ruling elite. The attraction of the potential significant increase in revenue for the State flowing from increased agricultural productivity leads the State to extend itself into the

countryside. The dependence upon the countryside increases, and, thus, the State must become more sensitive to their interests. This is very similar to Moore's (2001) notion of earned income. He has argued that a State that earns its revenue is a State that takes into account the interests of its revenue sources. A State earns its income if it builds an institutional infrastructure extending throughout society to enable it to collect revenue and must provide services in return to ensure quasi-voluntary compliance (reciprocity).

The above analysis is rather simplistic in its discussion of agricultural technology. Certainly, many less developed countries operate inside the technological frontier with respect to agricultural technology. They are using technologies which are not the most productive. However, most agricultural technology is location- and climate-dependent. That is, the technology works best only in particular locations and under specific climatic conditions. Working at other locations or under different climatic conditions requires adaptation at the local level and efforts must then be exerted to extend the technology throughout the rural areas. Thus, local resources must be utilized to activate the technology.

Whether such local efforts will be made is, of course, dependent on the potential productivity of the technology. If it is high, then the potential return to the State via revenue from taxation will also be high. However, in many cases this will likely not be enough. Doner, Ritchie, and Slater (2005) provide some valuable insight on this issue. Although their work is more broadly focused on the issue of how developmental states evolve, it is still quite relevant to the issues discussed here. They argue that, the greater the extent to which States are characterized by systematic vulnerability, the more likely they are to become effective at promoting economic development. The systematic vulnerability of a State is the result of "the simultaneous interplay of three separate constraints: (1) broad coalition commitments, (2) scarce resource endowments, and (3) severe security threats" (Doner, Ritchie, and Slater, 2005, p. 329). Simply, the more broadly based the ruling elite's coalition, the more likely it is that it will pursue policies enhancing the welfare of society. If the survival of the ruling elite is threatened, it focuses the attention of the elite on policies which aim at increasing the economic, political and perhaps military strength of the society. Finally, if resources for State revenue are difficult to come by, then the ruling elite must enhance productivity in order to enhance their own revenue stream. Alternatively, where revenue sources are more readily available (from natural resource taxation), if there are few threats to the political survival of the elite, and the elite are dependent upon a narrow coalition, then it is highly unlikely that the State will pursue productivity growth. Instead, patron-client politics are likely to prevail.

The argument of this paper is consistent with the analysis presented in the previous paragraph. Pro-poor economic development is likely to be pursued if the only source of revenue for the State is the taxing of household farming units (there is no easy access to sources of revenue via natural resources) and there is the potential for rapid growth in productivity. If household farms make up the bulk of the rural population, then the ruling elite's supporting coalition will be broadly based. The last factor—the existence of significant threats to the ruling elite—is a key factor focusing attention on policies aimed at enhancing overall agricultural productivity. This last factor seems to be important in terms of motivating the ruling elite to adapt and activate new technology.

With these ideas in mind, the next section will analyse the colonial experience of Taiwan Province of China and Korea under Japanese rule. This will then be compared to the colonial experience of South-East Asia. In the case of Taiwan Province of China and Korea, the colonization process was more developmental. It will be argued that these experiences illustrate the workings of the model outlined in this section.

IV. THE COLONIAL EXPERIENCE OF TAIWAN PROVINCE OF CHINA IN COMPARISON WITH THAT OF KOREA AND SOUTH-EAST ASIA

According to Acemoglu, Johnson and Robinson (2001), there are two types of administrative or State structures that colonial powers can construct in their colonies. Extractive States are those whose major purpose is to extract wealth from the colony as quickly as possible. The only investments that are made are for the rapid transport of resources and the creation of a level of security high enough to protect this process. As a result, few institutions are constructed to protect property rights for society at large or provide infrastructure (except that which is necessary for rapid resource extraction). There is also little investment in the education of the native population.

At the other end of the scale are developmental colonies. Institutions for the protection of property rights in general are provided, construction of infrastructure is widespread, and low levels (primary) of education are provided. This is not the result of the concern of the colonial power for those colonized; it is an unexpected by-product of attempts by the colonial power to benefit from the colony.

What determines which type of colony that will be created? Acemoglu, Johnson and Robinson (2001) argue that this is dependent on mortality rates

expected by prospective settlers. If mortality rates are high, few will settle in the colony, the emphasis will be on the short run, and the focus will be on the quick extraction of resources. Alternatively, when mortality rates are low, colonists will settle in large numbers, bringing their institutional structure with them. The emphasis will be on longer-term investments. These settler colonies (such as Australia, New Zealand and the United States) are likely to be much more developmental.

This analytical perspective does not really work when looking at Korea and Taiwan Province of China as colonized by Japan. The mortality rates facing Japanese colonists in these two colonies were low. However, these were not settler colonies. Initially, there was some emphasis on using these colonies as a place to settle part of the dense Japanese population, and some settlement did occur, but not on a very large scale. The manufacturing sectors were dominated by the Japanese, but the rural sectors remained firmly in the hands of the indigenous population. These were not settlement colonies.

What was it, then, that guided the Government of Japan in terms of policies for its two colonies? Would Japan construct extractive or developmental colonies? As it turns out, the colonies were more developmentally oriented. During both the Tokugawa (1600-1868) and the Meiji (1868-1917) periods, Japan had achieved significant growth in domestic agricultural productivity. During the late Tokugawa period, farmers had experimented with new techniques and the cross-breeding of seeds. This was a farm-based, pragmatic and evolutionary process of technological development which occurred over a long period of time. Because of the constraints imposed by feudalism, much of this technology remained localized, with little diffusion throughout Japan. In many cases, feudal lords prohibited the export of improved seeds or cultivating methods from their territories. "Although the Tokugawa period was characterized by significant growth in agricultural productivity, Japanese agriculture entered the Meiji period with a substantial backlog of unexploited, indigenous technology" (Hayami and Ruttan, 1985).

The Tokugawa period was brought to an abrupt close by the arrival of the United States Navy off the coast of Japan. This posed a significant threat to the survival of Japan as an independent entity. The upheaval that followed led to the replacement of the Japanese feudal elite by a new elite (the Meiji Restoration), whose focus, by necessity, would be on promoting rapid economic development, for it was only through this development that Japan could amass the political power necessary to preserve its independence. This new elite faced a threat, depended on an agricultural sector made up of the bulk of the population, and had a technological backlog to draw upon.

With the Meiji Restoration, the old feudal order collapsed and the newly established ruling elite sought to establish the institutions of a modern nation State. Fiefdoms were eliminated, and national communication was fostered. The old feudal class structure ceased to exist. The ruling elite reformed the land tax law, converting it from payment in kind to payment in cash. In addition, the rights of ownership were secured and the land tax was formalized. A system of experiment stations was established along with an extension system composed of veteran farmers. The latter were utilized to spread technical innovation. There had been significant investment in irrigation during the Tokugawa period; this sort of investment was carried on throughout the Meiji period as well.

As a result of the above, from 1880 to 1900, agricultural output grew at a rate of 1.6 per cent and productivity at 1.2 per cent. From 1904 to 1918, these numbers became, respectively, 2.0 per cent and 1.5 per cent. By historical standards, this was rapid growth (Yamada and Hayami, 1979). Improved productivity played a large role.

However, in the second decade of the twentieth century, the technological backlog was approaching exhaustion. The Government had significantly invested in its agricultural experimentation and extension system and crop breeding was being extensively carried out. Although this research would eventually lead to major sources of new technology, this would not occur until the mid-1930s. As a result, Japan faced a population-food problem just before the First World War. Rising food (rice) prices caused serious social disruption in urban areas, eventually resulting in the rice riots of 1918. These riots, which took place in all of the major cities of Japan, threatened the survival of the Japanese ruling elite. As a result, Japan sought to use its colonies as a source of rice for the homeland (Hayami and Ruttan 1985), the goal being to dampen any price increase.

An extractive colonization process would have had the Japanese colonial governments in Taiwan Province of China (then called Formosa) and Korea seek to extract as much rice (and other primary commodities) as quickly as possible. This would have dampened rice prices in Japan, allowing research on the mainland to create the technologies necessary to finance the mainland's economic growth. However, the Japanese colonial State chose a different route.

The technologies that had been developed in the Tokugawa and early Meiji period could be easily transferred to the environment of Taiwan Province of China, but much less so for Korea. In other words, significant modification of the technology was not necessary in Taiwan Province of China. Thus, the colonial government in Taiwan Province of China had a significant backlog of agricultural technology that could be relatively easily utilized, while in the Republic of Korea

this was less so. In terms of the model developed in the previous section, DBA shifted downward and to the right. This made it easier to create a process of cumulative causation, with pro-poor policies having a significant impact on pro-poor influence on policymaking, leading to more pro-poor growth, etc. The term "pro-poor" is understood to mean pro-agriculture, as the bulk of the poor work in agriculture.

The main motivation for the colonial elite to undertake pro-poor (pro-agriculture) policies was the fact that the Japanese ruling elite in both colonies was faced with a fundamental fiscal difficulty. In order to provide for a flow of rice from the colonies to the mainland, investments had to be made in infrastructure: irrigation, roads and communication. In order to pay for these investments, revenue was needed. This revenue could only be collected by extending the State's administrative and institutional structure into the countryside. However, to encourage quasi-voluntary compliance, the ruling elite had to provide services (public investment) in return. In Moore's (2001) terms, the ruling colonial elite in Taiwan Province of China and Korea depended on earned income. In order to generate revenue, they had to generate agricultural growth.

The investments made by the ruling colonial elite yielded significant growth in the agricultural sector (especially in Taiwan Province of China) and substantial structural change, i.e. significant expansion of non-agricultural sectors. It was the significant technological backlog that made it attractive to transfer such technology to the colonies. As pointed out above, these investments in technology transfer resulted in rapid growth rates in agricultural production. This also resulted in substantial structural change, with manufacturing activities increasing as a share of total output. These activities provided additional employment opportunities, additional sources of income.

One might argue that, while development was occurring during the colonial period and this growth was agriculturally based, this does not mean that such growth was in any way pro-poor. Although the bulk of the poor in these two colonies certainly resided in and earned their income in the agricultural sector, that does not mean that they benefited. After all, the colonial power had no direct interest in the poor farmers benefiting from agricultural growth.

However, there is a fundamental reason why the colonial elite would follow policies which would indeed end up benefiting the poor inadvertently. The ruling colonial elite had to earn its revenue via tax collection. One of the initial policies followed by the colonial State in both territories was to conduct a land survey, determine ownership and grant property rights to the owners. This was necessary in order to create an effective institutional structure for assessing and collecting

the land tax, which was initially the dominant source of revenue. As productivity in agriculture grew, via investment, revenue would increase. If agriculture prospered, so did the ruling colonial elite. However, in order to create quasi-voluntary compliance, there must be reciprocity. That is, if the State seeks to extract revenue, it must provide not only services in return, but also incentives for farmers to adapt the new technologies. More specifically, farmers must benefit from utilizing new technologies if they are to be effectively applied. Thus, the poor, as agricultural producers, must gain in the process.

Evidence supporting this conclusion is now readily available. From 1910 to 1939, real wages in Taiwan Province of China increased at an annual rate of 1.3 per cent a year. Data imply that, up to the 1930s, per capita consumption was rising. "In the colonial period the Taiwanese also consumed a steadily expanding flow of publicly financed services, among which those related to public health and education were most important and had far reaching consequences. From 1906 to 1936-40 the mean life expectancy of Taiwanese males at birth increased by 13.4 years to 41.1 and that of Taiwanese females by 16.7 years to 45.7" (Ho, 1978). In terms of education, by 1930-31, 33 per cent of school age children attended school and by 1943-44 this grew to 71 per cent (Ho, 1978).

A different story emerges from Korea. Per capita real consumption did rise at 2.3 per cent per annum from 1911 to 1940. This was accompanied by significant structural change in which the share of agriculture in GDP fell from 76 per cent to 41 per cent (Cha and Kim, 2006). In addition, primary school enrolment, literacy, and survival rates all increased (Kimura 1993).

However, the results with respect to Korea are not as clear cut as those for Taiwan Province of China. There is some evidence that farm income per household and agricultural wages may have declined (Kimura, 1993). More importantly, when one examines the production and export of rice, Korea's critical food grain, the colonial experience appears to be more extractive than developmental. Data provided by Kim (1977) shows that, from 1912 to 1932, rice production increased by 41 per cent, but exports of rice (mainly to Japan), increased by 164 per cent. The ratio of exports to production was .04 per cent in 1912. By 1933, this had become 53 per cent. From 1918 to 1933, per capita consumption of rice in Korea declined dramatically. Output of rice grew, but extraction of rice for the Japanese market grew much faster. From this perspective, Japan seems to have behaved in a more extractive manner with respect to Korea.

How is one to reconcile this with the calculations of Cha and Kim (2006) indicating that per capita real consumption in Korea rose consistently? Their results include consumption of agricultural goods, manufactured goods and services. Thus,

consumption of rice could go down, while consumption of other things would increase. Although grain consumption in general declined, the consumption of non-agricultural goods and services increased. What this seems to imply is that the growth process in colonial Korea was much more unequal in nature than in Taiwan Province of China. Since the poor relied mainly on grain consumption, the decrease in the availability of rice would have significantly affected them. This is reflected in the fact that Koreans seemed to be getting shorter, especially in the last two decades of the colonial period (Gill, 1998).

Thus, the Republic of Korea's colonial experience appears to be of a much less developmental and much more extractive nature in relation to Taiwan Province of China. This is likely due to several factors. Successful pro-poor growth is dependent, it has been argued, on a significant backlog of agricultural technology. Such a backlog was very limited, perhaps non-existent for the Republic of Korea. This is illustrated by the fact that while agricultural production from 1920 to 1939 grew at 1.62 per cent per year, this growth was completely due to increased input usage, not increases in productivity, not increases in technology (Ban 1979). The lack of technical innovation was the result of the fact that when Korea was colonized, its infrastructure, especially irrigation, was much less developed (Hayami and Ruttan, 1985). Also, the climatic and soil conditions were such that much of the Japanese agricultural technology could not be cheaply applied in Korea. Without the backlog of such technology, growth in Korea was much less likely to be pro-poor.

The main hypothesis of this paper is that the creation of a significant technological backlog creates the opportunity to transform a low-level trap situation into a high-level equilibrium in which the poor benefit. The ruling elite extend the State's administrative structure into the rural areas to extract revenue, in return for which they must provide public services and make public investments (in order to create quasi-voluntary compliance). Taiwan Province of China illustrates this process under adverse circumstances. A colonial power became the ruling elite, and, although they did indeed undertake pro-agriculture and thus, indirectly, pro-poor policies, they were motivated by revenue concerns, and the pro-poor result was an incidental by-product of colonization. The ultimate goal of the Japanese was self-aggrandizement and the strengthening of the Japanese State and, as a result, much of the benefit of growth in Taiwan Province of China accrued to the Japanese. Thus, if under these extreme circumstances a technological backlog led to pro-poor (Taiwanese) effects, then this is strong support for the proposition argued in this paper. This is further illustrated by the fact that, after the Second World War, agriculturally based pro-poor growth led to substantial poverty reduction.

The case of the Republic of Korea shows what happens when the technological backlog in agriculture is more limited. The ruling elite still sought to extract revenue and in return did provide public services and investments in agriculture. However, the pro-poor aspect of growth was much more limited. It should be pointed out that the Japanese colonial State was going about the construction of the rural infrastructure necessary to activate the complete potential of the agricultural technology being transferred from Japan. Significant investments were being made in irrigation and other infrastructure, efforts were being made to distribute new seed varieties, and extension systems were being organized. Thus, from 1930 to 1939, the rate of growth of agricultural production jumped to almost 3 per cent a year (Ban, 1979). It would seem that the foundations for future pro-poor growth were being established in the latter part of the colonial period of the Republic of Korea.

After the Second World War, Korea became independent. In very short order, the Korean peninsula split into North and South, the former becoming Communist. With the defeat of the Nationalist army in China, much of the Nationalist elite and army retreated to Taiwan Province of China. Thus, almost immediately, both the Republic of Korea and Taiwan Province of China became subject to severe threats. These threats were partly external—from mainland China and the Democratic People's Republic of Korea—and partly internal—the fear of rural peasant unrest. Thus, the ruling elite in both the Republic of Korea and Taiwan Province of China was constrained to direct significant investment into the agricultural sector, further enhancing rural infrastructure and technology. This enabled rapid agricultural growth to continue.

In addition, significant land reforms were carried out in the Republic of Korea and Taiwan Province of China (as well as Japan). This provided a firm foundation for pro-poor growth. External and internal threats to the new governing elites certainly played a role in terms of providing an environment conducive to land reform. However, it must also be pointed out that, during the colonial periods, the position of the landlords in both territories had been significantly weakened. In Korea, tenancy disputes had begun to grow in the 1920s and accelerated during the 1930s. Most of the disputes were short-run in nature involving, on average, very few participants per case. The Government of Japan, dealing with tenancy disputes at home, promulgated the Tenant Arbitration Ordinance in 1932 and the Regulation for the Establishment of Owner Operators in 1939. The former allowed parties to a dispute to submit claims to non-binding arbitration. In 1934, the Agricultural Lands Ordinance was initiated, guaranteeing a tenancy contract of at least three years, allowing tenants to propose rent reductions when crops failed

and automatically renewing the rental contract as long as there were no violations (Shin, 1996).

The result was that more than 80 per cent of tenancy disputes led to partial or complete victory for the tenant. Rental rates from 1933 to 1938 declined. These results were concentrated in the more commercialized regions of the agricultural sector (Shin, 1998). Thus, Korean landlords found themselves facing increased resistance from peasant producers and Japanese policy increasingly tilted toward the interests of the latter.

A similar process also seems to have unfolded in Taiwan Province of China during the latter part of its colonial period. In the second decade, of the twentieth century, peasant unrest began to occur in the sugarcane-producing areas of Taiwan Province of China (sugar was produced on relatively small, peasant household farms). These tenant disputes then spread to the rice-growing regions. In response to this unrest, the Japanese initiated a programme to create tenant-landlord associations which would serve as mechanisms for settling disputes, formalizing contracts and making the contracts long-term in nature. In addition, cooperatives were established to attend to the storage and processing of rice and sugar and provide peasant farmers with credit and transportation. In 1939, rental rates were fixed while rice prices fell, undermining the position of the landlords. Thus, by the Second World War, landlords in Taiwan Province of China had been significantly weakened (Ka, 1995).

The point is that the land reforms in the post-war period in Taiwan Province of China and the Republic of Korea were not merely the result of external pressure and security threats. They came about also because the landlord class had already been seriously weakened during the latter part of the Japanese colonial period.

Let us now briefly examine the experience of South-East Asia. This is a vast part of Asia, with considerable variation in geographical, social, political and historical conditions. However, the initial conditions existing in much of South-East Asia during the process of colonization differed dramatically from that in Taiwan Province of China and the Republic of Korea during their colonial period. Excluding Java, population densities throughout South-East Asia were much lower, and land was much more abundant. In addition, many of these countries had significant natural resources to draw on. Thus, this region can be characterized as being abundant in land and natural resources and labour-scarce in relation to North-East Asia.

The vent-for-surplus theory of international trade developed by Myint (1958) has often been applied to South-East Asia. In this theory, it is presumed that, because of surplus land (natural resources), a less developed country would operate within its production possibilities. The lack of utilization of land/natural resources is due to a lack of demand for products produced via the surplus resources. Thus, when a country's economy is integrated into the global economy via trade, production would grow quite dramatically as exports requiring intensive use of land/natural resources expand, bringing into production the previously unutilized resources. Thus, trade is a vent for the utilization of surplus land and natural resources.

Thus, a sort of free growth occurs in that surplus land/natural resources are utilized to expand production without significantly reducing the production of other goods. The colonial governments in South-East Asia were actively seeking to promote such production for their home markets, but mainly it was for foreign markets. Much of this growth was due to the reproduction of traditional varieties and technology over more land. There was little effort to increase yields by developing and applying high-yield varieties (except in Java) (Booth 2007a). Thus, agricultural growth was extensive rather than intensive.

These agricultural exports became the main source of revenue for the colonial governments in South-East Asia. This revenue was extracted via trade taxes and taxes on income generated from export production. This implies that revenue and expenditures in South-East Asia for the first four decades of the twentieth century were tightly linked to primary product export growth. "Long-run elasticities of both revenues and expenditures with respect to exports were close to unity in most parts of the region" (Booth 2007b).

The implication of the above is fairly straightforward. Much of South-East Asia had a ready source of revenue to finance colonial government expenditures, a source of revenue which was, relative to the situation in Korea and Taiwan Province of China, easy to extract. Thus, the constraint on policy choices by the ruling elite was relatively relaxed in comparison with Korea and Taiwan Province of China. As a result, there were greater resources available and a greater temptation to use them in non-productive ways. The colonial elite was thus dependent upon a much smaller coalition in order to remain in power. Finally, these colonies did not face significant external/internal threats. Japan faced a powerful threat in the form of rising rice prices and, earlier, possible colonization which threatened to undermine the ruling coalition in the motherland.

More importantly, the revenue extraction process in South-East Asia did not involve creating an institutional structure organized in such a way as to both raise agricultural production and extract revenue. There was no institutional structure constructed on the basis of reciprocity; the State provided technology in return for which it collected revenue. This institutional infrastructure evolved in Korea and Taiwan Province of China.

V. POLICY IMPLICATIONS AND SUMMARY

How does a State become effective at reducing poverty? This question was answered within the context of a poverty trap model. The answers to this question that come from this model are of two types. First, one can improve the effectiveness of the poor to influence policymaking so as to be more pro-poor in its impact. This will likely involve the creation of accountable, more democratic political institutions. This is the institutional approach of modern economies. However, the means through which this is done are not well understood, and attempts to achieve this have, to date, not been very successful.

Alternatively, one can try to increase the productiveness of pro-poor policies. As the bulk of the poor in many countries live in rural areas, this would require increasing the effectiveness of agricultural policies. The productivity possible as a result of agriculturally based policies would depend on the existence of a technological backlog that can be adapted, transferred and applied. This will tend to eliminate the low-level trap in which the poor have little influence on policy and policy has little impact in terms of reducing poverty. The existence of such technological potential, while necessary for pro-poor development, is not likely to be sufficient. The ruling elite's governing coalition is likely to broaden to incorporate the rural poor if the former faces threats, both internal and internal, to their political survival. If so, the ruling elite, in search of revenue, will extend its institutional structure into the countryside, in return providing the means to access and utilize the technological backlog. The lower the availability of a technological backlog, the less pro-poor the State will be.

The main policy implication concerns sub-Saharan Africa and parts of South Asia. Particularly in the former, the ruling elite has pursued self-aggrandizement at the expense of the poor. Attempts have been made to enhance the influence of the poor via institutional/political reform. These have had limited success. Little is likely to change, even if a technological backlog exists, as long as the ruling elite does not face internal or external threats to its political survival. However, the difficulty in much of Africa is that, even in those cases in which the political elite face internal or external threats, the technological potential for rapidly expanding

agricultural productivity does not exist. This is the result of several factors. First, agricultural research in sub-Saharan Africa remains fragmented, with more than half the countries employing less than 100 full-time equivalent researchers each. Second, while research and development spending grew at 2 per cent a year in the 1970s, it dropped to 0.8 per cent in the 1990s. In 2000, Africa invested $0.70 for every $100 of agricultural output—lower than the 1981 level of $0.95. This implies that funding for developing agricultural technologies has become increasingly scarce and irregular (Beintema and Stads, 2004). For many parts of Africa, a technological backlog does not exist.

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A SIMULATION FRAMEWORK TO STUDY POLICY FORMULATION AND EVALUATION OF ECONOMIC VIABILITY AND SUSTAINABILITY OF SMALL AND MARGINAL FARMERS

*Usha Sridhar and Sridhar Mandyam**

This paper proposes an economic computational agent-based framework, referred to here as FarmSIM, to model the micro-level economic and financial behaviour of farmers. We model macro-level external environmental impacts of costs, prices and rainfall through a set of flexible power functions. The framework allows us to trace a "digital future" of a farming community over a number of "seasons", effectively offering the ability to test an appropriate policy on the community. FarmSIM may provide a valuable test-bed for gaining a direct insight into economic viability and sustainability issues in relation to policy implementation.

The paper suggests an evaluation framework, FarmSIM, to assess the efficacy of policy formulation by Governments and other institutions concerned before the policies are implemented. The paper demonstrates the utility of FarmSIM by posing important questions relevant to pricing, profitability and indebtedness in the farming community in the form of simulation models within the FarmSIM framework. Realistic data are used to assess the dynamics and the effects of interactions of core variables over time.

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I. INTRODUCTION

The prospect of an agrarian crisis in the developing world is becoming all too real. Researchers associate a diversity of issues with this possibility, ranging from economic unsustainability of agriculture arising from the cost and pricing structures of inputs and produce, declining agricultural yields, shrinking acreages of agricultural land, and, among several other things, an increasingly asymmetric global food pricing regime, and, finally, an unpredictable climatic change that can seriously damage agricultural yield in the near future (Patnaik, 2009; Patnaik, 2003; Glipo, 2008; Philip, 2008; Aerthayil, 2008; Hiremath, 2007). The situation in South Asian countries in general, and particularly India, is far more serious (Ghosh, 2009; India, Department of Economic Affairs, 2007; India, 2008). These are a complex set of issues with a high degree of uncertainty, and can perhaps collectively or even singly derail the best of policies formulated at the level of national Governments.

In many South Asian countries where there is a large degree of fragmentation of land holdings, the primary impact of this projected crisis is expected to befall the small and marginal farmers, typically owning plots of less than one hectare. Many planning agencies and researchers have identified financial viability—the ability or inability of these small and marginal farmers to make a profit from agriculture—as a core issue that makes the farmers highly vulnerable to a diversity of adverse external situations. Since these farmers' income is small in any season, they need to raise capital through loans to work in subsequent seasons. The question of economic sustainability arises from the ability or inability of these farmers to sustain the farming business over time without falling into a debt trap.

National planning agencies are formulating policies to address many of the vulnerabilities of small and marginal farmers (India, 2007; 2008). However, there are several difficulties in reliably quantifying how the small and marginal farmer is impacted by even small perturbations to the cost of inputs and the price realizable for his produce. This is because there is such wide variation in input costs, and realization of the prices of agro produce – the supply chain is long for most commodities, and the diversity of grades and packaging alternatives leave tremendous scope for any average price and cost indicator to be just that – only an average indicator. Regional and geographic variations coupled with the diversity in cropping patterns add to the complexity of national-level policy formulation, implementation and grass-roots monitoring of impacts of costs, pricing and profitability (Deshpande and Naika, 2002; Gandhi and Koshy, 2006).

To address the problem of policy evaluation, economists typically attempt to draw inferences from historical data at some gross geographic scale and develop models to project the implications of a policy. These approaches require many assumptions on market structure and price visibility that are difficult to justify in the context of our need here to examine economic viability at a micro-level. For instance, the strong localization of distribution/-collection of agro produce often precludes the possibility of obtaining a better price. Smaller farmers may choose to "distress" sell to a local middleman for a price lower than a higher support price if obtaining a higher price involves either time or cost penalties. Also, overall profitability of operations is closely tied to scale, and these approaches do not readily allow macro-level price and cost conditions to be reflected in micro-level financial conditions of individual farmers.

Since these complexities compound the problem of policy formulation and evaluation in practical situations it is desirable to examine the possibility of having a test bed that gives planners the means to set up a simulated agricultural operational environment on which they could test and refine policies.

In this paper, we propose a simulation framework to evaluate policies related to the financial viability and economic sustainability of these small and marginal farmers. The purpose of the framework is to analyse the farmer's repayment pattern in order to allow modelling of the agricultural and financial operations of the farmer at a *micro-level*, involving his decisions on how big a loan to take to cover expenses for the next sowing season. How that decision might be impacted by a *macro-level* environment comprising costs, prices and weather is what will tell us how vulnerable the farmer is—whether he would make a profit, and whether his business is sustainable. Given the ability to plug in models in the simulation that will *map macro-level impacts on micro-level conditions,* it would be possible to examine the economic viability of the agricultural activity of the individual farmer in relation to the specific types of external environments, including weather or market prices, in which he operates.

We have approached the question of the economic viability of agricultural activity from the perspective of simulated economic agents representing individual farmers in a suitably constrained operational and financial environment. The simulation framework and models described in this paper permit us to follow the financial accounts of individual farmers at a *micro-level*, over a period of time covering several sow-harvest seasons. The operations are driven by simple and customizable rules which tell a farmer when to take credit and how much of it he needs in order to survive and grow. The farmers receive cost, price and weather information from a simulated "*macro environment*", with rules to calibrate yield

from the farm on the basis of weather conditions. Price and cost rules may be set up in our simulator to handle conditions in which, for instance, large supplies caused by good weather can depress prices, and shortages caused by repeated poor-weather periods can push up prices and costs.

This simulation approach allows us to generate plausible "digital futures" for agricultural activity on the basis of a set of postulated rules for how the future environment will shape up, and how it might impact micro-level variables. We do this here by simulating the time evolution of agents mimicking the economic behaviour of different types of farmers. The goal is to demonstrate how the framework may be used to observe measures of viability and indebtedness under favourable and unfavourable external conditions.

In our demonstration, we simulate not only small and marginal farmers but also farmers who own larger parcels of land, allowing for the possibility of endowing the community with a level of diversity which mirrors typical land distribution patterns. Specific properties can be applied to the financial behaviour of individual farmers, although farmers in a class do have somewhat similar properties.

The primary goal in this paper is to present a methodology for policy evaluation using simulation of economic activity at a *micro-level* as a feasible mechanism to assess *macro-level* behaviour. The methodology is implemented using a simulation framework, which we call FarmSIM, that allows us to mimic the behaviour of individual economic agents. We do not attempt to present any specific agricultural policies or evaluate their impact. We do, however, present examples of questions that could be asked of the framework to assist in the evaluation of certain classes of policies related to the financial viability of small and marginal farmers. In similar vein, it is to be noted that the data used for the demonstration of the simulation framework has been constructed to resemble that in a typical Indian agricultural scenario. It is not real historical data, but only "realistic" data used to generate results. The purpose is only to demonstrate how, given real data, the computer-based simulation can help in policy formulation and evaluation.

We show in this paper that the simulation approach allows new insights to be obtained into possible mechanisms for risk mitigation in the financial "life" of the small and marginal farmer agents. We believe it may also offer a new methodology to examine impacts of macro-level policies on regional or geographical groupings of farming communities at a micro-level, permitting an assessment of how they may be fine-tuned through simulation in order to make them more effective. Also, causal relationships may be investigated in a manner that may make it possible for policy implementation to be proactive rather than reactive.

We believe that the FarmSIM framework is equally applicable to the study of policy evaluation issues in any geographic region and is not country-specific in any way. It offers the flexibility to accommodate a diversity of data entities as well as micro- and macro-level models.

The paper is organized as follows. Section II presents an overview of the simulation framework and approach. The types of data and models for agents and the environment used to demonstrate the features of the framework are presented in section III. The core concepts underlying the mechanisms for simulation of external environmental impacts, and the types of micro-level decision rules, together with the measures of financial performance and sustainability that are calculated through the simulation runs are outlined in section IV. Further technical details of specific illustrative models and scenarios selected for simulation in this demonstration together with decision rules for the agents are described with appropriate pseudo-code in the annexes. Results are presented in section V, and recommendations are summarized with concluding remarks in section VI.

II. SIMULATION FRAMEWORK AND APPROACH

The central concept in our simulation framework is to define states:

S_t^j, t=1,..,T, j=1,.., N

for every "farmer" agent, where N denotes the total number of agents, and T denotes the number of time steps over which the simulation is run.

Let $S_t = \{S_t^1, S_t^2,...S_t^N\}$ denote the set of states of all agents in time step t, and similarly let $S^j = \{S_1^j, S_2^j,...S_T^j\}$ denote the set of all states of agent j over the time steps 1 through T. The state set S_t^j comprises a number of individual variables characterizing the attributes of the farmer agent j at time t. These variables include size of land owned, farmer type, loan type, family size, and other data pertaining to individual farmers, as shall be detailed in section III.

We also define a set of variables $E_t = \{E_1, E_2,..,E_T\}$ to characterize the state of the external environment over time steps t=1,..,T. Each state of the environment, E_t, comprises a set of variables that capture features of the "projected future" of the environment. Explicit future values of these variables need to be provided to the framework, typically through the use of external models.

The simulation calculates the state of each agent in time step t as a markovian transformation of its own state at the previous time step (t-1), modulated by a known environmental state at time t:

$$S_t \leftarrow f\,(S_{t-1}, E_t),\ t=1,..T \quad (1)$$

given the initial state of agents, S_0.

The states S^i characterize economic or financial "state of afairs" of the farmer agents as they engage in the activity of agricultural production, and a time step is thus the equivalent of a season – from sowing to harvesting and sale of produce.

This micro-level activity is governed by a set of "operational laws" or rules which specify how they deploy available financial resources towards agricultural inputs and family expenses, how much they need to borrow, if required, to pursue agricultural activity, and how much they can retain as profits to continue operations in the next time period.

A central mechanism which needs to drive these operations is clearly a cash flow process, which allows profits and losses to be carried over from season t to (t+1), embedding in itself the amounts payable towards loans. Also, clearly required here is a decision point where each farmer agent needs to assess how much, if any, of credit is required to run the operation. The process, variables and assumptions made in their choices are described in detail in the next section.

Another feature of the framework and approach is the means to modulate the computed micro-level state of each agent by the "known" state of the environment in the manner prescribed in (1). These "environmental laws" are a set of rules and functions that determine how macro-level variables defining the state of the environment E_t, described in greater detail in the next section, will impact micro-level variables.

The framework also provides the means to define and measure the performance of the community of farmers in terms of their financial state of affairs. We can define a set of indicators

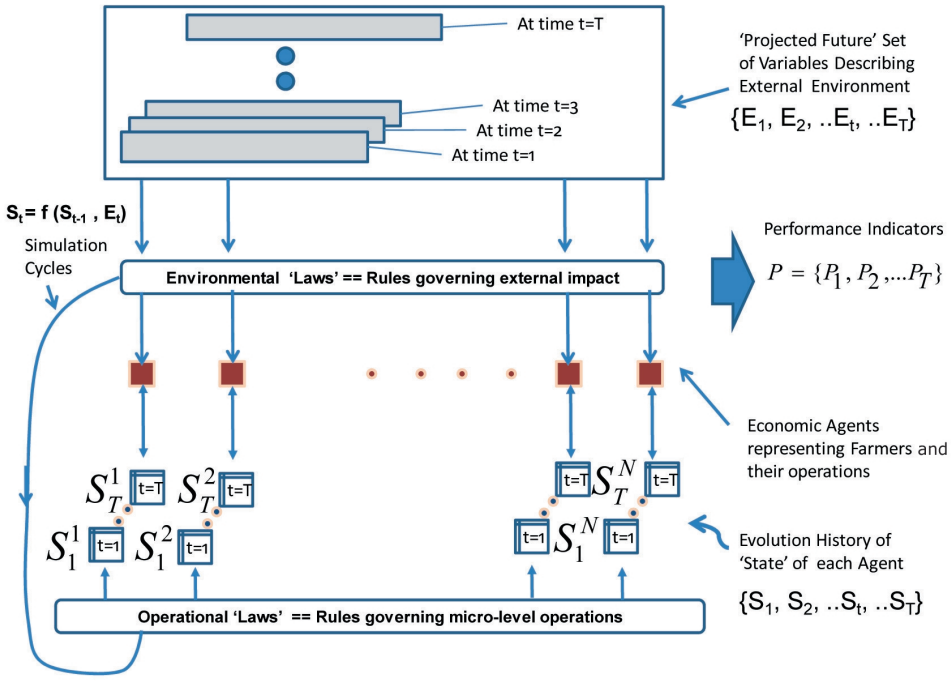
$$P = \{P_1, P_2,...P_T\}$$

for each time step, and use predetermined conditions on them to alter the decision conditions, if required.

The overall approach adopted to implement this basic schema described above is presented diagrammatically in figure 1.

The key elements in the simulation are the farmer agents representing individual farmers, the red squares in the middle of the drawing. To monitor each agent's financial operations, we shall endow each agent with the capability to

Figure 1. Basic schematic diagram of simulation flow



determine cash flows which he needs to balance each farming season. These operational "Laws" which are applied by each agent individually are shown as a box at the bottom of the drawing in figure 1. In order for us, as external observers, to observe this "community of farmers" over time, we shall have a local storage of the history of transactions.

In sum, FarmSIM is essentially a simulation framework, and it is possible to set up the system to simulate a "digital future" for a set of farmer agents, by taking them through a desired number of time steps. In order to use the framework to study policy formulation and evaluation, it is necessary to set up data for the agents, the environment, and a set of formulas that connect the external macro-environment to the micro-environment.

In order to demonstrate how the framework may be used, we shall consider the following scenario features to capture some of the essential micro- and macro-level structural details of a community of farmers. The framework itself does not preclude the possibility of extending the scenario in many ways. Some of these possible extensions are also outlined in a later section.

a) Community of farmers

We consider a community of farmers owning agricultural land of different sizes, and associated assets, such as trees, barns and pumps. The type of farmer is characterized by the size of his land.

b) Agricultural activity

We shall allow the farmers to engage in agricultural activity as their primary source of income, but we shall also allow for some non-farm income. For his main activity, the farmer is thought to examine his finances at the start of a season, determine whether credit is needed—and, if so, how much—based on current balances and taking into account family expenses during the season, and then allocate resources to purchase inputs. The farmer then waits for the harvest at the end of the season, and sells the produce at a price determined by the external environment, using the returns to pay back loans, possibly earning a profit, and pursuing the activity into the subsequent season.

Although our framework allows each farmer to choose different types of crops to sow each season, we consider in this paper only situations where a single crop is sown by all landowners. This restriction allows us to focus on the fundamental issues of relative economic viability without the distraction of having to account for the relative benefits of differing yields and prices. Since we only want to demonstrate the viability of our framework, this enforced uniformity permits a direct analysis for one crop—rice—in this paper, leaving multi-cropping optimizations as a second-order effect for later study.

c) Loans

Farmers have access to loans covering working capital and personal family expenses in every season. We consider for the purpose of this study situations where repayments of loans can be made over multiple seasons at an interest rate that is uniform across all farmer types. In principle, the framework does not place restrictions on the possibility of applying differential rates for different subgroups of farmers, should that mirror a factual situation.

d) Contiguous land parcels, uniform climatic impact

We shall assume that lands are contiguous, only rain-fed (i.e. no farmer has the advantage of canal-based irrigation), and extend over a rather small geographic region – small enough to render them equally and uniformly impacted by the climatic environment.

e) Rainfall and prices characterize external environment

The external environment comprises a time series of rainfall data by season, and base price data by season. We shall model the impact of rainfall over yield with the use of tuneable power functions for the purpose of this demonstration. Similarly, we shall model price-setting through the use of power functions to mimic possible asymmetries in the pricing situation. Needless to say, the functions may be tuned to capture a similarly non-linear real external environment, or even be replaced by a real "fitted" external function derived from an analysis of historical data.

f) Performance measures

We have computed a number of measures to capture the state of affairs of the farmers over time. These may be studied across multiple dimensions to draw conclusions on how the macro-environment could change.

III. DATA AND AGENT MODELS

For the purpose of demonstrating the FarmSIM framework, we have set up the following data elements to capture the state of a farmer agent.

Agent attributes

All farmers are characterized by a set of basic data attributes:

Table 1. Basic data for each agent

	Data Variable	*Name*	*Data Type*
1	Farmer type	**Type**	Numeric
2	Land size (ha)	**ls**	Numeric
3	Family size	**fs**	Numeric
4	Number of trees	**nt**	Numeric
5	Crop grown	**ctype**	Numeric
6	Loan	**loan**	Numeric
7	Number of cattle	**nc**	Numeric
8	Farm equipment	**feqp**	Numeric

Farmer type is determined by the size of the land. We consider five types of farmers as shown in table 2, characterized by the size of their land holding.

Table 2. Farmer type vs. land holding size

Type	*Name*	*Land size (hectare)*
1	Marginal	< = 1 ha
2	Small	> 1 ha & < = 2 ha
3	Medium	> 2 ha < = 4 ha
4	Medium-medium	> 4 ha < = 10 ha
5	Large	> 10 ha

Distribution of farmers

In this simulation, we use a community of farmers numbering 400, whose distribution by land size is designed to approximately mirror a typical Indian distribution. Table 3 presents the number in each type category, and the cumulative distribution of land ownership appears in figure 2.

Table 3. Land Distribution

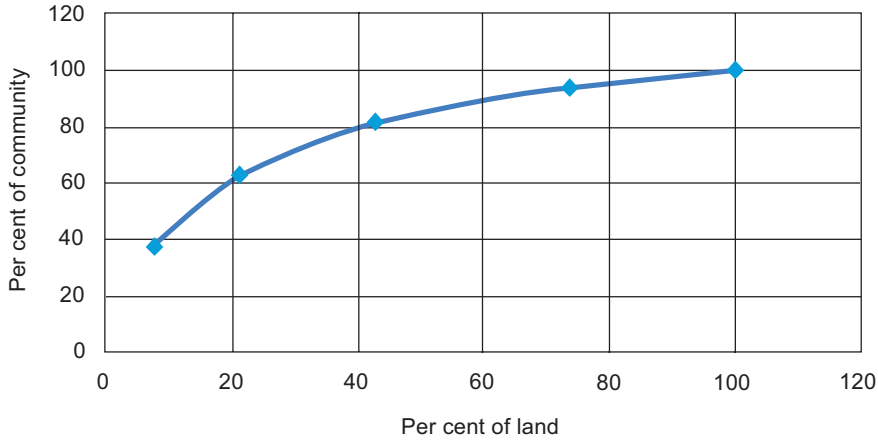
Farmer type	*Number*	*Percent of total (%)*	*Total land size owned (ha)*	*Per cent of total land (%)*
Marginal	150	37.50	87.34	7.61
Small	100	25.00	157.25	13.70
Medium	75	18.75	246.60	21.49
Medium-medium	50	12.50	353.50	30.80
Large	25	6.23	303.00	26.40

The resulting cumulative land distribution chart is depicted in figure 2.

Micro-level agent operational models

The fundamental task of the agent in our simulation is to perform agricultural activity. For this purpose, the agent requires financial resources. We consider the following variables and relationships as representative of the financial condition of the agent:

Figure 2. Cumulative land distribution chart



a) The basic cash flow across seasons is modelled as follows for every agent *j* in time step (season) *t*:

$$coh_{jt} + if_{jt} - tc_{jt} - tl_{jt} + trev_{jt} = coh_{it+1} \quad (1)$$

where *coh* denotes *cash-on-hand* brought forward from the previous season (available at the start of season *t*), *if* denotes the cash inflows possible in this season from non-farm activities, *tc* is the estimated total cost of production for this season, *tl* is the total loan amount payable in this season, *trev* is the projected income from sale of the agricultural production, and the right-hand term represents the cash-on-hand carried forward to the next (t+1) season.

Other than cash on hand, the remaining variables are further related to other variables as described below.

b) The total cost of production, tc_j for farmer *j* in time step *t* is:

$$tc_{jt} = c_{jt} s_j \quad (2)$$

where tc_{jt} (in $) is calculated as a product of cost, c_{jt} (in $/ha) in time step t, farm yield y_{jt} (tons/ha) in time step *t*, and land size, s_j (in hectare).

c) The total revenue earned by farmer *j* in time step *t* is:

$$trev_{jt} = p_{jt} y_{jt} s_j \quad (3)$$

where $trev_{jt}$ (in $) is calculated for farmer *j* as a product of sale price, p_{jt} (in $/ton) in time step t, farm yield y_{jt} (tons/ha) in time step *t*, and land size, s_j (in hectare).

d) The net profit in the operation for farmer j in time step t is simply:

$$np_{jt} = trev_{jt} - tc_{jt} \quad (4)$$

In order to begin sowing operation in season time step *t*, the farmer needs to acquire financial resource equivalent to tc_{jt} ahead of the start of the season. We also assume that the farmer needs to provision an amount equivalent to $fexp_{jt}$ to cover family expenses in the period *t*.

e) His total expenses te_{jt} in time *t* is the sum of family expenses denoted by $fexp_{jt}$ for period *t*, the total cost tc_{jt} for operations in period *t*, and any loan liabilities (see g below), tl_{jt}, for period *t*:

$$te_{jt} = fexp_{jt} + tc_{jt} + tl_{jt} \quad (5)$$

f) A farmer needs to determine if his expected inflow is adequate to cover total expenses of te_{jt} for this season. If it does, then he proceeds to sow and wait for harvest, or else he needs to borrow the difference:

$$gap_{jt} = te_{jt} - if_{jt} - coh_{jt} \quad (6)$$

g) In our simulations, we provide working capital to farmers at a pre-settable interest rate of *r* per cent per season (time steps) over a selectable tenure of *n* time steps. We assume that the loan is paid back on the basis of equated seasonal instalments (referred to here as *esi*).

The *esi* value for farmer *j* payable for a loan of gap_{jt} is calculated as *n* equal instalments, payable in seasons *(t+1), (t+2), ...(t+n)*, where *n* is the term selected.

$$esi_{jt,\,k} = (gap)_{jt} r_{jt} \frac{(1+r)^n}{(1+r)^n - 1},\ k=1, 2,..n \quad (7)$$

The implication of (7) is that the payments on a loan taken in time step *t* begin in time step *t+1*. Hence, in time *t*, we need to accumulate *esi*'s for any loans taken in time steps *t-1, t-2...t-n*.

tl_{jt} thus represents the total loan *esi*'s payable in time *t*. As we can expect, if the gap amounts are progressively smaller (larger) over time, the tl_{jt} amounts in

each step will fall (rise) and the farmer may borrow progressively smaller (larger) amounts. If the converse in brackets occurs, the farmer will progressively fall deeper into debt.

Given the initial value of cash-on-hand and loan liability at time *t=0*, we can now go through time steps over all farmers using land distribution data to determine profitability at each time step. We also need to take a decision for every farmer via a rule that determines if there are sufficient funds available to start agricultural activity in any period.

The rule allows using credit (i.e., a loan) to continue operations if the profitability of operations fails to cover personal expenses and working capital. It is possible to set up several alternative decision rules on the basis of the threshold loan burden, which, when crossed, can signal an intent to sell off the land and exit the business. Annex I lists possible decision rules for when to take a loan and when to make such an exit. *FarmSIM* allows the construction of any rule using the agent variables in combination with those representing the environment.

Our model allows farmers to generate other income in two ways. One is to seek intra-seasonal employment at a predetermined number of days and at a preset wage. The other way is the sale of assets.

The simulation framework allows all the above variables and associated states to be stored and transformed via (1) over a preset number of time intervals.

There are two variables that will directly impact the profitability of agricultural activity. They are yield y_t, and price p_{jt}.

In the agent-level micro-model described in this section, we have captured the basic "operational laws" of the individual farmer's financial and agricultural activity. We now need to set up a set of "environmental laws" or formulas that will translate variables representing the external environment to set values for yield, price and cost at the micro-level. This is the subject of the next section.

IV. MODELS FOR ENVIRONMENTAL IMPACTS AND SCENARIOS FOR SIMULATION

In this section, we discuss mechanisms for capturing the micro-level impact as determined by a macro-level phenomenon, and suggest scenarios to establish a simulation of the "digital life" of agents over a defined number of time periods. As mentioned in section II, the primary goal of the simulation is to step through

time evolution of the agents, *given* a preset projected external environmental condition.

Many different types of external environmental variables may be taken up for consideration. Examples include weather (as measured by rainfall), output prices, input costs, competitive conditions and transportation costs. In this paper, we illustrate the features of FarmSIM limiting our view of the external environment to three variables: rainfall, output prices and input costs.

Suppose we wish to simulate T number of time steps (i.e. seasons) of agricultural activity for a set of farm agents, we could set up three series:

Rainfall (mm) : R_t, $t=1,..T$

Base price for crop ($/ton) : Pr_t, $t=1,..T$

Input cost for crop ($/ha) : C_t, $t=1,..T$

These series of values represent a "projected" future external environmental condition. In a typical policy evaluation situation, these data could represent a scenario that needs to be studied, as a "what if" condition. Note that all three variables have a one-way influence on the farmer agent's operations, i.e., they can modify the crop yield, realized prices and profitability, respectively, but individual agents have no control over them.

Given the time series for the above variables, we now need mechanisms to transform them to produce values for micro-level variables y_t and p_t, at the level of the individual farmer. This transformation can be achieved using a variety of different types of models that relate the environmental variables to y_t and p_t (see Annex II for details).

In order to bring a level of realism to the numbers in the simulation, we have chosen two seasons per year, and used near real values for prices, yields and costs for rice in these seasons. That renders a 100-step run equivalent to stepping through 50 years.

Since our objective is to demonstrate how the framework may be set up to examine questions related to the viability and economic sustainability of agricultural activity in the face of dynamic changes to prices and yields caused by external factors, we have considered three different environments to influence the 100 time step simulation runs.

Three different rainfall patterns corresponding to respective environments have been selected:

(a) ***Environ1*** was constructed with the current global climatic changes in mind, leading to an alarming increase in the frequency of drought and floods. One third of the season's time steps therefore included drought and floods;

(b) ***Environ2*** assumed normal monsoons over all the 100 steps;

(c) ***Environ3*** lies between these two extremes.

These weather scenarios and their attendant impacts on crop yields are modelled in FarmSIM through the use of power functions, more technical details of which may be found in Annex II.

We have also simulated asymmetry in realizable prices using a parameterized non-linear function of land size. This gives us three different scenarios for prices, labelled *pf1, pf2, pf3.* The variation in the prices realized by the farmers is captured in these functions, to emphasize the fact that small and marginal farmers generally sell in distress, especially in hostile weather conditions, such as drought and floods. More technical details of the functions may be found in Annex II.

V. RESULTS

We shall now present some results from running the simulation for the farmer agents and alternative external scenarios as defined in the previous section. The set of rules defined allow each farmer to take decisions on how to handle the financial condition he faces in each time step, determine what level of credit he might want to access based on the profitability he expects. Given the projected external environmental factors, the simulation proceeds over the preset number of periods, and records a predefined set of indicators over the entire run.

The utility of the framework in the evaluation of a policy is that it thus provides a virtual community of farmers who can now be "subjected" to alternative external environments covering rainfall, crop yield and pricing conditions, to determine the impact of a host of pricing, costing or other financial policies. While we shall not propose policies in this paper, we shall explore interesting questions that might assist in the evaluation of policies.

In order to illustrate the classes of investigation that can be performed for policy evaluation, we shall present results in graphical form in the following sections, identifying the entities whose relationship we have explored. As may be seen, it is

possible to pick one of many measures of financial viability that FarmSIM records over the 100 simulation steps. But we shall use net profit as defined before, since it is easiest to relate to it as a descriptor of financial condition, and explore its variations with different environmental factors.

Here again, there will be many possible combinations. In the interest of brevity, we shall study profitability profiles associated with the *six* possibilities arising from two rainfall scenarios X three pricing function scenarios. Specifically, we shall study the three pricing function scenarios, *pf1*, *pf2* and *pf3*, in conjunction with the two rainfall scenarios *environ1* and *environ3*. We shall apply these profiles to all farmers regardless of land size.

These profiles are pictured in figure 3. The first column of graphs refers to all combinations *pf1, pf2 and pf3* with the first selected rainfall scenario *environ1*. The second column refers to the three combinations *pf1, pf2 and pf3* with the second selected rainfall scenario *environ3*. All six graphs are 3D plots of the net profit achieved against the land size owned, for every time step in the simulation.

To better relate land sizes and farmer sequence numbers in the explanations that follow, we need to note only, that farmer sequence numbers are sorted by increasing land size, i.e. if sequence number for two farmers *farmer_j* and *farmer_k* are such that $j>k$, then their land sizes $ls_j > ls_k$.

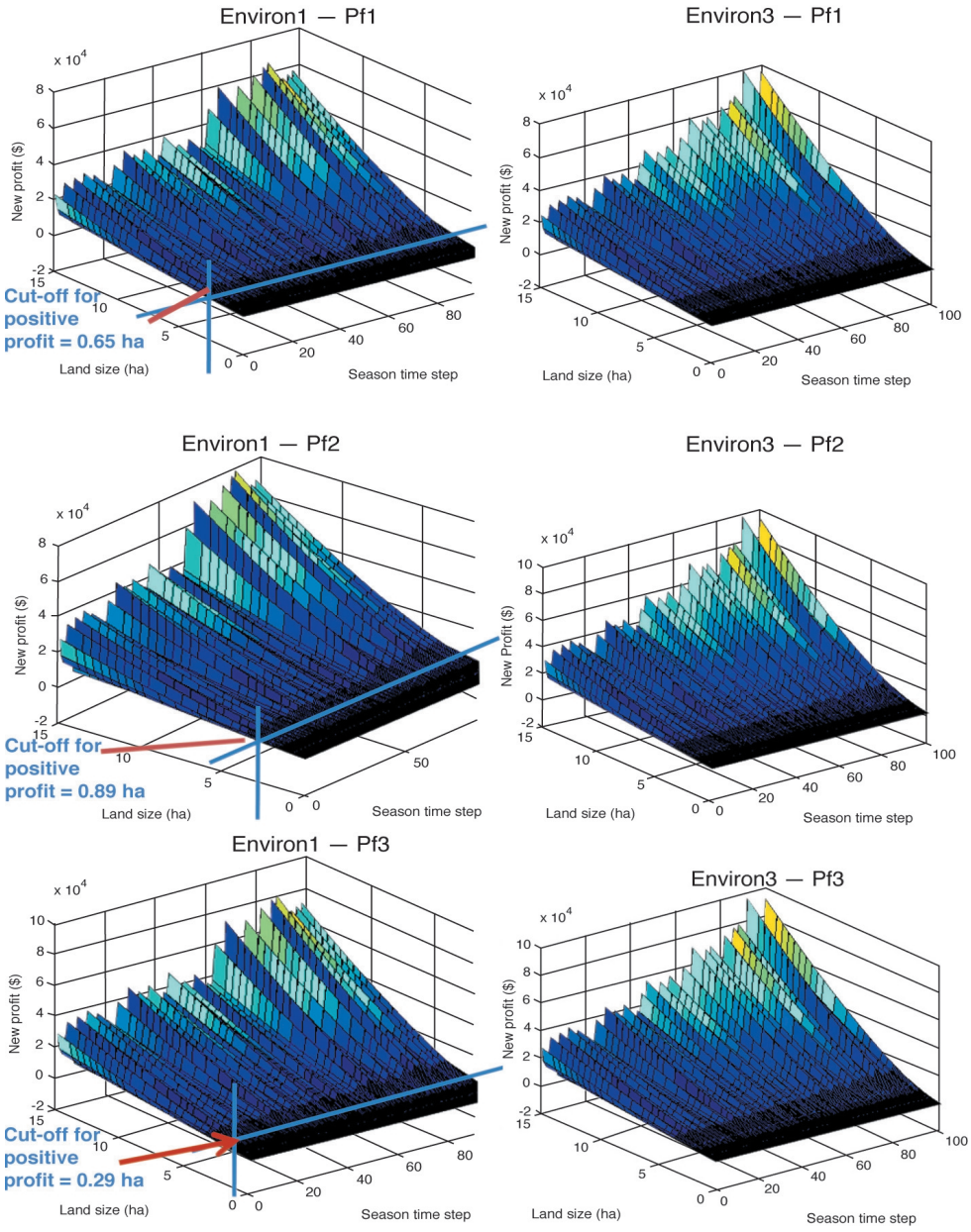
The following subsections illustrate how the evaluation framework can be used to obtain answers to specific questions. The flexibility of simulator allows for making appropriate internal changes and for also enabling external subsystems to be integrated for this purpose.

Profitability and land size

Given a projected rainfall pattern, crop yield and prospective prices, it is useful to know what is the smallest land size that will yield a profit for a farmer. Such a cut-off size may be used to select farmers with smaller land sizes for a non-farm employment scheme, for instance, with the assurance that their operations would have otherwise failed. We examine the question relating land sizes to profitability here.

With net profit being a function of agricultural yield, one would expect a cut-off land size below which profits would be termed unviable for continuing agricultural activity without seeking external financial credit. Evidently, such a cut-off would also be dependent on external factors, such as rainfall and prices.

Figure 3. Profitability profiles for selected environmental factors



Under this scenario of *environ1* and *pf1*, profits are negative for owners of small land plots, but turn positive when the land size reaches 0.65 hectare. Small profits are visible for this farmer even under extreme conditions of drought and floods. This cut-off of 0.65 ha is marked in the top-left corner plot of figure 3.

We now continue an analysis of the impact of land size on profits for the same *environ1* and a different price function, namely *pf2*. Land size of 0.10 ha continues to give negative returns; a land size of 0.89 ha is at least required to make modest profits under all weather conditions in this scenario. These cut-offs are marked in the plots on the left-middle row and bottom row of figure 3.

The plots show that, with *pf3*, a better pricing function has begun to yield positive returns for a marginal farmer with just 0.29 ha. The point of inflection in the land size for this scenario is 0.29 hectare as profits turn positive for all 100 time steps.

In general, our simulator permits determination of the cut-off sizes for viability of operations based on positive profits for any chosen combination of parameters related to costs, pricing and rainfall. Hence, policies that need to use this type of criteria to establish the priority for selecting beneficiaries can benefit from studies of this nature.

Profitability and environment

Similarly, we could ask which classes, and how many in the community of farmers, given their current financial conditions, would likely turn delinquent on their loans, if the prospective weather conditions worsened—for example, if there were two sequential periods of drought. If we had provided the simulation with data on multiple crop options, we could have asked which combination might have given better succour to indebted farmers, given the impending drought years. Such information would be vital to evaluate a policy on loan waivers, for instance. Unlike with omnibus loan waivers, the simulation could identify specific subpopulations as targets for policy implementation and differentiate between different regions based on the severity of the external environment.

For this purpose, we need to explore the relationship between profitability, indebtedness and the weather. We examine the impact of severe weather conditions on profitability over different land sizes. The three plots on the right of figure 3 display the effect of rainfall on profits, using *environ3* for the three price functions *pf1*, *pf2*, and *pf3*. Noting that *environ2* represents a rather "healthy" rainfall pattern as compared with *environ1* and *environ3*, we chose not to explore its pattern. We

therefore have two alternative rainfall scenarios to consider for the same price function.

As is evident in figure 3, farmers fair better in *environ3* compared to *environ1* due to better prevailing weather conditions used in the former, as is evidenced by higher values for net profit. This methodology can be used to study the impact of environment on other performance indicators in a similar fashion. Clearly, though the weather affects all the farmers, small and marginal farmers are less able to cope with the vagaries of environment due to the small parcel of their land holdings.

There are many ways in which the simulation may be used as a test bed to determine how effective policies related to welfare might be in real situations. By setting different severities for the external environment, it is possible to assess which classes of a community, in relation to their current financial condition and their land size, may become vulnerable. This type of information is invaluable for fine tuning welfare policies.

Profitability and prices

As a final example, we could ask what impact the setting of support prices has on the individual indebtedness of farmers in the community. While the relevance of the answer to a pricing policy is evident, what is not obvious is that the simulation framework can offer insights on how to create a differentiated pricing scheme that can help reduce the vulnerability of specific groups of farmers in different regions who are impacted in different ways by the external environment. Consider, for instance, the possibility of offering a higher price for crops in areas that have had poorer rainfall as opposed to those that have had a bumper crop, so as to equalize revenues across communities. This is discussed below.

In this subsection, we shall explore the possibility of studying how macro-level price support policies may be evaluated in relation to profitability at the farmer level. As mentioned above, price asymmetries that result in different price realizations for farmers with differing scales of production (resulting from different land sizes) distort the farmers' revenue and hence the profits accruing to farmers for that season.

We shall first examine the question of how the value of a support price impacts individual profitability, given the external rainfall and yield conditions. Close examination of figure 3 shows that the farmers with larger land holdings obtain larger profits than their counterpart with smaller land holdings, though all are exposed to the same vagaries of the environment. It is possible to arrive at a price function that could help even the small and marginal farmers fare better for

a season, even under hostile weather conditions. Different price functions can be simulated and their impact on farming operations can be tested out in the above manner even before they are implemented. FarmSIM allows for tracking performance indicators such as profit and the level of indebtedness at the micro-level of a farmer agent over time. As mentioned above, the framework allows for proactive testing of proposed policies, such as those relating to price and interest rates.

Economic viability

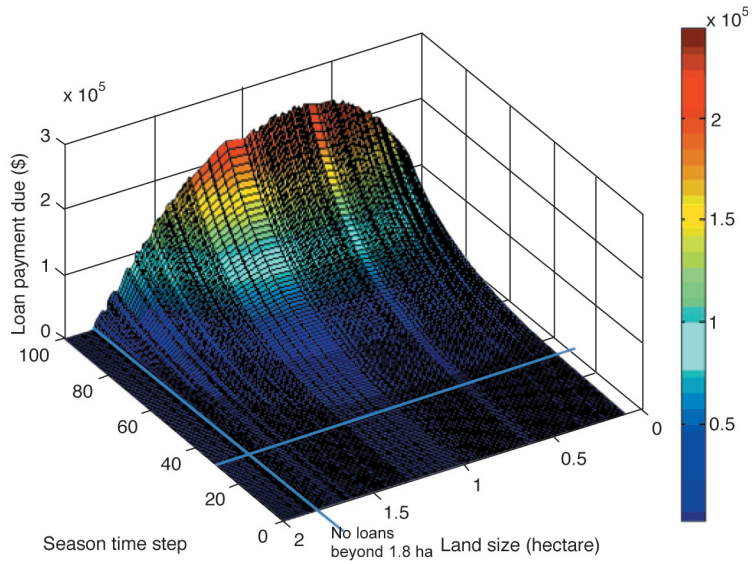
Can the economic viability of a farmer be assessed by analysing the credit patterns resulting from internal and external factors that influence his farming operations? By observing his creditworthiness over time, it might be possible to determine when he is likely to fall into the debt trap and what measures should be put in place to prevent this.

The level of indebtedness of the farming community is a key measure, not only for the financial sector, which advances credit to them, but also for a variety of government agencies that are responsible for formulating policies related to pricing, subsidies and welfare. We use indebtedness as measured by "*esi*", i.e., the amounts paid by farmers towards loan repayment, traced over the 100 season time steps, as a means for uncovering patterns that indicate what types of farmers might turn delinquent under given external conditions.

Figure 4 plots the amount of a loan being repaid in a time step against the size of the farmer's land. The shape of the 3D plot shows, firstly, that the loan payments grow with time for nearly all farmers. This is an expected consequence of drops in yield caused by poorer projected weather conditions as time progresses. It is also evident that, even though smaller farmers may borrow less (in proportion to their land sizes), they also have smaller incomes, and this results in continued indebtedness. Farmers with larger land sizes are seen to progressively borrow less, as is evidenced by the shape of the falling contour on the north wall of the 3D plot.

As can be seen in figure 4, there are no loans payable by even smaller farmers until season time step reaches about 30. Thereafter, for agents with small land sizes, up to about 1.8 hectares, the loan amount payable per season begins to rise over time steps. In this scenario, agents with land size that is over this cut-off do not take loans over the entire simulation run with this rainfall setting. The profits of small and marginal farmers vary from negative to modest values over the 100 run time horizon. At the same time, they are under pressure to take loans to continue their farm work, leading them ultimately into a debt trap.

Figure 4. Loan instalment payable over time vs. land size

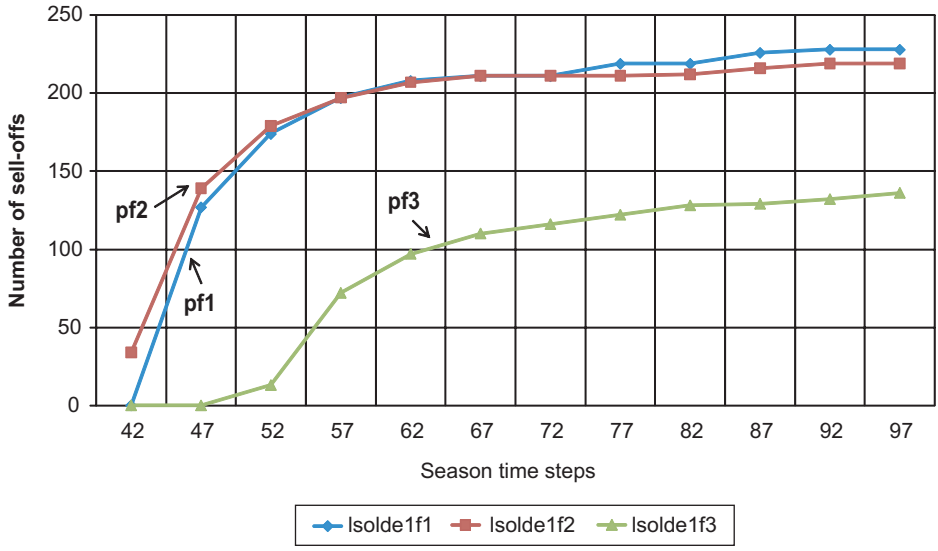


Economic sustainability

How should the policy impact be continuously monitored and evaluated to ensure that agriculture as a means of livelihood can sustain the economic survivability of the farmers? Can many scenarios be simulated in advance for a better understanding of this complex phenomenon?

We study sustainability by observing the conditions that force small and marginal farmers to stop agricultural work or sell off their assets due to a loan burden. Using a sell-off rule that makes farmers sell their lands when the total loan burden exceed twice the market value of the land (Rule 3 of Annex I), we record the number of farmers who hit the threshold and decide to sell off for different pricing functions *pf1*, *pf2* and *pf3* with environment *environ1*. The graph of the cumulative number of land sales shown below (figure 5) shows that a larger number of farmers hit an unsustainable level around the forty-second season with *pf1* and *pf2*, reaching the total number of about 215 sell-offs. But the third price function, *pf3*, which offers a higher price multiplier over the base price for all farmers, improves the overall sustainability profile, with a reduced number of about 130 sell-offs. In the graph, we have labelled the curves *lsolde1f1*, *lsolde1f2* and *lsolde1f3*, to indicate that the curves record the number of lands sold for the combination *e1* (*environ1*), and price functions *f1* (*pf1*), *f2* (*pf2*) and f3 (*pf3*).

Figure 5. Price function impact on cumulative sell-offs



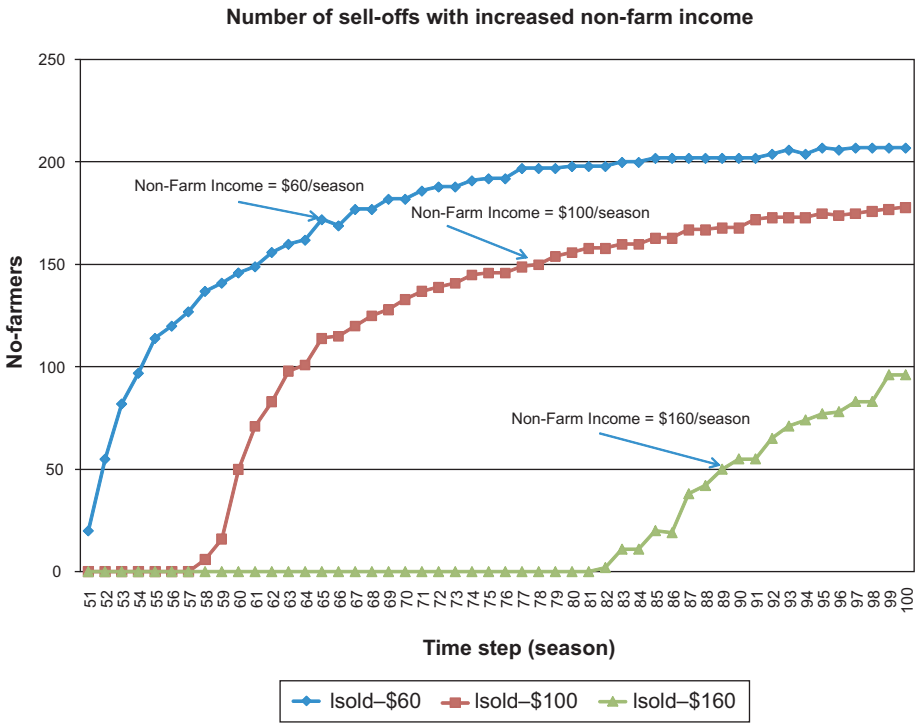
One of the possibilities from enabling improved sustainability scenarios from improved price realizations is to determine the price level at which *none* of the small and marginal farmers encounter a situation that forces them into a state of indebtedness, forcing them to skip agricultural activity or sell assets. We have found in our simulation that, when the price multiplier is larger than 4.7 for the smallest land size, there are no sell-offs.

Another mechanism in the simulation that can cause an improvement in the sustainability is the possibility of injecting an improved non-farm income, since it can reduce reliance of farmers on external loans.

We examine three alternatives, allowing the equivalent of $60, $100 and $160 of non-farm income per season. The resultant sell-off counts obtained using Sell-Off Rule 3 are graphed below in figure 6.

All three cases use price function *pf1*, and environment *environ1*. Clearly, cumulative sell-offs are lower with higher non-farm incomes.

Figure 6. Impact of non-farm income flows on sustainability (sell-offs)



VI. CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

This paper proposes a simulation framework to help formulate and evaluate the effectiveness of policies that concern the economic viability and sustainability of small and marginal farmers. The framework offers mechanisms to model the macro-level environmental impacts of prices, costs and other "uncontrollable" factors, such as rainfall, on the micro-level economic activity of farming communities. The framework allowed us to capture farmer-level financial decisions on working capital investments and loans, offering us a low-level view into the farmer's "account-book". By modelling his decisions in a Markovian sense over a sequence of seasons and modulating the local micro-level decisions through impact models accounting for external factors, the framework permitted the examination of financial viability and economic sustainability issues for a simulated community of farmers.

We have used realistic baseline data for micro-level farmer agents. Although we assumed mono-cropping pattern (rice only), the yields, prices and costs were set close to real average values applicable to rice cultivation in India. We used a "fictitious" *digital future* scenario for rainfall, driven by the popular but as yet unproven notion that there would be more frequent occurrences of flooding and drought in the near future. We also employed power functions with pre-selectable constants to model how rainfall could modulate yields and hence production. These are fully programmable in FarmSIM, and other scenarios could be easily generated.

That the overall scenarios generated from simulation runs in FarmSIM fairly follow scientific observations regarding the situation on the ground with small and marginal farmers is really no surprise because we built our models to capture these very notions. What is interesting, however, is the possibilities that emerge in engaging real-world policy formulation and implementation issues in this area, with the capability of creating an effective test bed that can well mimic specific farmer communities in just the right level of financial detail.

The FarmSIM framework has helped us explore and evaluate several issues that are pertinent to the formulation and evaluation of policies affecting the farming community. The flexibility of the framework, the effect of the interaction of several variables and the framework's ability to allow us to follow the impact of the model over time gives, we believe, sufficient credence to the use of the findings to further refine policy measures. It is recommended that evaluation using a simulation framework such as the one proposed herein, be a part of policy implementation and administrative activity so that the success of the policy can be tracked before and after it is put into action. Listed below are a few such possibilities, highlighting key results:

(a) Agent-based simulation offers a highly flexible and viable framework to model macro-level economic impacts on micro-level financial decision issues in the farming community;

(b) Financial viability and sustainability can be studied using this methodology by creating appropriately granular data and models, which can be independently built and verified (for instance, the rainfall-yield model can be built and verified externally);

(c) Since micro-level models can be data-driven, they can be customized to match the requirements of specific farming communities in different agro-climatic zones by capturing their specific socio-economic and financial characteristics. Loan and other decision behaviours can be captured in special rule classes;

(d) Since macro-level behaviour is common to specific communities, the methodology can provide high-level insights as to how specific policy changes, such as a 1.5 per cent rate cut, or a 20 per cent increase in MSP, etc. can impact any group of farmers;

(e) Since the methodology tracks time evolution, it becomes possible to gain insights into issues of sustenance over time. An example is an assessment of how many seasons of non-farm income of a certain level injected every season into the income of a marginal farmer, will make his household debt free. The answer to such a question can help implement a region-specific employment guarantee scheme;

(f) Finally, using real climate models as they become available, it should be possible, using this methodology, to assess the long-term impact on micro-level farm economics and its sustainability.

In principle, FarmSIM, can be extended in many ways. One of the key extensions planned is to explore the significance of collaboration and active information sharing among groups of farmers. This will enable us to study if there are any conditions under which small and marginal farmers can use their collective strengths to "set" prices rather than "accept" macro-level prices. It would also perhaps be possible to determine what micro-level financial adjustments small farmers can make to be seen as a consolidated "collective" farm of a medium to large size by potential markets, so as to gain the virtual benefits of scale and price but maintain the higher efficiencies of small size.

ANNEX I

MICRO-LEVEL AGENT RULES

Loan rules

In the micro-level world of the farmer agent, a key decision needs to be taken on *whether* to take credit to pursue agricultural activity in a season, to cover cost of inputs and personal expenses, and if so, *how much*. This payback period will depend on the overall loan burden and the additional season payback amount (*esi*) which is viable considering the current *esi*.

Among the many ways in which the hard financial decision that the farmer faces can be posed, we consider one generic cut-off. It is to determine the balance between the projected net profit over the loan period considered (i.e., *n* future periods) with the sum total of the projected loan payments to be made over the same period – effectively indicating "paying ability", denoted as q_{jt}, for the farmer *j* in time step *t*, defined as Rule 1:

$$q_{jt} = \frac{n = np_{jt}}{\Sigma_{k=t+1}^{t+n} tl_{jk}} \quad \text{(I.1)}$$

We use q_{jt} as one of many threshold measures in rules to determine if a loan may be taken at this time step.

The applicable rule is described in the pseudo code below:

```
Loan (Rule 1):  For farmer agent j in time step t
if gap_jt < 0                                   // Refer Eq (6)
    %Calculate esi_jt, t=t+1,..t+n              // Refer Eq (7)
    if q_jt > Q                                 //
                                  // Can not take full loan,Q = 4
        nl_jt = fexp_jt           // nl = New Loan = family exp
        update esi_jt             // new esi calc to lower loan
        skip_jt = 1               // Set the 'skip' flag
        break;
    else
        nl_jt = -gap_jt       // loan taken to cover agri operation
    end
end
```

The implication of the above rule is that the agent can decide whether to skip agricultural activity in a season based on his assessment of how much of a loan burden he can carry forward. A "Q" value greater than 4 will tell him to skip farming activity this season at the risk of losing all potential profit, and take out a loan to cover only his family expenses during the season, thereby reducing the future burden.

The simulation framework we have developed also allows a farmer agent to determine whether he should exit the agriculture business by selling of his land and assets – obviously in the dire circumstance of an overwhelming debt spiral. The rule for this decision is to first determine if agricultural activity has been skipped for five sequential seasons, and then if the total loan burden has been increasing over more than three periods. Pseudo code for Sell-Off Rule 2 is as follows:

```
Sell-Off (Rule 2): For farmer agent j in time step t
if skip_jk = 1, k=t & t-1... t-4,          // Skipped 5 seasons

    if tl_jt > tl_jt-1 > tl_jt-2 > tl_jt-3  // Total loan burden increasing
    set ts_jt = 1                           // Set Sell-Off flag
    break
    end
end
```

Another alternative to the above rule is Rule 3, which states that a farmer can decide to sell off his land assets if the total loan payable (sum of *esi*'s in period *t*) in a period *t* exceeds the market value of his land by a factor of two. This is expressed through the following pseudo code:

```
Sell-Off (Rule 3): For farmer agent j in time step t
if skip_jk = 1, k=t & t-1                  // Skipped 2 seasons
    if tl_jt > 2*mkt_val                   // Total loan burden exceeds
                                           // 2*land value
    set ts_jt = 1                          // Set Sell-Off flag
    break
    end
end
```

ANNEX II

ENVIRONMENTAL IMPACT MODELS AND SCENARIOS

Rainfall

The use of a rainfall index to model the impact on land yield is a common concept globally in weather-driven crop insurance, and many studies have been undertaken in India to develop actuarial models to capture the impact of rainfall levels on risk of yield variation and premium (Manuamorn, 2007).

Since in our simulation model we do not employ stochastic elements and are not concerned with risk premiums, we consider rainfall as merely an external means of modifying yield for all the lands under consideration, by first categorizing the level of rainfall over a lexicographic scale of 1 to 5 as below:

Annex table II.1. Lexicographic scale to describe level of rainfall

Rainfall level	*Value (R)*
Above normal	5
Normal	4
Deficient	3
Drought	2
Flooding	1

Note that "flooding" is placed lowest at 1, below drought, to account for the fact that its deleterious effect on production is, more often than not, worse than drought.

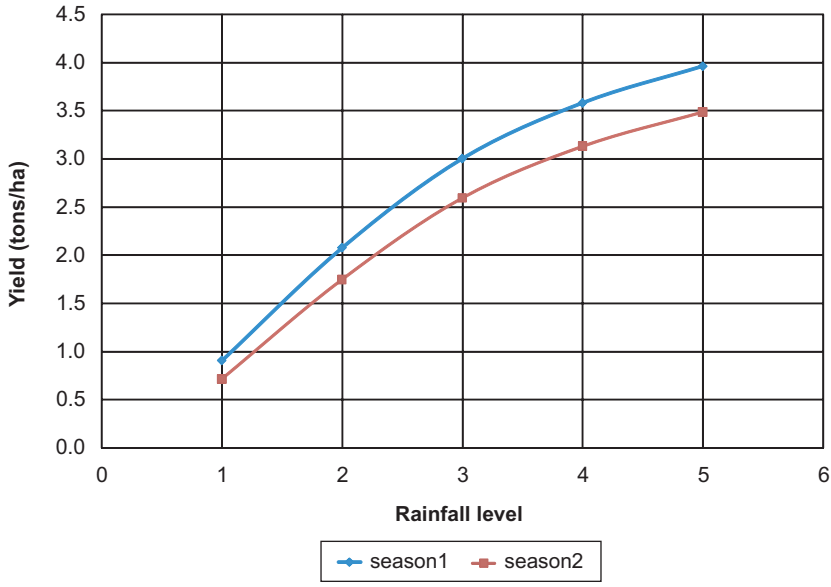
Now, we model the general impact of rainfall, R, on yield using the power function:

$$y = k_1 e^{k_2 R} \qquad \text{(II.1)}$$

Where *y* denotes yield, k1 and k2 are pre-selected constants designed to produce a slowly increasing function of *R* in a range appropriate for representing practical yield value of the chosen crop, rice in this instance. Assuming a yield value of 3.6 tons/ha for rice as a base level for a "normal rainfall" season, we

expect the yield to vary, as depicted in annex figure II.2, for selected values of k1 and k2.

Annex figure II.1. Rainfall-yield power function example

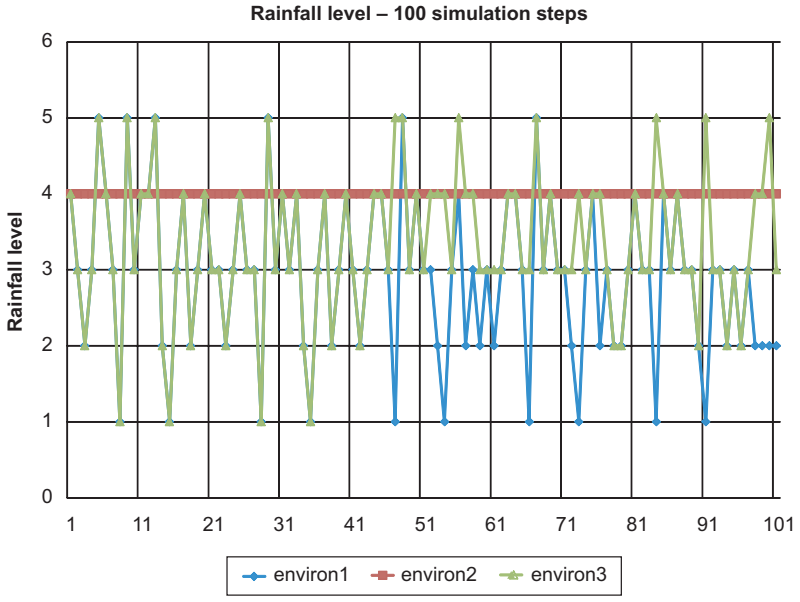


Given this class "environmental law" that modifies yield, we can construct a time series of "known future" using the values of 1 through 5 to represent a future climate scenario. If we were required, for instance, to generate a 60-season scenario, we need to create a 60-length string of "plausible" rainfall levels. A "normal" rainfall scenario over the next 100 seasons would be a 100-length string of 4's.

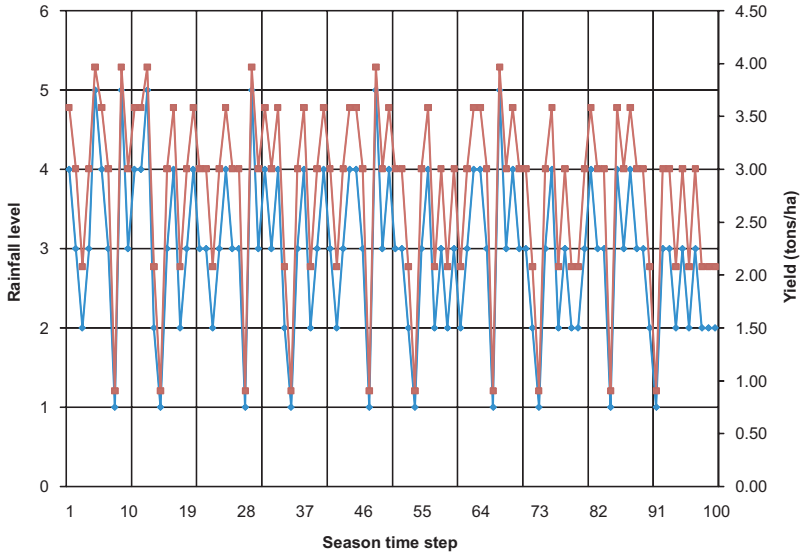
Climatologists have been drawing attention to the possibility of more frequent drought and floods over the next few decades as a result of global warming. In our simulation, we have set up scenarios to take into account such possibilities by setting up three sequences appropriately. The three alternative environmental sequences are charted in figure II.3. The environment selected in a simulation run impacts yield on the basis of the chosen rainfall-yield transformation.

Each of these rainfall patterns will produce a different type of yield impact depending in the type of power function selected for the transformation. Figure II.4

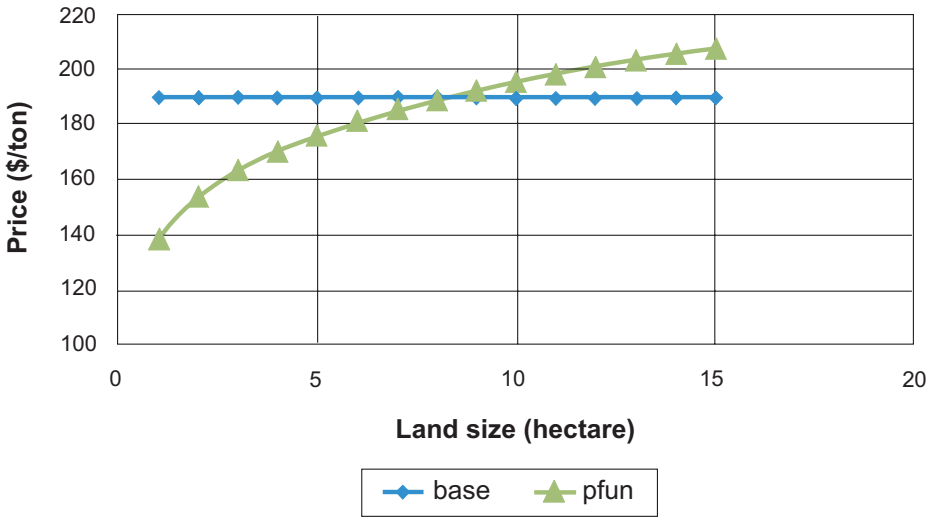
Annex figure II.2. Three rainfall patterns for environmental simulation



Annex figure II.3. Rainfall to yield transformation over season time step



Annex figure II.4. Price function example



illustrates, for instance, how *environ1* modulates yield over the 100 seasons using a function as shown in (II.1) with certain preset parameters.

In essence, the power functions and selected environmental scenarios help transform the selected weather scenario into a "projected" agricultural yield scenario, following a general maxim that "good" rains herald "good" yield, which in turn produces a higher supply.

Price and cost model

There needs to be a more detailed discussion of possible practical situations that we could consider regarding the setting of the sale price realized in simulation modelling. There are several issues related to the price that farmers realize for their farm output. Firstly rice, the crop we have considered here for uniformity, has a government announced minimum support price (MSP) that is designed to fall between the procurement (by government) price and farm-gate open prices. This, and the wide variation in prices by grade and season, causes the overall price realizable to vary widely both across geography as well as season (Deshpande and Naika, 2002).

Additionally, weather patterns are known to impact prices through the attendant yield variations as well. In seasons when there is good rainfall in rain-fed agricultural regions, the yield is expected to improve (as we have modelled in II.1 above), and overall production rises, resulting in a fall in prices.

There is another fundamental cause of variation in prices. It has been observed by many researchers that large and medium farmers, by virtue of their size, usually realize a price that is considerably higher than that which small and marginal farmers realize for the same crop. Often, this is because the middle-level buyers consider the scale of a purchase at farm gates, offering larger farmers higher prices. Smaller farmers are unable to hold out longer, while large farmers can stock produce and also use bulk transport to seek better prices away from their farm.

Annex figure II.5. Price power function transforming land size

In order to model the type of biased price realization mechanism that may be prevalent, we use power functions to distort a base price, favouring larger farmers with higher price realizations. The generic function we use to capture the required behaviour is the following:

$$p = k_3 s^{k_4} \qquad \text{(II.2)}$$

Where *k3* and *k4* are constants selected to provide appropriate scaling to relate land size *s* to price *p*. Prices are proportional to land size. A graphical characterization example of the price power function is shown in annex figure II.5.

In this illustration, we have used a function of the form (II.2), with k3 = 0.6 and k4 = 0.15 to generate a function that modifies a base price of $190 per ton in accordance with land sizes. The effect is that farmers with a lower scale of production receive smaller realizable prices, while farmers with larger land sizes gain a price advantage. Obviously, these functions can be tuned to match the situation observed on the ground.

In order to implement this price function concept, we use different price multipliers which are multiplied with a base price. By selecting the parameters *k3* and *k4,* we have generated different functions *pf1*, *pf2*, and *pf3*. Figure II.5 charts the three sets of functions. For each curve, the rate at which the price multiplier curves flatten out as the land size increases is different.

In this study, we model costs directly as a function of land sizes as opposed to the diversity of prices, although the simulation framework itself provides for any suitable link function to be plugged in. In principle, costs are expected to be lower for larger farms due to economies of scale, but recent studies point to many causes that defy conventional wisdom. The non-linear increase in the cost of labour with land size is one example.

In sum, the weather and price impact functions render the total production, obtained as a product of yield and land size, non-linearly varying with rainfall and land size, respectively. This produces interesting possibilities for capturing variations in profitability behaviour in relation to land size. For instance, in a good weather season, when production rises for the entire community, the expectation of good returns can be dashed if prices fall for economic reasons, even though total revenue as a product of price, yield and land size may rise in the bargain. But this may impact small farmers quite differently from large farmers.

Similarly, a drought may hit yield for all farmers, large and small – but larger farmers may yet recover costs due to the combination of relatively higher prices and larger outputs.

It should be noted again here that the purpose of the above discussion is to draw attention to several of the possible alternative means of modelling external impacts on micro-level variable in FarmSIM. It is also possible to define externally "fitted" functions that may be derived from historical data, should the situation demand it.

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OPENNESS AND TECHNOLOGICAL INNOVATION IN EAST ASIA: HAVE THEY INCREASED THE DEMAND FOR SKILLS?

*Rita K. Almeida**

This paper examines whether the increased openness and technological innovation in East Asia have contributed to an increased demand for skills in the region. We explore a unique firm level data set across eight countries in the East Asia and Pacific region. Our results strongly support the idea that greater openness and technological innovation have increased the demand for skills, especially in middle-income countries. In particular, while the presence in international markets has been skill enhancing for most middle-income countries, this is not the case for manufacturing firms operating in China and in low-income countries. We interpret this to be supporting the premise that, if international integration in the region continues to intensify and technology continues to be skilled biased, policies aimed at mitigating the skills shortages should produce continual and persistent increase in skills.

I. MOTIVATION

East Asia is undergoing a deep structural change, with employment in the region rapidly changing from agricultural activities into manufacturing and services, and from resource-based products to labour-intensive low-technology products. Moreover, over the last decade, the share of skilled workers has been increasing significantly, even within narrowly defined sectors. In some rapidly growing

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economies, emerging skill shortages threaten to undermine the competitiveness of export-oriented firms with rising skills premiums. This paper investigates the extent to which the increasing openness (captured by exports and foreign direct investment) and technological innovation have increased the demand for skills. We explore a large cross-section of microdata for firms in the East Asian region.

Our results are consistent with greater openness and technological innovation increasing the demand for skills especially in middle-income countries. However, this is not the case for firms operating in China and in other low-income countries. There, a stronger integration of firms into the international markets is still associated with a greater specialization in low skill-intensive goods. These findings strongly suggest that international integration and the technology transferred to middle-income countries tend to be more skill-biased than for low-income countries. This is also consistent with middle-income countries having a higher absorptive capacity and, thus, being recipients of more advanced technological innovations than low-income countries.

Recent decades have been characterized in many developing countries by increased income inequality favouring the most skilled workers. In particular, income inequality between skilled and unskilled workers increased in several countries after trade liberalization (e.g., Hanson and Harrison 1995, 1999a, 1999b; Revenga 1997; Robbins 1996). This has become a particularly severe problem in developing countries because of the potential negative social consequences associated with high poverty levels and income inequality. Moreover, a large chunk of worker reallocation has occurred within industries (between low and high skilled workers) rather than across industries (e.g., Hanson and Harrison 1995; Robbins 1996). This evidence suggests that there has been a simultaneous increase in the share of skilled labour (in total employment) and an increase in the returns to skills (e.g., Hanson and Harrison 1995; Robbins 1996) following episodes of trade liberalization. This increase in prices and quantities cannot be explained solely by increased (product-level) import competition from developed countries.

Most of the empirical work looking at the determinants of skill upgrading in developing countries has traditionally focused on aggregate sector data and/or on the role of foreign direct investment. For example, Hanson and Harrison (1999a) find evidence for Mexico consistent with foreign direct investment (FDI) acting as a channel for the spread of technology across countries. This literature is based on the assumption that foreign firms bring to their overseas subsidiaries a variety of managerial, organizational and technical innovations that otherwise would not have been available to the host country. Skilled labour is needed to adapt and diffuse these innovations further in the host economy. Increased firm openness could also lead to a larger technology diffusion, which in turn could affect the

demand for skills. In particular, firms importing state-of-the-art intermediate inputs would be naturally exposed to greater technology diffusion. Similarly, firms present in international markets are also under more pressure to innovate by international competition. Therefore, both activities may require higher ratios of skilled labour. Alternatively, greater openness could lead to a greater specialization in the production of goods intensive in unskilled labour (factor relatively abundant in developing countries). Therefore, a lack of skill upgrading, or even skill "downgrading" could be suggestive of openness leading to a relative specialization in low skill intensity products.

The evidence for developing countries on these links is quite scarce. For Latin America, Fajnzylber and Fernandes (2004) explore cross-sectional firm level data for Brazil. They find that increased levels of international integration (including foreign ownership) were associated with an increased demand for skilled labour. However, they find the opposite for China, where integration was negatively associated with the use of skilled labour. Consistent with this positive association between skilled labour and firm openness, Almeida (2008) shows that, in East Asia, more globally integrated firms and those adopting newer technology are more likely to take longer to fill external job vacancies, especially for skilled positions in middle-income countries. This is interpreted as evidence that technology, especially that which is transferred from abroad, has been biased towards more skilled labour and that the supply of skills has not been adjusting fast enough. As microdata sets became available with longitudinal information, economists started exploring changes in the degree of firm openness and technological innovation and relating it with changes in the firm's demand for skills. In general, these studies have found strong evidence of self-selection into the international activities so that the causal effect, when positive, is smaller than the cross-sectional estimates. For example, Doms and others (1997) and Pavcnik (2003) find no evidence that changes in technology adoption and global integration increased the use of skilled labour. For Indonesia, Fernandes and Sundaram (2008) find opposite effects for export and import activities. In their sample, firms increasing their export intensity also increase the use of less skilled labour while firms increasing the imports of inputs tend to hire more skilled labour.

The increasing shares of educated workers in the workforce in the region and the rising industry skills premiums have been well documented in the literature by Di Gropello and Sakellariou (2008). Exploring household level data, they find robust evidence of increasing shares of skilled/educated workers in the long run across the region and of increasing skills wage premium. This simultaneous movement along quantities and prices is likely to be a consequence of an increase in the demand for skilled labour. In fact, if only the supply of skills had expanded,

one would observe higher shares of skills but most likely a lower relative price. However, with household level data, there are severe limitations on determining whether the demand for skilled workers has occurred within narrowly defined industries and whether it can be explained by openness and skill-biased technological change. This happens because household level data rarely contains information pertaining to openness, technology adoption or detailed sector of activity. Firm level data, in contrast, rarely contains information on the education of the workforce, except the more subjective occupational classification (skilled/unskilled indicators). Our paper relates closely to this recent international industrial organization literature exploring micro firm level data and emphasizing the importance of plant heterogeneity (e.g., Roberts and Tybout, 1997). We explore a large cross-country firm level data set covering eight countries in East Asia to investigate whether the increased integration into global economic activities (captured by exports and FDI) on the one hand, and technological innovation on the other, has contributed to the increasing demand for skilled workers. The data set we explore is particularly suitable to study this topic. On the one hand, it collects information on the educational composition of the workforce (the share of the workforce with more than a secondary education). This is arguably a more meaningful indicator of skills than the usual occupational classification based on the share of skilled labour in the total workforce (proxied by the share of managers, professionals and unskilled workers).[1] On the other hand, it collects information on whether firms export, have foreign-owned capital or have recently adopted new technology. The data also collect other firm characteristics usually not observed (such as the manager's education, investment in research and development or geographical location within the country).[2]

The empirical approach we adopted in the paper is very simple. We compare the use of skilled labour by similar firms located within the same country, sector of activity (3-digits) and size category but having different degrees of openness (captured by exports or FDI) or technological innovation. In our baseline specification, we control for several firm characteristics that could arguably be

[1] Average years of education and share of skilled workers (captured by the occupational classification) are two measures closely related in our data for most of the countries in the region. However, they are not perfectly correlated. In the annex, we test the robustness of our main findings to this alternative definition of skills. Reassuringly, the qualitative results are similar.

[2] A related question is whether increased openness has better benefited the more skilled workers. In the short run, assuming that the labour supply is constant, increases in the demand for skilled labour will translate into higher skill premiums. The main problem of looking at wage premiums to access this trend is that they are also likely to capture other factors, especially if labour markets are not competitive (e.g., in the presence of labour market frictions). Moreover, we choose not to tackle this question due to several missing data on labour earnings.

simultaneously correlated with greater use of skilled labour and with greater openness/technological innovation (as age of the firm, public ownership, education of the manager and firm sales per employee). Our main assumption is that the degree of firm openness and the adoption of new technology could lead to increased demand for skilled labour. This could happen if technology is skill-biased or if firms, following the increased openness, make greater investments in skill-biased technology.

Our findings show a robust positive correlation between FDI, technological innovation and share of educated workers at the firm level. Therefore, openness and the adoption of new technology have contributed to skills upgrading in the region, especially for middle-income countries. The latter suggests that openness and technology adoption have been more skill-biased in middle-income countries than in low-income, which again is consistent with firms there having a higher absorptive capacity. In China and in other low-income countries, the effect of greater openness is not associated with heightened skills, but, rather, with a greater specialization in low-skill-intensive goods. The latter may be explained by the fact that these countries have a comparative advantage in low-skill intensive goods (due to a relative abundance of unskilled labour). And, the increasing international integration leads to a greater specialization in the products intensive in this more abundant factor. In sum, the findings in the paper support the idea that international integration and technological innovation in middle-income countries has been a key determinant of the increasing demand for skills in East Asia. These results have clear implications for policy. If international integration continues to intensify and technology continues to be skill-biased, policies aimed at mitigating the persistent skills shortages in the region will only be successful if they foster continual acquisition of skills rather than producing temporary increases in skills.

The paper is structured as follows: Section II presents the data set used and reports within- and cross-country descriptive statistics for the main variables. Section III proposes an empirical methodology. Section IV presents the main empirical findings, and section V discusses several robustness checks and the heterogeneity of the results by income group. Section VI concludes the paper.

II. DATA

The main data set we use is large firm level data collected by the World Bank, called *Enterprise Surveys*, which covers eight developing countries in East Asia, namely Cambodia, China, Indonesia, Malaysia, the Philippines, the Republic of Korea and Viet Nam. The surveys used in this paper were conducted between 2002 and 2005, and the samples were designed to be representative of the staffing

of firms according to their industry and location within each country.[3] We will explore one cross-section of data for each country as follows: Cambodia (2003); China (2002, 2003); Indonesia (2003); Malaysia (2002); Philippines (2003); Republic of Korea (2005); Thailand (2004); and Viet Nam (2005).

The information available in the *Enterprise Surveys* has several advantages for analysing this topic. First, the data is based on a common questionnaire across a large set of countries, yielding comparable information on several firm level characteristics. In particular, the survey collects information on age, size, geographical location, three-digit International Standard Industrial Classification (ISIC) sector of activity, and foreign and public ownership. Most importantly, it collects information on whether the firm participates in international trade (captured by the import and export shares). Second, the surveys collect detailed and comparable information on the current skills of the workforce, both with the share of workers with secondary and upper education as well as with the share of skilled workers (proxied by managers, professionals and non-production workers). Finally, the surveys also collect detailed balance sheet information at the firm level, including total sales and value added. Table 1 reports the summary statistics, and the main variables used in the paper are defined in annex table A.1.

The original data covers 9,776 firms distributed across a wide range of sectors (Manufacturing 77.54 per cent, Construction 1.37 per cent, Services 20.09 per cent and Agro-Industry 1.00 per cent). Within the manufacturing sector, numerous industries are covered: auto and auto components, beverages, chemicals, electronics, food, garments, leather, metals and machinery, non-metallic and plastic materials, paper, textiles, wood and furniture.

A major caveat in these surveys is the reduced representativeness of the non-manufacturing sample in most countries. Services are only a significant part of the sample for Cambodia, China, the Republic of Korea and, to a lesser extent, Viet Nam. For all the other countries, non-manufacturing sectors are either not included or have a reduced sample. This naturally compromises the comparison

[3] *Enterprise Surveys* have been used extensively to study the link between technology adoption and firm openness (Almeida, 2008, and Almeida and Fernandes, 2007), the investment in job training (Pierre and Scarpetta, 2004; Almeida and Aterido, 2008) as well as other topics as informality (Svensson 2003, Gatti and Honorati, 2008), effect of labour regulations (Almeida and Carneiro, 2009) and business environment and firm size (Aterido and others, 2007). The main disadvantage of using the *Enterprise Surveys* is that, for most countries, there is only one cross-section available. For the sake of comparability, we only include one wave of data for each country (the most recent wave). The surveys in Thailand, Malaysia and Mongolia include a worker module which could provide some additional measures of skills (e.g., type of education, core skills used in the workplace) at the worker level.

Table 1. Summary statistics

Main variable	*Obs.*	*Mean*	*S.D.*	*Min*	*Max*
Share of high educated workers	8 396	26.75	30.76	0	100
Share of skilled occupations	9 623	34.31	29.63	0	100
Total employment	9 776	369.04	1 665	1	67 598
Exporter	9 418	0.34	0.47	0	1
Foreign ownership	9 662	0.19	0.40	0	1
Technological innovation	9 650	0.48	0.50	0	1
Age firm	9 693	14.94	13.27	0	215
Public ownership	9 546	0.14	0.35	0	1
Education of the manager	9 776	0.96	0.19	0	1
Sales per employee	9 374	6.40	3.11	-4.6	19.9
City > 1 mln individuals	9 059	0.37	0.48	0	1
City 250 k-1 mln individuals	9 059	0.17	0.38	0	1
City 50 k-250 k individuals	9 059	0.17	0.37	0	1
City > 50 k individuals	9 059	0.13	0.34	0	1
Access to external finance	7 540	0.60	0.49	0	1
ISO certification	9 085	0.30	0.46	0	1
R&D activities	5 970	0.33	0.47	0	1
R&D/Sales	5 970	1.82	9.32	0	100
Computer use	5 181	0.59	0.49	0	1
E-mail/Internet use	6 334	0.58	0.49	0	1
High-tech manufacturing sectors	7 580	0.42	0.49	0	1
Low-income countries	9 776	0.22	0.41	0	1
Low-middle income countries	9 776	0.63	0.48	0	1
Upper-middle income countries	9 776	0.09	0.29	0	1

Source: *Enterprise Surveys* (World Bank).

Note: All variables defined in table A1 in the annex.

of the main findings separately for manufacturing and services. We thus chose to report the main empirical findings of the paper only for the sample of manufacturing. This is a severe limitation of the paper since the shares of skilled labour have increased more in services than in manufacturing across most of the countries in the region (see Di Gropello and Sakellariou, 2008).

The two main measures of skills we explore in the paper are the share of workforce that is highly educated (i.e., the share of the workforce with more than

a secondary education) and the share of skilled occupations (i.e., the share of the workforce that are managers, professionals and non-production workers). The *Enterprise Surveys* collect detailed information on the occupational composition of the workforce using the following categories: management, professionals, skilled production workers, unskilled production workers and other non-production workers.[4] In particular, we consider the group of skilled workers as being the sum of management, professionals and non-production workers while the unskilled workers are the sum of skilled and unskilled production workers. In most of the earlier work on this topic (for example, Pavcnik, 2003), this has been the most commonly used measure since it is frequently available.[5]

Table A2 in the annex presents the summary statistics for the share of skilled workers in the workforce. Panel A reports the share of highly educated workers (i.e., the share of the workforce with more than a secondary education) while Panel B reports the share of skilled occupations (i.e., the share of the workforce that are managers, professionals and non-production workers). The countries with the highest share of skilled labour are Indonesia and the Republic of Korea, with China and Thailand following behind.[6] For all countries, there is robust evidence that the share of skilled labour in total employment is higher for services than for manufacturing (e.g., Di Gropello and Sakellariou, 2008). In fact, among all the countries with information, the services share is more than double. Within manufacturing, the countries with the smallest shares of skilled labour are Viet Nam and Cambodia, where only 10-11 per cent of the workforce has more than a secondary education.

III. EMPIRICAL METHODOLOGY

We follow the rest of the empirical literature on this topic and estimate a reduced form equation where the dependent variable is a measure of the firm's use of skilled labour with a specification of the following type:

[4] We have also proxied the use of skilled labour by its share in the total firm compensation (wages and salaries plus bonuses and other benefits). Reassuringly, the findings (not reported) are in line with the ones reported in our main specification. We chose not to report these findings due to the reduced sample size, and the low reliability of the estimates.

[5] Yet, some of the non-production workers might themselves be engaged in low-skill tasks. Therefore, we will test the robustness of our main findings to an alternative measure of skills that is defined by excluding this group of workers (and considers only manager and professionals).

[6] Cambodia has a high share of skilled labour in the sample (both in Panel A and B). However, this is explained solely by the larger share of services in the sample for this country.

$$Share\_Skills_{jsc} = \alpha O_{jsc} + \beta T_{jsc} + \gamma Z_{jsc} + \ln Y_{jsc} + \mu_s + \mu_c + \varepsilon_{jsc}. \quad (1)$$

where $Share\_Skills_{jsc}$ is a proxy for the skill composition in firm j in sector s and country c (e.g., share of high educated workers or share of skilled occupations), O_{jsc} is a measure of firm openness (captured by foreign direct investment and/or export intensity),[7] T_{jsc} is a measure of recent technological innovation within the firm, Z_{jsc} are firm-level characteristics (e.g., age of the firm, size, public ownership, education of the manager), and Y_{jsc} captures sales per employee. μ_s and μ_c are sector- and country-specific fixed effects. Finally, ε_{jsc} is an (unobserved) firm-specific error term.

The main coefficients of interest in the reduced form (1) are α and β. α captures the differences in the skill composition of the workforce for firms with different degrees of international integration but located in the same country and 2-digit ISIC sector of activity (and holding all the other Z_{jsc} variables constant). A positive estimated $\hat{\alpha}$ suggests that a greater openness at the firm level is associated with an increased demand for skills. Similarly, a positive $\hat{\beta}$ suggests that firms having recently adopted new technology have also experienced increased demand for skills. As indicated in detail below, with our reduced form equation, it is very difficult to disentangle correlation from causality.

It can be shown that the reduced form equation we estimate is close to the one derived from a minimization problem where each firm chooses its variable inputs (skilled and unskilled labour) by minimizing a cost function, subject to an output constraint. For example, Berman and others (1994) and Pavcnik (2003) estimate an equation similar to (1) and interpret that it has a "relative demand for skilled labour" (see also Fajnzylber and Fernandes (2004) for an application in developing countries). The main difference between the reduced form (1) and this minimization problem is that the share of skilled labour is also a function of the firm's capital-labour ratio and the skill wage premium.[8]

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[7] We have also tried to control for the degree of firm imports. Since this information was available only for a smaller group of firms we chose not to include it.

[8] Assuming a trans-logarithmic production function and logarithmic variable costs, it can be shown that the firm's demand for skills is of the form: $Share\_Skills_{jsc} = \alpha O_{jsc} + \gamma Z_{jsc} + \beta T_{jsc} + \phi SW_{jsc} + \lambda \frac{\ln K_{jsc}}{\ln Y_{jsc}} + \ln Y_{jsc} + \mu_s + \mu_c$, where SW_{jsc} is the relative wage of skilled workers in firm j sector s in country c, Y_{jsc} is the firm's value added and K_{jsc} is the firm's capital stock. Equation (1) is very similar but assumes that the term $\phi SW_{jsc} + \lambda \frac{\ln K_{jsc}}{\ln Y_{jsc}}$ is captured either by the country or sector fixed effects, or alternatively by the error term ε_{jsc}. In the estimation of equation (1) we proxy the firm value added by firm's sales in order to maximize the number of observations.

We faced two major obstacles when trying to control for these firm characteristics in our reduced form. First, the number of observations for which there is information on mean wages and capital stock is significantly smaller (less than half). Moreover, we find robust evidence that, within countries, firms not reporting information on inputs or capital stock are not a random sample. Second, in the reduced form we explore, these variables are likely to be endogenous and simultaneously determined with the dependent variable (share of skilled labour) at the firm level. Unfortunately, we do not have a good instrument for any of these variables in our data. Even though we choose not to include them directly the detailed set of country and sector dummy variables included (covering a total of 14 sector categories) will likely mitigate this problem. Moreover, this problem is most likely mitigated further in our preferred specification where we control for a country-sector-size time invariant effects.

Controlling for country-sector-size time invariant effects also helps address the concern of the estimates capturing any spurious correlations. In particular, a visual investigation of the data pointed out that the share of skilled labour varied significantly by firm size due to reasons not necessarily directly related with the effect of openness. In particular, the share of skilled workers within a firm is likely to be a decreasing function of firm size simply because of a scale factor. Thus, in our preferred specification, we control for country-sector-size time invariant effects instead of controlling independently for each of these. In other words, identification of the effect of openness will come from comparing the skill composition of the workforce in firms as similar as possible in observable characteristics and operating in the same country, the same three-digit manufacturing sector and in the same size category.

Finally, in our robustness, we will also test the robustness of our main findings to the comparison of firms located in the same geographical region (captured either by size dummies or by country-sector-city dummies). This is important since one of the reasons why some firms might use more skilled labour is its relative price. Assuming that labour markets are competitive at the local level and that firms take prices as given in their localities, the relative price of skilled labour would be well captured by the country-sector-city dummy.[9]

Needless to say, there will still be several problems associated with interpreting α or β in a causal way. In particular, endogeneity, reverse causality and omitted variable problems are all likely to be sources of concern. We do not

[9] Pavcnik (2003) and Fajnzylber and Fernandes (2004), and most of the literature, also omit the relative wages in the reduced form equation they estimate.

have a valid exogenous instrument for firm openness or technological innovation and thus will be severely limited in the extent to which we will be able to disentangle simple correlation from causality in our exercise. Reassuringly, however, our main findings will be robust to several specifications and sub-samples. First, following Pavcnik (2003), we control for unobserved characteristics common to a geographic location or industry, which could affect both the demand for skills and firm openness. We test this by adding to our reduced form city and country-industry-city fixed effects. Second, we try to minimize omitted variable problems by exploring the detailed information available in the *Enterprise Surveys*. In particular, it is possible that the more educated managers are simultaneously more likely to engage in international activities and also better in identifying more able/skilled workers. Controlling for the manager's human capital (captured by its educational level) could mitigate this problem. Third, there is robust evidence that firms self-select into international activities, with the more productive and those with a more educated workforce being more likely to be more open (see e.g., Tybout, 2000). In particular there is robust evidence of self-selection into exports and into foreign direct investment (e.g., Tybout, 2000; Fernandes and Isgut, 2005; Almeida, 2007). One way to overcome this would be to assume that this positive correlation could be captured by a firm time invariant effect and control for firm heterogeneity. Unfortunately, our data does not have a longitudinal dimension for most of the countries and we are thus unable to account for this heterogeneity.[10] Alternatively, we propose to proxy the degree of firm openness with sector and regional aggregates for foreign direct investment and exports (which are arguably more exogenous to firm outcomes). In particular, we have computed regional and sector averages for foreign presence and export intensity.[11] Finally, we will test the robustness of our findings to different samples. We specifically will consider the following diverse samples: country level, low income versus middle income (high income), manufacturing versus services, high tech versus low tech, and capital city versus other cities. We will also test the robustness of the main results by exploring alternative measures of technological innovation in the firm.

[10] The only exception is the *Enterprise Survey* in Cambodia, where the surveys were conducted in two different years and some firms can be traced over time. However, with only two waves, there is little time variation on the share of exports or foreign direct investment at the firm level to identify the effect of openness precisely.

[11] In these specifications, we do not control for regional sector-fixed effects because of perfect colinearity. The results (not reported but available on request) are similar to the ones presented in our base specification except that they tend to be statistically weaker for all the variables of interest.

IV. MAIN EMPIRICAL FINDINGS

Before discussing the main findings, we summarize briefly the evidence on the two main channels of the demand for skilled labour discussed in the paper: firm openness and firm technological innovation. Tables 2 through 4 report the share of firms that export, share of firms with FDI and the share of firms adopting new technology, by country and manufacturing sector of activity, respectively. The last row in each table reports mean share of exporting firms, share of firms with FDI and the share of firms adopting new technology for all countries in each manufacturing sector, respectively. The last column in each table reports mean share of exporting firms, share of firms with FDI and the share of firms adopting new technology for all manufacturing sectors in each country, respectively.

We measure export intensity using a dummy variable equal to one when firms export and foreign ownership with a dummy variable equal to one for firms with more than 10 per cent of foreign capital.[12] Cambodia and Malaysia are the

Table 2. Share of exporting firms, by country and manufacturing sector

	Food & Agro-industry	*Textiles*	*Garments & leather*	*Metal & machinery*	*Electronics*	*Chemicals & plastics*	*Wood & paper*	*All manufacturing*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Cambodia	–	0.50	0.93	–	–	–	–	0.92
China	0.04	0.63	0.39	0.16	0.30	0.05	–	0.25
Indonesia	0.17	0.42	0.43	0.45	0.85	0.24	0.49	0.39
Malaysia	0.74	0.88	0.92	0.79	0.93	0.81	0.87	0.83
Philippines	0.11	0.40	0.47	–	0.71	–	–	0.37
Republic of Korea	0.13	0.65	0.41	0.37	0.50	0.36	0.26	0.38
Thailand	0.91	0.43	0.74	0.43	0.66	0.42	0.50	0.56
Viet Nam	0.47	0.79	0.88	0.23	0.45	0.28	0.43	0.42
All Countries	0.38	0.51	0.56	0.26	0.44	0.40	0.48	0.42

Source: Author's calculations based on the *Enterprise Surveys* (World Bank).

Note: Table reports the share of exporting firms in the sample, by country and manufacturing sector. Exporting firms are defined as those exporting at least 10% of their sales. The last row reports the mean share of exporting firms for all the countries. The latter is a weighted average of the mean share of exporting firms in each country weighted by each country's sample size in the total sample. The last column reports the mean share of exporting firms for all manufacturing sectors. Again, this is the weighted average of the mean shares in each sector, weighted by sector size in the total country sample.

[12] In table A1 in the annex, we report definitions for all the variables used throughout the paper.

countries with the greatest share of exporting firms. In Malaysia, exports are also present across a significant share of all the manufacturing sectors. On average, 83 per cent of the firms in Malaysia export, and this share is never below 74 per cent in each manufacturing sector. Cambodia is also a country with high export intensity in our sample but, as discussed above, this is simply driven by the fact that 60 of the 62 firms in manufacturing operate in the Garment and Leather sector (not reported), which is the sector with the highest propensity to export in the region. The Electronics sector represents the largest share of exports in Indonesia, Malaysia and the Philippines, while Garment and Leather ranks first for Cambodia and Viet Nam. In China and Republic of Korea, the highest propensity to export is in Textiles, while in Thailand it is in Food Products and Agro-Industry.

Similarly, table 3 reports the share of firms with at least 10 per cent foreign capital across countries and sectors. As expected, there is a higher share of firms that export than ones reporting having some foreign capital. The findings in table 3 are similar to the ones reported for exports in table 2. Cambodia and

Table 3. Share of firms with foreign direct investment, by country and manufacturing sector

	Food & Agro-industry	*Textiles*	*Garments & leather*	*Metal & machinery*	*Electronics*	*Chemicals & plastics*	*Wood & paper*	*All manufacturing*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Cambodia	–	1.00	0.82	–	–	–	–	0.82
China	0.12	0.32	0.20	0.22	0.29	0.08	–	0.23
Indonesia	0.04	0.15	0.13	0.39	0.65	0.24	0.08	0.17
Malaysia	0.19	0.31	0.24	0.27	0.61	0.41	0.22	0.32
Philippines	0.07	0.14	0.28	–	0.67	–	–	0.25
Republic of Korea	0.19	0.00	0.06	0.18	0.08	0.32	0.10	0.15
Thailand	0.21	0.20	0.18	0.33	0.61	0.14	0.11	0.26
Viet Nam	0.12	0.22	0.18	0.12	0.32	0.10	0.06	0.12
All Countries	0.13	0.20	0.24	0.22	0.39	0.21	0.10	0.22

Source: Author's calculations based on the *Enterprise Surveys* (World Bank).

Note: Table reports the share of firms in the sample with at least 10% foreign capital, by country and manufacturing sector. The last row reports the mean share of firms with FDI for all the countries. The latter is the weighted average of the mean share for each country, weighted by each country's sample size in the total sample. The last column reports the mean share of firms with FDI for all manufacturing sectors. Again, this is the weighted average of the mean shares in each sector, weighted by sector's size in the total country sample.

Malaysia lead the penetration of FDI with 82 per cent and 32 per cent of the firms in the sample reporting at least 10 per cent of foreign capital, respectively. Unlike the case for exports, Electronics is the sector in the region with the highest FDI penetration (39 per cent of the firms). More than 60 per cent of the firms in this sector in Indonesia, Malaysia, the Philippines and Thailand report at least 10 per cent FDI penetration. A closer examination shows that this is the sector where the share of foreign capital is highest in the region, reaching 30.8 per cent of total capital.

Finally, table 4 reports the mean share of firms adopting new technology across countries and manufacturing sectors. We define a firm as having adopted new technology when it reports having "introduced a new technology that substantially changed the way the main product was produced in the three years prior to the survey" (*Enterprise Surveys*). On average, 48 per cent of the firms in the sample report having adopted a new technology that significantly changed the

Table 4. Share of firms adopting new technology, by country and manufacturing sector

	Food & Agro-industry	*Textiles*	*Garments & leather*	*Metal & machinery*	*Electronics*	*Chemicals & plastics*	*Wood & paper*	*All manufacturing*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Cambodia	–	1.00	0.85	–	–	–	–	0.85
China	0.49	0.30	0.33	0.44	0.51	0.48	–	0.44
Indonesia	0.37	0.44	0.44	0.49	0.79	0.51	0.47	0.46
Malaysia	0.32	0.30	0.30	0.50	0.61	0.39	0.36	0.39
Philippines	0.67	0.61	0.46	–	0.76	–	–	0.60
Republic of Korea	0.63	0.61	0.24	0.51	0.92	0.76	0.48	0.55
Thailand	0.65	0.57	0.63	0.79	0.81	0.53	0.50	0.66
Viet Nam	0.58	0.58	0.65	0.62	0.75	0.64	0.55	0.61
All Countries	0.54	0.50	0.47	0.55	0.60	0.51	0.50	0.53

Source: Author's calculations are based on the *Enterprise Surveys* (World Bank).

Note: Table reports the share of firms in the sample recently adopting new technology, by country and manufacturing sector. A firm reports having adopted new technology when it significantly changed the way its main product is produced. The last row reports the mean share of firms adopting new technology for all the countries. The latter is a weighted average of the mean shares in each country weighted by each country's sample size in the total sample. The last column reports the mean share of firms with adopting new technology for all manufacturing sectors. Again, this is the weighted average of the mean shares in each sector, weighted by sector's size in the total country sample.

way the main product was produced (see table 1). Technological innovation was greater for Cambodia and Thailand, but, again, the findings for Cambodia are driven by the selected set of industries included in our sample. Electronics and Metals and Machinery are the sectors with the greatest technological innovation according to this definition.

Figures 1 to 3 report each country's share of skilled workers (proxied by the share of the workforce with more than a secondary education), by the degree of global integration (measured by exports and FDI penetration) and technological innovation, respectively. At the aggregate level, we find some evidence that countries with a larger share of firms engaged in exports, with FDI or adopting new technology also report a greater share of more educated workers. Nonetheless, there are exceptions—such as China or Viet Nam for exports and Cambodia for FDI. In non-exporting Chinese manufacturing firms, for example, on average 22 per cent of the workforce has more than 12 years of education, but, for exporting Chinese firms, the number is 7 percentage points smaller.

Figure 1. Share of high educated workers: cross-country correlation by export status

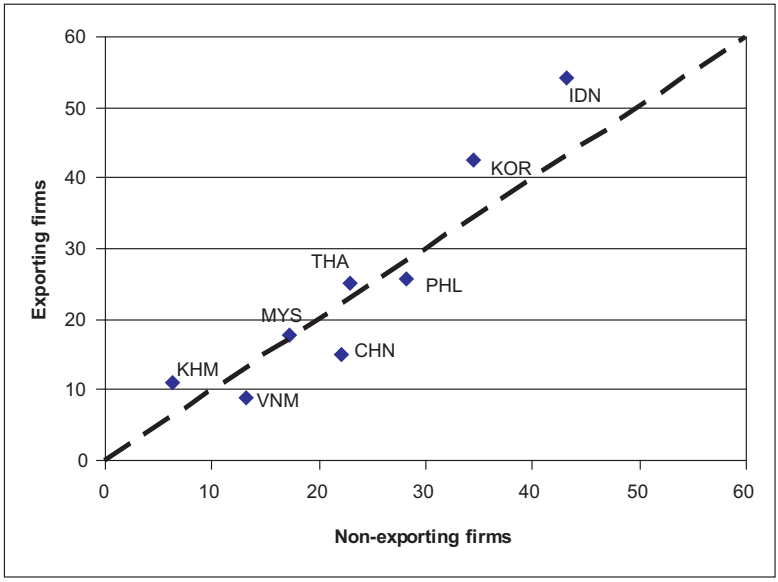

Figure 2. Share of high educated workers: cross-country correlation by foreign ownership

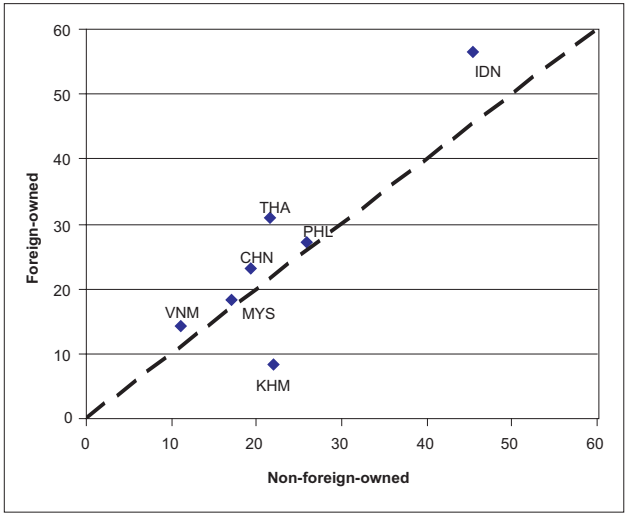

Figure 3. Share of high educated workers: cross-country correlation by technological innovation

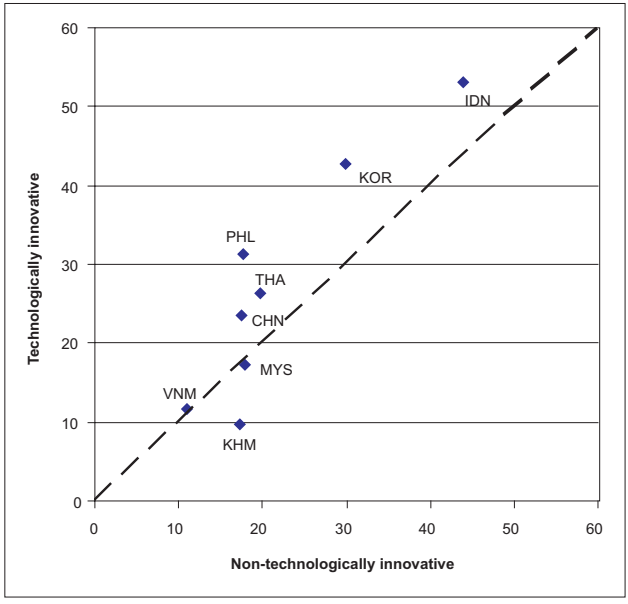

Table 5 reports the least squares estimates of equation (1). The dependent variable is the share of workers with at least secondary education (i.e., with 12 or more years of schooling). We argue that this is a better measure for proxying human capital in the workforce than the commonly used skilled/unskilled classification, where it is more difficult to guarantee within and across country consistency in the worker's classification. Columns (1) to (5) differ in terms of the firm controls included in Z_{jsc} and the set of time invariant effects considered. In column (1), we start by including the age of the firm and public ownership after controlling for three-digit industry fixed effects (total 14 categories) and for country fixed effects separately. Column (2) considers country-sector fixed effects, column (3) adds country-sector-size fixed effects, column (4) adds education of the manager and column (5) adds (log) sales per employee. The specification in column (5) will be the baseline specification throughout the paper. The control variables in the baseline specification, in addition to the country-sector-size dummies, include export intensity, foreign ownership, and degree of technological innovation, age of firm, public ownership, education of the manager and (log) sales per employee.

Two interesting facts come up in the table. First, for most specifications, there is no robust correlation between being an exporter and the use of a more educated workforce; second, technological innovation and foreign ownership are both associated with greater demand for more educated workers. The former lack of correlation is likely to be driven by two forces which could have offsetting effects in developing countries. On the one hand, in developing countries, globalization may lead to specialization in the goods intensive in the more abundant factor in the country, or unskilled-labour-intensive goods. This is likely to lead to an increase in the relative demand for unskilled workers (and also to a reduction in the skilled-unskilled wage differential). On the other hand, if technological change has been skill-biased, and if openness is associated with greater technological innovation, exports and FDI could act as channels for the international diffusion of skill-biased technologies developed in industrialized countries. This force is thus likely to increase the demand for more skilled labour.[13]

It is worth stressing that, in our baseline specification (reported in column (5)), we compare the demand for skills in firms with different degrees of openness and technological innovation but which are located in the same country, three-digit sector and size category, and with similar profiles regarding age, public ownership, manager education and sales per employee. In column (5), the positive correlation between FDI and technological innovation is positive and statistically strong.

[13] So could imports, but, again, this variable is available for a smaller set of countries. However, we will test our findings to control for this activity.

Table 5. Openness, technological innovation and the demand for skills

	(1)	(2)	(3)	(4)	(5)
Exporter	-0.003	0.003	-0.041	-0.050	-0.0653*
	[0.0350]	[0.0360]	[0.0386]	[0.0386]	[0.0388]
Foreign ownership	0.219***	0.249***	0.230***	0.216***	0.209***
	[0.0393]	[0.0399]	[0.0411]	[0.0410]	[0.0414]
Technological innovation	0.318***	0.315***	0.282***	0.268***	0.265***
	[0.0331]	[0.0333]	[0.0341]	[0.0342]	[0.0342]
Age firm	-0.00350***	-0.00345***	-0.00555***	-0.00566***	-0.00555***
	[0.00126]	[0.00127]	[0.00132]	[0.00131]	[0.00130]
Public ownership	0.315***	0.320***	0.335***	0.327***	0.333***
	[0.0487]	[0.0493]	[0.0534]	[0.0532]	[0.0534]
Education of the manager	–	–	–	0.709***	0.696***
				[0.109]	[0.109]
Sales per employee	–	–	–	–	0.0223***
					[0.00829]
Industry fixed effects?	Yes	No	No	No	No
Country fixed effects?	Yes	No	No	No	No
Country-industry fixed effects?	No	Yes	No	No	No
Country-industry-size fixed effects?	No	No	Yes	Yes	Yes
Observations	6 072	6 072	6 072	6 072	5 976
R squared	0.19	0.20	0.27	0.27	0.28

Source: Author's calculations are based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is the logarithm of the share of workforce with more than the secondary education. Columns (1) through (5) report different specifications. In addition to the firm characteristics reported in each column, column (1) controls for 3-digit industry fixed effects (total 27 categories) and for country fixed effects separately, column (2) controls for country-industry fixed effects and column (3) through (5) control for country-industry-size fixed effects. All the variables are defined in table A1 in the annex. The specification in column (5) will be the baseline specification throughout the paper. The control variables in the baseline specification, in addition to the country-industry-size dummies, include exporter, foreign ownership, technology adoption, age of the firm, public ownership, education of the manager and (log) sales per employee.

The results in column (5) of table 5 also highlight other interesting correlations for the control variables. First, older firms, located in the same country, three-digit sector and size category, have a smaller share of highly educated workers. Second, publicly owned firms are more likely to use more educated workers. It is worth stressing, however, that this premise holds even after conditioning on sector of activity and on firm size. This positive correlation is in line with the empirical evidence found by others in developing countries (e.g., Earle and Telegdy, 2008). Third, firms with more educated managers (measured by whether managers have a post-secondary education) are also prone to use a more educated workforce. This finding is capturing either the complementarities across skills in the different jobs, or the better capacity of highly educated managers to screen and select more educated workers. Finally, we also find robust evidence that firms with larger (log) sales per employee tend to use more educated workers (after conditioning on sector and size). As mentioned above, under some assumptions on the functional form for the production and cost function, the relative demand for skilled labour would imply that the demand for skills is a function of value added. Since in our data set this information is available for a smaller number of firms, we choose to control for sales per employee instead.[14] A positive coefficient signals the presence of increasing returns to scale (e.g., see also Pavcnik, 2003).

V. ROBUSTNESS AND HETEROGENEITY OF RESULTS

In tables 6 and 7, we do some robustness checks over the baseline specification (reported in column 5 of table 5).

Table 6 controls for additional firm characteristics, such as city location (in columns 1 and 2) and access to finance (in column 3). As discussed above, controlling for geographical location is important because one of the reasons why some firms might use more skilled labour is its relative price. Assuming that labour markets are competitive at the local level, and that firms take prices as given in their localities, the relative price of skilled labour would be well captured by the country-sector-city dummy. Moreover, by controlling in column (2) for country-sector-city fixed effects, we can also assume that firms face a similar supply of skilled workers. Reassuringly, the findings in columns (1) and (2) for the main variables of interest remain similar to the ones reported in our main specification. Moreover, firms located further away from the capital city tend to use less educated workers than firms located in the capital city (omitted category).

[14] Controlling for log value added per employee would lead also to a positive correlation between scale of production and demand for skilled labour.

Table 6. Openness, technological innovation and the demand for skills: robustness

	(1)	(2)	(3)
Exporter	-0.0923**	-0.120***	0.0773*
	[0.0395]	[0.0369]	[0.0408]
Foreign ownership	0.259***	0.276***	0.187***
	[0.0423]	[0.0413]	[0.0432]
Technological innovation	0.264***	0.285***	0.220***
	[0.0350]	[0.0344]	[0.0368]
City >1 mln individuals	0.165***	–	–
	[0.0621]		
City 250 k-1 mln individuals	-0.127**	–	–
	[0.0626]		
City 50 k-250 k individuals	-0.127**	–	–
	[0.0567]		
City > 50 k individuals	-0.253***	–	–
	[0.0618]		
Access to external finance	–	–	-0.050
			[0.0403]
Baseline firm characteristics?	Yes	Yes	Yes
Country-industry-size fixed effects?	Yes	No	Yes
Country-industry-city fixed effects?	No	Yes	No
Observations	5 592	5 592	4 937
R squared	0.26	0.23	0.30

Source: Author's calculations are based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is the logarithm of the share of workforce with more than the secondary education. Column (1) assumes the baseline specification (column 5 of table 5) controlling in addition to the location of the firm (city level). Column (2) controls for the firm characteristics in the baseline specification controlling for country-industry-city fixed effects (instead of the country-industry-size fixed effects in the baseline). Column (3) reports the baseline specification controlling in addition to the firm's access to external finance. All the variables are defined in table A1 in the annex.

This finding is likely to capture the scarcity of more educated workers in localities further away from the capital city. In column (3), we further test to see whether our main findings are driven by the more open firms having a greater access to external finance (omitted variable up to now). In particular, it is plausible that firms differ in their ability to finance new technological investments and presence in international markets and that their financial situation might also affect their ability to attract more skilled workers. The results show that, after controlling for access to finance, the correlation between exports and use of more educated workers becomes positive and strong. However, a closer investigation shows that this fact is fully explained by the exclusion of China from the sample. Firms in China do not report information on access to finance, and we will show below that export-oriented Chinese firms tend to use less skilled labour.

Table 7 reports the robustness of our main results after controlling for alternative proxies of the technological sophistication in the firm. Even though in our preferred specification we already control for country-sector-size fixed effects, we worry that heterogeneity in the firm's technology could explain the main findings in table 5. This could happen if firms with a more advanced technology were more likely to be open and adopt more frequently new technology and also use more skilled labour. Column (1) controls for whether the firm has an ISO certification, column (2) for whether the firm conducts any R&D activities, column (3) for the share of R&D in total sales, in column (4) for the computer use and in column (5) for the e-mail/Internet use in daily activities. Even though the findings show that the effect on exports is not robust, the effect of FDI and technological innovation remains positive and strong after controlling for most of these variables. The major exception relates to the findings in column (4) of table 7, where the correlation between skills and FDI becomes statistically insignificant. This suggests that the presence of FDI and the use of computers are closely correlated and that it is difficult to disentangle the two effects. It is also interesting to note that all these variables capturing technological advancement are also positively correlated with the use of more educated workers. This strongly suggests that more advanced technology is complementary to the degree of human capital in the firm (e.g., Berman and others, 1994). In sum, the results in these tables show that the negative correlation between exports and use of skills is not systematically strong while the one for FDI and technological innovation tends to be so.

In tables 8 and 9, we test the robustness of our main findings to restricting the sample to different groups.

Table 7. Openness, technological innovation and the demand for skills: robustness technological variables

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Exporter	-0.0658	-0.144***	-0.147***	-0.276***	0.0323
	[0.0416]	[0.0468]	[0.0470]	[0.0679]	[0.0419]
Foreign ownership	0.199***	0.241***	0.223***	0.068	0.110**
	[0.0435]	[0.0496]	[0.0497]	[0.0682]	[0.0446]
Technological innovation	0.244***	0.235***	0.281***	0.324***	0.113***
	[0.0372]	[0.0426]	[0.0420]	[0.0551]	[0.0385]
ISO certification	0.283***	–	–	–	–
	[0.0403]				
R&D activities	–	0.316***	–	–	–
		[0.0439]			
R&D/sales	–	–	0.00889***	–	–
			[0.00212]		
Computer use	–	–	–	0.517***	–
				[0.0581]	
E-mail/internet use	–	–	–	–	0.438***
					[0.0425]
Baseline firm characteristics?	Yes	Yes	Yes	Yes	Yes
Country-industry-size fixed effects?	Yes	Yes	Yes	Yes	Yes
Observations	5 492	4 127	4 127	2 824	4 111
R squared	0.29	0.27	0.26	0.30	0.33

Source: Author's calculations based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is the logarithm of the share of workforce with more than a secondary education. Columns (1) through (5) take the baseline specification (column 5 of table 5) and add firm-level variables. Column (1) controls for whether the firm has an ISO certification, column (2) for whether the firm conducts any R&D activities, column (3) for the share of R&D in total sales, in column (4) for the computer use and in column (5) for the e-mail/Internet use in daily activities. All the variables are defined in table A1 in the annex.

Table 8 replicates our preferred specification in column (1), while columns (2) and (3) present the results when restricting the sample to high- and low-technology manufacturing sectors.[15] While there is strong positive correlation between technology and FDI, and the use of educated workers for low- and high-technology sectors, the negative correlation between exports and the use of educated workers is strong only for the set high-tech sectors. This negative correlation is fully driven by the inclusion of the Chinese firms in the sample. In fact, if we were to exclude China from the sample in the regressions reported in table 8, exports and skills would be positively correlated within countries for the low- and high-technology sectors, though not strong in the latter case (these results are not reported but are available on request). As discussed above, this finding

Table 8: Openness, technological innovation and the demand for skills: robustness manufacturing sample

	Manufacturing	*Low-tech manufacturing*	*High-tech manufacturing*
	(1)	*(2)*	*(3)*
Exporter	-0.0653*	0.0471	-0.229***
	[0.0388]	[0.0505]	[0.0599]
Foreign ownership	0.209***	0.107*	0.276***
	[0.0414]	[0.0550]	[0.0628]
Technological innovation	0.265***	0.215***	0.329***
	[0.0342]	[0.0431]	[0.0551]
Baseline firm characteristics?	Yes	Yes	Yes
Country-industry-size fixed effects?	Yes	Yes	Yes
Observations	5 976	3 391	2 585
R squared	0.277	0.284	0.238

Source: Author's calculations are based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is the logarithm of the share of workforce with more than the secondary education. Columns (1) through (3) take the baseline specification (in column 5 of table 5) and run it again for all the firms in the manufacturing sectors (column 1), manufacturing low-technology sectors (column 2) and for the manufacturing high-technology sectors (column 3). All the variables are defined in table A1 in the annex.

[15] We consider high-technology manufacturing sectors the following three-digit ISIC sectors: Auto or Auto-component, Chemical and Pharmaceutical, Electronics or Metals and Machinery industries. The low-technology manufacturing sectors are: Beverages, Food, Garment and Leather, Non-metallic/ Plastic Materials, Wood and Paper, Textiles. These definitions follow Parisi and others (2006).

Table 9. Openness, technological innovation and the demand for skills: robustness alternative samples

	Cambodia	*China*	*Indonesia*	*Malaysia*	*Philippines*	*Republic of Korea*	*Thailand*	*Viet Nam*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Exporter	-0.0664*	0.121***	-0.0992**	-0.0814**	-0.064	-0.0698*	-0.151***	-0.102**
	[0.0388]	[0.0417]	[0.0397]	[0.0394]	[0.0395]	[0.0394]	[0.0482]	[0.0464]
Foreign ownership	0.213***	0.139***	0.236***	0.213***	0.229***	0.207***	0.258***	0.0965**
	[0.0415]	[0.0450]	[0.0426]	[0.0434]	[0.0423]	[0.0418]	[0.0513]	[0.0466]
Technological innovation	0.266***	0.167***	0.270***	0.277***	0.243***	0.268***	0.308***	0.285***
	[0.0342]	[0.0387]	[0.0351]	[0.0353]	[0.0349]	[0.0345]	[0.0402]	[0.0402]
Baseline firm characteristics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry-size fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5 949	4 114	5 515	5 657	5 485	5 791	4 681	4 640
R squared	0.28	0.31	0.26	0.28	0.29	0.27	0.27	0.28

Source: Authors calculations based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is the logarithm of the share of workforce with more than the secondary education. Table reports the results for the baseline specification (column 5 in table 5) but restricting the sample to exclude one country at the time (excluded country reported at the top of each column). All the variables are defined in table A1 in the annex.

could be explained by the self-selection of firms into the exporting activity. However, this is not the case in China, and especially among the high-technology sectors, where the workforce in exporting firms tends to have fewer years of schooling.[16] The latter is likely to reflect the fact that the comparative advantage in this sector is based mostly on low wages (low skills) and not so much on high-quality products.

The importance of China in driving the results previously discussed is clearly documented in table 9. There, we investigate whether our findings are very sensitive to the inclusion/exclusion of each country in the sample. Table 9 reports the sensitivity of our preferred specification when excluding one country at a time. The findings show that the positive correlation between technological change and FDI and the use of more educated labour are positive and significant across all the specifications. As discussed above, the negative and strong correlation between the exporting intensity and the use of more educated workers is driven solely by China. There, the effect of specialization dominates the potential increase in the demand for skilled labour associated with technological change, leading to a strong negative correlation between export intensity and the use of more educated workers.

Finally, table 10 estimates our preferred specification (in column 5 of table 5) separately for different income groups in our sample. Column (1) restricts the sample to low-income countries (Cambodia and Viet Nam), column (2) to middle-low income (China, Indonesia, Philippines and Thailand) and column (3) to middle-upper income (Malaysia).[17] The findings show that, for the low-income countries, there is a strong correlation between FDI and the use of a more educated workforce, which is not robust to the middle-income or even low-middle income countries. This finding is suggestive that the technology transferred by foreigners to low-income countries is more advanced than the one operated by similar domestic firms (which then translate into higher skill use). Rather in low-middle income and in middle-income countries, there is a strong positive correlation between technological innovation and the demand for educated workers, which does not hold in low-income countries. The link between exports and demand for skills is also different across low and middle-income countries. Among low-income countries, there is no systematic correlation while, among low-middle and middle-income countries, the correlation is negative and strong. A closer investigation shows that this finding in the low-middle income countries is driven only by China, where the specialization effect of exports dominates (see also Fajnzylber and Fernandes, 2004).

[16] High-technology sectors include Auto and Auto Components, Chemicals and Pharmaceuticals, Electronics, and Metals and Machinery.

[17] The Republic of Korea is not included in table 10 as it is a high-income OECD country.

Table 10. Openness, technological innovation and the demand for skills: robustness across income groups

	Low-income	*Low-middle income*	*Middle-income*
	(1)	*(2)*	*(3)*
Exporter	0.00159	-0.115**	-0.0958**
	[0.0746]	[0.0489]	[0.0474]
Foreign ownership	0.459***	0.0721	0.0785
	[0.0933]	[0.0512]	[0.0486]
Technological innovation	0.015	0.297***	0.280***
	[0.0589]	[0.0395]	[0.0380]
Baseline firm characteristics?	Yes	Yes	Yes
Country-sector-size effects?	Yes	Yes	Yes
Observations	1 865	5 077	5 396

Source: Author's calculations based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is the logarithm of the share of workforce with more than a secondary education. Columns (1) through (3) take the baseline specification (in column 5 of table 5) but run it separately for low-income countries (column 1), low-middle income countries (column 2) and middle-income countries (column 3). All the variables are defined in table A1 in the annex.

Finally, we investigate the robustness of our main findings against the skills measure used in the paper (captured by the share of workers with more than a secondary education). Alternatively, we measure skills using the share of managers, professionals and non-production workers in the total workforce. The results in table 11 show that qualitatively the results are similar to the ones reported in table 8, although the effect of FDI on skills is not statistically strong. This suggests that although the occupational classification is similar, firms with foreign capital have a more educated workforce. These findings reinforce the fact that the two skills measures do not capture the same dimension of the human capital in the firm.

Table 11. Openness, technological innovation and the demand for skills: alternative skills definition

	Manufacturing	*Low-tech manufacturing*	*High-tech manufacturing*
	(1)	*(2)*	*(3)*
Exporter	-0.106***	-0.0206	-0.230***
	[0.0228]	[0.0312]	[0.0325]
Foreign ownership	0.0148	0.00603	0.0465
	[0.0243]	[0.0348]	[0.0342]
Technological innovation	0.0810***	0.105***	0.0523*
	[0.0195]	[0.0271]	[0.0276]
Baseline firm characteristics?	Yes	Yes	Yes
Country-industry-size fixed effects?	Yes	Yes	Yes
Observations	6 865	3 916	2 949
R squared	0.26	0.22	0.18

Source: Author's calculations based on the *Enterprise Surveys* (World Bank).

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is logarithm of the share of skilled occupations (captured by managers, professionals and non-production workers). Columns (1) through (3) take the baseline specification (in column 5 of table 5) but run it separately for manufacturing sectors (column 1), manufacturing low-technology sectors (column 2) and manufacturing high-technology sectors (column 3). All the variables are defined in table A1 in the annex.

VI. CONCLUSION

East Asia is undergoing a deep structural change with the demand for skills increasing significantly in the region, even within narrowly defined sectors. Job creation in the region is also increasingly biased towards the use of more skills. This paper investigates the extent to which the increased openness (captured by exports and foreign direct investment) and recent technological innovation in the region have contributed to a greater demand for skills and, thus, for the observed skill upgrading. We explore a large set of cross-sectional micro data across eight East Asian countries.

Our results are consistent with greater openness and technological innovation at the firm level being associated with an increasing demand for skills, especially for middle-income countries. In particular, we show that the presence in international markets through exports has been skill-enhancing for most middle-income countries, although this is not the case for firms operating in China

and in low-income countries. There, a stronger integration in international markets is associated with greater specialization in relatively low-skill-intensive goods. These findings strongly suggest that international integration and technology transferred to middle-income countries tend to be more skill-biased than for low-income countries. This evidence is fully consistent with middle-income countries having a higher absorptive capacity and, thus, being recipients of more advanced technological innovations than low-income countries. Rather, in China and other low-middle income countries, where the absorptive capacity is smaller, the effect of greater openness is associated with a stronger specialization in low skill-intensive goods.

In sum, the findings in the paper support the idea that international integration and technological innovation in middle-income countries has been a key determinant of the increasing demand for skills in East Asia. These results have clear implications for policy. If international integration continues to intensify and technology continues to be skill-biased, policies aimed at mitigating the persistent skills shortages in the region will only be successful if they foster the continual acquisition of skills rather than producing temporary increases in skills.

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ANNEX

Table A1. Definitions: Main variables

Variable	*Definition*
Share of highly educated workers	Share of the workforce with more than the secondary education
Share of skilled occupations	Share of the workforce that are managers, professionals and non-production workers
Exporter	Dummy variable equal to 1 if the firm exports directly or indirectly
Foreign ownership	Dummy variable equal to 1 if the firm has more than 10% foreign capital
Technological innovation	Dummy variable equal to 1 if the firm introduced a new technology that substantially changed the way the main product was produced in the three years prior to the survey
Age firm	Years since the firm started operations
Public ownership	Dummy variable equal to 1 if the government owns a positive amount of the firm's capital
Education of the manager	Dummy variable equal to 1 if the manager completed at least secondary education
Sales per employee	Firm total sales divided by the number of total employees
City > 1 mln individuals	Dummy variable equal to 1 if the firm is located in a city with population greater than 1 million individuals other than capital city
City 250 k-1 mln individuals	Dummy variable equal to 1 if the firm is located in a city with a population between 250,000 and 1 million individuals
City 50 k-250 k individuals	Dummy variable equal to 1 if the firm is located in a city with a population between 50,000 and 250,000 individuals
City > 50 k individuals	Dummy variable equal to 1 if the firm is located in a city with a population between smaller than 50,000 individuals

Table A1. ***(continued)***

Variable	*Definition*
Access to external finance	Dummy variable equal to 1 if a firm finances its investments through commercial banks or leasing arrangements.
ISO certification	Dummy if the firm has an ISO certification.
R&D activities	Dummy variable equal to 1 if the firm reports having design and R&D expenditures (e.g., labour costs with R&D personnel, materials or subcontracting costs).
R&D/Sales	Share of R&D expenditure divided by the firm's total sales.
Computer use	Dummy equal to 1 if the firm uses computers on their daily activities.
E-mail/Internet use	Dummy equal to 1 if the firm uses Internet or e-mail in their daily activities.
High-tech manufacturing sectors	Dummy equal to 1 if the firm operates in the auto or auto-component, chemical and pharmaceutical, electronic or metals and machinery industries.
Low-tech manufacturing sectors	Dummy equal to 1 if the firm operates in the beverage, food, garment, leather, non-metallic/ plastic materials, paper, other manufacturing, textiles, or in the wood and furniture industries. These definitions follow Parisi et al. (2006).
Low-income countries	Dummy variable equal to 1 if firm is located in Cambodia or Viet Nam.
Low-middle income countries	Dummy variable equal to 1 if the firm is located in China, Indonesia, the Philippines or Thailand.
Upper-middle income countries	Dummy variable equal to 1 if the firm is located in Malaysia.
Country-industry fixed effects	Dummy variable equal to 1 for each combination of country and three-digit sector of activity.
Country-industry-size fixed effects	Dummy variable equal to 1 for each combination of country, three-digit sector of activity and size category. We consider five size categories: micro (1-10 workers), small (10-50 workers), medium (50-100 workers), large (100-250 workers) and very large (>250 workers).

Table A2: Share of high educated and skilled workers, by country and sector of activity

	Manufacturing	*Services*	*Agro-industry*	*Construction*	*Other*	*Total*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Panel A. Share of high educated workers						
Cambodia	10.76	22.64	0.94	4.79	–	16.28
China	20.31	53.20	–	–	–	31.50
Indonesia	47.40	–	64.33	–	–	47.89
Malaysia	17.53	–	–	–	–	17.53
Philippines	27.24	–	–	–	–	27.24
Republic of Korea	37.64	45.88	–	62.14	18.89	43.88
Thailand	24.06	–	–	–	–	24.06
Viet Nam	11.41	32.00	–	28.33	80.00	14.43
Panel B: Share of skilled occupations						
Cambodia	0.166	0.713	0.458	0.353	–	0.572
China	0.342	0.766	–	–	–	0.480
Indonesia	0.201	–	0.115	–	–	0.199
Malaysia	0.239	–	–	–	–	0.239
Philippines	0.258	–	–	–	–	0.258
Republic of Korea	0.328	0.378	0.521	–	0.333	0.372
Thailand	0.182	–	–	–	–	0.182
Viet Nam	0.217	0.634	0.358	–	1.000	0.274

Source: Author's calculations based on the *Enterprise Surveys* (World Bank).

Note: Panel A reports the mean of the share of highly educated workers (more than a secondary education), by country and sector of activity. Panel B reports the mean share of skilled occupations (management, professionals and non-production workers), by country and sector of activity.

LOGIT AND PRINCIPAL COMPONENT ANALYSES OF THE MANAGEMENT OF MARINE PROTECTED AREAS IN NORTH-EASTERN ILOILO, PHILIPPINES

*Cheryl Joy J. Fernandez and Kim Hang Pham Do**

Marine protected areas (MPAs) are considered a common tool for the protection of coastal, marine and fishery resources. Recently, literature on fishery management has been paying attention to the importance of the social dimensions of MPAs and their impacts on MPA success. This paper presents an overview of the management of MPAs in the region of North-Eastern Iloilo, Philippines, and examines the interaction between the civil society and market forces of different institutional arrangements. Using the logit and principal component analyses, the paper shows that the conflicts between economic actors are still in existence today, and knowledge appears as a key factor for evaluating MPA success. Moreover, having MPAs does not seem to bring the communities any other benefit than the stated objectives, such as food security and marine conservation. The paper also discusses how contrasting objectives and expectations from various stakeholders could exacerbate conflict in the management of MPAs.

I. INTRODUCTION

As an archipelago, the Philippines is endowed with diverse fishery resources, 17,460 km of coastline and 2,200,000 km^2 of marine area. It is located entirely in the tropics of the western Pacific Ocean, near the centre of diversity for many marine organisms, such as molluscs and corals. Most types of tropical

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coastal ecosystems, such as coral reefs, sea grasses and mangrove forests, are found in the country. The country's marine resources are highly valued, both economically and socially, with fisheries contributing approximately to 4.3 per cent of the country's gross domestic product (GDP), or about 22 per cent of the country's total agricultural production sector (Philippines, 2008a). Since the beginning of Spanish colonization, Philippine fisheries and coastal management have been managed through a central authority, i.e. bureaucratic authority, until the fall of the Marcos regime in the mid-1980s (Pomeroy and Carlos, 1997). Throughout time, fishery resources, particularly mangroves, corals and fish, have been continuously threatened. High demand for natural resources in both local and international markets continues to increase. Moreover, the revising and consolidation of all laws and decrees affecting fishing and fisheries, or "Presidential Decree No. 704" of 1975, does not seem to encourage the protection of fisheries, and is considered "ineffective in promotion of sustainable management and development" of Philippine fisheries (Pomeroy and Carlos, 1997).

In the Philippines, the marine protected area (MPA) has been considered a fishery management tool for "integrated ocean management" since the early 1990s (Sumaila and Charles, 2002). The MPA became an important policy that involved a dynamic and a participatory process whereby an integrated strategy was employed for the conservation and sustained multipurpose use of the coastal zone. It also took into account traditional, cultural and historical perspectives (Webb, Maliao and Siar, 2004, p. 138). However, in some countries, managing MPAs is changing from management development to implementation. Examples include Canada (Guénette and Alder, 2007), Scotland (Staed and McGlashan, 2006) and the Philippines (Fernandez, 2006). Currently MPAs make up about 8 per cent of the area of South-East Asian coral reefs (Burke, Selig and Spalding, 2002). However, the success rate of MPAs in South-East Asia is low: an estimated 14 per cent of the 332 MPAs in South-East Asia are effectively managed and only about 10 to 38 per cent of MPAs in the Philippines are effectively or partially effectively managed (Pomeroy and others, 2007a; Gjertsen, 2005). This rate reflects the difficulty in implementing MPAs. Moreover, it shows that much work is still needed to make MPAs successful in South-East Asia.

Recently, two problems have been found in the management of MPAs in the Philippines: MPAs are not as effective as expected; and there are managerial or territorial conflicts among stakeholders. MPAs are not attaining their objectives. For example, Gjertsen (2005) and Alcala (2001) show that only 10 per cent of all MPAs are working effectively. The Haribon Foundation carried out surveys on coastal areas—environmentally critical areas that have, by law, been designated

marine recreation areas and seashore parks—and concluded that only 44 out of 439 MPAs (10 per cent) can be classified as "fully implemented" in the Philippines.

The literature on MPAs has shown that a combination of integrated social policies could be the key to achieving effective management of MPAs (Balgos, 2005; Anthoni, 2003; Jameson and others, 2002; White and others, 2002; Fernandez and others, 2000). According to Jones (2002) and Tyler (1999), public policies on the management of MPAs can generate conflicts over natural resources. Though MPA seems to be an effective solution, human development and overpopulation threatens the fishery sector. Therefore, the effectiveness of MPAs is still unclear. In the Philippines, and other developing countries where the population depends on coastal and marine resources, the management of MPAs is a continuing challenge for policymakers and practitioners.

Two of the main issues, therefore, in the management of MPAs in the Philippines that challenge many resource managers and national decision makers are: how MPAs could benefit society, and why poverty remains persistent even after MPAs have been implemented. Addressing these issues is the primary objective of managing conflicts over fishery resources in the interests of both long-term sustainability and short-term economic feasibility in South-East Asia, where fish is considered a primary source of dietary protein and income generation by more people than anywhere else in the world (Burke and others, 2002).

This paper presents an overview of the current management of MPAs in North-Eastern Iloilo, Philippines and examines whether the conflicts between various management regimes still exist. The paper is organized as follows. The next section begins with a brief review of MPAs and then describes the study area profile. Section III presents the methodology. In section IV, the interaction between the civil society and market forces are discussed. In this section, various economic players in MPA management are identified as well as the factors affecting the success or failure of MPAs. Key findings and concluding remarks follow in the last section.

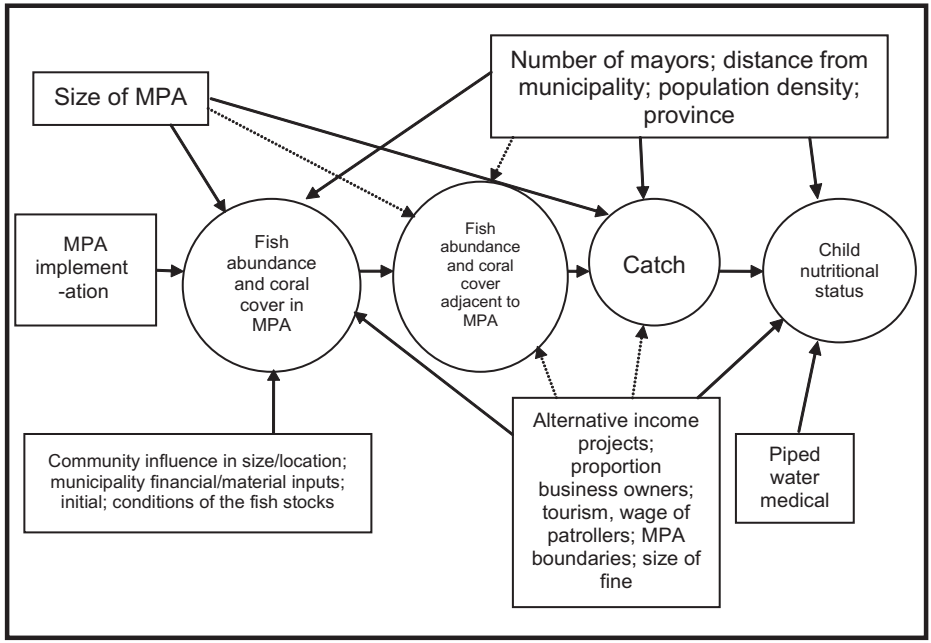
II. FOUNDATIONS AND STUDY AREA

The management of MPAs can be seen as a habitat protection and a fishery management tool in the Philippines (Philippines, 2001; Pomeroy and others, 2004). Management is also considered a process of policies that have been in place since the beginning (Pomeroy and Carlos, 1997; Fernandez and others, 2000; Balgos, 2005; Pomeroy and others, 2007a). In addition, the links between the

biological factors and the social factors play an important role in MPA management (Christie, 2004).

Gjertsen (2005) also observed the relationships between marine protected areas, coral reef health and the source of human well-being; this significance is shown in figure 1. MPAs can improve coral reef condition and can increase the fish population through spill-over effects. Since the MPA's implementation has an indirect effect on children's nutrition status, a rise in the fishermen's income, will likewise improve the quality and quantity of food for their children.[1] Therefore, ecosystem improvement and children's well-being are factors in the livelihood success of an MPA, but these indicators are dependent on exogenous variables (biological, social, political, economic conditions). Some other non-MPA activities, such as paying patrollers, financial inputs and availability of other income projects, are also essential to MPA success. However, livelihood schemes in the Philippines

Figure 1. Relationships between marine protected areas, coral reef health and human well-being



Source: Gjertsen, 2005, p. 202.

[1] For further details, see Gjertsen (2005) and the references therein.

do not work effectively because of such constraints as administration loans, and ineffective and inadequate planning and marketing infrastructures (Balgos, 2005).

Brief Demographic and Fisheries Profile of North-Eastern Iloilo

The Philippines is composed of three major island regions, namely Luzon, Visayas and Mindanao, which are predominantly rich fishing grounds. Iloilo Province is located in the Visayas region, bounded by the Province of Capiz to the north, Antique to the west, Panay Gulf and Iloilo Strait to the south, and the Visayan Sea to the east. The Visayan Sea has been identified as the most productive fishing area in the country (Ferrer, 2009). The province is the country's fourth largest fish producer and the second in terms of fish worth as reflected in fish prices (Philippines, 2008b). It has 42 municipalities, two cities and 1,721 *barangays*,[2] earning the status of a first-class province with a total voting population of 1,100,000 (Philippines, 2009).[3] Thus, the province is a major player in the country's fisheries industry.

Even though the province is well developed, poverty afflicts 60 per cent of its municipalities, and there is a high incidence of child malnutrition (Fernandez, 2006). Most municipalities are classified as "low-income" (from third to fifth), and fishing is the main source of income (see table 1). Moreover, the population of each municipality ranges from 18,298 to 57,673, but the majority of the population are from coastal communities and fishing is, not surprisingly, the primary occupation. For example, 97 per cent of Carles is composed of coastal barangays, while Balastan has only 8.6 per cent. Carles, Concepcion and Ajuy have the highest numbers of registered fishermen.

Moreover, MPAs are established through local government mandates that are incorporated under the Integrated Coastal Resource Management (ICM) programme of the national Government.[4] Costs, which range from PhP 50,000

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[2] In the Philippines, a province is composed of several municipalities (towns). Each of these towns has several *barangays*, which is the native Filipino term for "village", "district" or "ward". Barangays are the smallest administrative divisions in the Philippines.

[3] Philippine provinces and municipalities are broken up into six classes according to average annual income, based on the previous three calendar years. A first-class province is a province where annual income is at least PhP 300 million (US$ 6 million), while a first class municipality has an income of at least PhP 55 million (US$ 1.2 million). A second class municipality has PhP 45 million or more but less than PhP 55 million. A third class municipality has PhP 35 million or more but less than PhP 45 million. A fourth class municipality has PhP 25 million or more but less than PhP 35 million; and a fifth class municipality has PhP 15 million or more but less than PhP 25 million. The lowest class, the sixth, is reserved for those municipalities with an income below PhP 15 million.

[4] The aim of ICM is development and conservation of coastal resources and conflict mediation as well as multisectoral participation in planning and management.

Table 1. Demographic and fisheries profile of the municipalities of North-Eastern Iloilo Province, Philippines

	Ajuy	*Balasan*	*Batad*	*Carles*	*Concepcion*	*Estancia*
Income classification	Third	Fourth	Fifth	Third	Fourth	Third
Total Population (2007)	47 113	27 384	18 298	57 673	36 881	39 479
Number of *barangays*	34	23	24	33	25	25
Land area (km^2)	175.52	57.3	52.61	103.52	97.2	30.55
No. coastal brgy (percentage of total)	18 (53 per cent)	2 (8.6 per cent)	6 (25 per cent)	32 (97 per cent)	18 (72 per cent)	16 (64 per cent)
Main source of income	Fishing	Farming, Fishing	Fishing	Fishing	Fishing	Fishing
Malnutrition	..	..	1 per cent: 34 (2004)	1.128 per cent (2000)	..	1 per cent: 34 (2007)
Surface area of municipal waters (km^2)	250	0.6	8	368	320	10
Length of shoreline (km^2)	74.83	3.5	8.2	94.7	120	28.51
No. of islands	0	0	2	30	17	3
Registered Municipal Fishermen	3 185	120	142	4 500	3 211	1 296
Wardens, patrol boats	65, 2	0	60, 3	100, 3	160,6	45, 1
No. of MPAs	1	0	1	1	1	1

Sources: Iloilo, 2001; Fernandez, 2006; Philippine National Statistics Coordination Board, 2009.

Notes: San Dionisio, a municipality in Iloilo is not included in the study for logistical reasons. *Barangay* is the native Filipino term for "village", "district" or "ward"; a barangay is the smallest administrative division in the Philippines.

(US$ 1,064) to 100,000 (US$ 2,128) are usually shouldered by non-governmental organizations (NGOs) and local government (Fernandez, 2006). There are different phases of MPA establishment and management and related activities in which the proponents of management are *barangays*, local and national governments, NGOs and people's organizations (Philippines, 2001, p. 69).

Meanwhile, MPA protection can be set at a variety of levels—from total prohibition of activities to regulation at different intensities. There can also be a 'no-take' zone or a regulated zone. In "no-take" zones, human access is restricted.[5] On the other hand, some fishing methods (such as hook and line) are allowed in "regulated" areas, but destructive fishing methods, such as trawling, are prohibited. The majority of MPAs have been established, designed and located (e.g., size has been determined) on the basis of socio-economic and political issues, the desire to restore depleted fishing stocks, and food security (Fernandez and others, 2000). Therefore, the establishment of an MPA is not restricted to specific organisms but can emanate from cultural heritage or even social concerns.

III. METHODOLOGY

This section describes the data collection process, firstly by discussing the survey interview and the survey questionnaire, followed by key informant interviews and focus-group discussions.

Our methodology for selecting appropriate procedures and key success factors is guided by several studies[6] that highlight stakeholder perception and questionnaire surveys as relevant sources for MPA evaluation. For instance, Webb, Maliao and Siar (2004) used local area perception, while Himes (2007) used stakeholder analysis of biological, economic and socio-cultural indicators. In addition, Oracion, Miller and Christie (2005) used the Likert-scale to capture the perceptions of the fishery, tourist and business sectors.

Survey interview and social survey questionnaire

A total of 213 survey questionnaires were implemented in six municipalities of North-Eastern Iloilo. The municipality of San Dionisio was excluded due to logistics and safety considerations. Data collection based on questionnaires was

[5] No-take zone refers to an area in which human access is totally prohibited while a regulated zone refers to areas with different levels of human access and use are implemented.

[6] Such as Christie and others, 2002; Webb and others, 2004; Oracion and others, 2005; Pomeroy and others, 2007a; and Himes, 2007.

conducted through face-to-face interviews of 200 fishermen, 6 municipal agriculture officers (as the representatives of the public sector), and 7 fisherfolk association officers and NGO officers as representative of the private sector. The questionnaires were presented by two hired enumerators to fishermen at their homes, to public sector officers at the municipal town halls, and to private sector representative in their offices or residences. The first section of the questionnaire was composed of a classification section, which is also one of the two demographic sections. It includes the respondent's position and number of years involved with fishing, in addition to factual information relating to MPA.[7]

The second part of the survey presents Likert scale statements in response to eight questions.[8] Two of the questions are about perceptions regarding changes after the establishment of MPAs and another one concerns knowledge of MPA regulations. If the MPA goal is to enhance or maintain food security, the appropriate indicators to use are S1 (local marine resource patterns) and S2 (local values and beliefs regarding the marine resources) (Pomeroy and others, 2004, p. 135). Since the main objective of MPA establishment in North-Eastern Iloilo is to enhance and maintain food security, then the S1 and S2 indicators of the International Union for the Conservation of Nature (IUCN) are appropriate.[9] S1 is the way people use and affect coastal and marine resources and it determines if the MPA management strategies being implemented have impacts on income, livelihood patterns and cultural traditions. Moreover, it shows who is affected by MPA establishment as well as the activities involved in MPA management. On the other hand, the S2 indicator measures how people make choices and understand actions related to marine resource use and management based on their values concerning what is good, trustworthy and desirable, and their beliefs of social systems and processes (Pomeroy and others, 2004, p. 138). It reveals people's values and beliefs regarding marine resources as well as their usage and management practices. Decision makers should take these values into account in order to manage coastal resources effectively.

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7 Factual information refers to MPA size, municipality and economic sector classification.

8 See subsequent subsections for a full description of the Likert scale used in this paper.

9 According to Pomeroy and others (2004), there are three indicators that reflect the goals and objectives of MPAs, namely, biophysical, socio-economic and governance. In this paper, we focused on the socio-economic indicators.

The last five questions in the survey ask whether there are conflicts among fishermen, the public sector and the private sector. Respondents have the opportunity to indicate whether conflicts are still prevalent, and, in the affirmative, to describe and assess them.[10]

The third section includes open-ended question on the perceived and actual costs and benefits to stakeholders of establishing an MPA. Demographic information, such as membership and activities in coastal management organizations or groups, belong to this section. In addition, it includes primary and secondary income information. Demographic information is essential to capture the characteristics of the respondents and to break down responses and opinions into meaningful groups in the analyses.

The last section includes open-ended questions on the reasons why an MPA should be established. Since conflict is assumed to be an important social dimension that may affect the effectiveness of an MPA, conflict scenarios are posed at the end of the questionnaire. These scenarios are adapted from previous work by Fernandez (2006).[11] The answers can capture the relationships among major players in MPA management.

All data collection took place in June and July 2008. However, due to inconsistencies and a lack of precise information on the fishing population per *barangay*, proportionate sampling has been done. In the municipality of Ajuy, 38 people were interviewed, 25 in Balasan, 40 in Batad, 26 in Carles, 40 in Concepcion, and 31 in Estancia. The snowball approach is used in determining the respondents (Weible and others, 2004). This approach is a type of purposive sampling that relies on the people in the community to direct the enumerators to particular sources of information. The respondents are therefore the stakeholders and, as such, are directly involved in MPAs. Moreover, it is oftentimes used if the budget of the study is small but it captures stakeholder attributes very well. It is appropriate to use this method since the target group of this paper are the fishing and management entities only.

[10] These conflict statements are based on the findings of Fernandez (2006). Results show that there are conflicts among different economic actors in coastal resource management in North-Eastern Iloilo. Fernandez believed that there is no distinct management arrangement for effective management of MPAs.

[11] Conflicts adapted from the results of Fernandez's (2006) study and results show that there are conflicts among different economic actors in coastal resource management in North-Eastern Iloilo, Philippines.

Key informant interviews and focus-group discussions

Along with the questionnaires, key informant and focus group discussions are also used to determine current coastal management activities and the situation in the area. Face-to-face key informant interviews are conducted to address qualitative gaps. The main objective is to gather information from different sources in the community and, in this case, from different stakeholders. This method is relevant to the study because key informants have first-hand knowledge of the subject matter and can provide valuable insights regarding the nature of the problems and recommendations as well. According to the International Development Research Centre (IDRC) (2003), focus group discussion involves approximately 6 to 12 persons guided by a facilitator, during which group members talk freely and spontaneously about a certain topic. This method is a way to elicit different opinions that cannot be captured in a key informant interview. The researchers are able to initiate and expand the discussion because of the method's participative nature. Its main objective is to obtain in-depth information on concepts, perceptions and ideas of a group as well as to clarify some issues related to the survey proper. This gives a level of consistency between the data yielded by key informant interviews. Discussions were held in Barangay Nipa, in the town of Concepcion, where fishermen and other members of fisherfolk associations are present.

Likert scale, Logit and the Principal Component Analysis

A five-point Likert scale was adopted to analyse conflict scenarios and determine whether respondents have a thorough understanding of the regulations of an MPA. The scale is a type of psychometric response scale used in a questionnaire in order for respondents to specify their level of agreement with a particular statement. The scale adopted in the paper is (1) strongly disagree; (2) moderately disagree; (3) neither; (4) moderately agree; and (5) strongly agree. Its aim is to measure the knowledge and attitudes of respondents. This is the most convenient way of capturing respondents' attitudes and knowledge regarding the status of an MPA. Often, Likert scales are treated as summative scales using the analysis of variance and are treated as ordinal data using non-parametic tests.

In addition, the Principal Component Analysis (PCA) is a technique for reducing complexity in the data. Its purposes are the following: (1) to understand the variation in the data; (2) to form predictive models; and (3) to model response variable in terms of principal components (PCs) and to reduce the number of variables in the model (SAS Institute, 1985). The method provides an objective way of "aggregating" indicators so that variation in the data can be accounted for as concisely as possible (Jollands and others, 2004, p. 295). It approximates the

data into fewer dimensions. Each dimension, called the principal component, represents a linear combinations of the original variables.

Since the paper explores the sources of variation of MPA success in North-Eastern Iloilo, PCA captures the most variance of these data in low-dimensional subspace. This means that the PCA is a data reduction technique used to lessen the redundancy of the variables used. For example, data may be described into two or three dimensions. Meanwhile, the subspace will be formed by the span of the first few principal components, wherein a span of a set of vectors is the vector space consisting of all linear combinations of the vectors (SAS Institute 1985, p. 1). Results are usually shown through an eigenvalue matrix table, a correlation matrix and score plot figures.

Moreover, the use of logit regression is appropriate in this paper compared to the ordinary least squares regression (OLS) because OLS assumptions are violated when using a binary response variable.[12] The aim of the regression is to accurately predict the category of outcome for individual cases by calculating the probability of success over the probability of failure. The probability of success is expressed in odd ratios. The regression provides knowledge of the relationships and strengths among the variables. It also shows significance, wherein coefficients are statistically tested.

IV. RESULTS

Table 2 summaries the estimated results obtained from logit regressions, presenting several different conflict levels in the management of MPAs. Based on the tests of likelihood ratio and chi-square criterion, a conflict between NGOs and fishermen (C4) is dropped because it is not significant.

The likelihood ratio and chi-square are statistically significant (see table 2), implying that conflicts between fishermen and the public and private sectors, are still in existence today. As reflected by five-point Likert scale statements in which the highest mode is five and the lowest is one, the high value implies a higher level of conflict. Significant determinants of resource conflict in North-Eastern Iloilo include C1, C2, C3 and C5. For example, the modes of C1, C2 and C3 are equal to five; therefore, respondents strongly believe that there is conflict between fishermen and the government. These results are highly significant at $p > 0.001$.

[12] An OLS estimator is unbiased and has the minimum variance of all unbiased estimators. The residuals have constant variance and the errors are normally distributed.

Table 2. Goodness of fit tests – general logit for conflict variables

Conflict variables	Likelihood ratio		Pearson chi-square	
	Value	Sig.	Value [a]	Sig.
C1 *(conflict between municipal and commercial fishermen)*	51.340***	.000	56.233***	.000
C2 *(conflict between government and commercial fishermen)*	21.623***	.000	21.921***	.000
C3 *(conflict between government and municipal fishermen)*	42.455***	.000	43.615***	.000
C4 (*conflict between NGOs and fishermen*)	2.070	.150	1.965	.161
C5 *(conflict between NGOs and People's Organization)*	15.372***	.000	13.818***	.000

Note: [a] * (0.025) p > 5.02, **(0.01) p > 6.64, ***(0.001) p > 10.83; a people's organization is a bona fide association of citizens with a demonstrated capacity to promote the public interest and it has an identifiable leadership, membership, and structure. Its members voluntarily band together in order to work for their own betterment, development, and the greater good. An example of a people's organization is a fisherfolk association (Ajuy Development Office, 2006; Estancia Provincial Legal Office, 2004).

Factors affecting MPA establishment

Adopting the social factors as key indicators of success for examining the effects of an MPA management system, we examined two logit models with two different successful indicators: (1) improvement of the coastal environment (S1); and (2) improvement of the coral reef (S2).

Tables 3 and 4 show the analysis of fishermen's behaviour towards MPA success. Both regressions represent the corresponding independent variables, coefficients, odd ratio, z statistics (Wald test) and p-value.

The likelihood ratio chi-square of 102.15 with a p-value of zero in table 3 implies that the first model (S1) fits significantly. The significant variables in this model are C3 (municipal fishermen and the government), Knowledge (knowledge on MPA regulation indicator), and MPA (MPA size).

Table 3. Logit model to determine factors associated with S1 (local marine resource patterns)

Dependent Variable: S1; Log likelihood = -60.278665; LR chi-square (10) = 102.15; Prob > chi-square = 0.0000

Variables [a]	*Coefficient*	*Odd ratio*	*Z*	*P-value* [b]
C1 *(conflict between municipal and commercial fishermen)*	0.9255	2.52	1.62	0.106
C2 *(conflict between government and commercial fishermen)*	-0.0946	0.91	-0.17	0.868
C3 *(conflict between government and municipal fishermen)*	1.4208	4.14	2.71	0.007***
C5 *(conflict between NGOs and People's Organization)*	0.7110	2.04	1.19	0.233
PrValue	-0.0004	1.00	-1.30	0.194
SecValue	-0.0017	1.00	-0.88	0.377
MemOrg	-0.6791	0.51	-1.00	0.315
Knowledge	0.6473	1.91	3.50	0.000***
MPA (size)	0.1538	1.17	2.38	0.017*
Priority	-0.7424	0.48	-1.26	0.209
_cons	-2.7138		-3.32	0.001***

Notes: [a] The dependent variable is a binary choice of 1 and 0: 1 = successful; 0 = not successful.
[b] *p < 0.10, **p < 0.05, ***p < 0.01.

In Table 4, where S2 is the dependent variable, the significant variables are C1 (commercial and municipal fishermen) and Knowledge (knowledge on MPA regulation indicator). The likelihood ratio tests the overall fit of the model and shows that the second model also fits the data relatively well, with a chi-square distribution of 45.06 and a p-value of 0.000. Results of the two models show that the knowledge indicator is a key factor for evaluating and improving the condition of the coastal environment.

There is an a priori expectation that there will be overlapping and conflicting rules as well as varying regulations due to the existence of different MPA management regimes (McKean, 2000). It is clear that the effectiveness of managing coastal resources through an MPA depends on an appropriate mix of property rights (common, private and state).

Table 4. Logit model to determine factors associated with S2 (local values and beliefs regarding the marine resources)

Dependent Variable: S2; Log likelihood = -113.1969; LR chi-square (9) = 45.06; Prob > chi-square = 0.0000

Variables [a]	*Coefficient*	*Odd ratio*	*Z*	*P-value* [b]
C1 *(conflict between municipal and commercial fishermen)*	0.8549	2.35	1.78	0.075*
C2 *(conflict between government and commercial fishermen)*	0.2289	1.26	0.60	0.550
C3 *(conflict between government and municipal fishermen)*	-0.3154	0.73	-0.78	0.437
C5 *(conflict between NGOs and People's Organization)*	0.3443	1.41	0.92	0.358
PrValue	0.0004	1.00	1.59	0.111
SecValue	-0.0001	1.00	-0.41	0.680
MemOrg	0.1379	1.15	0.31	0.755
Knowledge	0.4928	1.64	3.40	0.001***
MPA (size)	0.0156	1.02	0.39	0.700
Priority	-0.4438	0.64	-0.94	0.346
_cons	-2.5781		-4.00	0.000***

Notes: [a] The dependent variable is a binary choice of 1 and 0: 1 = successful; 0 = not successful.

[b] *p < 0.10, **p < 0.05, ***p < 0.01.

These results are consistent with the study by Fernandez (2006), which revealed that, during the process of implementing various coastal development programmes and projects, there are "conflicts over management plans and strategies" between and among subsistence fishers, commercial fishing operators, politicians and their pressure groups, fish processing plants, barangays, and non-governmental organizations. Furthermore, due to a misunderstanding of the laws, there is a conflict between the local government and the Northern Alliance for Coastal Development and between municipal (small-scale) and commercial (large-scale) fishermen.

The Principal Component Analysis

The eigenvectors of the correlation matrix are given in table 5. The PCA was performed using the PRINCOMP procedure of the SAS system (SAS Institute, 1985), which standardizes data to zero mean and unit variance. This standardization is important in this study, given that the variables display widely different mean and relatively different standard deviation (see tables 1-4). Several tests are available for determining how many PCs to retain. The Cattel's Scree plot of eigenvalues (figures 2 and 3), the Jollife-amended Kaiser eigenvalue criterion (table 5) and an examination of proportion of variance accounted for by the PCs suggest retaining four PCs (which account for 69 per cent of the variation, as shown in table 6. Note that the order in which the PCs are listed in table 6 reflects the order in which they are derived from the PCA. The first PC (PC1) accounts for 41 per cent of the total variation in the data (table 6).

Algebraically, PC1 is shown as:

$$PC1 = -0.039X_1 + 0.196X_2 - 0.018X_3 - 0.009X_4 + 0.118X_5 + 0.082X_6 + 0.357X_7 + 0.352X_8 + 0.307X_9 + 0.337X_{10} + 0.288X_{11} + 0.330X_{12} \quad (1)$$

where X_1-X_{12} are the original social economic variables and indicators used in the analysis.

Table 5 and the equation (1) above show that the first component (PC1) has high positive coefficients (weights) on knowledge (X_7) and conflict variables X_8 – X_{12}, The PC1 can be interpreted as a knowledge and conflicts indicator, with higher scores indicating higher knowledge and conflicts related the management regimes. It implies that the issue of the effectiveness of the MPA could be reflected in whether the actors have conflicts with each other or not. This has the same implication from the results of the logit regression (see table 2). The PC2 accounts for 13 per cent of the total variation, and has high positive weights on membership characteristics (X_5 and X_6). It can be called a membership indicator, with a higher PC2 indicating higher membership or experience. The PC3 accounts for 8 per cent of total variation and has high positive weights on income variables (X_3 and X_4), and the PC4 accounts for 7 per cent of the total variance and has high positive weight on MPA size (X_2) and the years in service or fishing (X_1).

However, the third and fourth PCs explain a small portion of the total variation and they are not as important as the first two PCs. The four principal components comprise approximately 69 per cent of total variation. These PCs are useful for decision makers.

Table 5. Correlation structures (eigenvectors) for principal components

	PC1	*PC2*	*PC3*	*PC4*	*PC5*	*PC6*
YrsServ (X_1)	-0.039	0.302	0.028	-0.551	0.577	0.390
Mpa (X_2)	0.196	0.180	-0.165	0.461	0.511	0.161
PrValue (X_3)	-0.018	-0.050	0.660	0.266	-0.236	0.634
ScValue (X_4)	-0.009	-0.062	0.674	0.090	0.442	-0.555
MemOrg (X_5)	0.118	0.588	0.086	0.014	-0.251	-0.209
MemYrs (X_6)	0.082	0.605	0.158	-0.181	-0.240	-0.068
Knowledge (X_7)	0.357	-0.066	0.015	-0.097	0.014	0.015
C1 (X_8)	0.352	-0.104	0.024	0.016	0.069	-0.049
C2 (X_9)	0.307	-0.151	0.012	-0.146	-0.131	-0.137
C3 (X_{10})	0.337	-0.028	0.056	-0.115	-0.057	-0.112
C4 (X_{11})	0.288	-0.227	-0.007	-0.156	-0.064	0.062
C5 (X_{12})	0.330	0.067	0.057	0.012	0.021	0.108

Table 6. Principal Component Analysis summary statistics

PC number	*PC*	*Decision variables (eigenvalues)*	*Variance (percentage)*
PC1	Conflict variables	Knowledge (0.357) C1 (0.352) C2 (0.307) C3 (0.337) C4 (0.288) C5 (0.330)	41 per cent
PC2	Membership Characteristics	MemOrg (0.588) MemYrs (0.605)	13 per cent
PC3	Income	PrValue (0.660) ScValue (0.674)	8 per cent
PC4	Other Factors	YrsServ (-0.551) Mpa (0.461)	7 per cent
			69 per cent of total variation

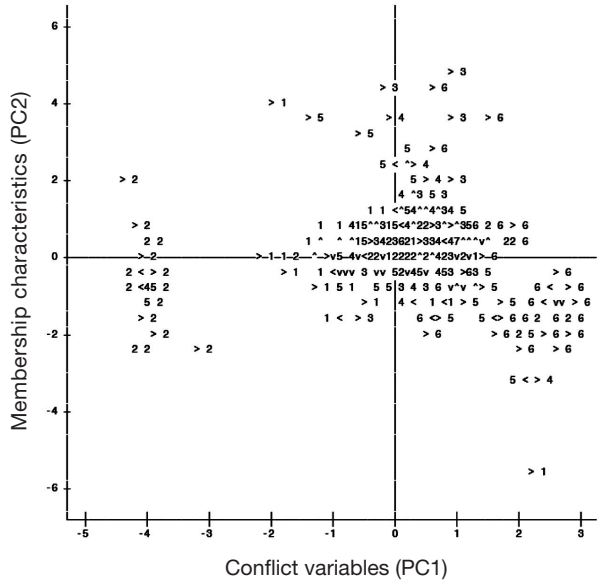
The PCA results confirm the logit regression results, where awareness of MPA rules and regulations does not directly influence fishing or secondary incomes. This could be explained by the externality and free riders, whereby fishermen may violate MPA regulations to enjoy a good service (i.e., without paying anything or making a contribution smaller than the benefit they derive). For instance, lenient implementation may cause disobedience from the fishermen.

Meanwhile, figures 2 and 3 present a summary of the relationships among observation and show relationship patterns among principal components. The observations labelled 1-6 are the municipalities in North-Eastern Iloilo. The figures show patterns of these observations among the principal components (PC1, PC2 and PC3). Relationships can be observed through the scores. For example, in figure 2, the horizontal axis represents PC1, in which the intensity of conflict increases along the x-axis from left to right. Therefore, intense conflict is characterized by a high PC1 score. The same interpretation goes for PC2 and PC3. A high score for PC2 means many years of membership in and experience with relevant organizations. Moreover, municipalities which score poorly in PC3 are characterized by little or no income.

Score plots are a good way to draw patterns from different components. Figure 2 shows the relationship of conflict to membership, wherein the knowledge variable can be drawn from the patterns of different municipalities. It is shown that the majority of the observations from the fourth quadrant are from Batad (3) and Carles (4), where respondents generally are not members of any coastal organization, but they strongly agree that there are conflicts in North-Eastern Iloilo. These observations reflect the profile of North-Eastern Iloilo municipalities. Balasan's observations agglomerate in the second and third quadrants. Fishermen in this municipality lack skills and knowledge about MPA regulations. Unlike other municipalities, Balasan does not have an MPA, and its residents are only familiar with other coastal programmes, such as mangrove reforestation and aquaculture development.

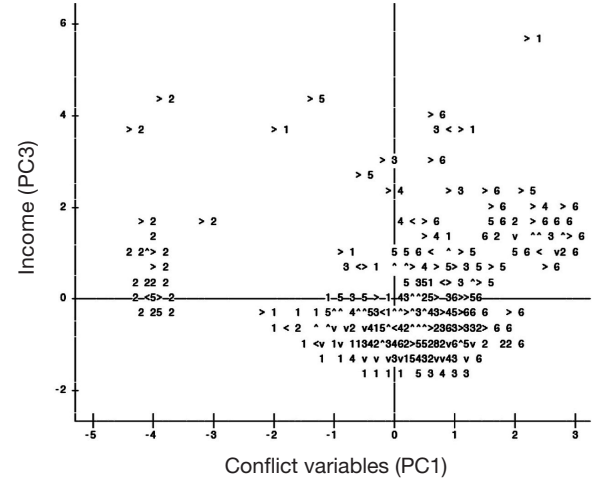
We observe that, in most areas with a long coastline and a large number of fishermen, local governments tend to prioritize MPAs over other fishery strategies, but there is high exposure to conflict among actors. For instance, Concepcion has many coastal communities in which fishing is the primary livelihood but, at the same time, an MPA is a priority project. Despite many patrol boats and wardens (sea/coastal police) among the North-Eastern Iloilo municipalities, conflicts are still rampant. Moreover, fishermen from nearby provinces take advantage and poach in these municipal waters. Membership in organizations is not popular in Batad probably because they have a smaller water surface area with fewer coastal *barangays*.

Figure 2. Score plots for Principal Component 1 (PC1) and Principal Component 2 (PC2)



Notes: 1- Estancia; 2- Balasan; 3-Batad; 4-Carles; 5-Ajuy; 6-Concepcion

Figure 3. Score plots for Principal Component 2 (PC2) and Principal Component 3 (PC3)



Notes: 1- Estancia; 2- Balasan; 3-Batad; 4-Carles; 5-Ajuy; 6-Concepcion

In figure 3, the majority of the observations from the municipality of Ajuy (5) strongly agree with the conflict statements, even if an MPA is not a priority fishery programme of the local government. Conflict statement scores are high, revealing the current political instability, which is reflected by large numbers of wardens and patrol boats in the municipality.

V. CONCLUDING REMARKS

Like many other countries, the Philippines has a problem with the management of MPAs. Threats to the successful establishment of MPAs are rapid population growth, high demand for marine products, lack of employment (other than resource extraction), law enforcement constraints and poverty (McManus, 1985). The Philippines has the highest per capita seafood consumption rate in South-East Asia (33.8 kg/year) and a high ratio of people to coastline (3,000/km^2) (Wilkinson and others, 1994). The number of coastal inhabitants dependent on coral reef resources may reach several tens of thousands per square kilometre of coral reef. This situation places intense pressure on the remaining resources. As one of most important fishing grounds in the country, MPAs in Iloilo's north-eastern region are worth examining, for they reflect the conditions of a coastal-dependent region. This paper studies the relationship between socio-economic variables and the successful management of MPAs. Specifically, it attempted to observe factors that might explain MPA effectiveness, such as conflict, information and membership.

The study revealed that the success of managing MPAs depends on the success of managing social conflicts. The management of MPAs in North-Eastern Iloilo is not achieving its objectives because it failed to increase coral reef cover sustainably or improve the overall conditions of the coastal environment. In poor fishing communities of the areas studied in North-Eastern Iloilo, MPA is not an effective coastal management strategy and fishermen have very poor knowledge of MPA.

Researchers observed that, without taking into account the human dimension in the management of MPAs*, ceteris paribus*, the goal of establishing the MPAs could not be met. Fishermen who are not members of a social economics organization and lack knowledge of MPAs could earn more income than those who are members because of free-riding problems. In North-Eastern Iloilo, fishermen seem to believe that their right to fish in the fishing areas (MPA zone) is being violated, but fishing in a non-MPA zone could cost them more (in terms of fuel and time, for example).

The results of this research indicated that bureaucratic regimes have more conflicts than community-based and co-management regimes, especially MPA management solely operated by local government. The public sector has the bulk of the budgets for coastal management, and its influence cannot be disregarded. In addition, human (e.g., conflict) and non-human (e.g., size) threats to MPAs are not controlled, though there have had attempts at negotiation and dialogue in order to solve conflicts. The success of MPAs management could therefore be very limited in the absence of educational measures to increase fishermen's awareness regarding MPAs.

Since the management of MPAs in North-Eastern Iloilo is not attaining its objectives; policymakers should reconsider the strategies for establishing MPAs. The government and public sector should correct their overlapping mandates and regulations. Further studies should include more serious issues, such as pollution, waste management, and coastal population growth, to analyse the impact of MPAs. There should also be a focus on the links between MPAs and poverty alleviation.

ANNEX

The models used in this study are composed of a dependent variable that is binary (0, 1) and a set of independent variables. Two logit models are adopted, each given success indicators: improvement of the coastal environment (S1); and improvement of the coral reef (S2). Using the non-linear likelihood estimation, the probability P_i, is defined as follows:

$$\text{Prob } P_i(Z_i = 1) = \frac{\exp(\alpha + \beta X_i)}{1 + \exp(\alpha + \beta X_i)} \quad \text{(A.1)}$$

where $Z_i = 1$ if MPA is successful and $Z_i = 0$ if otherwise.

The vector of X, $X = (X_1, X_2, X_3..., X_n)$, is the set of independent variables for determining the success of MPA. In this paper, there are two regressions. The first determines which among the five conflict variables (C1, C2, C3, C4, C5) are significant. Any insignificant conflict variables are dropped from the analysis. The second regression is composed of the significant conflict variables and a set of independent variables.

Specifically, the first regressions have the following general form for all conflict variables.[13]

$$\text{logit}[\theta(S1)] = \log\left[\frac{\theta(S1)}{1 - \theta(S1)}\right] = \alpha + \beta_i \text{ conflictvariable} \quad \text{(A.2)}$$

Equation A.2 is for the first success indicator, S1.

$$\text{logit}[\theta(S2)] = \log\left[\frac{\theta(S2)}{1 - \theta(S2)}\right] = \alpha + \beta_1 \text{ conflictvariable} \quad \text{(A.3)}$$

Equation A.3 is for the second success indicator, S2.

On the other hand, the second logit regression will have the following forms:

[13] Equations 1.1 and 1.2: conflict variable = (C1, C2, C3, C4, C5).

$$\text{logit}[\theta(\text{SUCCESS1})] = \log\left[\frac{\theta(S1)}{1-\theta(S1)}\right]$$
$$= \alpha + \beta_1 C1 + \beta_2 C2 + \beta_3 C3 + \beta_4 C4 + \beta_5 C5 + \beta_6 \text{Knowledge} + \beta_7 \text{mpa} + \beta_8 \text{priority} + \beta_9 \text{PrValue} + \beta_{10} \text{SecValue} \quad \text{(A.4)}^{14}$$

Equation A.4 is for the first success indicator, S1.

$$\text{logit}[\theta(S2)] = \log\left[\frac{\theta(S2)}{1-\theta(S2)}\right]$$
$$= \alpha + \beta_1 C1 + \beta_2 C2 + \beta_3 C3 + \beta_4 C4 + \beta_5 C5 + \beta_6 \text{Knowledge} + \beta_7 \text{mpa} + \beta_8 \text{priority} + \beta_9 \text{PrValue} + \beta_{10} \text{SecValue} \quad \text{(A.5)}$$

Equation A.5 is for the second success indicator, S2.

The above equations show that regressions have two dependent variables (*S1*, *S2*) which are run separately. On the other hand, the independent variables are the following: conflict between municipal and commercial fishermen (C1); conflict between government and commercial fishermen (C2); conflict between government and municipal fishermen (C3); conflict between NGO and fishermen (C4); conflict between NGOs and POs (C5); regulation knowledge (Knowledge); size of MPA (mpa); whether MPAs are priority coastal project (priority); membership to organizations (MemOrg); fishing income (PrValue); and secondary income (SecValue).

[14] Equations A.4 and A.5 can be altered, depending on the previous logit regressions with conflict variables. Only conflict variables which are found to be significant are included in these equations.

Table A.1. Summary and description of variables for LOGIT regression

Variable Name	*Description*
Statement Variables	
S1	Referring to whether there is a improvement in the quantity or quality of coral reefs
S2	Referring to whether there is an improvement in the overall coastal environment
Knowledge	Whether respondents have knowledge with MPA regulations
C1	Whether there is conflict between municipal and commercial fishermen
C2	Whether there is conflict between the government and commercial fishermen
C3	Whether there is conflict between the government and municipal fishermen
C4	Whether there is conflict between NGO and fishermen
C5	Whether there is conflict between NGOs and POs
Other Variables	
Mpa	Size of MPA in hectares
Priority	Whether MPA is a priority coastal project
MemOrg	Whether respondent is member of any environmental/natural resource group
PrValue	Weekly primary income value, referring to fishing income, in PhP
SecValue	Weekly secondary income value, in PhP
YrsServ	Number of years in service
EcType	Economic type i.e. fisherman, public or private sector

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THE PHILOSOPHY OF THE SUFFICIENCY ECONOMY: A CONTRIBUTION TO THE THEORY OF DEVELOPMENT

*Prasopchoke Mongsawad**

The King of Thailand's philosophy of sufficiency economy highlights a balanced way of living. Three principles—moderation, reasonableness, and self-immunity—along with the conditions of morality and knowledge can be applied to any level of the society—from an individual to a country. This article proposes that the philosophy of sufficiency economy conveys new theory in addressing current development challenges, which are issues of institutions, human capital, environmental sustainability and the role of government. The philosophy of sufficiency economy, as a new paradigm of development, aims at improving human well-being as a development goal.

I. PAST THEORY AND CHALLENGES

The theory of development, which influenced the world from the mid-1940s to the 1970s, viewed the problem of less developed countries stemming from low capital and resource misallocation. Economists during this period believed that development was equivalent to a growth process that required high capital and resource reallocation from low-productivity agricultural sectors to high-productivity manufacturing sectors. Rostow (1960) argued that countries had to go through successive stages of growth, from the taking-off stage to the sustaining growth stage. Also, savings-led growth was considered essential (Harrod 1939; Domar 1957). However, there was a problem of capital accumulation in less developed countries—people were too poor to save. It was thought that foreign aid, together with the right combination of savings and investment, would solve the capital

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accumulation problem. These patterns of growth-driven development and structural change dominated development theory at that early stage (see, for example, Singer, 1950; Lewis, 1955; Kuznets, 1955; and Prebisch, 1962).

When the theory of a non-linear long-term growth process emerged, it was considered to be a reason why a country experienced multiple stable equilibria. One equilibrium occurs at a high level of investment, thus resulting in high output and income. The other occurs at low capital and investment levels, which leads a country to a poor income situation. A country might be stuck in a bad equilibrium; such a situation is called a poverty trap. This poverty trap, together with problems of inadequate infrastructure, high social overhead capital and coordination failure, could impede the growth and development of a country for a long time. The Big Push or public-led policy helps accelerate the economy and pushes the economy out of the poverty trap (Rosenstein-Rodan, 1943; Nurkse, 1953).

Because of the successes of active Keynesian government and the Marshall Plan in the 1940s, the government was regarded as a prime mover in correcting all problems obstructing economic growth during this period. This type of economic development valued a strong role for the government. There were huge market interventions from the government, such as directing and coordinating investment flow, subsidizing investment, and opening new investment opportunities by creating new industries, especially in relation to import-substitution industries.

After the glory days of State-led development stressing capital accumulation and structural change, problems began in the 1970s. The record showed that, even with high income and industrialization growth rates, countries still suffered from high unemployment, high income inequality, excessive debt, high inflation, unbalanced growth and economic instability. As a result of these failures in the development process, the second era of development theory emerged in the late 1970s. This phase of development theory is based on the neoclassical theory, originating from the works of Milton Friedman in the 1960s, which reasserted classical principles in new models.

This phase of development theory viewed the problems of underdevelopment as resulting from overly active government. Therefore, sustaining growth and stability required that government interventions—which included price distortions in the domestic factors of production and commodity markets, and barriers to international trade—be removed. The economy would then achieve efficient movement of resources among sectors, appropriate technology adoption, and an increase in capital accumulation.

From the late 1970s to the late 1990s, government failure was blamed for impediments to development. Instead, laissez-faire government was suggested as more effective (Krueger, 1990). This was an era of neoliberalism, which emphasized liberalizing domestic and international markets for both goods and factors for production, which would help a country to achieve a sustained economic growth. This market-oriented development strategy dominated the world, especially during the 1980s. The Washington Consensus,[1] a set of reforms aimed at stabilizing the economy via liberalization and openness, is evidence of the development thought during this stage.[2] However, neoliberalism eventually lost some of its credibility because of unrealistic assumptions of efficient markets and resource allocation that a country would achieve through market liberalization. Stiglitz (2002) commented that, without higher capacity to cope with risk, liberalization increased countries' risk exposure. Markedly, there were several economic collapses—such as the Mexican peso crisis in 1994, the Asian financial crisis in 1997 and the Russian ruble crisis in 1998. Also, most countries under the Washington Consensus performed poorly in terms of growth and poverty reduction (Rodrik, 2002). More importantly, the practice was not applicable to less developed countries that had been bombarded by problems of imperfect markets, incomplete or missing markets, asymmetric information, or dysfunctional or missing institutions.

The institutional problem is currently seen as one of the most challenging hurdles to development. The problem of dysfunctional or missing institutions is the root of several problems associated with market and non-market activities. Additionally, the new kinds of market failures, such as an incomplete market, transaction costs, imperfect and costly information, and the absence of futures markets (Meier, 2001, p. 21) interest economists because they are believed to be obstacles to economic growth and development.

Furthermore, capital accumulation was later seen as an insufficient source of sustainable economic growth. Technology and human capital are crucial for driving long-term economic growth. Effective use of human capital as well as the existence of a suitable institution that encourages the acquirement of technology, have been placed high on the research agenda because of the complementary effects between them.

[1] See Williamson (2000) and (2002).

[2] Many developing countries and countries with economies in transition adopted the neo-liberal economic policy and the Washington Consensus.

The role of government has shifted from minimal to optimal.[3] Government becomes more active when it takes on the important task of improving the institutional setup by strengthening or creating institutions. With the right institutions, economic incentives will be created and the market will function properly. Nevertheless, the government must pay attention, not only to economic matters, but also to social development issues, including politics. Still, the problem of good governance remains an agenda of development theory.

Others focus not on aggregate economic growth but on the broader aspect of development. At the 2006 Copenhagen Consensus Conference, well-known economists, United Nations ambassadors and senior diplomats from 24 countries (accounting for 54 per cent of the world's population), prioritized current major world challenges[4] that needed immediate attention. Those ranking at the top were: communicable diseases; sanitation and clean water; malnutrition and hunger; and education. All of them target improvement of people's quality of life.

The Millennium Development Goals[5] are also aimed at improving the well-being of people, especially in less developed countries. The Goals are to eradicate extreme poverty, to achieve universal primary education, to promote gender equality and to empower women, to reduce child mortality, to improve maternal health, to combat HIV/AIDS, malaria and other diseases, and to ensure environmental sustainability. Human well-being is considered a key to achieving all other aspects of development.

Another challenge to development concerns environmental issues. Environmental sustainability has received much attention in the international arena since the Brundtland Report, *Our Common Future* (WCED, 1987), was published. It is obvious that environmental degradation and depletion of resources are clear and present dangers, and pursuing economic prosperity at the expense of the environment and natural resources is considered unsustainable. Therefore, environmental protection and natural resource conservation are requisites for development.

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[3] See, for example, Adelman (1999) and Meier (2001).

[4] Major world challenges include climate change, communicable diseases, conflicts and armed proliferation, education, financial instability, governance and corruption, malnutrition and hunger, migration, sanitation and clean water, and subsidies and trade barriers.

[5] The goals agreed to by world leaders at the Millennium Summit (see General Assembly resolution 55/2 of 8 September 2000). The purposes were to eradicate extreme poverty and specify a series of targets to be reached by 2015.

From the previous discussion of past theories and other development concerns, there are still challenges in development that need to be addressed: the problems of institutions, of human capital, of environment and of the role of government.

This paper proposes a new theory of development: the philosophy of sufficiency economy. Both the theoretical framework and the practices of the philosophy are discussed in addressing the above-mentioned development challenges. The theoretical framework is in section II; section III presents the contribution of the philosophy to development concerns; and concluding remarks are included in section IV.

II. THEORITICAL FRAMEWORK

King Bhumibol Adulyadej proposed the philosophy of sufficiency economy (PSE) to people of Thailand on 4 December 1997.[6] The philosophy guides people in living their lives according to the middle path. The concept of PSE can be applied to the individual level, the community level and the national level. The following is a synthesis of the philosophy, with royal approval:

> *"Sufficiency economy" is a philosophy that stresses the middle path as the overriding principle for appropriate conduct by the populace at all levels. This applies to conduct at the level of the individual, families, and communities, as well as to the choice of a balanced development strategy for the nation so as to modernize in line with the forces of globalization while shielding against inevitable shocks and excesses that arise. "Sufficiency" means moderation and due consideration in all modes of conduct, as well as the need for sufficient protection from internal and external shocks. To achieve this, the application of knowledge with prudence is essential. In particular, great care is needed in the utilization of untested theories and methodologies for planning and implementation. At the same time, it is essential to strengthen the moral fibre of the nation, so that everyone, particularly political and public officials, technocrats, businessmen and financiers, adhere first and foremost to the principles of honesty and integrity. In addition, a balanced approach combining patience, perseverance, diligence, wisdom and prudence is indispensable to*

[6] For more detail on the emergence of PSE, see Thongpakde (2005).

cope appropriately with the critical challenges arising from extensive and rapid socio-economic, environmental and cultural changes occurring as a result of globalization.

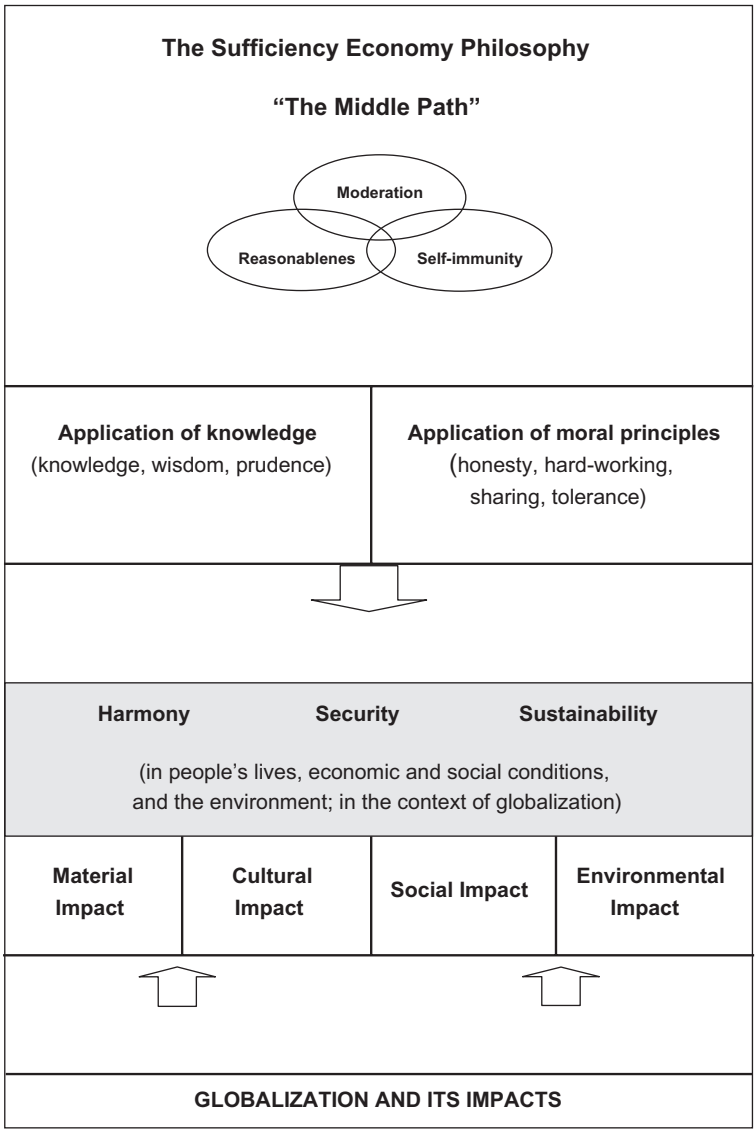
Figure 1 illustrates the PSE framework. The three interlocking elements represent the three principles of the PSE: moderation, reasonableness and self-immunity. These three principles are interconnected and interdependent. Moderation conveys the idea of people living their lives on the middle path, not the extremes. People should rely on themselves without overindulgence. This way of living occurs when people have reasonableness—accumulated knowledge and experience, along with analytical capability, self-awareness, foresight, compassion and empathy. They must be aware of the consequences of their actions, not only for themselves but also for others. The third principle, self-immunity, refers to the ability of people to protect themselves against any external turbulence and to cope with events that are unpredictable or uncontrollable. It implies a foundation of self-reliance, as well as self-discipline. Apart from these three components, two other conditions are needed to make the principles of sufficiency economy work: knowledge and morality. Knowledge encompasses accumulating information with insight to understand its meaning and the prudence needed to put it to use. Morality refers to integrity, trustworthiness, ethical behaviour, honesty, perseverance, and a readiness to work hard.

By practicing these three principles with the two underlying conditions, people would be able to live securely in harmony in a sustainable society and environment. Such a way of living does not signify self-sufficiency; rather, it reflects self-reliance—the ability to tolerate and cope with all kinds of malign impacts of globalization.

The application of PSE is not limited to the individual; it can also be applied to several different practices, one of which is private business. PSE encourages corporate pursuance of sustainable profit via ethical approaches, including good corporate governance, social responsibility, mindfulness of all stakeholders, and business prudence with risk management. The Siam Cement Group, the PTT Public Company, Toshiba Thailand, the Pranda Jewelry Company and the Chumporn Cabana Resort are examples of corporations implementing PSE (RDPB, 2008).

PSE can also be applied to a country's economic policy. The concept of PSE helps shape economic policy in managing factors of production: physical capital, human capital, natural capital and social capital towards achieving quality growth. Such growth stresses people's well-being, sustainable environment,

Figure 1. The philosophy of sufficiency economy framework



Source: Thongpakde (2005).

a steady growth rate, global risk management, and good governance (Mongsawad, 2007).

III. THE CONTRIBUTION TO DEVELOPMENT

This section shows how PSE is employed to address current development challenges. As indicated above, these challenges concern institutions, the environment, human capital and the role of government. PSE conveys new ideas in dealing with these concerns, and offers a new paradigm of development that treats improving human well-being as a development goal.

Institutions

At the current stage of economic development research, the new generation of development theorists (Meier, 2001) agrees that "institution matters." Institutional failure has caused a wide range of economic and development problems, ranging from asymmetric information, missing markets and moral hazard to governance and regulation issues (Yusuf and Stiglitz, 2001; Meier, 2001; and Bardhan, 2001). The problems concerning dysfunctional or nonexistent institutions are believed to be severe in developing economies. In the search for solutions to these problems, a great deal of contemporary literature has been devoted to extending the scope of research beyond economic boundaries to the cultural and societal issues that affect the economy in order to explain the institutional gap resulting in poor economic development through the concept of social capital.

Social capital, as defined by Collier (1998), is the internal social and cultural coherence of the society. This includes the norms and values that govern interaction among people and the institutions embedded in society. The two main components are government social capital and civil social capital. Government social capital represents formal institutions, such as law and order and good governance, while civil social capital implies informal institutions, such as trust, reciprocity, interpersonal networks and norms. Civil social capital has been recognized as an effective way of dealing with the absence of formal institutions in traditional societies.

Narayan (1999) points out the relationship between civil social capital and formal institutions in terms of both complementarity and substitution. In well-developed economies with strong formal institutions, civil social capital complements formal institutions, while, in less developed economies with absent or dysfunctional formal institutions, social capital becomes a substitute.

Civil social capital helps solve economic problems at the microlevel, as noted by Iyer and others (2005), because it changes the social environment, which affects individual decision-making. The problem of asymmetric information can be alleviated via social networks and trust, so cooperative activity can be achieved repeatedly. Because of these benefits, civil social capital is believed to assist in improving economic performance, civic engagement and human well-being (Whiteley, 2000; Knack and Keefer, 1997; and Narayan, 1999).

Trust, a key element of civil social capital as Dasgupta (2005) suggested, has been recognized as a very important factor in economic transactions. In a society without formal institutions, such as insurance and law and order, the informal institution can control trust through social appreciation and social punishment. The morality condition of PSE relates directly to this issue. According to this condition, trustworthiness, honesty, and integrity are essential in determining behaviour, decision-making and interaction among people in the society. Therefore, a society in which people have the PSE mindset, economic activities should be enhanced. Moreover, interpersonal relationships, kinship and social networks are other elements of social capital that are essential for the society. Individuals and society benefit from this network in several ways. For example, people in the community may look after or take care of each other, help each other out, ward off bad influences and help build networks. All of these can be witnessed in a community with a "sufficiency-oriented" mind.

The Koy-Rut-Tak-Wa community[7] is a good example of a Muslim community with a sufficiency economy mindset and strong social capital. Trustworthiness, integrity, honesty and altruism are fundamentals of this community. The community has never had incidences of violence, burglary, or drug or security problems. People in the community look after each other and reach out to others. The community polices itself and sets up a "house group" whereby houses in close proximity to each other look after each other and help each other when there is a need. Each house group has its own head, who represents the group in the community council. This social capital works very well in the Koy-Rut-Tak-Wa community.

The morality condition of PSE can be viewed as kind of social capital that direly needs to be embedded in the society. This social capital will help alleviate the institutional problems in the economy. It will assist in forming and shaping strong formal institutions, such as good and honest government. The morality condition as an informal institution also plays a very significant role by substituting for formal institutions in cases of dysfunctional or missing formal institutions. With

[7] Located in Nongchok, Bangkok Province, Thailand (NESDB, 2005).

strong trustworthiness, honesty, integrity, sharing, and altruism, there can be proper economic and non-economic activities.

Human capital

We all should be able to agree that the ultimate goal of development is not economic growth per se but, rather, to improve human well-being because the majority of the world's population still suffers from poverty, preventable diseases, and lack of other basic necessities.

Improving human well-being does not only involve monetary or asset value; people's ability to make their own choices is now widely considered vital as well. The alleviation of poverty, the building of capabilities, the reduction of vulnerability, and the protection of civil and political freedom are the key elements needed to improve the quality of people's lives.

Poverty is the major impediment to development and the main cause of low quality of life. In the developing world, people are extremely poor, and the society is often not self-reliant (El-Ghannam, 2002). PSE attacks this problem at a very fundamental level by emphasizing the idea that individuals and families, most importantly, must be self-reliant.

In Thailand, a typical family often grows cash crops or mono-crops that are profitable at the time. However, the profit from these crops depends on the market price, and this dependence increases the family's vulnerability to external price shocks. Oversupply of the product reduces the price tremendously, thereby forcing the family to borrow for reinvestment. What is even worse is that they then have to borrow money in order to buy their own food since they cannot eat their cash crops.

In order to achieve self-reliance, according to PSE, a family should change from mono-crop or cash-crop farming to integrated farming. A combination of plants, especially food plants, such as rice, vegetables and fruit, are recommended for planting on the farm. Before the produce or value-added transformed produce is put up for sale, a sufficient quantity of it should be kept for the family's own consumption. Also, farm animals, such as cattle, play a significant role in the integrated farm, as they provide for the family's consumption needs. Measures such as this build self-reliance—doing away with that characteristic of poverty.

A real-life example is Boonchuey Klongkaew, a Thai farmer from Ban Nong Glang Dong village who adopted the PSE approach of self-reliance.[8] The 70-year-

[8] Ban Nong Glang Dong village, Prajuabkirikan Province, Thailand (NESDB 2005).

old Booncheuy once grew cash crops, such as sugar cane, pineapple and tapioca, on his 64-rai farm in the hopes of high profits. However, he accumulated a huge amount of debt and became poor. After he started practicing integrated farming, though, his life turned completely around. He now has plenty of food to meet his own needs and more than enough surplus for trade. Additionally, he has enough money to repay all of his debts and to save for security. He now lives a peaceful life with dignity. He is now self-reliant.

The concept of self-reliance is also applicable at the community level. The villages of Ban Moung Wan and Koak Chareon[9] are good examples of communities that have engaged in savings schemes and successfully reduced expenses and debt while increasing their savings. These communities began with a microsavings scheme involving a group of 10 people. The members were required to save a very small amount of money every week. Over time, the group has become much bigger and stronger, with 667 members and a savings account of 7.5 million baht.

Instead of obtaining loans from outside banks, people now borrow from the community savings account, which creates benefits for the community. The profits from the lending are divided into two parts: one is returned to the members and the other is used for community activities. This kind of savings exemplifies the immunity aspect of PSE, whereby people help guard themselves against external shocks.

Community shops, rice mills and car services are examples of how these two villages have successfully helped the communities. Parts of the benefits from these projects, including the savings programme, are contributed to the community welfare fund, which is used for community activities and to help orphans, the poor and neglected elders.

These welfare programmes and mutual activities, as well as many other programmes and activities[10] suggested by PSE, significantly enhance the immunity of the communities and reduce their vulnerability to various kinds of shocks (for example, economic, cultural, social). Examples of such welfare systems are community health centres, community cooperatives, village funds, funeral funds, and cultural and religious activities.

Other key aspects of improving human well-being are the opportunity to build one's own capability and reduce one's vulnerability so that the future can be

[9] Ban Moung Wan and Ban Koak Chareon villages, Burerum Province (NESDB 2005).

[10] See, for example, NESDB (2004), NESDB (2005), Buasai (2006), and RDPB (2008).

shaped and choices made. To achieve these aspects of well-being, one needs to acquire knowledge—one of the key conditions necessary for achieving PSE. Without knowledge, it would be impossible to be reasonable and self-immune, as these two principles require rational decisions, information gathering, previous experience, analytical skills and adaptability. Accumulating knowledge, therefore, is essential, whether through a formal educational system or through real-life experience.

One inspiring instance of a person who accumulated knowledge to build his capability and reduce his vulnerability is Vinai Suwanatri, a farmer from Ban Lum Ma Kam.[11] In 1999, Vinai employed what he calls the "five knows": (1) know yourself; (2) know the problem; (3) know the resources; (4) know how to manage; and (5) know how to plan. Utilizing this information, he analysed his life and his mistakes. He realized that he had to change the way he lived. He stopped drinking, smoking and gambling. He started saving and put an end to unnecessary spending. He shifted from a cash crop to an integrated farm and embraced the environment. Within three years, he had paid off all of his debt and was out of the poverty trap. He found that his true happiness came from practising PSE. Now, he has security in life and helps educate other people about what he learned from his experience.

At the community level, Koy-Rut-Tak-Wa[12] placed emphasis on education by founding a community Islamic elementary school. The school not only provides a formal curriculum but also stresses real-life issues to guard against bad influences from outside the community, such as drugs and violence.

Another example of the impact of PSE on education is that of Ban Bau village, one of 900 villages in the Inpaeng network[13] practising the PSE. Ban Bau village has set up a project called "Children of the Inpaeng", which aims at action-based learning from both the community (culture and experience) and the outside world. Such skills as critical thinking, decision-making, leadership and teamwork are emphasized. The results are impressive, as there has been a great deal of improvement in the children's learning process (UNDP, 2007, p. 44).

The aspect of the PSE that improves human well-being entered the international arena when UNDP investigated the contribution of PSE to human development. It stated that, like the UNDP agenda on development, the heart of

[11] Ban Lum Ma Kam, Chachengsao Province (RDPB 2008).

[12] Koy-Rut-Tak-Wa community in Nongchok, Bangkok Province, Thailand (NESDB 2005).

[13] The Inpaeng network covers 900 villages in four north-eastern provinces of Thailand (UNDP 2007).

development in the context of the PSE is people's well-being. People focus on living up to their own potential and lead the fullest life possible in freedom and dignity.

However, the PSE provides more for human development in two respects. One is through PSE process (that is, the three principles), which can be used for analysing situations, identifying objectives, setting plans and taking decisions (UNDP, 2007, p. 70); this process is applicable at any level of society. The other is the mental and spiritual development aspect of PSE. When embraced in any type of development, these values yield mental and spiritual well-being at the individual level and provide an ethical focus culture at the organizational level.

Moreover, PSE enables people to reap benefits from the insight into peacefulness; they have more profound lives as a result of the moral principle. Hard work, integrity, honesty, sharing and altruism play vital roles in human well-being. With a balanced-way of living, morality lifts up people's spirits and shows that living is a deeply meaningful phenomenon. This represents another kind of freedom: freedom from the trap of materialism in which many people find themselves today. It is a freedom enjoyed by those who have the PSE mindset.

Environmental sustainability

One of the biggest concerns, not only for economists but also for governments, non-governmental organizations and ordinary people, is the environment. To achieve economic prosperity at the cost of environmental degradation, deforestation, pollution, and depletion of resources is now viewed by many as poor decision-making.

As Stiglitz (2006) pointed out, a country aiming for high GDP growth might employ bad policies and make bad decisions on environmental issues; an example is Papua New Guinea's decision on gold and copper mines in 1984, which resulted in devastating environmental problems several years later. GDP growth numbers can be illusive because they do not account for the depletion of resources or environmental degradation. If they accounted for the environmental degradation, then GDP growth could be significantly lower. ADB (1997) and Bojö (1996) (cited in Thomas and others, 2000, p. 86) estimated the cost of degradation of natural resources (such as soil degradation), in China and Africa. Their studies showed that soil degradation cost the GDP of China as much as 5 per cent and as much as 10 per cent of the agricultural GDP of Africa.

Several studies have shown a correlation between income growth and environmental degradation. One such study is Naidoo (2004), which showed the impact of the depletion of resources, as with forest clearance, on income growth. The findings indicated a strong positive relationship between the two: the larger the forest clearance of a country, the faster the growth rate. Likewise, Thomas (2001) investigated a relationship between GDP growth and the indicators of environmental sustainability (for example, changes in carbon dioxide emissions and changes in forest cover). The result showed a strong negative relationship. All the evidence confirms the notion that the high income growth that a country achieves is sacrificed by the depletion of natural resources and the environment.

Environmental degradation, such as water pollution, unarguably has a stronger effect on the poor, whose incomes depend mainly on natural resources. Additionally, the poor are more vulnerable to the health hazards caused by environmental degradation.

This problem affects not only monetary value (such as the cost of medical care and the loss of cultivated areas) but also the quality of people's lives. In both the industrial and agricultural sectors, overexploitation and abuse of the environment aimed at achieving high income have led to environmental problems that have had tremendous negative effects on human well-being. Humans should embrace the environment and live in harmony with it.

The sustainable development concept of Brundtland's (WCED, 1987), emphasizing responsible consumption by the current generation without compromising that of future generation, is consistent with PSE. Reasonableness and moderation with regard to the environment and natural resources will lead to environment sustainability. The self-immunity aspect of PSE reminds people to embrace the environment and to conserve it for the future.

One serious case of unreasonableness and immoderation in environmental consumption is deforestation or forest clearance. Deforestation denudes mountains, giving rise to mudslides during heavy rainfall. In Thailand, there have been mountain mudslides that cost people their lives and destroyed property, including houses, infrastructure and cultivated lands.

After a devastating mudslide in 1996, Ban Wang-lum village, a small community in the southern Thai province of Ranong (NESDB 2005), began adhering to PSE. To preserve the forest, the moderate, reasonable and self-immune villagers stopped cutting trees from the mountains and, in 1999, started planting timber trees in their own "community forest". A seven-member committee was formed to monitor the utilization of the forest. Now, instead of cutting trees from the forest

for the construction of houses, the villagers use the proceeds from the community forest. The community forest is viewed as a resource for the community's immunity and prevents further depletion of the environment.

Another PSE practice in addressing problems of environment degradation and natural resource depletion is sustainable agriculture. Sustainable agriculture adopts PSE in the sense that one needs to be moderate, reasonable, and self-immune, together with being hard-working and acquiring knowledge. Sustainable agriculture practices organic farming, which eliminates the use of chemical fertilizer and chemical pesticide. Chemical fertilizer is one of the main causes of soil degradation (that is, soil acidity), which reduces the productivity of crops. Chemical pesticides not only kill insects but also endanger the environment, which in turn harms people. Instead, the natural materials that can be found locally are used to make organic fertilizer and insecticide.

Aiming to make a profit, farmers normally plant mono-crops or cash crops, which are totally dependent on market prices, thereby increasing the farmers' vulnerability to external price shocks. Also, the practice usually harms the environment, as farmers tend to overuse chemical substances to increase production. This type of practice is unsustainable over the long run. To address this problem, the King of Thailand suggested that farmers employ the New Theory of Agriculture, an application of PSE.

The New Theory of Agriculture recommends that farmers follow three-stage procedures. In the first stage, farmers should divide the land into four parts as follows:

(1) Growing rice (30 per cent);

(2) Growing vegetable and fruits (30 per cent);

(3) Water reservoir (30 per cent);

(4) Residential and other uses (10 per cent), so that they can have food sufficiency or food security.

After farmers have food security, they can expand their production processes and move to commercial activities in the second stage. Finally, in the third stage, they may further expand their production processes and have cooperation in the community in the form of cooperative stores or a rice mill factory (Wibulswasdi and others, 2010, p. 23).

The New Theory of Agriculture is a kind of sustainable agriculture, as it promotes integrated farming, which consists of rice, big trees, small plants and other medicinal herbs. Big trees help improve soil retention and provide natural fertilizer, while small plants help retain moisture. Also, prolific wind-blown seeds from trees on hilltops help accelerate natural regeneration (UNDP, 2007, p. 49). This is a kind of farm that helps improve the ecology, conserve the environment, and benefit people's well-being. Several success stories of farmers who employ the New Theory of Agriculture can be witnessed from all over Thailand (see, for example, NESDB, 2004 and RDPB, 2008). These farmers now have better lives and continue to conserve the environment.

The PSE concept on environmental sustainability is applicable not only to rural areas but also to cities. With moderation, reasonableness, self-immunity and awareness of social well-being, people, businesses and public organizations will be more conscious of environment protection.

We can see that the essence of PSE regarding environmental issues is to guide people to live in harmony with nature. By being reasonable and moderate in natural resources utilization (never overexploiting or abusing the environment), and by being self-immune through environmental conservation, people can successfully live in harmony with nature.

Role of government

Government plays a significant role in the economy, as the market alone sometimes cannot function efficiently or properly. Those concerns about market functions that can impede development, such as asymmetric information, imperfect and missing markets, and law enforcement problems, still require government action. The optimal role of government in building strong institutions and in deepening and facilitating market functions is the key.

With the concepts of moderation, reasonableness, self-immunity, together with the conditions of morality and knowledge, government should be able to achieve an optimal role. A PSE-oriented government will aim at maximizing the welfare of the people while following the middle path. Policymaking should be done with prudence and vigilance, and should be subjected to experience and knowledge assimilation. No policy is launched without careful evaluation in order to avoid a detrimental impact on the economy. In this manner, the economy will be able to withstand any kind of malign shocks from the outside world.

Wibulswasdi and others (2010) showed that government could apply PSE to its three main operations: (1) macroeconomic management, (2) government policy design, and (3) planning of development strategy. Under macroeconomic management, government can employ a conservative fiscal policy, a prudent monetary policy, and cautious rules regarding external shocks. In designing a policy, government should apply the PSE concept in order to strengthen people's capacity and emphasize the sufficiency mindset. Lastly, in planning a development strategy, government should not only focus on industrial development, but also pay more attention to rural development for achieving strong communities, quality growth and good quality of life, since weakness in rural areas would lead to severe economic, social and political problems in the future.

The Government of Thailand has thus far applied PSE in designing policies; especially those that help alleviate poverty and encourage communities to be strong and self-reliant. For example, the Government encourages communities to employ the following elements;

(a) Schemes to reduce expenses through more home production, use of local new materials, energy savings, elimination of costly local entertainment and promotion of local markets;

(b) Schemes to increase income by encouraging community enterprises, producer groups and local tourism;

(c) Schemes for local savings;

(d) Promotion of local leadership and use of community plans;

(e) Activities to preserve and protect the environment;

(f) Schemes to promote social capital, including local welfare schemes, community rice mills, and other cooperative schemes (UNDP, 2007, p. 48).

The Bank of Thailand's inflation-targeting policy is also an example of macroeconomic management policy that is influenced by PSE. This policy compromises short-run growth to attain economic stability and sustainable growth in the long run (Bank of Thailand, 1999).

Good governance should also be a product of a PSE-oriented government. Codes of conduct together with the principle of morality, which can be applied at both the individual and government levels, will enforce good conduct, resulting in good governance and a culture of honesty in the government. This good governance

will, in turn, create trust in the society. Once people have faith and trust in their government, civic and economic activities will be successfully accomplished and will consequently contribute to the development goals of the nation.

IV. CONCLUSION

From a growth-driven to a sustainable development policy, countries still face clear and present challenges in development. Those challenges stem from dysfunctional institutions, poor quality of people's lives, environmental degradation, and the optimal role of government.

As this paper has argued, the philosophy of sufficiency economy of the King of Thailand conveys a new paradigm for development. Emphasizing the three principles of moderation, reasonableness and self-immunity together with the two conditions of knowledge and morality, this philosophy helps address those development challenges.

Trustworthiness, honesty, integrity, sharing, and altruism, the important elements of PSE, can be considered the social capital embedded in society that encourages proper economic and non-economic activities. PSE acts as an informal institution that can substitute for a formal institution in cases of a dysfunctional or missing formal institution. It also helps shape strong formal social capital in the society.

One of the most important applications of the PSE is to help improve human well-being. The PSE emphasizes the self-reliance of an individual and of a community, together with the essentials of education. Poverty reduction can be achieved, by which PSE helps people reduce vulnerability, build their own capability to shape their lives, and have choices.

With the PSE mindset, people will be moderate, reasonable and self-immune; therefore, they will not overexploit or abuse the environment or natural resources. They will embrace the environment, conserve it for the future and live in harmony with nature.

Finally, a government with a PSE mindset would be able to achieve the optimal role in maximizing its people's welfare. Such a government will make policy with prudence and vigilance, resulting in good governance and a culture of honesty.

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THE DEVELOPMENT OF THE SOFTWARE INDUSTRY IN POSTREFORM INDIA: COMPARATIVE REGIONAL EXPERIENCES IN TAMIL NADU, ANDHRA PRADESH, AND KERALA

By Rajendra Kumar, Cambria Press, New York, 2009
ISBN 978 1 60497 619 9, 244 pp.

OVERVIEW

The Development of the Software Industry in Postreform India: Comparative Regional Experiences in Tamil Nadu, Andhra Pradesh, and Kerala is an illuminating attempt by Dr. Rajendra Kumar to develop a coherent analytical framework in order to document and evaluate the reasons behind three successful cases in which high-tech industries were promoted for development and economic growth. Targeted at scholars and policymakers, it is an in-depth look into the role that regional political, cultural and enabling policy environments play in high-technology-based economic development, focusing on the software industry and information technology-enabled services (ITES) in India. The conclusions and findings of the author are a significant contribution towards understanding the different strategies and options available to developing regions in supporting the growth of this type of industry and making them competitive globally.

As highlighted by Dr. Kumar, tech companies based in India have emerged as major software producers and exporters globally. He starts off by analysing India's success in developing this industry, looking at what he calls "the many puzzling issues" that have not been examined previously. The first issue discussed is how an industrially backward economy could rise to the top of a hi-tech industry and become a global player so quickly. According to the author, this type of growth is considered impossible in contemporary economic development theories. The second issue discussed is how the state has played a significant role in pushing this developing economy forward within an overall neoliberal policy regime, a factor which he considers as needing further study. The third issue examined is the interesting and complicated story of India's success, with its regional variations, in the growth of this industry.

A FUNCTIONAL APPROACH

The book comprises nine chapters, apart from the foreword and preface. The functional labelling of the chapters and sections is a useful method of organizing the book for easy reference and contributes to its highly technical nature. There is an appendix with some interesting comparative tables that contain relevant data on regions in India ranging from the 1990s to about 2005.

METHODOLOGY AND BACKGROUND ON THE CASE STUDIES

In chapter 1, the author begins by setting the tone that the Indian ICT industry has been able to sustain annual growth rates in the range of 30-40 per cent since the early 1990s, when the country embarked on ambitious economic reforms. The author goes on to show that, within the country, the growth of this industry has been highly uneven, with the southern and the western regions leading the way. He focuses in on this unevenness in order to conduct a comparative analysis on the role of regional policies and characteristics in the development of this industry. Since the southern region of India has progressed well, with such states as Karnataka and its Bangalore area spearheading the way, Dr. Kumar opts to focus on Tamil Nadu and Andhra Pradesh, as the rise of these states characterizes the development of the industry. These three states combined accounted for over 60 per cent of national software exports in 2005-2006. He uses Kerala, which he considers a late bloomer, as a shadow case to form a testable theory and back up his findings.

In chapter 2, the author examines the reasons why the current economic development schools of thought and existing literature do not adequately capture the nature and drivers of success in high-technology and knowledge-based industries. The author's main approach to forming his theories is by comparing the differences in the methods and organization of production between traditional manufacturing-based industries in developing countries with the characteristics of production in knowledge-based industries, such as software development.

A point of interest is the author's argument that "dominant-class" coalitions consisting of industrialists and professionals helped protect and advance specific interests, a case in point being Tamil Nadu and Andhra Pradesh. In contrast, the autonomous political character of Kerala, resulting from the struggles and accomplishments of marginalized castes and social groups, were partly responsible for its failure to implement policies similar to those of the other two states. This unexpected consequence illustrates the differentiations in the impact of policies and actions which could be seen as very positive in one way but stifling in another.

Chapter 3 outlines the various phases of the development of the software industry in India as a whole, and links these stages to milestone policy changes adopted at the country level. Packed with interesting historical information, it stresses the significance of the shift from a protectionist, hardware-production-oriented national policy to a pro-software export-oriented one. This involved fiscal, tax and import duties, related incentives and the setting of standards for technical education.

The first IT company started in the late 1960s, and the number of companies operating in India grew steadily. There is evidence of rapid growth after 1991. Software exports from India grew from $4 million in 1980 generated by 21 companies to $16,941,500 (excluding ITES) generated by 6,500 companies by 2005. The explosive growth depicted in the book, starting in 1991, is linked to economy-wide liberalization of industrial licensing, trade and foreign exchange policies as well as the relaxation of the rules on equity ownership by foreign firms. This not only increased the number of companies in operation but also improved the technological sophistication of the software development work done within India as more and more foreign companies entered the scene. Also of importance is the rise of the Tamil Nadu, Andhra Pradesh and Kerala regions during the mid-1990s, following in the footsteps of Karnataka.

The time line for the central Government's policy actions given in this chapter starts with the establishment of a separate Department of Electronics in 1970, followed by the establishment of the Electronics Commission, which were both intended to develop the hardware and software industry as well as formulate related policies. The author believes that the single most important national-level policy initiative taken to promote the software industry was the Software Technology Parks of India (STPI) scheme in 1988, which resulted in the establishment of software technology parks in major urban centres. These parks included ready-to-use infrastructure, such as satellite telecommunications facilities and single window clearance for projects, thereby lowering the start-up and operations costs of software companies.

THE IN-DEPTH TECHNICAL ANALYSIS

In chapter 4, the author uses multivariate time-series regression models to analyse various factors associated with the growth in software exports nationwide and in selected states. His analysis reveals that states with relatively better initial conditions, such as availability of skilled labour and good infrastructure, performed better in subsequently developing this industry. An interesting finding is that the literacy rate at the start of the reforms did not show a relationship with software

export growth. He goes on to state that, apart from the initial factors, the availability of skilled labour played a major part in the growth of the industry. He backs his argument with figures such as the high proportion of fresh engineering graduates in the states that excelled in terms of software exports.

THE THREE CASE STUDIES

Chapters 5, 6 and 7 contain a wealth of information on the development of the software industry in the three selected case study states of Tamil Nadu, Andhra Pradesh and Kerala. These chapters discuss the historic development of the software industry in each of the states and compares other factors, such as the structure and types of companies, policy initiatives taken by the state to develop the industry, which included regulatory and labour policy reforms, efforts to improve skilled labour and industry-specific infrastructure availability, promotion of linkages to global markets and expertise, and stimulation of local demand.

Chapter 5 looks at the growth in software and software services exports from Tamil Nadu, which grew at an annual rate close to 100 per cent from 1993 to 2005, starting with a 0.2 per cent share of the national total and ending with 13.4 per cent in 2005. Leading up to this rapid growth phase, the industry here was made up of companies started by Indian nationals, with the period between 1991 and 1995 showing evidence of the entry of multinational corporations (MNCs). The author emphasizes the critical role played by the different types of companies, including foreign-expatriate Indian companies, by comparing the number of such companies in Chennai with the rest of the country.

In Tamil Nadu, priority for this industry was only given in the mid-1990s marked by the setting up of the first STPI in 1995, 7 years after the programme was started. The first major state government policy initiative came in 1997 when the first IT policy was announced. However, software companies were already taking advantage of the available general incentives and tax subsidies for mega- and super-mega projects during the 1990s. An important effort of the state government worth mentioning is the inclusion of industry stakeholders in the decision-making process concerning the industry. While the first phase (1995-2000) focused on industry-specific infrastructure, skilled labour improvements and regulatory reforms, the second phase (2001-2006) was focused on attracting more large companies and creating linkages between local and multinational companies and international markets.

Similar to Tamil Nadu, Andhra Pradesh (discussed in chapter 6) also experienced growth in software and software services exports between 1993 and

2005 at an annual rate over 75 per cent holding a share of 11.9 per cent of the national total in 2005. The main difference between the two regions was that, by the mid-1990s, there were more MNCs in Andhra Pradesh. This was the result of a decision of the state government to attract large MNCs. Overall, the policy initiatives and direction taken by both regions are very similar and resulted in similar growth patterns.

The discussion on Kerala in chapter 7 highlights the differences in the strategies implemented and links them to exports growth in order to test the author's theories and tactfully lead to the introduction of his "competitive flexibility" model. Unlike the previously discussed two regions, Kerala experienced only a 39 per cent annual growth rate in software and software services exports in the same period. Kerala was the last of the three states to adopt specific policy initiatives aimed at promoting this industry; incentives for investment and tax concessions for the industry were only introduced in 1998.

Fascinatingly, a STPI called Technopark (endowed with excellent facilities) was established in Kerala in early 1990s. However, though the infrastructure was conducive to the growth of this industry, the state did not attract enough companies until the end of the 1990s. According to the author, this was mainly due to the perception that labour in the state was militant and the government was hostile towards capitalists. Kerala was seen as being a hotbed for trade unions and was ruled by a leftist coalition from 1996 to 2001. The second phase (2001-2006), where there was a noticeable jump in exports after 2002, started off with a change of government in the state, which announced a new IT policy in 2001. This policy directly addressed the concerns of private companies in regard to labour issues. Subsequently, the state focused on attracting more companies and expatriate professionals to invest in the region and improving linkages with international markets.

In chapter 8, Dr. Kumar further looks at the role of the state in each of three regions and examines the various reasons for the success of Tamil Nadu and Andhra Pradesh, while using Kerala to showcase deterrents to growth.

THE COMPETITIVE FLEXIBILITY MODEL

Dr. Kumar's' new "competitive flexibility" model, presented in chapter 9, tries to capture the essential elements of strategies which give credibility to the hypothesis that increasing globalization presents tremendous opportunities for developing regions to become globally competitive in a hi-tech field.

This chapter, as with the proceeding chapters, once again summarizes and compares the different factors that influenced software export growth in the three regions and then goes on to discuss the pitfalls of existing literary paradigms in explaining this growth, in order to build a stronger argument for his new model. One of his main points to counter common literary models which are built around innovation economics is that the state did not play a significant role in providing specialized R&D or finance to the industry. The author's final point is that regional strategies are still relevant even in modern knowledge-based economies, where regional and national boundaries have become increasingly irrelevant; appropriate development strategies, as discussed in the book, attract companies to take advantage of local resources and capacities and enable them to link up to international networks of production and innovation.

CONCLUSION

Dr. Kumar explains the success of the selected regions in India in terms of four critical factors: availability of adequate skilled labour and specialized infrastructure, pro-employer labour and policy reforms, ethnic linkages of immigrant professionals abroad who returned to establish firms in their native states, and their existing technological capabilities at the beginning of reforms. He believes that the most important strategy adopted by the successful states was to provide specialized factors of production (skilled labour and infrastructure) for the industry.

The author is clinical in his approach and focuses only on the situation in India in order to add depth to his research and findings. He correctly points out that, even in countries such as India, where there is visible evidence of success in software and ITES exports, there is a serious lack of research on how the different strategies adopted by the subnational regions influenced the specific development path of the industry in the respective regions. This is probably the strongest argument for the significance of this book, while the rich compilation of historical, factual and analytical information should encourage all interested practitioners, policymakers and even laymen to have a copy of this book.

Using time-series regression modelling, the author identified some key conditions that had positive or negative relationships with the growth of the software and ITES industry in India. This valuable and highly technical analysis is well worth reading in order to assist in unravelling the complex problems encountered in developing economic growth strategies.

As an added perspective, however, the author could have given some comparisons to global figures in terms of software exports, engineering graduates,

and other factors which could have given the reader a better understanding of the industry as a whole and highlighted India's position within it. This limitation also resonates in his discussion of the national level policies which shaped the growth in software exports in India – comparisons of similar or different approaches by other countries would have fulfilled the readers' urgent desire to compare development strategies in a global context.

It is sensible to note that, in attempting to promote his competitive flexibility model, the authors' focus on criticizing contemporary paradigms and models gives the reader a slightly ambiguous view of real life development options. He refers merely to the models in the literature that generalize traditional industries into one group which, for example, calls for vertical and horizontal integration rather than vertical specialization as one element of the success strategies. A case in point is the author's discussion of Michael Porters' development framework, where he does not consider the similarities of Porters' model in action in real world situations, to his own competitive flexibility model. For example, in the case of ceramics manufacturers, vertical specialization could be seen as a way to promote SMEs by outsourcing decal application and ornate painting work, which promotes collaboration in order to improve competitiveness. This could lead the reader to question whether the competitive flexibility model is a "new" theoretical framework as claimed by the author or an amalgam of existing paradigms. Nevertheless, awareness of this would urge the astute policymaker to consider applying the competitive flexibility model on other traditional industries in late-developing countries.

*Preminda J. Fernando**

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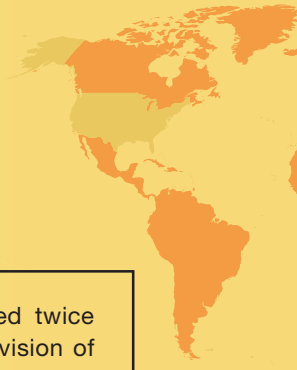

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