China's New Development Strategy: Environment and Energy Security

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Abstract:

This paper analyzes China's development strategy by focusing on both global and regional approaches to solving problems of energy security and ecological imbalance by addressing specifically the problems of China's energy security. PRC's growing energy dependence has become a major concern for both economic and national security policymakers in that country. The ambitious goal of modernization of the economy along the lines of the other newly industrialized economies(NIEs) of Asia has succeeded only too well, and it is difficult to reorient economic priorities. If examined rigorously, such an economic strategic assumption can be seen to entail the goal of creating further technological capabilities. In particular, China seems to be firmly committed to the creation of a largely self-sustaining innovation system as part of a knowledge-based economy of the future . Such innovation systems, called *positive feedback loop innovation systems* or POLIS have been created by advanced countries, and NIEs such as South Korea and Taiwan are proceeding to create these as well. But this will add to its energy burden and further dependence on the US as the power which controls the key sea lanes. Only a strategic reorientation to building a self-sustaining POLIS and appropriate regional cooperation institutions can lead to the way out of the current dilemma for China. Fortunately, such a model of POLIS which is distributionally and ecologically sensitive can be built for China and applied strategically to lead towards a sustainable development trajectory.

However, time is of the essence. Given the path dependence of development unless strategic disengagement from the existing path followed by a strategic engagement with the alternative strategy is begun within the next five years, it may well be too late. The stakes are indeed very high. A more detailed strategy paper based on the key ideas from the alternative strategy outlined here with concrete quantitative scenarios and feasibility studies along the lines of models sketched in the appendix (and other, more detailed models) will go some distance towards giving the appropriate analytical foundations for the policy makers. The preliminary results confirm the predictions regarding fossil fuel-based energy shortage and lead towards a serious consideration of alternative energy sources. Achieving the twin goals of energy security and ecological balance are challenging but not impossible for China. Serious policy research can be used effectively if there is the political will to do so. The goal of regional cooperation is also achievable if patient negotiations in good faith can start in earnest. In particular, cooperation with other Asian economies, particularly Japan, Indonesia, Viet Nam and India will be crucial.This paper has sketched out the complexities of cooperation and conflict between China and Japan. Future work will address the problems of Regional cooperation for China in the East, South and South Asian context as well as in the context of Africa and Latin America.

1. Introduction:

This paper analyzes China's development strategy by focusing on both global and regional approaches to solving problems of energy security and ecological imbalance by addressing specifically the problems of China’s energy security. PRC’s growing energy dependence has become a major concern for both economic and national security policymakers in that country. The ambitious goal of modernization of the economy along the lines of the other newly industrialized economies(NIEs) of Asia has succeeded only too well, and it is difficult to reorient economic priorities. China’s remarkable growth during the last twenty five years has led to a rapid increasae in energy demand, and its hunger for energy is apparently insatiable. There are of course both economic and ecological aspects of this insatiable demand for energy. There are also security issues that exercise the Chinese leadership increasingly. In this paper I examine the measures that China is taking to achieve energy security and the motivations behind these measures. I also look at China's investment in overseas oil exploration and development projects, interest in transnational oil pipelines, plans for a strategic petroleum reserve, expansion of refineries to process crude supplies from the Middle East, development of the natural gas industry, and gradual opening of onshore drilling areas to foreign oil companies. The key question is: can China hope to achieve both equitable growth and energy security over the next two decades? I suggest the kind of mathematical modeling and political economy analysis that may be necessary to answer this two-pronged question rigorously.

China faces at least two pressing sets of energy policy challenges. The first is a problem of short run efficiency and therefore relates to the immediate need to improve management and coordination of the nation’s energy supply. During the last five years economic growth has been more than 8% per annum. At the same time, energy demand grew by about 15% annually while oil imports grew at 30% per year. In today’s China, electrical power shortages are widespread, and transport bottlenecks constrain the ability of the industry to move both coal and oil to where they are needed.

There are also longer term energy policy challenges. These concern the continuing inability of China’s government to formulate a coherent energy policy which could provide the basis for the effective management of the energy sector and its environmental consequences for the next fifty years and beyond.

China’s entry into the WTO has already had and in the future will have diverse consequences for its economy and energy. The best overall assessment from the Chinese perspective is that although the short run adjustment costs--- for example, the increase in unemployment in the agricultural sector--- may be high, the long run economic benefits from integration into the world trading system are likely to be considerable. In particular, it is assumed that the export-led growth will continue and will also lead to the modernization of the economy along the lines of the other newly industrialized economies(NIEs) of Asia. If examined rigorously, such an assumption can be seen to entail the goal of creating further technological capabilities. In particular, China seems to be firmly committed to the creation of a largely self-sustaining innovation system as part of a knowledge-based economy of the future (Simon,1996; Simon and Goldman,1989; Lu, 2000). Such innovation systems, called positive feedback loop innovation systems or POLIS(Khan, 1998; 2003; 2004a) have been created by advanced countries, and NIEs such as South Korea and Taiwan are proceeding to create these as well.[1] Can China do the same? And will China's entry into the WTO help or hinder such efforts? While the answers here are not clear, it is reasonable to say that its WTO membership[2] will open the way towards diversification of energy import sources. However, I will argue that much depends on US-China bilateral relationship also. Furthermore, as I will show, the current strategy of indiscriminate growth only without regards to sustainability or equity will make China's growth deeply problematic even in an open economy context of rules-based trading in the WTO framework.

In what follows, I will begin by identifying the most important aspects of the energy demand and supply in PRC in order to ascertain China's energy dependence. This will enable us to look at both economic welfare and sustainability issues as well as security issues which are discussed in section 3. Section 4 discusses the China-Japan relations in the field of energy against a broader background of cooperation and conflict. This section also illustrates some of the problems that China and other potential partners for regional cooperation will need to face and solve. In conclusion, I draw attention to the real dilemma faced by the ambitious Chinese leaders and suggest that multilateralism and regional cooperation are the best strategic responses available to China.

2. China's energy dilemma: demand, supply and distributional issues

China is now the world's second largest consumer of energy, accounting for some 12% of global energy demand, but its rate of increase of demand is some four to five times that

[1] A formal and complete description of POLIS as an innovation system ,and contrasts with NIS(national innovation system) of which POLIS is both an extension and an extended critique, is outside the scope of this paper. Khan (2004a) gives a formal description and two existence theorems in topological spaces. Technically, non-linearities and multiple equilibria are at the heart of a formal proof of POLIS and its properties. Khan (2003) presents both a conceptual and concrete critique of NIS by comparing and contrasting the national innovation system (NIS) with POLIS in the context of Taiwan.

[2] For welfare aspects of China's entry into WTO see Khan, Haider A., "China's Entry into the WTO: ICT Sectors, Innovation, Growth and Distribution", July (2002b) - (Website address: http://www.e.utokyo.ac.jp/cirje/index.htm)

for the rest of the world. So what happens in China's energy sector will affect the rest of the world as well. Table 1 below gives a picture of China's actual and projected energy consumption till the year 2015.

China's energy sector displays continuing dependence on coal. China is the world's largest consumer of coal, accounting for more than 30% of global coal consumption. Further, coal provides approximately 64% of China's primary energy demand. While such dependence on coal is not necessarily a huge problem, it has two unfortunate consequences. The first problem is that the use of coal is characterized by low energy efficiency. The second problem is that extensive coal usage without clean technologies creates pollution at a large scale.

The intrinsic energy value of a unit weight of coal is known to be less than that for oil and gas. The recovery rates for many of China's coal mines are also low, meaning that much of the country's coal resource is left in the ground, never to be recovered. Table 1 below confirms this. Furthermore, the efficiency of appliances which use coal in China continues to be substantially lower than the average in OECD countries. Progress has been slow in enhancing the efficiency of consumer electrical appliances and implementing building codes which reduce heat losses. Finally, the continuing low level of end-user prices has failed to provide consumers with incentives to save energy.

Table 1

Primary Energy Consumption in China (quadrillion Btu)

Year	Coal	Natural Gas	Petroleum	Total
1980	12.5	0.6	3.8	17.3
1985	16.9	0.5	4.0	22.2
1990	20.7	0.6	4.9	27.0
1995	27.5	0.7	7.2	35.2
2000	22.7	1.2	9.7	36.7
2005	26.4	2.2	11.2	43.2
2010	33.3	3.4	14.2	55.3
2015	40.1	5.3	17.9	69.1

SOURCE: Energy Information Administration (EIA), *International Energy Database*, Washington, D.C., 2002.

NOTES: Totals may not sum because of other fuels and rounding. Figures for 2005–2015 are EIA projections, reference case.

From table 1 above it is clear that China’s energy consumption will be 4 times what it was in 1980 by the year 2015.The share of oil during the same period will be on the increase also.China shifted from being net oil exporter to net oil importer in 1993.What explains the increasing dependence on oil? Table 2 below is an input-output decomposition of China’s energy use. Scrutinizing table 2 below we can see that it is intimately related to final demand shift. Within the final demand shift, both household and investment needs are responsible for the lion’s share. Thus, China’s industrialization strategy and the increasing prosperity of households can explain its increasing dependence on energy imports. This is not likely to change in the near future.

Table 2

	Coal	Oil&Gas	Electricity	Petroleum	Coke
Total change	5.78	14.09	36.55	12.65	37.24
Technical change	-30.42	-38.55	-42.24	-46.21	-48.64
Energy technical change	-40.16	-47.84	-55.91	-48.97	-59.29
Non-energy technical change	9.75	9.29	13.67	2.77	10.65
Final demand shift	36.19	52.63	78.78	58.86	85.88
Level	61.35	61.35	61.35	61.35	61.35
Distribution	4.73	6.84	0.18	4.26	-3.62
Composition	-29.9	-15.55	17.26	-6.75	28.15
Sources of Final demands shift					
Household Consumption	20	24.39	39	22.67	40.42
Government consumption	2.7	4.86	3.4	5.2	2.28
Investment	15	35.96	42	36.9	52.25
Export	23.4	12.87	28	22.4	42.93
Import	-23.6	-45.8	-32	-38.17	-33.68
Others	2.6	2.4	1.7	1.9	1.6

Table 3

Primary Energy Production in China (quadrillion Btu)

Year	Coal	Natural Gas	Petroleum	Total
1980	12.6	0.6	4.5	18.1
1985	17.7	0.5	5.4	24.3
1990	21.9	0.6	6.0	29.4
1995	28.3	0.7	6.4	35.4
2000	18.4e	1.1e	7.0	27.8e
2005	n.a.	n.a.	6.7	n.a.
2010	n.a.	n.a.	6.6	n.a.
2015	n.a.	n.a.	6.5	n.a.

SOURCE: EIA, *International Energy Database*, Washington, D.C., 2002.

NOTES: Totals may not sum because of other fuels and rounding. Petroleum includes crude oil, natural gas liquids, and refinery processing gain. Figures for 2005–2015 are EIA projections, reference case. Total is primary energy only.

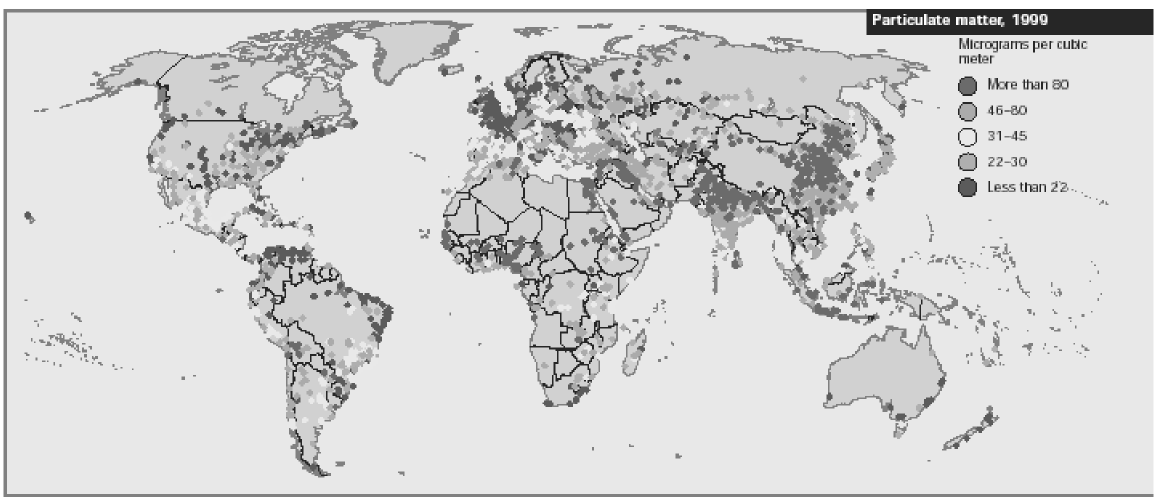
e = estimated.

n.a. = not available.

Although domestic production figures have not been projected till 2015 in table 3 above, simple extrapolation would show that import dependence is here to stay. Thus the conclusion that follows from the evidence presented in tables 1 and 2 seems to be that China's import dependence will be a policy problem for at least till 2025, if not for even a longer period. The vulnerability from potential disruption of supplies can be extensive. .

Scenarios run by the EIA and the RAND corporation in the US show the effects on GDP when supply is disrupted because of unforeseen geopolitical events or natural disasters. These effects are in the three to four per cent range when prices shift unfavorably affecting supply and production and can be larger when the shocks are unpredictable and much substitution out of imported fossil fuels may not be feasible. In the appendix, I outline a model that looks at the distributional impacts of such disruptions in a linear approximation scenario. In particular, poverty impacts are derived. The preliminary results suggest strongly that almost all of China's growth induced poverty reduction gains can be destroyed through disruptions in the energy markets alone. In addition, the ecological consequences of the current fossil-fuel dependent development strategy are already proving to be serious. The following global pollution map for the year 1999 makes this point clear. The most developed parts of China are also among the most polluted areas in the world.

Figure 1: Global Pollution and the Chinese Situation 1999



A global map of nitrogen dioxide in the atmosphere from Germany has revealed the most precise view yet of pollution hotspots around the world. The instrument used was the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY), developed by John Burrows at the University of Bremen, Germany.

The following map, based on 18 months' worth of satellite data, shows very high levels of NO_2 above major European and North American cities and across much of North-East China.[3] The Chinese cities are revealed to be the largest cluster with the most population.

[3] Data for the map were obtained between January 2003 and June 2004 from the European Space Agency's Envisat satellite, which scans the globe every six days.

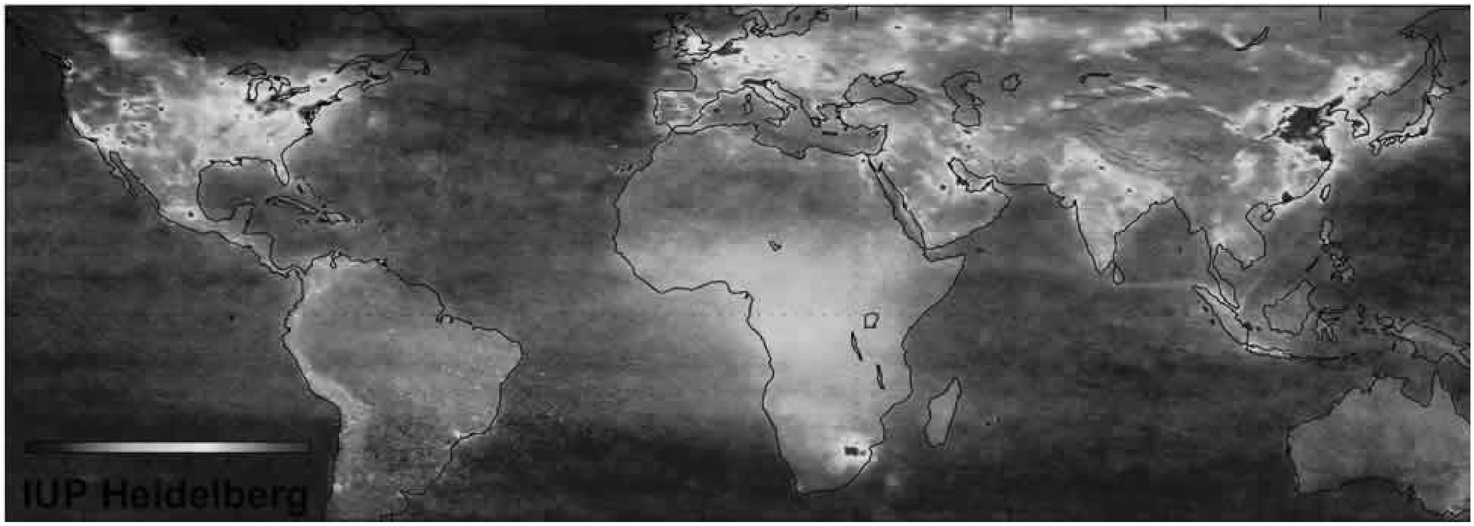


Figure2: Chinese Cities' Nitrogen Dioxide concentrations[4] Oct. 2004. Source: Envisat

Coal mining in particular as it is practiced in China is an environment-degrading process. In order to minimize degradation of water, soil, air, and human health, it is extremely important to formulate strict rules, regulations, acts, and laws keeping local socio-economic, geologic, environmental settings in mind. The usual principles documents such as the Equatorial Principles and World Bank Standards are written in generalized terms and are not enforceable or applicable to a particular country. The Equatorial Principles are suggested by lenders to borrowing companies as recommended sets of rules which encourage an environmental assessment and corporate social responsibility before a lender can loan out a huge sum of money. These principles also emphasize the need for participation by local stakeholders in projects carried out by private companies that borrow money from a financial institution like ADB. What China needs is to formulate a strong legal framework similar to or, given the fragility of her environment and dense population, even stronger than those in India or the USA in order to control environmental degradation, monitor compliance, and enforce rules and laws applicable during all phases of coal mining.

Some Distributional Issues:

By any measure—even discounting by a few percentage points to satisfy the skeptics---China's economic growth over the last two decades has been impressive.[5] However

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[4] Nitrogen dioxide maps like that shown here have been produced using nadir-sounding data: while NO_2 concentrations vary widely across the troposphere they are evenly spread across the upper atmosphere, the stratosphere. So nitrogen dioxide levels measured above the remotest parts of the Pacific were used to determine a general column for stratospheric nitrogen dioxide, which could be subtracted from the global data to determine tropospheric vertical column values. Although NO_2 is formed naturally by lightning and by microbes in the ground, it is also released into the atmosphere from the burning of fossil fuels by power plants, heavy industry and vehicles. Large quantities of the gas can cause respiratory problems and lung damage, and can also contribute to harmful ozone forming near ground level.

particularly since 1995 the distributional situation has deteriorated . This has happened both spatially and in almost a fractal way within provinces and nationally. The Gini index and other measures of inequality all bear this out.

Although rapid growth has led to a large reduction in absolute poverty, there are questions as to how much more mere growth-induced poverty reduction can succeed in the future. According to some observers, China has large pockets of chronic poverty that will be hard to tackle by high growth alone. The model of appendix 1 which is a short to intermediate run model, yields groth-poverty elasticities in the range of .6 to .85. Furthermore, according to my preliminary calculations using this model, the severity of poverty can not be diminished by growth alone. In fact, in some instances, for exmple among the rural poor households in Gansu province, growth actually worsens poverty severity. This is not an argument against growth; but it does point to using a more distributionally sensitive and inclusive approach to growth and redistribution. In particular, increasing both physical assets including land and the social capabilities of the poor will be crucial if the current administrations declared goal of a harmonious society is to be achieved.

For China's policy makers all the above issues pose serious strategic questions. What options are available to them? What can be realistically done over the short and medium terms ? Fortunately, a distributionally sensitive strategy which is ecologically sustainable is available.

In the next section, I review and assess the steps taken and suggest in broad outlines a strategy most likely to succeed. If there is serious interest, the sectoral and regional details can be worked out within the course of a few months by an international team of competent researchers with heavy Chinese participation and policy inputs to Chinese policymakers from such a group of experts can then lead to rapid implementation of energy, infrastructure and other sectoral policies along with poverty reduction and capabilities enhancement policies.

3. China's energy dilemma: strategic moves

China's energy dilemma has renewed concerns about long term energy security. Several decades ago, the same concerns existed but the solution was also clear and simple--- to increase domestic production. Our analysis indicates that this is no longer a viable option.[6] Discovery of large reserves is unlikely. Thus oil is seen as a source of vulnerability in Beijing. Since plans for building a POLIS depend crucially on oil, it

[5] The quality of Chinese statistics has been questioned. However, even critics such as Rawski accept that the long-term trend growth rate is impressive. See Thomas G. Rawski, 'Measuring China's recent GDP growth: where do we stand?' www.pitt.edu/ tgrawski, Aug.2002.

[6] See also Christoffersen (1998) for an analysis of the situation particularly with respect to China's relations with Russia and Central Asia in historical perspective.

could make China vulnerable to foreign pressures. Many years of debate within the state council has not resolved this difficult problem. Policy makers have been divided over whether domestic production should be increased or explore for oil abroad. In practice both the paths are being followed. I will argue that neither is going to reduce vulnerability to a large extent soon. In the medium to long run, however, there is a third option available; but it will require both rethinking development priorities at home and reorienting diplomacy towards greater regional cooperation. But let us look at the existing divided strategy first.

The centerpiece of the current strategy seems to be an ambitious scheme of investment in overseas oil projects together with continuing domestic exploration. The state owned oil companies of China are the key players in both arenas. During the 1980s China launched three large oil companies. The China National Offshore Oil Corporation(CNOOC) has controlled most of the offshore oil businesses since its founding in 1982. The China National Petrochemical Corporation (Sinopec) was founded in 1983 and is responsible for refining and marketing. The China National Petroleum Corporation (CNPC) was founded in 1988 by the ministry of petroleum industry. In 1998 the government reorganized CNPC and Sinopec and created two vertically integrated oil companies. However, CNPC is still China’s dominant upstream oil company and Sinopec the main downstream company in the industry.

Initially, the government maintained a two-tiered pricing policy that required CNPC to sell to its industrial customers at a fraction of the market price. The resulting cash flow constraint led to limited exploration. From the users’ perspective, artificially low price of oil led to inefficient energy use for industrial production and transportation in particular. In 1993, the government relaxed the pricing policy increasing the first tier crude price. CNPC was the main beneficiary, as indeed was the intention. CNPC officials knew that unless the money was quickly invested it would be confiscated. The coincidental appointment of Zhou Yongkang who favored Chinese investment abroad led to rapid overseas expansion of investment.[7] Since this time, views of top CNPC officials have mattered a great deal in China’s foreign energy investments. However, they are chosen ultimately by the Communist Party leadership. Hence it can be rightly said that the Party is the final arbiter.

The importance accorded to foreign investment in the energy sector is shown by the fact that CNPC has invested in energy from Canada to Kazakhstan. In 1997 it pledged over $8 billion for oil concessions in Canada, Venezuela, Iraq and the Sudan. Such activities underline the high priority attached to these projects. They can also lead to increasing tension between China and the US. For example, in 1997, CNPC acquired a sixty per cent stake in Kazakhstan’s Aktyubinskmunaigaz Production Association. CNPC beat out Texaco, Amoco and Russia’s Yujnimost by agreeing to pay $320 million bonus to the Kazakh government and to conduct a feasibility study on the construction of an 1800

[7] For a detailed description see, Kenneth Lieberthal and Michel Oksenberg . 1998. *Policy Making in China: Leaders, Structures, and Processes* , Princeton: , Princeton University Press.

mile pipeline to Western China. This was estimated to cost $ 3.5 billion.In September 1997, CNPC followed similar tactics to defeat Petronas, Unocal and Amoco to win a controlling interest in Uzen, Kazakhstan's second largest oilfield with reserves of 1.5 bb.

In June 1997, a consortium of Chinese oil companies signed a 22-year production sharing contract with Iraq to develop half of the Al-Ahdab field after thhe lifting of UN sanctions. Al-Ahdab is the country's second largest oilfield. Prior to the US invasion of Iraq, CNPC was negotiating for rights to develop three other Iraqi fields. These are Halfaya, Luhais and Suba.

However, the US invasion of Iraq and the subsequent occupation has put these plans in great jeopardy. The global energy situation is now marked by even more uncertainty and the Chinese must feel more vulnerable than ever. It is always possible that US imperialism will fail like all imperialist powers to ultimately control the middle eastern oil or even the sea routes permanently. But the realists in China must know that the current situation is one of US dominance. Apart from its domestic snafus reflected in the facts such as that Kazakhstan-China pipeline plans were shelved in 1999, the US preeminence as a military power and its willingness to use this power for various purposes including protecting control over overseas oil, China's energy dependence seems logically to lead to dependence on the US hegemony. What is the way out? I suggest that rethinking development strategy and increasing regional cooperation offer the best hope for China.

Strategically, Chinese development path has been so far marked by the East Asian model.According to this model heavy state involvement together with the promotion of market led industrialization through export promotion is the best strategy for development. As an industrialization strategy, this can succeed up to a point. However, as the Asian financial crisis demonstrated, there are risks as well (Khan1997, 1998, 2004 a and b).The Chinese strategy has led to high growth and a lopsided distribution together with energy dependence. Following this path further without qualification, as the current leadership seems to have grasped, will exacerbate the negative aspects with the inevitable growth slowdown. However, there is an alternative which I have developed in detail elsewhere. Here I will merely sketch the main outline.

In my development of an alternative strategy(Khan 1983, 1982a and b, 1997,1998, 2002, 2003, 2004 a and b; Khan and Sonko 1994) based among others on an extension of Schumpeterian theory of innovation and Sen's capabilities, the key is a distributionally sensitive approach with clear recognition of ecological constraints.The main idea is to moderate the growth rate and hence short term dependence on fossil fuels and minimize consequent ecological problems.With a proper poverty reduction strategy---called 'growth plus'strategy[8]--- the adverse distributional consequences from moderate growth can be avoided. In fact, with a properly moderate 'growth plus'strategy, the capabilities of the great majority of the poulation caan be enhanced along with the productive capacity. This will lead to the creation of a domestic market for commodities that are produced in a much more ecologically sustainable manner. Furthermore, the goal of a

[8] This is discussed in detail in chapter 1 of Khan and Weiss (2007).

transition to a relatively non-fossil fuel based knowledge and information economy will be facilitated and the transition will occur more quickly and smoothly under the proposed POLIS strategy. Although the move away from fossil fuels can only be gradual, a beginning must be made not in a makeshift way, nor for the purpose of window dressing but in a genuinely strategic manner at the highest policy making level.

Therefore, serious attention must be paid to the scope and necessity for developing and harnessing alternative energy sources, including renewable ones. Starting from the realistic assessment that in the short and medium run fossil fuels will be still the predominant ingredients in China's energy mix, serious and credible plans will need to be formulated for increasing the share of alternative energy sources . For example, China has rich potential for solar, wind, and tidal energy. China may also consider the potential of modern bio-fuels. Given the importance of agriculture in the economy even with rapid growth and industrialization, it may be possible to find a win-win solution by choosing an appropriate crop mix that also enhances the country's energy security. Bio-gas energy can also play an important part in this mix. In addition, there is a pressing need for reducing system loss, and improving energy efficiency in buildings and transportation sectors. The Chinese government should also be cognizant that coal is a fossil fuel and coal-fired power plants are one of the primary sources of global warming. China's future energy choices must be mindful of the impacts of climate change for the sake of the future generations in China and the world. A strategic step consistent with the POLIS strategy suggested here that will signal credibility is for the Chinese government to initiate a public consultation process for formulation of a national energy strategy, so that all the relevant issues can be discussed and resolved in an open, participatory, and transparent manner. Creation of a domestic market system in a harmonious society which is the goal of the current regime will in fact require such a move.

The question of domestic market creation leads also to considerations of cooperation in Asia. For reasons of regional financial stability, reciprocal exporting and energy security greater cooperation in each of these spheres is an urgent necessity. China along with the other countries in Northeast Asia must proceed to diffuse tensions and build up regional institutions. Given the historic hostilities this will be no easy task. Yet the enlightened self-interests of the countries together with imperatives of regional peace and prosperity lead logically towards cooperation. There is much here to learn from European integration experience, particularly about the role of enlightened leadership. No doubt, there are special Asian features and special Asian roadblocks that might require particular Asian approaches to negotiation and conflict resolution at times. But China's energy dilemma is one compelling reason for that country to take the initiative and start a dialogue. There is no time to lose. In particular the dialogue with Japan is of great significance. I now turn to a brief analysis of the problems of and prospects for cooperation between China and Japan in the near future.

4. China-Japan Energy Relations: Conflict and Cooperation

The current relation between China and Japan in the energy security area continues a historic dialogue which has at times been difficult. The most recent moves, on the surface at least, seem to signal increased willingness to cooperate on the part of both the countries in some crucial areas of mutual concern.
On April 11, 2007, the Japan-China Joint Press Statement was announced in Tokyo, Japan, during the time Chinese Prime Minister Wen Jiabao visited Japan. In the statement, the content related to the energy sector in particular is as follows:

(2) Reinforcement of mutually beneficial cooperation
(i) Energy and environmental cooperation

Both sides welcomed the announcement of the "Joint Statement by Japan and the People's Republic of China on the Further Enhancement of Cooperation for Environmental Protection". Both sides affirmed their sincere efforts at tackling the global environmental issues affecting the two countries. Furthermore, both sides confirmed that they would focus their cooperation on areas such as prevention of water pollution in vital waters including the Bo Hai and Huang Hai regions and the Yangtze basin, building recycling societies, air pollution prevention, measures to combat climate change, prevention of drifting marine litter, and measures for tackling acid rain and yellow sand.

Both sides welcomed the holding of the First Energy Ministerial Policy Dialogue and the announcement of a joint statement concerning energy cooperation enhancement. Both sides agreed that they would strengthen their cooperation focusing on energy-realted issues such as energy conservation, coal and nuclear power etc. Such cooperation will also include model projects for the promotion of energy conservation and environmental businesses. Furthermore, attempts will be made to bolster cooperation within multilateral frameworks for the promotion of energy conservation in the Asian region.

Both sides supported the activities of the Japan-China Board of Assistance to Greening Activities. They confirmed that they would further promote reforestation cooperation programs carried out in China by Japanese private entities, and that the two countries would cooperate toward sustainable forest management.

Starting in the 1980s, contrary to belligerent political rhetoric at times, China and Japan has cooperated economically in a number of areas. However, there were and still are many potential areas of conflict. It may be recalled that China has received a great deal of Japanese aid in the past.The section below gives a brief overview of this relation which may have paved the way for cooperation in the areas of energy and environment.

Overview of Official Development Assistance (ODA) to China

Official Development Assistance (ODA) to China began in 1979 and from that time to the present, approximately 3.1331 trillion yen in loan aid (yen loans), 145.7 billion yen in grant aid, and 144.6 billion yen in technical cooperation have been implemented. Grant aid is financial assistance that is extended to recipient countries without imposing an obligation of repayment. Loan aid involves the provision of loans under relaxed conditions (low interest, long repayment period) to recipient countries. These are in principle untied loans. Technical cooperation involves the technologies being provided to recipient countries to spread the use of technology among people in developing countries and improve technical levels.

Past ODA projects in China included large-scale economic infrastructure projects, including the building of roads, airports and power stations, as well as infrastructure projects in medical and environmental areas. These projects have played a significant role in the realization of China's current economic growth.

For example, through Japanese loan aid (yen loans), a total length of 5,200 km of railway lines were electrified, and in the area of seaports, approximately 60 large-size berths capable of taking ships in excess of 10,000 tons were built. In addition, the China-Japan Friendship Hospital that was established through grant aid is one of the major medical institutions in the Beijing metropolitan area, treating approximately 3,000 patients each day.

Assistance includes more than infrastructure projects. In the area of technical cooperation the Japan International Cooperation Agency (JICA) has accepted trainees from China for the purpose of providing assistance to cultivate administrative personnel. As of FY2003 JICA had accepted a cumulative total of over 15,000 trainees, and the Association for Overseas Technical Scholarship (AOTS) had accepted more than 22,000 trainees to nurture the human resources required for industrial promotion. JICA has also dispatched 5,000 experts to China.

Large-scale Economic Infrastructure Projects (Loan Aid)
Airports
Shanghai Pudong International Airport Construction Project (40.0 billion yen)
Beijing Capital Airport Terminal Area Expansion Project (30.0 billion yen)
Lanzhou Zhongchuan Airport Expansion Project (6.3 billion yen)
Wuhan Tianhe Aerodrome Construction Project (6.3 billion yen)
Xi'an Xianyang International Airport Terminal Expansion Project (3.09 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 111.6 billion yen

Railway Lines
Beijing-Qinhuangdao Railway Expansion Project (87.0 billion yen)
Guiyang-Loudi Railway Construction Project (30.0 billion yen)
Chongqing Urban Railway Construction Project (27.1 billion yen)
Beijing Subway Construction Project (19.7 billion yen)
Datong-Qinhuangdao Railway Construction Project (18.4 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 641.8 billion yen

Roads
Hangzhou-Quzhou Expressway Construction Project (30.0 billion yen)
Liangping-Changshou Highway Construction Project (24.0 billion yen)
Xinxiang-Zhengzhou Highway Construction Project (23.5 billion yen)
Guiyang-Xinzhai Highway Construction Project (15.0 billion yen)
Heilongjiang Heihe-Beian Road Construction Project (12.6 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 195.1 billion yen

Seaports
Qinhuangdao Port Expansion Project (67.4 billion yen)
Qingdao Port Expansion Project (59.7 billion yen)
Huanghua Port Construction Project (15.4 billion yen)
Shenzhen Dapeng Bay Yantian Port 1st Phase Construction Project (14.7 billion yen)
Dalian Port Dayao Bay 1st Phase Construction Project (6.7 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 272.6 billion yen

Power Stations
Tianshengqiao Hydroelectric Power Project (118.0 billion yen)
Jiangxi Jiujiang Thermal Power Plant Construction Project (29.6 billion yen)
Wuqiangxi Dam Construction Project (25.2 billion yen)
Shanhe Thermal Power Plant Construction Project (24.6 billion yen)
Beijing Shisanling Pumped Storage Power Station Construction Project (13.0 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 488.2 billion yen

Fertilizer Plants
Weihe Chemical Fertilizer Plant Construction Project (26.9 billion yen)
Inner Mongolia Chemical Fertilizer Construction Project (21.4 billion yen)
Jiujiang Chemical Fertilizer Plant Construction Project (21.4 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 106.3 billion yen

Steel Plants
Shanghai Baoshan Infrastructure Improvement Project (31.0 billion yen)
Environment Protection
Prevention of Air Pollution
Environment Model City Project (Guiyang, Chongqing, Dalian) (30.7 billion yen)
Forestation
Ningxia Afforestation and Vegetation Cover Project (8.0 billion yen)
Sewage System
Xiang River Basin Hunan Environment Improvement Project (3.1 billion yen)
Beijing Sewage Treatment Plant Construction Project (2.6 billion yen)
Cumulative total of aid in this area excluding the above-mentioned projects: 857.8 billion yen

Human Resources Development Projects
Inland Higher Education Project (88.8 billion yen)
Infrastructure Projects in Medical and Environmental Areas
The Project for Construction of the China-Japan Friendship Hospital (Grant aid: 16.430 billion yen)
The Project for Construction of the China-Japan Friendship Environment Protection Center (Grant aid: 10.499 billion yen / Technical cooperation: 1.997 billion yen)

Energy Loans
The State Department of China authorized the Bank of China as the delegate to negotiate with the Japan Import and Export Bank. In 1979 May, the two sides signed a memo for energy loan, the amounts of which reached 420 billion Yen. And in 1984 and 1992, Japan Import and Export Bank provided two other energy loans to Bank of China, which reached 580 billion and 700 billion Yen respectively. Thus, the total amount of energy loan Japan provided to China is 1.7 trillion Yen.

Dateline of China-Japan Energy Issues

East China Sea Dispute between China and Japan	
Reason: unclear borderline definition in East China Sea.	
1969	Four corporations including TEIKOKU OIL in Japan applied for the oil gas development right to Japanese government
1970	China started to explore oil and gas resources in East China Sea.
1982	Japan proposed the principle of "midline" to China, for division of the water area of East China Sea between the two countries.
2004 May	China started to develop the Chunxiao Gasfield in East China Sea.
2004 June	China proposed that the two countries should cooperatively develop the resources in this area.
2004 June	Japanese government set up the "sea right related cabinet minister conference", encouraging Japanese enterprises explore resources in East China Sea.
2004 July	Japan began to conduct seabed resource surveys to the east of their unilateral "midline" in the East China Sea, an area disputed between the two countries.
2004 Oct	Japan and China held the first round of talk on the East China Sea issue.
2005 Apr	Japanese government started to accept enterprises' application for East China Sea resource development and exploration.
2005 May	Japan and China held the second round of talk on the East China Sea issue.
2005 July	Japanese government granted the TEIKOKU OIL the right to explore gas in East China Sea.
2005 Aug	TEIKOKU OIL completed all the government-required procedures.
2005 Sep	Japan and China held the third round of talk on the East China Sea issue. Japan accepted China's proposal of cooperative development in this area.
2006 Mar	Japan and China held the fourth round of talk on the East China Sea issue.
2006 May	Japan and China held the fifth round of talk on the East China Sea issue. The two sides reached an initial intent of cooperative development
2006 July	Japan and China held the sixth round of talk on the East China Sea issue.
2007 Mar	Japan and China held the seventh round of talk on the East China Sea issue.
2007 Apr	The Prime Minister of China visited Japan, during which he had talk with the Prime Minister of Japan about East China Sea dispute. They agreed the acceleration of the future talks on this dispute. And a basic time table for the dispute resolution has been reached.

Dateline of China-Japan Energy Issues

1972	
Nov. 27	Japan-China Association on Economy & Trade was founded in Tokyo.
1974	
Jan	The Foreign Minister of Japan – Masayoshi Ohira – visited China, during which the two countries signed the China-Japan Trade Agreement in Beijing.
1978	
Feb	Signing of the China-Japan Non-governmental Long-term Trade Resolution in Beijing.
Aug	The Foreign Minister of Japan – Tadashi Sonoda – visted China. Signing of the Sino-Japanese Peace and Friendship Treaty in Beijing.
1980	
May 28	Scientific Cooperative Agreement between People's Republic of China and Japan was signed and became effective in Tokyo.
May 29	Agreements between China and Japan on cooperative oil exploitation in South and West Bohai Bay was signed in Tokyo.
Dec 15	Bohai Oil Corporation and Chengbei Oil Development Corporation (CODC) of Japan signed the Chengbei Oilfield Development Contract. The total investment capital reached 270 million US dollars. It put into operation in 1986, and it is the first Chinese-Japanese joint venture in this regard.
1981	
Jun 23-24	China-Japan Scientific Cooperation Committee held the first meeting in Beijing.
Dec 15-16	The second China-Japan government member meeting was held in Tokyo. During the meeting, the two parties signed a summary about the capital cooperation of Daqing oil chemical industry and Baogang Steel 1st stage construction.
1982	
Feb 18	China and Japan signed an agreement for cooperation on the coal exploration in Liuzhuang coal mine zone, in Anhui Province of China. It is the first project that Chinese geological industry cooperated with a foreign country.
1983	
Sep 5	Petroleum companies from China, Japan, UK and US signed a contract stating they will cooperatively explore the oil in the South China Sea. The contract was signed in Beijing.
1984	
Dec 17	China and Japan signed an agreement on atomic energy between Chinese government and Japanese government.
1989	
Mar	Japanese Export and Import bank provided a loan of about 72.6 billion Yen to Bank of China. And this loan was supposed to be used in the exploration of China's land oil fields such as Liaohe oil field in Northern China.

	Bozhong 28-1 oilfield jointly developed by China and Japan was put into operation
1990	Bozhong 34-2/4E oilfield jointly developed by China and Japan was put into operation
1993	
May 18	China-Japan Energy Communication Association is founded in Beijing.
1994	
Feb	According to Chinese custom's statistics of 1993, Japan had become the largest trade partner of China.
May 3	China-Japan Nuclear Safety Agreement was signed in Beijing
1995	
Aug 29	Because of China's nuclear experiment, Japan announced the suspension of interest free loans and aid provided to China.
1996	
	Diaoyu Island dispute became the hot point in China-Japan relationship.
	July 17th, Japan claimed that Diaoyu Island belonged to Japan.
	The two countries' debate kind of restrained the economic cooperations between the two countries.
2006	Joint Statement of Energy Ministers of China, India, Japan, Republic of Korea and the United States was announced in Beijing, China
2007	
Apr 11-13	Chinese Prime Minister Wen Jiabao visited Japan
Apr 11	the Japan-China Joint Press Statement was announced in Tokyo, Japan. In this statement, the two countries reinforced their agreement on energy cooperation in the future.
Apr 12	The first minister-level energy policy dialogue between China and Japan was held in Tokyo. The two sides singed an agreement in which the two nations committed to cooperate on developing energy resources and building nuclear power plants in China. Both parties agreed that the energy dialogue will be held once a year and is expected to address energy conservation and other issues. They also decided to hold a "China-Japan energy-saving and environment protection symposium" in Beijing this September.
	And the China-Japan energy cooperation symposium was held. About 180 companies and research institutions, totally more than 600 entrepreneurs, of two countries attended the symposium. They are divided into 4 groups: electricity, oil and gas, coal, and new energy, for discussion. And 6 cooperation accords and/or agreements also were signed in various areas including electricity and gas.
	China National Petroleum Corporation (CNPC) and Nippon Oil Corporation of Japan agreed on the cooperation in the area of overseas oil and gas development.

	Nippon agreed to provide oil refining techniques and oil chemical techniques to China, and it agreed to promote more technique cooperation on new energy development such as biofuel. At the same time, both sides agreed to cooperate more in energy safety and environment protection.
	China National Offshore Oil Corporation (CNOOC) and Mitsui & Co. Ltd of Japan also signed an accord on liquefied natural gas (LNG) spot trading on the same day.
	China Datang Corporation (CDT), one of the five large-scaled power generation enterprises in China, and Kyushu Electric Power and Sumitomo Corporation of Japan signed a framework agreement about cooperation in the area of renewable energy. The three companies will construct a wind farm in Neimenggu Province of China.

5.Conclusions and Future Directions

In this paper I have sketched the energy dilemma for China in this century. As long as the current geopolitical situation persists the pursuit of present development strategy of China will further increase its energy dependence. For both political and economic reasons China needs to rethink its development strategy. I have sketched such an alternative strategy that relies much less on fossil fuels and emphasizes regional cooperation. This POLIS strategy will ultimately lead to a sustainable economy based on growth with equity. A transition to a non- fossil fuel based knowledge and information economy will also be easier to effect under the proposed strategy.

However, time is of the essence. Given the path dependence of development unless strategic disengagement from the existing path followed by a strategic engagement with the alternative strategy is begun within the next five years, it may well be too late. The stakes are indeed very high. A more detailed strategy paper based on the key ideas from the alternative strategy outlined here with concrete quantitative scenarios and feasibility studies along the lines of models sketched in the appendix (and other, more detailed models) will go some distance towards giving the appropriate analytical foundations for the policy makers. The preliminary results confirm the predictions regarding fossil fuel-based energy shortage and lead towards a serious consideration of alternative energy sources. Achieving the twin goals of energy security and ecological balance are challenging but not impossible for China. Serious policy research can be used effectively if there is the political will to do so. The goal of regional cooperation is also achievable if patient negotiations in good faith can start in earnest.In particular, cooperation with other Asian economies, particularly Japan, Indonesia, Viet Nam and India will be crucial.This paper has sketched out the complexities of cooperation and conflict between China and Japan. Future work will address the problems of Regional cooperation for China in the

East, South and South Asian context as well as in the context of Africa and Latin America.

Appendix 1: Growth Impacts of the energy sectors--- A simple SAM-based Model

Fixed Price Modeling in a SAM-based Framework:

In this section the Social Accounting Matrix is presented as a data gathering framework as well as an analytical tool for studying the effects the energy sectors on growth. Appendix two presents the methodology for estimating the impact of growth generated by the energy sectors on poverty alleviation. The origins of social accounting can be traced as far back as Gregory King's efforts in 1681, but more recent work stems from the attempts by Richard Stone, Graham Pyatt, Erik Thorkbecke and others. [9]

In the methodological framework of this study the SAM is used for mapping production and distribution at the economy wide level. In this section, first a general SAM is described. Then it is shown how the method for studying the effect of growth within this framework follows logically from its structure. The model used is a simple version of a class of SAM-based general equilibrium models.[10] It summarizes succinctly the interdependence between productive activities, factor shares, household income distribution, balance of payments, capital accounts, etc. for the economy as a whole at a point in time. Given the technical conditions of production the value added is distributed to the factors in a determinate fashion. The value added accrued by the factors is further received by households according to their ownership of assets and the prevailing wage structure. In the matrix form the SAM consists of rows and columns representing receipts and expenditures, respectively. As an accounting constraint receipts must equal expenditures.

As is elaborated further in Khan and Thorbecke (1988), the SAM framework can be used to depict a set of linear relationships in a fixed coefficient model. For deciding the question of determination, the accounts need to be divided into exogenous and endogenous ones. For instance, in the China SAM, there are three endogenous accounts. These are factors, households and production activities, leaving the government, capital and the rest of the world accounts as exogenous.[11]

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[9] For a description of SAM as a data gathering device, see G. Pyatt and E. Thorbecke, *Planning Techniques for a Better Future* (Geneva: ILO, 1976). Khan(1997) also has a chapter on this alone.

[10] In Walrasian general equilibrium models the flexible price vector determines the equilibrium. In a Keynesian (dis)equilibrium model in the short-run the quantities vary while the price vector remains fixed.

[11] See Khan and Thorbecke, op.cit., Ch. II for more theoretical details and empirical examples. The presentations here follow the cited work closely.

Table 1: Simplified Schematic Social Accounting Matrix

				Expenditures				
				Endogenous Account			Exog.	Total
				1	2	3	4	5
Receipts	Endogenous Accounts	Factors	1	0	0	$T_{1.3}$	x_1	y_1
		Households	2	$T_{2.1}$	$T_{2.2}$	0	x_2	y_2
		Production Activities	3	0	$T_{3.2}$	$T_{3.3}$	x_3	y_3
	Exog.	Sum. Of other accounts	4	l_1'	l_2'	l_3'	t	y_x
		Total	5	y_1'	y_2'	y_3'	y_x'	

Looking at Table 2, which represents a SAM, we can see immediately that

$$y = n + x \qquad (1)$$

$$y = 1 + t \qquad (2)$$

Now if we divide the entries in the matrix Tnn by the corresponding total income (i.e. y_n), we can define a corresponding matrix of average expenditure propensities. Let us call this matrix A. We now have:

$$y = n + x = Ay + x \qquad (3)$$

$$y = (1\text{-}A)^{-1}x = Mx \qquad (4)$$

M has been called the matrix of accounting multipliers by Thorbecke, for these multipliers, when computed, can account for the results (e.g. income, consumption, etc.) obtained in the SAM without explaining the process that led to them. Let us now partition the matrix A in the following way.[12]

[12] Ibid.

$$
A = \begin{bmatrix} 0 & 0 & A_{13} \\ A_{21} & A_{22} & 0 \\ 0 & A_{32} & A_{33} \end{bmatrix} \qquad (5)
$$

Table 2: Schematic Representation of Endogenous and Exogenous Accounts in a SAM

		Expenditures				
		Endogenous	Sum	Exogenous	Sum	Totals
Receipts	Endogenous	T_{nn}	n	Injections T_{nx}	x	y_n
	Exogenous	Leakages T_{xn}	1	Residual Balances T_{xx}	t	y_x
Totals		$y_n/$		$y_x/$		

Source: H.A. Khan and E. Thornbecke, Choice and Diffusion of Technology in a Macroeconomic (SAM) Framework

Given the accounts factors, household and the production activities, now we see that the income levels of these accounts (call them y_1, y_2, y_3 respectively) are determined as functions of the exogenous demand of all other accounts. In this respect, what we have is a reduced-form model which can be consistent with a number of structural forms. This is quite satisfactory as far as tracing the effects of a certain injection in the economy is concerned or for prediction purposes when the structural coefficients are more or less unchanged.

One limitation of the accounting multiplier matrix M as derived in equation (2.2) is that it implies unitary expenditure elasticities (the prevailing average expenditure propensities in A are assumed to apply to any incremental injection). A more realistic alternative is to specify a matrix of marginal expenditure propensities (C_n below) corresponding to the observed income and expenditure elasticities of the different agents, under the assumption that prices remain fixed. The C_n matrix can be partitioned in the same way as the A matrix above. The most important difference between the two partitioned matrix is that $C_{32} \neq A_{32}$. Expressing the changes in income (dy) resulting from changes in injections (dx), one obtains,

$$dy_n = C_n dy_n + dx \qquad (6)$$

$$= (I - C_n)^{-1} dx = M_c dx \qquad (7)$$

M_c has been called a fixed price multiplier matrix and its advantage is that it allows any nonnegative income and expenditure elasticities to be reflected in M_c. In particular, in exploring the macroeconomic effects of exogenous changes in the output of different product-cum-technologies on other macroeconomic variables, it would be very unrealistic to assume that consumers react to any given proportional change in their incomes by increasing expenditures on the different commodities by exactly that same proportion (i.e. assuming that the income elasticities of demand of the various socioeconomic household groups for the various commodities were all unity). Since the expenditure (income) elasticity is equal to the ratio of the marginal expenditure propensity (MEP_i) to the average expenditure propensity (AEP_i) for any given good i, it follows that the marginal expenditure propensity can be readily obtained once the expenditure elasticity and the average expenditure propensities are known, i.e.,

$$y_i = MEP_i / AEP_i \qquad (8)$$

$$MEP_i = y_i \, AEP_i \qquad (9)$$

$$\text{and } \sum_i MEP_i = 1 \qquad (10)$$

Thus, given the matrix A_{32} of average expenditure propensities, and the corresponding expenditure elasticities of demand, y_i the corresponding marginal expenditure propensities matrix C_{32} could easily be derived.[13]

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[13]See Khan and Thorbecke (1988) for some examples.
See also G. Pyatt and J.I. Round, "Accounting and Fixed Price Multipliers in Social Acounting Matrix Framework," *Economic Journal* Vol. 89, Dec. 1979, p. 861.

Appendix 2: Energy Sectors, Growth, Distribution and Poverty.

Multiplier Decomposition,Growth and Poverty Alleviation Sensitivity

Since poverty in the present context is measured by identifying a poverty line in monetary terms incomes of the various household groups are the crucial variables. In particular, sectoral growth generated by the energy sectors must be linked to incomes of the various households in order to determine the exact extent of the alleviation of poverty through growth. The exact effect of income growth on poverty, of course, depends on the sensitivity of the adopted poverty measure to income. In this paper the Foster, Greer and Thorbecke (1984) P_α class of additively decomposable poverty measure is selected for this purpose. For α=0,1,n this measure becomes the headcount ratio, the poverty gap and a distributionally sensitive measure that gives specific weights to each poor person's shortfall, respectively.

If we apply Kakwani's (1993) decomposition to the P_α measure for specific sectors and households i and j respectively, the change in $P_{\alpha ij}$ can be written as follows:

$$dP_{\alpha ij} = \frac{\partial P_{\alpha ij}}{\partial \bar{y}_i} + \sum_{k=1} \frac{\partial P_{\alpha ij}}{\partial \theta_{ijk}} d\,\theta_{ijk} \qquad (11)$$

Here $P_{\alpha ij}$ is the FGT P_α measure connecting sector j to household group i, y_i is the mean per-capita income of household group i, and θ_{ijk} is the income distribution parameter. Under the unrealistic but simplifying assumption of distributional neutrality:

$$d\frac{P_{\alpha ij}}{P_{\alpha ij}} = \eta_{\alpha i}\left(\frac{d\bar{y}_i}{\bar{y}_i}\right) \qquad (12)$$

where $\eta_{\alpha i}$ is the elasticity of P_{ij} with respect to the mean per capita income of each household group i resulting from an increase in the output of sector j. dy_i on the right hand side is the change in mean per capita income of household group i. This can be written as (by considering the fixed price multiplier matrix)

$$dy_c = m_{ij}\, dx_j \qquad (13)$$

where dx_j is the change in the output of sector j on a per capita basis for group j. We can now rewrite the aηverage change in poverty measure as

$$d\frac{P_{\alpha ij}}{P_{\alpha ij}} = \eta_{\alpha i} m_{ij}\left(\frac{dx_j}{\bar{y}_i}\right) \qquad (14)$$

By aggregating across the household groups we can arrive at the overall poverty alleviation effect

$$d\frac{P_{\alpha j}}{P_{\alpha j}} = \sum_{i=1}^{m}\left(\frac{dP_{\alpha}ij}{P_{\alpha}ij}\right)\left(\frac{n_i}{n}\right) = \sum_{i=1}^{m}\left(\frac{dP_{\alpha ij}}{P_{\alpha ij}}\right)\left(\frac{P_{\alpha ij}}{P_{\alpha j}}\right) \qquad (15)$$

Since we are considering a P_α measure

$$d\underline{P_{\alpha j}} = \sum^{m}\left(\underline{dP_{\alpha ij}}\right)\left(\underline{\Sigma(z-y_k)/z)^{\alpha}}\right) \qquad (16)$$

$P_{\alpha j} \quad _{i=1} \left(P_{\alpha ij}\right) \left(\Sigma(z-y_l)/z)^{\alpha}\right)$

where q_i is the number of poor in the ith group and the total number of poor $q=\sum_{i=1}^{m} q_i$

Let $s_{\alpha i}$ be the poverty share of household group i (naturally $\sum_{i=1}^{m} s_{\alpha i} = 1$)

$$s_{\alpha i} = \sum_{k=1}^{qi}\left(\frac{z-y_k}{z}\right)^{\alpha} \Big/ \sum_{l=1}^{q}\left(\frac{z-y_l}{z}\right)^{\alpha} \qquad (17)$$

We can further rewrite the expression for the average change in overall poverty alleviation.

$$\frac{dP_{\alpha j}}{P_{\alpha j}} = \sum_{i=1}^{m}\left(\frac{dP_{\alpha ji}}{P_{\alpha ij}}\right) s_{\alpha i} \qquad (18)$$

Combining equations 14 and 18
we now have,

$$\frac{dP_{\alpha j}}{P_{\alpha j}} = \Sigma s_{\alpha i}\eta_{\alpha i}\, m_{ij}\left(\frac{d_{xj}}{\bar{y}_i}\right) \qquad (19)$$

Thorbecke and Jung(1996) separate the income increase via the modified multiplier effect from the sensitivity of the poverty measure formally in equation (19) by defining the following two entities:

1. $m^{/}_{\alpha ij} = s_{\alpha i}m_{ij}$ gives the modified multiplier effect in terms of income of a poor group.
2. $q_{\alpha ij} = \eta_{\alpha i}(dx_j/\bar{y}_i)$ represents the sensitivity of the poverty index to the change in income. I adopt their terminology and call this the poverty sensitivity effect.

But each multiplier m_{ij} can be further decomposed:

$$m_{ij}=\eta_j d_{ij} \qquad (20)$$

where n_j gives the (closed loop) interdependency effects and d_{ij} the distributional effects of a change in demand for the product of sector j on household group i.

Thus,

$$dP_{\alpha j}/P_{\alpha j} = \sum^{m} m^{/}_{\alpha ij}q_{\alpha ij} \qquad (21)$$

$$= \sum_{i}^{m}(r_{\alpha ij})\,(s_{\alpha ij}d_{ij})(q_{\alpha ij}) \qquad (22)$$

The d_{ij} on the right hand side can be further decomposed by multiplicatively decomposing the total distributive effects. Given the structure of C_n matrix in section 2. $D=D_3D_2D_1$ where $D_3= (I-C_{22})^{-1}$; $D_2=C_{21}C_{13}$, and $D_1=(I-C_{33})^{-1}$

The particular element for each household i and sector j can be selected from these three matrices.

Thus the contribution of an increase in output of a particular sector j to poverty alleviation can be decomposed multiplicatively into its two components: (i) the contribution due to the change in mean income of the poor across all groups and (ii) the sensitivity of the particular poverty measure to this change in average income of the poor.

Appendix 3: Joint Statement of Energy Ministers of China, India, Japan, Republic of Korea and the United States (Beijing, China on December 16, 2006)

1. The energy ministers of China, India, Japan, Republic of Korea and the United States, which together account for nearly half of world oil consumption, met in Beijing, China on December 16, 2006 to discuss ways to promote energy security, stability, and sustainability. Energy is crucial to sustainable economic and social well-being in developed and developing countries. Our common challenge is to ensure sufficient, reliable and environmentally responsible supplies of energy with reasonable prices, as well as more efficient utilization of energy.

2. In recent years, fluctuations and increases in international oil prices have exerted a negative impact on the world economy, in particular for the developing countries. It is in this context that the energy ministers of the five countries held this meeting to review the world energy situation and the implications of increased oil prices on the global economy and to discuss cooperative efforts to advance: sufficient energy investment, energy conservation and efficiency, development of alternative energies and utilization of clean and efficient energy technologies, including those related to nuclear energy and clean coal and establishment of oil stockpiles. Our collective efforts are of great significance for the stability of the international oil and other energy markets and for enhancing global energy security.

3. We recognize that the reasons behind the oil price volatility are complex and manifold, including growing demand for oil, concerns over the adequacy of investment in oil production capacity in the long-term, current low levels of spare production capacity, refining capacity bottlenecks, prolonged political instability in some oil producing regions and market speculation.

4. We recognize that current high oil prices are affecting energy demand and investment. We affirm that market-based pricing helps send the appropriate signals for energy conservation and efficiency, and investment in conventional and alternative energies. We encourage investment based on market principles in oil and gas exploration and production so as to increase the supply capacity of oil and gas.

5. We recognize that China, India, Japan, Republic of Korea and the United States share common interests in the energy area. Our policies to accelerate the development and deployment of new energy technologies and improve energy efficiency will significantly enhance our energy security as well as global energy security. In order to

strengthen our collective energy security, we agree to enhance our cooperation in the following areas:

i.Diversifying our energy mix to make wider use of clean and alternative energy, such as clean coal, nuclear energy and renewables, including in the transport sector. To this end, we will expand collaboration in research, development and deployment of alternative energy technologies such as clean coal, nuclear energy, renewables, hydrogen, bio-fuels, hybrid vehicle technologies and carbon sequestration,

ii.Improving energy conservation and efficiency, which provides cost-effective solutions to enhancement of energy security, reduces green-house gas emissions and helps attain sustainable development

iii.Strengthening cooperation on strategic oil stocks to promote international energy security. Past experience has shown that international coordination, such as through the International Energy Agency (IEA), in response to significant supply disruptions benefits world energy markets.

iv.Improving transparency of data in the market through better sharing of information to enhance oil market stability. In this context, we welcome implementation of the Joint Oil Data Initiative (JODI) and will continue to provide timely market data on oil.

v.Encouraging extensive and in-depth cooperation among the business sectors of the five countries in areas including energy efficiency, alternative energies and transportation. In this context, we welcome the progress of the Asia-Pacific Partnership on Clean Development and Climate (APP) and the collaborative efforts it has catalyzed between the business and public sectors in diffusing clean energy technologies and best practices in energy intensive sectors.

6.We call on all countries of the international community to enhance global energy security through the following measures:

i.Open, transparent, efficient and competitive energy markets to encourage investment in the whole energy supply chain, especially in oil and gas exploration and production, including transparent and effective legal and regulatory frameworks.

ii.Diversification of energy supply and demand and energy sources.

iii.Promotion of energy conservation and energy efficiency measures as well as development and deployment of environmentally sustainable energy technologies.

iv.Cooperative energy emergency response through strategic oil stocks.

v.Safeguarding critical energy infrastructure and sea route security for transportation of oil and gas.

vi.Improved quality and timeliness of energy data made available to the market.

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