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Advanced Analytics for Green and Sustainable Economic Development

Supply Chain Models and Financial Technologies

Zongwei Luo

Advanced Analytics for Green and Sustainable Economic Development:

Supply Chain Models and Financial Technologies

Zongwei Luo
University of Hong Kong, China

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Preface

INTRODUCTION

Traditional Supply Chain Management (SCM) aims at movement of goods and services from one end of this chain to the other through different stages so as to improve the efficiency, productivity and profitability of the entire process. As SCM spans across the economic functions of the entire value chain of a product or service, it is vital for a company to join in, form, or coordinate its business related supply chains, forming various kinds of business relationships. Supply chain relationship management, or relationship management in supply chains, increasingly becomes one of the core functions in today's market place for companies to strive for business competiveness.

ENTERPRISES IN TRANSITION

Examples always help understanding. Pearl River Delta (PRD), a south region in China, is a region where the world's largest manufacturing base is located. In PRD, various economic functions of the entire value chain of a product or service are conveniently located together in a close geographical area. The enterprises have established various smoothly running industrial clusters with various business relationships formed.

With the emphasis now on environmental protection and high technology development in China's trade policy, many of those enterprises, small and medium sized and labor-intensive, have been losing their competitiveness. They are in low-end industries, with low capitalization, in relatively low technological conditions. Transformation, upgrade, and relocation are the only way out for them, which have now become the national encouraged policy, being enforced in China. Hong Kong government is urged to take pro-active role in helping them access financial resources, technology know-how, and market intelligence information.

Now it is a critical moment to innovate technologies and solutions for those enterprises to transform and upgrade while in consistency with China's new processing trade policy. Market potential and financial resources are the major two concerns for them. On the financial resources side, cross border financing technology and solution innovation is particularly important to improving the financial situations for Hong Kong invested enterprises in PRD and to help them retain the employment in the middle of a current financial tsunami.

On the hard hand, upgrade, transform, and relocation present challenges on the supply chain management for those enterprises. The supply chains would become even longer and more complex with more diverse transportation networks across different and sparse regions. This would put serious threats on enterprises' products and services market potentials as it hinders the market observation and feedback.

Strong demand is there for market information disclosing and sharing leading to the discovery of market demand and feedback, especially during the transform period. The information often is rather expensive to obtain in the long and complex supply chains, as they tend to span across the economic functions of the entire value chain of a product or service. It is vital for a company to join in, form, or coordinate its business related supply chains, forming close business relationships with business partners. Supply chain relationship management, thus, increasingly becomes one of the core functions in today's market place for companies to strive for business competiveness. The supply chain relationship modeling and analysis will lead to informed decision making and better market adaptation capabilities in the fast changing business environment.

SUPPLY CHAIN RELATIONSHIP MANAGEMENT FOR SUSTAINABLE DEVELOPMENT

Supply chain relationship management emerges to be a key business capability to help address these challenges in the upgrade, transform and relocation of these enterprises, especially small ones. SCM, spanning across the economic functions of the entire value chain of a product or service, presents challenges and opportunities for relationship management to enhance enterprises' capability for market adaptation. Traditional SCM, aiming at movement of goods and services from one end of this chain to the other through different stages so as to improve the efficiency, productivity and profitability of the entire process, often widen the distance of an enterprise to the market. Supply chain relationship management, on the other hand, helps narrow the distance for agile market adaptation, studying the business interconnections of how a company can join in, form, or coordinate its business related supply chains by establishing various business relationships with its partners. Supply chain relationship management increasingly becomes one of the core functions in today's market place for companies to strive for business competiveness. Supply chain relationship management presents the following characteristics in order to help enterprises' decision intelligences for dynamic market adaptation:

ADVANCED ANALYTICS WITH SUPPLY CHAIN MODELS AND FINANCIAL TECHNOLOGIES

The green and sustainable development trend has been centric in all the hearts in major economies. Sophisticated green analysis for sustainability demands advanced analytics to cope with large data volume dispersed in every corner and to help deal with the risks and identify opportunities in the sustainable economy development. Advanced analytics are essential to high-value decision management towards building a sustainable competitive advantage in the green economy.

Advanced analytics will provide innovative concepts, methods, tools, and application development to drive better decision makings with practical relevance to the green and sustainable economy development.

This book on Advanced Analytics would contain a set of contribution with various focuses on the development of innovative techniques and tools to help clarify/answer some urgent questions in this global trend for sustainable economy development.

The book contains 12 selected chapters with abstract following their titles for your easy reading through. I hope you enjoy your reading.

Chapter 1, *Low Carbon Economy – Finance and Technology Models*, by S. Sureshkukar; The climate change is forcing a low carbon growth model not only for the developed nations but also for the developing countries, and particularly the emerging major emitters belonging to the emerging economies like china and India. New types of policies, partnerships and instruments, which dramatically scale up present climate change efforts, will be needed, if efforts to mitigate climate change and adapt to its effects are to succeed. The focus of this chapter will be on these and related issues pertaining to financial and technological aspects of the challenges confronting us in this context. The methodology used is essentially based on current literature and tacit knowledge arising from related experience along with its explicit accounts.

Chapter 2, *Carbon Markets and Investments: VAM's Case Analysis*, by J. Zambujal-Oliveira; In a world where greenhouse gases (GHG) carry a price, organizations can create financial instruments that are tradable on the carbon market by investing in projects that reduce GHG emissions. The purpose of this study is to critically analyze an investment project from EcoSecurities to mitigate the emissions of methane from a coalmine located in China's Sichuan province. This project generates carbon credits that are later sold to governments and organizations under the Kyoto Protocol. In order to evaluate this investment, we conducted an analysis centered in its net present value, and we take into consideration a set of external variables and the financial and economic situation of EcoSecurities. This study concludes that Ecosecurities project investment, since project's net present value is positive, it has a relevant impact on EcoSecurities strategy and improves the company's financial situation as it increases revenues and improves assets using efficiency.

Chapter 3, *Firms' Banking and Pooling in the EU ETS (2005-2007)*, by Julien Chevallier, Johanna Etner, and Pierre-André Jouvet; This article investigates firms' banking and pooling behaviors in the context of the EU Emissions Trading Scheme (EU ETS) during Phase I (2005-2007). It provides an overview of the questions raised at the firm-level by the introduction and implementation of the EU trading system in terms of allowances management. More specifically, the article details the banking behavior at the installation level, and the pooling of risks at the group level attached to allowance trading between the parent company and its subsidiaries. Based on case-studies of the most significant patterns in terms of allowances management among firms, the empirical analyses underline the efficiency of the banking instrument as a risk-management tool.

Chapter 4, *Mind the Gap Please! – Contrasting Renewable Energy Investment Strategies between the World Bank and Poor Customers in Developing Countries*, by Sam Wong; This chapter scrutinizes the World Bank's nine guiding principles for investment strategies on renewable energy in developing countries. Drawing on two World Bank-funded solar lighting projects in Bangladesh and India as examples, it demonstrates a wide gap in investment strategies between the Bank and local people. It suggests that a rigid distinction of renewable and non-renewable options risks restricting poor people to adopt an energy-mix approach to cope with poverty. The economic assumptions of the strategic choice for renewable energy investment pay inadequate attention to the cultural norms that shape people's preferences for energy sharing. A lack of participation of NGOs and local communities in shaping the Bank's investment strategies also undermines the effectiveness of its renewable energy policies in the long term.

This chapter suggests that the World Bank re-conceptualises the complex relationships between energy and poverty and seeks a better understanding of local people's daily energy consumption practices.

Chapter 5, *Alternatives to the Global Financial Sector: Local Complementary Currencies LETS and Time backed Currencies*, by Carl Adams and Simon Mouatt; This chapter explores complementary currencies and exchange systems and how they can provide some stability and competition to the vulnerability of the financial markets. The social economy, or 3rd sector, already plays a significant part in many societies. This is becoming more so as many governments and nations are facing decades of debt inevitably resulting in cut backs in key social and health services. In addition, the existing formal economic activity does not capture, value or support the full range of social and economic interaction within a nation. The chapter examines timebank systems, a particular type of complementary currencies and exchange system, and provides guidance on issues to consider in develop them. One of the finding from the evaluation is that as the number of people in the timebank system increases then more formality is needed to moderate the system and reduce potential for misuse.

Chapter 6, *Low Carbon Economy and Developing Countries: A Case of Nepalese Forest*, by Raghu Bir Bista; In forest, reduction of emission from deforestation and forest degradation (REDD) is considered as low carbon instrument. Financial Incentive scheme of this new climate change mitigation approach generates query about REDD's economic implication in developing country. This study is to examine empirically low carbon potential from avoided deforestation in Nepal. The case study is the Kafle community forest of Nepal. We used 10 meter radius circle sample plot for carbon inventory data collection. In addition, we conducted household survey through 48 households for data set collection.

This study finds that community forest contributes 45 percent livelihood income (fire wood, leaf litter, grass, water) to the forest dependent stakeholder's total income. This labor incentive based on labor contribution in forest management is distributed among the member households. This study further finds huge carbon income potentials. Annually, KCF can earn carbon income Rs. 39, 81,196, if KCF enters in REDD. It is 41 times higher than the present mean income Rs 24, 549.55 from the forest product sale. In mixed familiarity about REDD, the study finds only 44 percent households expecting that REDD will be a better livelihood alternative to the poor. 63 percent responds need and use of carbon income for livelihood objectives. From estimation, household stakeholders who have good asset holdings (land and Rlivestock) think that REDD will be not a better livelihood alternative to the poor. However, the household stakeholders who have literacy, different food sufficiency level, land holding (1>), different earning per day, Rsex, per day earning and age think that REDD will be a better alternative. Thus, the poor households expects livelihood role from REDD in Nepal. Therefore, REDD should be more beneficial to the poor household stakeholders and their livelihoods.

Chapter 7, *Transition to Low-Carbon Hydrogen Economy in America: The Role of Transition Management*, by Jacqueline C.K. LAM and Peter HILLS; This chapter describes the process of transition to low-carbon hydrogen economy in America and the role of transition management (TM) in such process. Focussing on the transition process of hydrogen-based energy and transport systems in America, especially California, this study outlines the key characteristics of TM that have been employed in managing the low-carbon transition of hydrogen economy. Several characteristics of TM have been noted in America's hydrogen transition, including: (a) the complementation of the long-term vision with incremental targets, (b) the integration of top-down and bottom-up planning, (c) system innovations and gradualism, (d) multi-level approach and interconnectedness, and (e) reflexivity by learning and experimenting,. These characteristics are instrumental in bringing about the development and initial commercialization of HFCVs and energy infrastructure in America.

Chapter 8, *Operational Hedging Strategies to Overcome Financial Constraints during Clean Technology Start-up and Growth*, by S. Sinan Erzurumlu, Fehmi Tanrisever, Nitin Joglekar; Clean technology startups face multiple sources of uncertainty, and require specialized knowhow and longer periods for revenue growth than their counterparts in other industries. These startups require large investments and have been hit hard during the current credit squeeze. On the other hand, clean technologies create important positive externalities for the economy. Hence, loan guarantees and other incentive schemes are being developed that are conditioned upon operational benchmarks. We offer a framework to establish the extent wherein operational hedging can reduce risk and increase the probability of obtaining financing. We examine a variety of evidence, ranging from production outsourcing to creation of joint ventures, to posit that operational hedging may affect both the marginal cost of capital and the marginal return on investment through mitigating the informational problems in the market. However, operational hedging may not be an effective strategy in all settings: the decision for creation of such hedges ought to weigh the benefits of reduced marginal cost of capital and the opportunity cost of reduced future growth potential against a status quo.

Chapter 9, *Warehouse Financing Risk Analysis and Measurement with Case Study in Carbon Trading*, by Ying Yin, Zongwei Luo; Warehouse financing has been emerged as one of the most effective financing approaches for small and medium-sized enterprises (SME). Its basic working mechanism is to transfer the company's assets to collaterals which are more acceptable by the bank. As a logistics service provider, the 3rd Party Logistics (3PL) coordinates and controls the whole financing process. With the professional 3PL's help, it is easier for SMEs to get loan from the bank. In the meantime, the 3PL's profit margin has also been increased by providing financing service in addition to their traditional logistics based functions. This chapter explains the basic working mechanism of warehouse financing, applies SCOR reference model to identify financing activities and the risks caused by them. Then this paper synthesizes four relevant risk analysis / management frameworks from previous literatures, and proposes a new risk framework and evaluation measures aimed specifically for warehouse financing. Finally, a case of carbon trading in China is studied using the previous framework.

Chapter 10, *Modeling Closed Loop Supply Chain Systems*, by Roberto Poles; In the past, many companies were concerned with managing activities primarily along the traditional supply chain to optimize operational processes and thereby economic benefits, without considering new economic or environmental opportunities in relation to the reverse supply chain and the use of used or reclaimed products. In contrast, companies are now showing increased interest in reverse logistics and closed loop supply chains (CLSCs) and their economic benefits and environmental impacts. In this chapter, our focus is the study of remanufacturing activity, which is one of the main recovery methods applied to closed loop supply chains. Specifically, we investigate and evaluate strategies for effective management of inventory control and production planning of a remanufacturing system. To pursue this objective, we model a production and inventory system for remanufacturing using the System Dynamics (SD) simulation modeling approach. Our primary interest is in the returns process of such a system. Case studies will be referred to in this chapter to support some of the findings and to further validate the developed model.

Chapter 11, *Bike Transportation System Design*, by Avninder Gill; The main objective of this chapter is to address the facility design and location issues in a public bike transportation system. The major decisions in introducing a public bike transportation system include determining the number of bike facilities and their locations. The present chapter considers a case study from city of Vancouver bike transportation system to demonstrate the importance of these decisions through a real world application. The city intends to decide the number and location of bike terminals. Addressing these two decisions is

the main focus of the present chapter and the chapter employs linear programming and center of gravity approaches to arrive at the solutions. The chapter also provides a basic introduction to bike facilities and discusses the sustainability benefits of bike transportation mode.

Chapter 12, *Data Center Technology Roadmap*, by Tugrul Daim, Timothy R. Anderson, Mukundan Thirumalai, Ganesh Subramanian, Nitin Katarya, Dhanabal Krishnaswamy, and Neelu Singh; Datacenters have been in existence all over the world for the past several decades. In today's dynamic world, especially with most of the businesses being heavily dependent on Information Technology, interconnecting various systems within the organization and the outside world is a mandatory requirement for the success of any business. Datacenters all around the world perform this role to some level of satisfaction. Since datacenters started to play a significant factor in any organization's success, companies realize the value of having a datacenter oriented strategy as one of the strategic initiatives for the success of their organization. Despite the agreement that the value of having such an initiative for datacenters is important, there is a lack of clarity in terms of the technical know-how involved in datacenters. Our objective here in this study is to fill that gap in the Industry. We wanted to portray the different facets of datacenters in terms of how can they be classified, what are the underlying technologies, what are the current challenges faced by the industry and where the industry is headed in the next 10years. We illustrate the evolution of the datacenter industry in the last decade and how it is going to continue in the next 10 years graphically in the form of a Technology Roadmap. We based our research on going through existing industry literature, analyze challenges and develop a technology roadmap for data center industry with emphasis on energy efficiency and cost reduction. The wide audience for this roadmap would include IT professionals, datacenter managers, company strategists, the Government as well as environmentalists. Our intention is to present the audience with a single-stop snap shot of the data center industry on how the industry has evolved over the time and where it is heading in the future. We present our findings based on analyzing the data obtained from literature research and expert knowledge. The key research areas of our study were challenges, market trends, technological innovation, energy efficiency, cost reduction and government involvement.

In this report, we take you through the general roadmap architecture starting with market drivers, products, technology and its components followed by our recommendations and inference from the study.

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Chapter 1
Low Carbon Economy–Finance and Technology Models

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ABSTRACT

The climate change is forcing a low carbon growth model not only for the developed nations but also for the developing countries, and particularly the emerging major emitters belonging to the emerging economies like China and India. New types of policies, partnerships and instruments, which dramatically scale up present climate change efforts, will be needed, if efforts to mitigate climate change and adapt to its effects are to succeed. The focus of this chapter will be on these and related issues pertaining to financial and technological aspects of the challenges confronting us in this context. The methodology used is essentially based on current literature and tacit knowledge arising from related experience along with its explicit accounts.

INTRODUCTION

The IEA estimates that limiting GHG concentrations to 450 ppm CO_2eq would require US$550 billion to be invested in clean energy from now to 2030. UNDP estimates the cost of adaptation at US$86billion. Most of the financing in the coming years will have to come from private sources, or from innovative funding mechanisms currently available or being developed. Current levels of ODA, while significant, are unlikely to be sufficient to finance the necessary investments.

For example, for energy-related activities, ODA, at present, provides US$5-7 billion per year, which is only 1% of the total amount required.

The international community is currently piloting a number of public policies, new market-based instruments and innovative financial mechanisms, to attract and drive direct investment towards lower-carbon and climate- resilient technologies

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and practices. In 2007, the private sector invested nearly US$150 billion of new money in clean energy technologies in response to these new policy and financial incentives. However, these financial flows often remain restricted to OECD countries and a small number of rapidly developing countries; barriers still need to be removed before they can be widely disseminated for easier access by other developing countries.

For example, the Kyoto Protocol created the Clean Development Mechanism (CDM) to promote both sustainable development and GHG emission reduction in developing countries. The CDM is a global cap-and-trade mechanism, which allows developing countries to earn credits for their emission reduction projects and sell these cheaper credits to industrialised countries. Despite its potential, there is strong concern that only a limited number of countries will benefit from the CDM, and that this mechanism could bypass Africa entirely. (UNEP, 2009)

Only five countries–China, India, Brazil, South Korea, and Mexico–are expected to generate over 80 percent of CDM credits by 2012. Current market rules all too often fail to attract investors into lower-carbon technologies and sustainable land-use projects. The specific market conditions of developing countries will need to be incorporated into the design of new market-based and innovative financial mechanisms. A number of reforms to the CDM are currently being discussed to achieve this objective (programme approaches, etc.). At the same time, developing countries will need assistance to put into place an enabling environment (e.g. public policies, institutions, human resources) so that they are in a better position to leverage these new sources of finance. A new order of partnership is needed between developed and developing economies–one that supports the development needs of developing countries but assists them onto a low carbon trajectory that leap-frogs the 20th century development patterns of the North.

Encouraging financial flows between rich and less well off countries is key as is the involvement of the private finance sector and global investment community. UNEP Finance Initiative and the UNEP Sustainable Energy Finance Initiative are some examples. More recently, the interaction between UNEP's Initiatives and other private finance networks has intensified.

Combating climate change is not about costs to the economy but an investment in the kinds of renewable, clean-tech and natural resource management economies able to generate low-footprint wealth and employment for over one billion people unemployed or under employed. The total investment required to avoid dangerous climate change is more than USD 1 trillion per annum, according to the International Energy Agency (IEA). Half of this amount could be redirected from business-as-usual investment in conventional technologies to low-carbon alternatives. The remainder (USD 530 billion) is required in the form of additional investment. World Bank estimates suggest that around USD 475 billion of the total annual investment must occur within developing countries. Around USD 400 billion per annum of investment will be required for mitigation investment. A further USD 75 billion per annum will be required for adaptation investment. (UNDP, 2009)

Developing countries will be most advantaged if public finance contributions are designed to maximise the leverage of additional private finance. Institutional investors could provide much of the capital, if an appropriate risk-reward balance is offered. Institutional investors, such as pension funds, insurance companies and sovereign wealth funds, are in a position to provide some of the required capital. It is estimated that pension funds alone control assets worth more than $12 trillion and that sovereign wealth funds have a further $3.75 trillion under management. However, to stimulate their engagement the expected returns on climate-change mitigation investment need to be commensurate with the perceived level of risk. This is not currently the case.

Public Finance Mechanisms (PFMs), which could deliver between $3 and $15 of private investment for every $1 of public money, are part of the solution. Public money can be used to increase returns or reduce risks, and can be an efficient way of mobilising institutional investor capital. Alongside efforts to reform carbon markets and to create the conditions needed for 'nationally appropriate mitigation actions' (NAMAs), PFMs also need to be examined and optimised if they are to facilitate the required scale and speed of private capital injection. The guiding principles of the Financial Mechanism under the UN Framework Convention on Climate Change should recognise the potential for use of public funds to leverage private finance. Much of the required capital will be directed via specialised low-carbon funds, such as those recently proposed by the World Economic Forum. However, it is likely that big listed firms, largely owned by institutional investors, may implement individual large-scale low-carbon projects. PFMs should be available to institutional investors in both contexts. Developing countries should be heavily involved in the development and application of PFMs. A pre-requisite of PFM success is host-country commitment to the investment. Reflecting this, developing countries should be heavily involved in the process of determining the outcome(s) of the competition between investors for the use of PFMs. Competition to provide PFMs might also be introduced. There is a marked difference in the extent to which Development Finance Institutions (DFIs) attempt to, and succeed in, engaging with the private sector. To create incentives to encourage this engagement, institutions providing successful PFMs could, over time, receive more resources from relevant national governments. (UNEP & Partners, 2009; IEA, 2009)

Drawing on World Bank research, climate-change mitigation investment in the developing world needs is estimated to be around USD 400 billion per annum. A further USD 75 billion per annum of investment may be required for adaptation. Both the public and the private sector have roles to play in meeting this challenge. In comparison to the USD 475 billion per annum investment required, the World Bank reports existing commitments of USD 9 billion per annum. This is less than 2 percent of the required amount. Public sector commitments may increase following the Copenhagen conference, but will still fall short of the required level. Demands on public finance are acute and this has been exacerbated by the current recession. The public sector commitments for the developing world currently under negotiation, if delivered to their maximum ambition, total around USD 110 billion per annum. The shortfall, in excess of USD 350 billion per annum, could be met by the private sector. (World Bank, 2009)

Part of the answer is to deploy Public Finance Mechanisms (PFMs). PFMs are financial commitments made by the public sector which alter the risk-reward balance of private sector investments. They include grants, concessional finance, risk mitigation instruments and market aggregation activities. UNEP's prior research provides more information on the range of PFMs available. (UNEP-SEFI, 2008) PFMs can leverage significant private capital. Previous research suggests that $1 of public investment spent through a well-designed PFM can leverage between $3 and $15 of private sector money

Energy production and consumption patterns: Reducing world carbon dioxide emissions by 50% by 2050, compared to 1990 levels, will require revolutionary changes in our energy production and consumption patterns. Notably, we will have to rapidly introduce mitigation technologies that are commercially viable and that have immediate impacts on GHG reduction at a negative cost. According to the IEA, many clean-energy technologies (renewable energy and energy efficiency) are ready to launch. Moreover, the bulk of end-use energy efficiency measures can be implemented at a negative cost. The McKinsey Global Institute has estimated that we could cut the projected growth of global energy demand up

to 2020 by at least half, by capturing opportunities which increase energy productivity—the level of output we achieve from the energy we consume. Additional annual investments of US$170 billion for the next 13 years would be sufficient to capture the energy productivity opportunity among all end users. (McKinsey Global Institute, 2007)

The economics of such investments are very attractive, with an average internal rate of return (IRR) of 17%, and are calculated to collectively generate energy savings, which can reach up to US$900 billion annually by 2020. In this scenario, 57% of the investments would occur in developing countries, notably China. Similarly, the IEA has shown that, on average, an additional one dollar invested in more efficient electrical equipment, appliances and buildings, avoids more than two dollars in investment in electricity supply. This ratio is highest in non-OECD countries. (World Energy Outlook, 2006) Achieving this transformational exercise will require a dramatic shift in public and private investments from traditional energy supply sources and technologies to more sustainable climate-friendly alternatives. The IEA estimates that US$550 billion/year needs to be invested in clean energy, from now to 2030, if we are to limit GHG concentrations to 450 ppm CO2e. (World Energy Outlook,2008)

Therefore, a number of new market-based instruments and innovative financial mechanisms are currently being piloted to attract and drive direct investment towards lower-carbon technologies and practices and to cut the costs of adaptation.

Climate change has the potential to affect many companies in both positive and negative ways and is likely to result in a Schumpeter's cycle of "destruction-creation." The degree to which a company is exposed to climate change will depend on a variety of factors, including their business model and geographical location. Government policies to manage the climate can create new markets for low-GHG and climate-resilient products and services, and profoundly alter costs and companies' current comparative advantages. For example, a recent energy-efficiency standard, introduced for existing buildings in France, has the market potential of €350 billion by 2012. Companies and investors are quickly realising that climate change is not merely a social, political, or moral issue - it is an economic and business issue/ opportunity as well. (Deutsche Bank Group,2007)

There is a range of the new financing mechanisms for mitigation, at the international and national/sub-national level.

Some examples: international schemes, national and sub-national schemes, public funds, ODA (multilateral, bilateral, and decentralized cooperation), multilateral funds, green economic stimulus, environmental fiscal reforms, export credits, rebates and subsidies, tax credits and tax free bonds, low interest loans, private funds, green equity finance, private investment funds, foundations, non-governmental organisations, global philanthropic foundations, corporate social responsibility (MNCs), national philanthropic foundations, corporate social responsibility (national corporations), market-based mechanisms, tradable renewable energy certificates, carbon cap-and-trade mechanisms (CDM, JI, voluntary), tradable renewable energy certificates, green insurance contracts, progressive approaches (NAMA, etc.), tradable renewable energy certificates, utility DSM, green mortgages, tax free climate change bonds, domestic carbon projects, innovative instruments transaction taxes (TOBIN), international CC finance initiative, air travel levy, global carbon tax, debt-for-efficiency swaps, international carbon auction funds, international non-compliance fees, efficiency penny, carbon taxes, energy taxes, auction of emission allowances, national non-compliance fees, green investment schemes, efficiency penny.

These schemes can be divided into four main categories:

1. public funds providing either grant or loan assistance;

2. private funds providing either grant or loan assistance;
3. market-based instruments; and
4. innovative financing instruments.

Market-based instruments and innovative financing instruments are two fairly recent developments in international finance. Market-based mechanisms, such as the cap-and-trade system, rely on markets to provide financial incentives to steer funding towards lower-carbon and climate resilient investments. Cap-and-trade schemes are intended to minimise the cost of a given level of pollution abatement by creating property rights to emit, administratively limiting the supply of permits to ensure the emissions target level is not exceeded and distributing permits (either by auction or by direct allocation). Subsequently a trade in permits is allowed so that emitters lacking permits are forced to buy them from those with a surplus because of abatement. (Deutsche Bank Group, 2007)

However, a key issue with a number of these new and innovative sources of finance is their acute regional and technological unevenness, with the bulk of these funds going to a few large emerging economies and to a small selection of technologies. The EU and the US currently receive the greatest share of both the new investment and the acquisition activity. Developing countries shared 22% of new investment (venture capital/ private equity, public markets and asset finance) in 2007, up from 12% in 2004. However, most of this investment was in China and Brazil, which together represented 17%. In actual financial terms, developing countries attracted US$26 billion in new investment in 2007, double 2006's total of US$13 billion (and 14 times 2004's US$1.8 billion). In 2007, investment in the least developed regions, such as Africa, was limited to asset financing of US$1.3 billion—mainly for biofuel plants. Although an estimated 575 million people still rely on traditional biomass in Africa16, the region accounted for less than 1% of the total private investment in clean energy in 2007.

Private sector investment in clean energy is strongly biased towards certain technologies. Wind was once again the leading sector in 2007, accounting for US$50.2 billion (43%) of new investment and extending its 2006 lead, when it received 38%. Solar and biofuels, respectively, attracted the second and third largest investment volumes. Together, all three technologies accounted for nearly 85% of new investment in 2007. In contrast, energy efficiency technologies, whose immediate deployment is critical to avoid dangerous climate change attracted only 2% of financing. (UNEP, 2008)

The CDM has huge potential in terms of allowing developing countries to earn credits for their emission reduction projects and to sell these credits to industrialised countries. The UNFCCC estimated that the CDM could range from US$10 and US$100 billion per year by 2030, depending on emission reduction targets and the price of carbon credits. A recent World Bank study on the potential for CDM in Africa concluded that 170 GW of additional power-generation capacity could be created in Sub-Saharan Africa through low-carbon projects eligible for CDM (i.e. projects recognised by the international community as reducing GHG emissions). This would equal roughly four times the region's current modern-energy production.

However, the analysis of the existing CDM pipeline reveals that only a limited number of countries are benefiting, and that the mechanism could bypass Africa entirely. Just five countries—China, India, Brazil, South Korea and Mexico—are expected to generate over 80 percent of CDM credits by 2012. Almost half of these credits will come from non-CO2 industrial gas emissions (such as HFC-23 destruction and N2O emissions capture) that are characterised by a high return on investment but have very limited sustainable development Benefits. (World Energy Outlook, 2006; World Energy Outlook, 2008;

Deutsche Bank Group, 2007; UNEP, 2008; World Bank, 2008)

The specific market conditions of developing countries will need to be incorporated into the design of the new market-based and innovative finance mechanisms. In addition, developing countries will need assistance to establish an enabling environment (e.g. public policies, institutions, human resource capacities) at all levels, so that countries are in a better position to leverage these new sources of finance to obtain better access to clean energy services. Furthermore, the potential of many of these instruments can be maximised by appropriately combining and sequencing different instruments. For example, the additional carbon revenues generated through the CDM for wind energy projects are not substantial enough to change the underlying profitability. In such a case, the use of feed-in tariffs in combination with carbon revenues can serve as the critical tipping point. Another example is when introducing regulations that require energy-efficient and climate-resilient building codes. Such regulations would be far easier to implement if they were combined with interest-free loans. Therefore another critical requirement will be to enhance the capacity of decision-makers at the local, regional and national level, to consider different options as part of an integrated climate change strategy.

The UNFCCC estimates that the additional investment and financial flows needed worldwide for adaptation will be US$60-182 billion in 2030. The largest component in this estimate is the cost of adapting infrastructure, which may require US$8-130 billion in 2030, one-third of which would be for developing countries. The UNFCCC also estimates that an additional US$52-62 billion would be needed for agriculture, water, health, ecosystem protection and coastal-zone protection, most of which again would be used in developing countries.

In total, it is estimated that US$28-67 billion in additional investment and financial flows will be required in 2030 for adaptation in developing countries. Others arrive at similar estimates for adaptation. The World Bank concludes that the incremental costs of adapting to the projected impacts of climate change in developing countries are likely to be approximately US$10-40 billion per year, while Oxfam International estimates this number to be over US$50 billion per year. UNDP suggests aid financing for adaptation could amount to US$86 billion per year by 2015. (Stockholm Environment Institute, 2008) The current levels of official development assistance (ODA) for adaptation in developing countries are extremely low (less than US$100 million per year). Even if increased significantly, they will probably be insufficient. Similar to mitigation, the past few years have witnessed an extremely rapid development of new sources of funding for adaptation and climate change management

In terms of market instruments, weather derivatives and CAT bonds are particularly important for mobilizing financing. As with mitigation, financial markets and the insurance industry can also play an important role in supporting adaptation to climate change, specifically through cutting the costs of adaptation—that is, how economies respond to climate change—by reallocating capital to newly productive sectors and regions and hedging weather-related risks. However, while market-based instruments are expected to play the leading role in mitigation, innovative financial instruments are likely to account for a larger share of funding in adaptation. One example of an innovative financial instrument is the Adaptation Fund. This Fund is unique in that it generates revenue through a two percent levy on emission permits—'Certified Emission Reductions' (CERs)—generated by the emission reduction projects under the Kyoto Protocol's Clean Development Mechanism (CDM).

The international community's ability to transform energy systems to meet future demands for growth and lower GHG emissions will ultimately depend on a burst of technological innovation over the next few decades. The potential of key