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Climate-Resilient Industrial Development Paths: Design Principles and Alternative Models

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Abstract

Global climate change is here. According to recent scientific reports, the earth has warmed by nearly half a degree centigrade over the last twenty five years. Even with robust mitigation efforts, the global climate could warm by up to 4 degrees centigrade due to past emissions. Under a business-as-usual, high consumption fossil fuel-based development path, it could warm even more, resulting in catastrophic and life-threatening destruction of earth's eco-systems.

The "climate imperative"—the urgent need to both mitigate and adapt to global climate change—has important implications for economic development paths in general and industry and energy policies in particular. Development models and practice historically have treated climate—and indeed, the natural environment in general—as exogenous. Future development models will need to incorporate both climactic uncertainty and the economic threats and opportunities arising from an evolving global climate regime. Developing countries, which are especially vulnerable to climate instability, will need to design energy and industry policies which aim to achieve not only economic and social objectives but which also enhance climate resilience.

This paper explores the broad contours of climate resilient industrial development paths. It defines development as an increase in local capacities for production and innovation and argues that the overarching goal of development is the generation of sustainable livelihoods. It suggests that. to be climate resilient, industry policies should have four key design features: 1) they are pro-active; 2) they promote industrial diversification; 3) they focus on mobilizing investment in environmentally sustainable industries and infrastructure, including low-carbon and renewable energy; 4) they are highly responsive to local geo-physical conditions and are based on principles of adaptive management; and 5) they are designed, implemented and governed via accountable partnerships involving government, business, and community actors.

The paper evaluates three development macro-models—neo-liberal, sustainable globalization, and new developmental—against the five design principles and finds that aspects of both climate vulnerability and climate-resilience are embodied in each. The paper concludes that responding to the climate imperative will require not a new synthesized one-size-fits-all model but a multiplicity of economic development paths. The effort to articulate the theory and praxis of such paths has barely begun.

Climate-Resilient Industrial Development Paths: Design Principles and Alternative Models

Lyuba Zarsky[1]

Introduction

The unfolding drama of global climate change has paradigm-shifting implications for development theory and policy. Despite recent findings that the Washington Consensus is adrift (Rodrik 2008), development practice remains largely wedded to global, market-driven neo-liberal policies based on maximizing GNP growth and high-energy consumption, by maximizing inflows of foreign investment, integrating with global supply chains, and eschewing pro-active industry policies.

The climate change imperative—the urgent need to both mitigate and adapt to climate change—has arisen at a time when many medium-income developing nations are on the threshold of major investments in industry and energy infrastructure. It is also a time of deep global economic inequity, spurring efforts by the global community—such as the Millennium Development Goals—to alleviate poverty and promote social development, including via new business models. Finally, the climate change imperative has emerged at a historical moment when development theory has been shaken loose by the economic, social and environmental shortcomings of neo-liberal orthodoxy. These three factors combine to create an opportune moment to consider how industrial transformation and economic development could—and indeed, must—evolve along new "climate resilient" paths.

This paper considers the broad contours of climate resilient industrial development paths and evaluates climate-resilience in three development models. It defines development as an increase in local capacities for production and innovation. However, it argues that the central objective of development strategies in a climate-constrained world is not industrialization *per se* but the generation of sustainable livelihoods.

The paper is in five sections. Section two reviews the recent science about global climate instability and outlines links between climate change and economic development. Section three broadly defines climate resilient development. Section four outlines five design features of climate resilient industry polices. Section five evaluates three economic development models against the design features: 1) neo-liberal globalization; 2) sustainable globalization; and 3) new developmental. The final section concludes and suggests directions for further research.

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Climate Change Imperative

Global warming is here. According to the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC 2007: 2), "warming of the climate system is unequivocal, as is now evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."

Scientific reports since the Fourth Assessment have found that the signs of global warming are accelerating faster than predicted, including melting of Arctic sea-ice, glaciers, and ice sheets. Sea level rise in 2009 was 80 percent greater than predicted by the IPCC just two years before. Over the past 25 years, temperatures have increased at an average rate of 0.19 degrees centigrade per decade (UNSW 2009). A September 2009 conference of climate scientists found that "since the late 1990s, greenhouse gas emissions have increased at close to the most extreme IPCC scenarios" and there is a significant possibility of 4 degrees warming before the end of the century (Science Daily 2009).

The scientific consensus, and the assumption of the Kyoto Protocol, is that the avoidance of dangerous climate instability requires that warming be kept below 1.5 degrees centigrade. A higher level of warming portends major regional and local impacts on eco-systems, human settlements, food production, and bio-diversity. New scientific evidence that past emissions had a significant probability of generating a warming of 2 degrees triggered intense protests at the December, 2009 Copenhagen climate talks by African NGOs who chanted "Two degrees is suicide!" (COP 15 (2009).

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The primary anthropogenic contribution to global climate change is the emission of carbon dioxide from the burning of fossil fuels and deforestation. As indicated above, under a business-as-usual scenario with no mitigation of emissions, the IPCC's Fourth Assessment in 2007 projected an increase of 3.5 degrees centigrade by the end of the century (IPCC 2007). Despite more than a decade of global climate diplomacy, global carbon emissions were 40 percent higher in 2008 than in 1990. Even if emissions were stabilized at the current rate and brought to zero by 2030, just twenty more years of emissions would result in a 25 percent probability that warming will exceed 2 degrees (ibid). In a 2009 review of the science since the IPCC's Fourth Assessment (UNSW 2009), an Australian team of climate scientists concluded:

If global warming is to be limited to a maximum of 2 degrees C above pre-industrial values, global emissions need to peak between 2015 and 2020 and then decline rapidly. To stabilize climate, a de-carbonized global society—with near-zero emissions of CO2 and other long-lived greenhouse gases—needs to be reached well within this century. …[E]very year of delayed action increases the chances of exceeding 2°C warming (UNSW 2009: 7).

Even with mitigation efforts, climate models predict that the planet will continue to warm as a result of past carbon emissions, necessitating human adaptation. The

impacts of climate change on humans are defined by the interface between bio-physical and socio-economic systems. The primary expected changes in bio-physical systems are 1) increased temperature and changes in rainfall patterns; and 2) sea-level rise and an increase in the incidence and severity of disasters (fire, storms). There is also increasing evidence of the possibility of ocean acidification with attendant loss of biological productivity of marine life. The bio-physical impacts will vary greatly by region and locale.

Bio-physical impacts will have a variety of secondary effects on socio-economic systems, including severe stresses on water availability (drought and flooding) and damage to existing assets and infrastructure. These stresses in turn, are likely to trigger a high degree of social stress and conflict, not least due to impacts on agriculture (Figure 1).

Figure 1
Expected impacts of climate change

Bio-physical impact	***Social impact***	***Economic impact***
Increased temperature and changes in rainfall patterns	**Reduced agricultural productivity (drought)** **Reduced marine productivity** **Water stress and scarcity** **Increased prevalence of disease** **Forced migration**	**Reduced supplies and higher prices for food** **Changes in arability and cropping patterns** **Reduced availability and higher prices for water** **Change in distribution of labor supply**
Sea level rise and increased incidence or intensity of disasters (storms, fires)	**Damage to assets and infrastructure** **Population displacement** **Conflict**	**High cost of insurance** **Disruption of supply inputs** **Disruption of final markets** **Sudden labor scarcity or influx**
Cumulative bio-physical impacts	**Carbon regulation** **Conflict**	**Rising fossil fuel prices** **Governance breakdown**

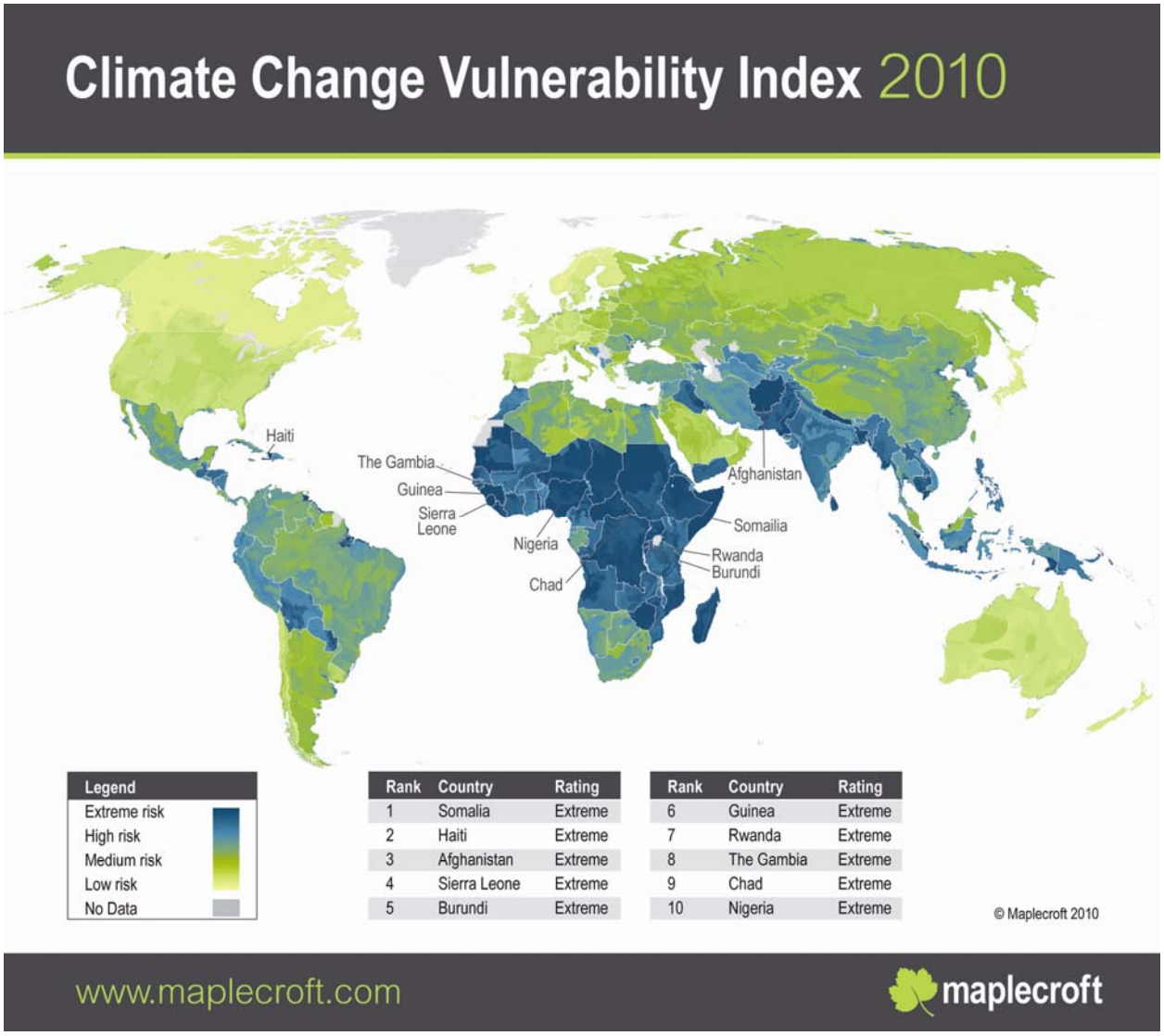
Source: Adapted from Tanner and Mitchell (2008)

The impacts of climate change will be felt most acutely by people in developing countries for two reasons. The first is bio-physical risk. Besides the poles, climate models show warming trends to be greatest in sub-Saharan and northern Africa, as well as parts of south, central and east Asia (IPCC 2007: Figure SPM2). Second, developing countries, especially least-developed countries, lack the capacity to adapt to climate stress. Adaptive capacity is a broad-ranging concept that spans basic socio-economic resilience stemming from wealth (income, technology, knowledge) to abilities to mitigate specific climate-related threats, such as climate monitoring and disaster planning.

Together, bio-physical risk and lack of adaptive capacity comprise the *vulnerability* of individuals, economies, communities or nations to adapt to global climate

change. In an effort to provide guidance on climate risk for global investors, the Canadian consulting group Maplecroft calculated a composite "climate change vulnerability index" based on bio-physical risk and adaptive capacity. Unsurprisingly, but worrisome nonetheless, the most vulnerable regions are the poorest (Figure 2).

Figure 2[1]
Climate change vulnerability map 2010



Rank	Country	Rating
1	Somalia	Extreme
2	Haiti	Extreme
3	Afghanistan	Extreme
4	Sierra Leone	Extreme
5	Burundi	Extreme

Rank	Country	Rating
6	Guinea	Extreme
7	Rwanda	Extreme
8	The Gambia	Extreme
9	Chad	Extreme
10	Nigeria	Extreme

Explanatory note: Maplecroft Climate Change Vulnerability Index (CCVI) rates 166 countries on their capacity to mitigate risks to society and the business environment posed by changing patterns in natural hazards, such as droughts, flooding, storms and sea level rises and the resulting effects on ecosystems. The climate change vulnerability factors are divided into six groups: economy; natural resource security; ecosystems; poverty, development and health; population, settlement and infrastructure; and institutions, governance and social capital; and comprises of 33 indicators. The CCVI was calculated using a Geographical Information System (GIS) model. Each cell represents an area of approximately 25km². For more information see www.maplecroft.com
Source: Maplecroft (2010)

To date, official development assistance and global adaptation finance have sought to reduce vulnerability primarily by increasing local capacities to undertake discrete climate adaptation efforts, such as climate monitoring and disaster response. It is clear, however, that to significantly increase climate resilience, developing countries must increase local economic productivity, in both agriculture and industry, generating higher incomes, as well as revenues for infrastructure investment, and better health.

Ironically, for many of the poorest people in developing countries, vulnerability to climate change is exacerbated by lack of access to reliable and affordable energy. While the earth is dangerously warming as a result of the historical emissions of fossil fuel-driven industrialization in OECD countries, some 2.4 billion people in developing countries still use traditional biomass fuels for cooking and heating; around 1.6 billion lack access to electricity (UNDP 2005a). Beyond enhancing human welfare, energy is a key input for industrial development, at both micro and macro levels.

Large developing countries like China, India, Brazil and South Africa have built dynamic industrial sectors driven largely by fossil fuels and, as a result, have emerged as the largest current and future absolute source of carbon emissions (though per capita emissions remain far below developed countries.) Defining the obligations of developing and developed countries for mitigating carbon emissions has become the pivot—and the stumbling block—of attempts to craft a global climate regime.

The climate imperative requires developing countries to integrate mitigation and adaptation as central features of development strategy, considering not only threats to lives and livelihoods but also new opportunities for industrial transformation. A global effort to regulate carbon and replace carbon-based energy infrastructure, for example, will spur dramatic growth of low carbon and renewable energy technology industries, including off-grid technologies. Developing countries may be able to leapfrog fossil fuel-based growth and create competitive advantages in low and no carbon energy and industrial technologies and processes. Given the large stakes, it is little wonder that the Human Development Report called climate change ”the defining human development issue of our generation” (UNDP 2007).

Defining Climate Resilient Development

The first step in defining climate resilient paths of industrial development is to define development itself. Rather than growth or poverty alleviation, this paper defines (economic) development as the building of local capacities for economic production and innovation. Such endogenous capacities are the foundation for both economic growth and poverty alleviation. Numerous studies, including by this author, have found that, in a global economy, promoting GNP growth without strengthening underlying local productive capacities generates economic enclaves dependent on foreign investment and export markets (Gallagher and Zarsky 2007). Also, attempts to alleviate poverty without enhancing local productive capacity founder when external assistance is withdrawn (Easterly 2002).

Local capacities for production and innovation embrace knowledge, skills, technology, infrastructure, human solidarity, and governing institutions. Such capacities not only create or enable the grasp of current opportunities to enhance productivity and social welfare, they also enable adaptation to changing conditions—economic, social or climactic. The capacity to adapt is a central feature of climate resilience.

The overarching objective of productive and innovative capacities is to provide and sustain livelihoods. In climate resilient development models, sustainability is a foundational principle for all economic activity. To be sustainable, livelihoods must be derived from productive activities that are:

- *Ecologically sound:* they must maintain the health of terrestrial, marine, air and atmospheric eco-systems and bio-diversity, at local and global levels;
- *Economically viable:* they must enhance local productive capacities and allocate them efficiently;
- *Socially resilient*: they must promote equity and social solidarity.

The ability to sustain livelihoods may be highly compromised under rapidly changing and uncertain climactic conditions, as well as a rapidly evolving climate regime which drives rapidly changing fuel prices. To maintain livelihoods, development strategies must explicitly incorporate knowledge of existing and projected local and regional climactic conditions and build in industrial and resource diversification and other strategies to enhance resilience.

The overarching goal of climate resilient industrial development should thus be to generate local capacities to sustain livelihoods for all people under a range of climatic conditions in ways that do not exacerbate global warming. Another way to say this is that the goal is to reduce vulnerability stemming from lack of an adequate livelihood. Many people in developing countries are already highly vulnerable to seasonal climate change and other risks.

The goal of promoting sustainable livelihoods conflates what are today often approached as separate objectives—poverty alleviation and industrial transformation. A focus on reducing vulnerability could invigorate current development efforts. As two leading climate and development researchers argue: “climate change may actually be an opportunity to create pathways out of chronic poverty through targeted efforts to enhance vulnerability reduction and adaptation” (Tanner and Mitchell 2008: 6).

Moreover, a focus on sustainable livelihoods removes the focus of development away from “growth for growth’s sake,” enabling a redirection away from wasteful high-energy, water-intensive consumption patterns. Finally, it embraces both wage and non-wage forms of livelihood and livelihoods derived from both agriculture and manufacturing.

Development strategies aimed at creating sustainable livelihoods thus have as their starting point three integrated objectives: 1) increasing income (and equity) by increasing the productivity of economic activities; 2) promoting growth in local capacities for production and innovation; and 3) increasing resilience of economic activity by incorporating knowledge about climate uncertainty and other environmental information.

With this starting point in mind, climate resilient development can be conceptualized as a socio-economic trajectory that generates and sustains human livelihoods in ways that both mitigate and adapt to global climate change. Central to mitigation is the transition to non-carbon energy sources. At the global level, it means developing along a path that stabilizes atmospheric concentrations within the range of 350-450 ppms, a level that is understood to be consistent with warming 1.5-2 degrees C. For developing countries, mitigation will primarily consist of ensuring that new investment in industry, transport, and infrastructure is based on low-carbon and/or renewable energy.

Figure 3
Adaptation and development: A continuum of investment activities

Address the drivers of vulnerability	**Build response Capacity**	**Manage climate risk**	**Confront specific climate changes**
Enhance underlying factors to reduce vulnerability to poverty and harm; increase local capacities for production and innovation; mobilize investment for low or non-carbon energy; promote solidarity and social problem-solving	Build robust systems for innovation and problem solving for both climate and non-climate related activities; e.g. communications and planning processes	Integrate climate information into decisions to reduce negative directs effects on resources and livelihoods; e.g. disaster management, 'climate proofing infrastructure'; build infrastructure to manage flood-drought cycles	Confront and respond to direct climate changes; e.g. sea level rise, melting glaciers, drought
←----------			----------→
Climate-resilient development			**Discrete adaptive**

Source: Adapted from McGray et al (2007) and Tanner and Mitchell (2008)

Climate resilient industrial development paths must be strongly focused on adaptation; that is, on reducing vulnerability to global climate change. A central aspect of adaptation is that both the change in global average temperature and local and regional impacts of global climate change are highly uncertain (Appendix Figure 9.2). One reason is that climate scientists poorly understand how local and global feedback loops interact.

In some parts of Africa, for example, it is not clear if rainfall will be greater or less or both. Moreover, models predict greater climate variability.

The subject of a burgeoning literature, adaptation requires the mobilization of investment in activities along a continuum (Figure 3). On one end are discrete actions that respond to particular emerging or expected climate changes; for example building or reinforcing sea walls in coastal cities or relocating populations of soon-to-be-submerged islands. On the other end are investments that promote adaptive capacity by targeting the drivers of vulnerability; like poverty, unsustainable industry, lack of sustainable livelihoods, poor health, lack of education, good governance, etc. In other words, reducing vulnerability to global climate change entails reinvigorating traditional development goals. Also critical to climate resilient development is investment in problem-solving and response capacities. There is great uncertainty as to how climate change will unfold and with what impacts. As stated above, capacities for social learning, deliberation and innovation will be at a premium.

Policy Design Principles

Climate-resilient development paths entail a high level of social planning and integration of knowledge, both scientific and traditional. They also require a high level of social solidarity, given the potentially catastrophic disruption to existing livelihoods. Implied is a central role for public policy, in terms of both content -- policy objectives and tools -- and the process of designing and implementing policy. Gleaned from a review of "traditional" development case studies, as well as a burgeoning literature on climate and development, this section outlines five principles as starting points for the design of climate resilient development policy.

Pro-active industry policy

Over the past two decades, neo-liberal approaches to development have eschewed pro-active industry policies aimed at nurturing targeted industry sectors in favor of industry-neutral "market-driven" integration into global supply chains. The performance, however, has been mixed at best. Latin American countries that rigorously followed the neo-liberal prescription, for example, have fared poorly in terms of growth and employment compared to China and other East Asian countries (Gallagher and Chudnovsky).

Industrial policy has two objectives in terms of linking climate and development. First, it aims to reduce vulnerability by promoting financially sustainable livelihoods. Second, as outlined by UNCTAD (2009: xiii), it seeks to "shift production and consumption patterns towards the use of those primary commodities, means of production, and consumer goods that place a lower burden on the earth's atmosphere than the current GHG [greenhouse gas] intensive ones". Linking climate change mitigation policies with traditional development goals, argues UNCTAD, "requires industrial policies that foster the creation of capabilities to produce or participate in the production of such goods and their subsequent upgrading" (ibid: xv).

Pro-active climate-resilient industry policy need not privilege import protection policies as in older ISI models. The goal, rather, is to identify efficient, climate-friendly, high employment industries and to nurture them by overcoming local market failures. A wide range of policy tools is available, including public support for research and development, science and technology policy, finance and credit, support for training and education, technology partnerships with multinational corporations, reforms in domestic patent law, etc. An Overseas Development Institute review of comprehensive policies for low carbon growth already employed by nine developed and developing countries concluded that "there is a role for government leadership to identify low carbon growth sectors which may provide competitive advantage and employment growth" (Ellis et. al. 2009: ix).

Figure 4

Tata BP Solar: The role of industry policy

Based in Bangalore, India, Tata BP Solar produces domestic and industrial solar water heating systems, solar lanterns, home lighting systems, water pumping systems, integrated PV systems for buildings and solar streetlights. In addition to 30% of the domestic Indian market, Tata BP Solar also has a 67% share of the Bangladeshi market, 25% in Nepal, 35% in Sri Lanka and over 90% in Bhutan. Company profits rose from 16 million rupees in 1991-2 to 4,690 million rupees (106 million USD) in 2004-5.

Tata BP Solar's commercial success is attributable to the interaction of global market forces and domestic policy. The joint venture partnership is a collaboration between BP and Tata Power Company, a member of India's renowned Tata business family. The government of India provided a supportive enabling policy environment. India's large-scale solar PV programmes are driven by government subsidies, with tax incentives and other financial incentives. In many cases, it is government agencies who take the lead on developing rural energy initiatives in India, by making a policy decision and bringing in an appropriate company (such as Tata BP Solar) with the required knowledge and capabilities to serve local markets.

Not all of Tata BP Solar's markets are located at the base of the pyramid. However, the company has demonstrated an ability to reach some of the poorest and most isolated communities. In the Himalayan region of Ladakh, Tata BP Solar worked with the Ladakh Renewable Energy Development Agency (LREDA) and the Indian Ministry of Non-Conventional Energy Sources to provide solar home systems to 80 remote mountainous villages, as the first phase of an initiative aimed at providing electricity to the whole Ladakh region.

In Punjab, the Tata BP Solar collaborated with the Punjab Energy Development Agency on a programme to deliver 225 solar water-pumping systems to farmers for irrigation purposes. Much of the success of Tata BP Solar's business model is the provision of a complete service to their customers. This long-term commitment is underpinned by the contractual relations established between the company and the local government. In Ladakh, end-users were charged for installation and maintenance, thus ensuring their commitment. Training was provided not only in technical skills, but also in educating and working with the end-users to ensure proper operation and maintenance of the systems.

Source: Wilson et al (2008)

There is ample evidence that pro-active industry policies can be effective in promoting climate-friendly industrial growth. Rock and Angel (2005) show that pro-active industry policies in East Asia are enabling a "sustainability transition." China's industry support policies have propelled its emergence as a leader in solar photovoltaic and wind technology, as well "clean coal" technologies such as direct coal liquefaction (UN-DESA 2009). Brazil's support for the development and deployment of a domestic sugar-based ethanol industry allowed it to capture a vibrant export market in the burgeoning global bio-fuels sector (ibid). In India, local government support enabled the emergence of a major domestic supplier of solar energy systems for households and industry (Figure 4).

Industrial diversification

Providing sustainable livelihoods in developing countries is largely a function of creating employment-generating enterprises (or agricultural operations) that are interlinked in productive industry sectors. Climate constrained industrial development thus has significant overlap with a development emphasis on industrial transformation and diversification. Many economists argue that diversification, rather than specialization, is the central driver of economic growth (Rodrik 2007).

Many developing countries have based their industrial development strategy on one or a handful of export sectors, either primary or manufacturing, integrated into global supply chains. Such a strategy makes livelihoods highly vulnerable to exogenous shifts, including rapid changes in exchange rates, emergence of lower cost competitors, global market collapse due to over-inflated expectations, etc. In the Mexican city of Guadalajara, for example, some 22,000 workers lost their jobs between 2001-03 due to a combination of global market contraction in the IT industry and the entry of China into the WTO (Dussel 2005).

For two reasons, industrial diversification is likely to become more central to sustaining livelihoods as climate change unfolds. First, fossil fuel prices will rise due to climate policy and / or scarcity. As a result, long global supply chains will be more expensive, especially those based on air and truck freight. Local companies will become more competitive in servicing local markets. Moreover, MNCs (multinational corporations) will increasingly seek local supply inputs for products aimed at both export and domestic markets. Secondly, climate events may make global supply chains more vulnerable to disruption. Insurance costs are likely to rise, further reducing the competitiveness of global input sourcing. A corollary to the renewed emphasis on industrial diversification is the rising importance of producing for domestic markets (Working Group 2009).

Investment

At the heart of climate resilient industrial development paths is the mobilization, leveraging, and strategic targeting of investment. Private and public, domestic and

international sources of capital and finance are required to rapidly ratchet up industries that promote sustainable livelihoods and transform production and consumption structures towards low or no carbon growth. "Countries that identify, target and secure new green investment and growth opportunities," concludes the Overseas Development Institute, "stand to benefit more from the transition to a low carbon economy" (Ellis et. al. 2009: ix).

Where will investment funds come from? At the international level, efforts to mobilize climate-related finance have focused on official development assistance, such as the Global Adaptation Fund, and emissions trading and offset schemes such as the Clean Development Mechanism (CDM) and the burgeoning Reducing Emissions from Deforestation and Forest Degradation (REDD) fund. To date, however, adaptation financing has been very meager, while CDM projects are concentrated in China and India, largely in hydro-electric dams and reducing emissions in dirty industries, such as cement and chemicals (International Rivers 2008). Indeed, the CDM has been widely criticized for its failure to promote sustainable development (Schneider 2007). Nonetheless, within the context of a strategic pro-active approach for industrial development, developing countries might find opportunities to gain or leverage investment through international climate-related funding mechanisms.

A much greater source of investment is private capital, including domestic savings and foreign direct investment (FDI). Policies that improve the overall functioning of domestic financial markets and the quality of FDI are key to climate resilient industry growth. In parallel with a pro-active approach to industry policy is a pro-active approach to investment, in both form and function. In terms of form, governments need to look towards new types of collaborations with investors, including via public-private partnerships and social entrepreneurship.

A pro-active approach to investment entails the creation and incorporation of decision-making frameworks to allocate investment in both industry and infrastructure in ways that optimize dual goals of increasing economic productivity while reducing climate risk, both local and global. Without such a framework, investment could be maladaptive. For example, massive investment in palm oil plantations in Indonesia to service global demand for bio-fuels exacerbates *global* climate risk because it increases net carbon emissions due to native forest clearing; and increases *local* climate risk because it undermines forest livelihoods and bio-diversity resources (Block 2009).

New decision-making frameworks are emerging that seek to evaluate returns on alternative investment options according to integrated indicators of economic productivity and climate risk (ECA 2009). Obviously, these frameworks entail first an assessment of climate risk based on scientific and local knowledge. Given the high level of uncertainty, assessments are based on a range of scenarios linking local and regional climate-weather interactions to potential economic losses to existing productive assets, as well as potential economic gains from adaptation investment.

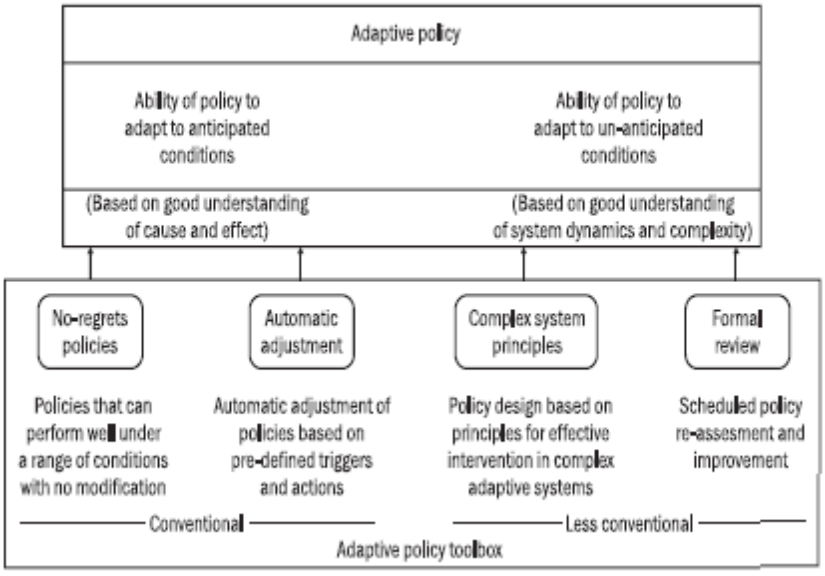
The Economics of Climate Adaptation Working Group applied such a framework to project the economic costs of climate risk and identify a portfolio of investment options to reduce risk in test cases in eight different regions of the world, including North and North East China (drought risk to agriculture); the Mopti region in Mali (risk to agriculture from climate zone shift); and Georgetown, Guyana (risk from flash floods). The study's findings are sobering i.e. that a "significant economic value is at risk" from climate change. Encouragingly, however, the test cases revealed that "rational measures to improve climate resilience are in many cases also effective steps to strengthen economic development" (ibid: 56). In Mali, for example, "the implementation of climate-resilient agricultural development could potentially bring in billions of dollars a year in additional revenue" (ibid: 12).

Knowledge-intensive local adaptive management

Climate resilient development policies, including industry policies, will have to be regularly re-evaluated and re-designed to adapt to anticipated and unanticipated local climactic conditions, as well as to new climate knowledge. Indeed, knowledge about local and regional bio-physical conditions and their socio-economic impacts will need to be foundational in shaping industrial development.

A new field of policy research is exploring principles for adaptive management and, led by the International Institute of Sustainable Development and The Energy Research Institute, applying them to climate change adaptation (Figure 5). Adaptive management is based on creating avenues for new information and changing conditions to be incorporated in policy redesign and implementation. It allows institutions to continually gain knowledge, make assessments, monitor, and change course or procedure.

Figure 5
Adaptive policy: A Conceptual Framework



Source: IISD and TERI (2006)

Adaptation to anticipated conditions is based on developing a comprehensive understanding of cause and effects (as much as possible); adaptation to unanticipated conditions requires a comprehensive understanding of overall system dynamics and complexity—in this case, the global climate system and its socio-economic interactions.

Four types of policies can be identified as adaptive:

- No regrets: policies that achieve desired objectives under a range of circumstances. In the climate change world, these policies have often been considered to be cost-effective investments in climate change mitigation.
- Triggers: policies that adjust automatically to changing circumstances. An example might be water pricing policies that change according to water supply (e.g. drought).
- Complex system: policies that derive from complexity theory, and which point towards effective intervention in multi-dimensional systems. An understanding of such policies will require investment in education and R and D.
- Review: policies that build-in review of prior policies and investment decisions.

Partnerships

Climate-resilient industry policy has a challenging agenda, demanding a high degree of knowledge, flexibility and social solidarity. While government must provide leadership, the primary form of governance and collective action should be partnerships between government, the private sector and civil society. All sectors are needed both to provide information and to undertake action, including the design and implementation of effective policy.

Tri-sector collaboration can take a variety of forms and have a variety of functions. At the macro level, an overarching "industry council" could be tasked with developing a comprehensive approach to investment and industry policy. One policy might be to promote micro-level "social business" partnerships that integrate environmental/climate and financial returns via credit, tax relief, business training, etc.

Climate Resilience in Three Development Models

The previous section sketched overarching objectives and policy design principles as foundational criteria for climate resilient industrial development paths. This section considers climate resilience in three development models: 1) neo-liberal globalization; 2) sustainable globalization; and 3) new developmental.

Neo-liberal globalization

The over-arching objective of the neo-liberal globalization development model is to increase the rate of economic growth measured as GNP (or GDP) per capita by market-based integration into the global economy. The primary policy prescriptions are

to maximize inflows of foreign direct investment (FDI) and integrate into global supply chains in which final products are generally exported to OECD countries. Economic growth promotes livelihoods directly by generating employment and indirectly by generating fiscal revenues for public goods such as education and health (Easterly 2002).

The fundamental design principle for industrial development in the neo-liberal model is to promote market forces. Pro-active industry policies are actively eschewed. The primary policy tools are liberalization, privatization and deregulation, as well as investment incentives aimed broadly at increasing the quantity of FDI inflows. Though apparently "neutral," neo-liberal industry policies tend to favor foreign investors and multinational corporations over local producers. They also give foreign investors maximum freedom over all aspects of business management (Rodrik 2007). Benefits to local productive capacities are assumed to come from knowledge and technology spillovers by MNCs, who also diffuse "best practice" environmental management standards to local producers (OECD, 2002).[2]

Rather than industrial diversification, the pursuit of comparative advantage is the primary route to economic and industrial growth in the neo-liberal globalization model. Developing countries are urged, for example, to specialize in low-wage manufacturing industries, monoculture primary commodities, and/or extractive industries. Investment plays a central role and the emphasis is on mobilizing private foreign capital. Indeed, the model could be renamed "FDI-led growth".

Finally, the neo-liberal globalization model treats the natural environment as exogenous to economic modeling and external to core industrial development goals. Generally, the environmental impacts of industry are conceived as externalities that can be ignored until incomes are higher. Rather than incorporating scientific knowledge and utilizing adaptive management to integrate and balance the twin objectives of economic growth and bio-physical resilience, the neo-liberal model emphasizes a singular policy tool-kit that aims to maximize efficiency and yield of commercial output.

The neo-liberal globalization model poses severe shortcomings for climate resilient development in terms of both mitigation and adaptation. First, a focus on GNP growth makes livelihoods secondary; an indirect outcome rather than the central objective of development. Moreover, the model virtually ignores bio-physical sustainability, creating a high level of livelihood vulnerability. Many studies have documented the reality of "jobless growth" and growth in commercial value at the expense of long-term resource productivity. Brooks et. al. (2009) provide a "dramatic example" from the Sahel:

> [D]evelopment policies in the 1950s and 1960s sought to achieve a shift from subsistence to commercial agriculture...to ensure that countries which were soon to be independent were capable of maintaining stable, functional national economies that were integrated into the world economy. The result was the intensification of agriculture, agricultural expansion into areas viewed as underutilized, the undermining of traditional risk-management measures and the marginalization of pastoralists. This all occurred during an usually wet period. When rainfall declined in the late 1960s, culminating in severe

> drought in the early 1970s, agriculture and pastoralism collapsed, resulting in a famine that killed hundreds of thousands of people and millions of animals, precipitating severe social disruption. Brooks et. al. (2009: 745)

The second shortcoming of the neo-liberal model lies in its "neutral" industry policies. A host of studies have shown that, in the absence of pro-active industry policy, FDI-led growth tends to promote industrial enclaves, rather than broad-based growth. The primary reason is that hoped-for knowledge, technology and human capital spillovers from MNCs have not materialized (Cordero and Paus 2008; Gallagher and Zarsky 2007; Hanson 2001; Jenkins 2006). Rather than seek local suppliers, MNCs source inputs globally, reducing potential contributions to sustainable livelihoods directly through employment and indirectly by inhibiting the growth of local enterprises with increased capacities for production and innovation. Besides creating livelihoods, such capacities are needed to promote a low-carbon transition rapid enough to stave off catastrophic climate change while simultaneously promoting sustainable livelihoods.

A third shortcoming is the neo-liberal model's emphasis on FDI as the primary source of investment in domestic industry. In addition to increasing vulnerability to exogenous disruption, FDI-led growth can retard the domestic financial reforms needed to mobilize domestic savings. Even in the poorest countries, pools of domestic savings are much bigger than foreign funds. In addition, tax "holidays" and other incentives minimize the contribution of MNCs to public funds. Both domestic savings and public funds are needed to mobilize the massive amounts of investment required for both climate mitigation and adaptation.

Another weakness of FDI-led growth is that it generates a competitive global bargaining context in which developing (and developed) countries are reluctant to raise and enforce local environmental standards or demand environmental conditionalities of MNCs, a phenomenon which I have elsewhere described as "stuck in the mud" (Zarsky 2004). The problem can be overcome only by global environmental standards that seek to internalize environmental externalities, such as carbon emissions. However, proponents of neo-liberal development -- including many developing country governments -- argue that global environmental standards, such as might be imposed in a global climate treaty aimed at reducing carbon emissions, obstruct development (i.e. growth) goals.

Citing the principles of state sovereignty and the right to development, as well as the purported environmental benefits of higher income as expounded in the "environmental Kuznets curve," they argue that developing countries should be free to set their own environmental standards. Combined with the reality that current atmospheric carbon concentrations are the historical responsibility of developed nations, this logic resulted in the distinction in the Kyoto Protocol between Annex I (developed) countries with obligations to reduce carbon emissions and Annex II (developing) countries with no specific mitigation obligations.

A final shortcoming of the neo-liberal model for climate resilience is that it puts MNCs singularly at the heart of industrial investment decisions that are likely to greatly affect the ability of local enterprises and communities to adapt to climate change. The

actual impacts of global climate change are highly uncertain and will unfold at local and regional levels. Collaborative governance is needed to determine climate-response actions, including potential trade-offs between reducing climate risk and increasing or maintaining economic growth.

The strength of the neo-liberal model lies in the potential role that foreign finance and FDI could play in promoting climate resilient industrial development. MNCs have significant financial, technological and management knowhow that could, given the right policy framework, be harnessed to promote bio-physically and socio-economically sustainable livelihoods. Mobilizing global capital markets for industry and infrastructure projects that reduce climate risk while promoting economic growth would help to fill the large need for adaptation financing.

Sustainable globalization

Building on the "corporate social responsibility" movement, progressive business leaders and Robert Zoellick, head of the World Bank, have recently called for a model of "inclusive and sustainable globalization" (WBCSD 2007; Zoellick 2008). This model shares many features of the neo-liberal model. The overarching objective remains increasing GNP growth by promoting FDI inflows through liberalization, deregulation and privatization policies, albeit with a more nuanced emphasis on integrating local producers into global supply chains (Moran 2006).

The sustainable globalization model has two distinctive features, both of which potentially contribute to climate resilience. The first is the call for environmental standards and objectives, including mitigation of carbon emissions, to be integrated into industry and business management. Two policy tools are recommended. First, global business firms are encouraged to voluntarily adopt "best practice" in all their production, distribution and marketing activities, wherever they are based. Second, the model explicitly recognizes the need for a global climate framework in which all states, developed and developing, shoulder obligations to reduce carbon emissions.

The second distinctive feature is the emphasis on the role of private-public partnerships (PPPs) to promote specific sustainable development objectives. Heavily promoted at the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, PPPs are emerging as a vehicle whereby global companies collaborate in specific capacity-building and infrastructure projects with local governments, international institutions, development groups, and other "development actors." The overwhelming number of WSSD Partnerships target water and sustainable energy projects (Biermann et. al. 2007).

In addition to helping deliver public goods, MNCs are also working in partnerships with governments and/or NGOs to promote enterprises for sustainable development, targeting especially the poorest income groups in developing countries (UNDP 2005b). The contribution of MNCs is either philanthropic, more recently called "social investment," or via core business activities through "social business" (Yunus

2007). Aimed at creating enterprises that are financially sustainable while serving the poor, such an approach can potentially achieve more in terms of climate resilient development than purely aid-driven initiatives. Off-grid sustainable energy and water enterprises, for example, are a fast growing sectors of MNC partnerships in social business (Figure 6). To date, however, social business has remained marginal to total MNC core business activity and to national development strategies.

Figure 6
Energiebeau: Partnering for off-grid energy

Energiebau is a mid-size German company providing and wholesaling solar electrification systems. In addition to serving customers in Germany and Europe, it delivers off-grid solar systems to remote communities, mostly in Africa. Energiebau partnered with the German capacity building development organisation InWEnt in a 1.1 million Euro public-private partnership to provide off-grid energy to rural communities. Local religious and community groups helped design and implement the project. The concept involves a village-level solar powered system supplemented by a generator in times of peak usage and bad weather. The generator is powered by locally cultivated jatropha oil, which provides income for local cultivators as well as energy fuel independence.

Source: Wilson et al (2008)

Despite its strengths, the sustainable globalization model has major weaknesses in terms of promoting climate resilient development. The primary weakness is that, despite innovations at the margin, it is based on the assumption that the combination of global environmental regulation, business goodwill, and global market forces can deliver sustainable development. Like the neo-liberal model, it promotes "neutral" industry policies that inhibit more muscular environmental commitments to channel paths of industry evolution (needed to mitigate climate change) and that have had limited results in nurturing local broad-based sustainable growth (needed to reduce vulnerability). Successful project-based PPPs that enhance local productive capacities provide pointers toward a new developmental model but remain sidelined until they are scaled up and incorporated into core thinking and policy about industrial development.

New developmentalism

A new developmental model has a different starting point than either neo-liberal or sustainable globalization models. While it aims to achieve GNP growth, the overarching objective is to promote endogenous productive and technological capacity, incorporated in the concepts of industrial transformation and diversification (Rodrik 2007). Moreover, unlike the neo-liberal and sustainable globalization models, which are rooted in a belief in the power of global market forces, new developmental models emphasize the centrality of local socio-economic and institutional landscapes in driving development outcomes. Countries which have adopted new developmental models, such as China, Singapore, and Brazil, generally have a better track record in terms of both

GNP and job growth than those like Mexico and the Philippines which have adopted a neo-liberal model (Amsden 2003; Evans 1995; Agosin and Meyer 2000).

Industry policy in new developmental models is based on the idea that governments must be pro-active to capture the benefits of global market forces, including spillovers from FDI, for industrial upgrading, transformation, and diversification. It is not the specific tools of industry policy—which span from performance requirements and credit subsidies to support for targeted research and development and investment in education and training—which make up the essence of new developmentalism. Rather, it is the commitment to determine what blend of industry-promotion policies are likely to work in a specific national context.

New developmentalism shares some features with "old" developmentalism based on import protection and export promotion. Both pro-actively use industry policy tools to nurture growth of targeted industries. However, the new developmental "broad-gauged" approach focuses more on overcoming market failures—including information and coordination--which inhibit industrial development (Stiglitz 2005). It also aims to work in partnership with MNCs to promote "quality" FDI; that is, investment in strategic industries and technologies. Finally, it looks to both domestic and export markets for possible industrial growth.

A new developmental framework offers several advantages over globalization-based models for climate resilient development. A strong and strategic role for government leadership in promoting industry could channel FDI, R&D, and public investment towards low-carbon and zero-carbon energy and industry growth. Moreover, the "embedded autonomy" framework of collaboration between government and the private sector provides partnership-based flexibility in adapting to changing climatic, as well as market, conditions (Evans 1995).

At the center of the new developmental model is the mobilization of domestic savings rather than foreign capital to promote industrial transformation (Bresser-Pereira, 2009). Nonetheless, foreign investment can play a strategic role in new developmental models, including by explicitly targeting low-carbon and other sustainable industries and technologies. For example, in December, 2007, China announced a "dramatic revision" of its foreign investment strategy, the "keystone" of which is an "emphasis on quality over quantity." The second of five new policies is:

> ...encouragement of investment in sustainable resources and environmental protection. Foreign investors are encouraged to support the newly implemented Circular Economy (i.e. sustainable development) and Cleaner Production policies, as well as invest in the area of environmental protection, sustainable resources and anti-pollution. The 2007 catalog greatly expands the list of encouraged investments in this area. On the other hand, foreign investment in high resource-use, high energy-use and high-pollution enterprises is restricted or prohibited.
>
> (Quoted in Dickinson 2007)

Despite its strengths, new development theory has three shortcomings in promoting climate resilience. The first is blindness to the natural environment. New developmental theorists generally have not integrated bio-physical constraints into development strategy and have ignored the potential interaction of industry and environmental, including climate policy. A large literature on "sustainable development" remains un-integrated into much new developmental thinking.

One exception is the work of "sustainability transition" researchers studying the interaction of global market forces and local institutions in promoting socio-technological innovations which point towards a more sustainable industrialization. In a study of cement and electronics industries, Rock et. al. (2009: 241) found that the "capitalist developmental states in East and Southeast Asia have been better able [than countries with neo-liberal policies] to harness global economic forces for technological and sustainability transitions through an openness to trade and investment and effective public–private institutions able to link cleaner technologies and environmental standards to production activities in firms."

The second shortcoming of the new developmental framework is that it does not explicitly target pro-poor growth, although it does focus on promoting employment. In all societies, poorer people, both urban and rural, are more vulnerable to risk in general and will be more vulnerable to climate risk. Moreover, the model is gender-blind, not differentiating between men and women in terms of capacities and constraints. Recent studies have shown that women are differentially and particularly vulnerable to climate change impacts, including food shortages due to drought or flooding and higher incidence of disease (Aguilar et. al. 2007). Women are also key agents of enterprise and resource management. To promote broad-based climate resilience, new development models will need to conceive of the poor as agents of enterprise and specifically adopt gender inclusive, pro-poor industry development policies.

The third shortcoming of the new developmental model for climate resilience is that its focus on social collaboration typically encompasses only (national) government and the private sector. A wider range of actors will be needed to chart a climate resilient trajectory of industrial development trajectory, including municipal governments, labor and community groups, international development organizations, and others. A summary of the conceptualization of climate resilience in the three development models is presented in Figure 7.

Figure 7

Climate resilience in three development models

	Development objectives	Industry policy	Diversification	Investment	Adaptive management	Partnerships
Climate resilience	Sustainable livelihoods Reduce climate risk (mitigation and adaptation)	Pro-active, targeted Promote local capacities for sustainable production and innovation Low carbon	Promote industry diversification Produce for local and export markets	Targeted, strategic Mobilizes domestic and foreign, public and private sources	Incorporates knowledge about local climactic conditions Adaptive management	Collaborative governance Private public partnerships Social business
Neo-liberal globalization	GNP growth Global economic integration	Neutral Promote FDI (spillovers)	Promote specialization Produce for export markets	Maximize FDI inflows Official aid		
Sustainable globalization	"Green" GNP growth Poverty alleviation Global economic integration	Neutral FDI spillovers Integrate in global supply chains	Promote specialization Produce for export markets	Maximize FDI inflows Social investment		Private public partnerships
New developmental	Industrialization Build-up of globally competitive domestic core manufacturing industries	Pro-active; targeted Promote local capacities for production Cleaner production technology	Promote industrial diversification Produce for export and local markets	Targeted. Strategic Mobilize domestic savings		Strategic collaboration with business

Source: Author conceptualization

Conclusion: From Models to Paths?

This paper has presented a theoretical framework to conceptualize the purpose and the practice of development given the imperative to mitigate and adapt to global change. It defined the objective of climate resilient development as the generation of local, broad-based productive capacities that can provide livelihoods that are environmentally and economically sustainable and that promote social solidarity. It outlined five principles for the design of industry policies that could nurture climate-resilient sustainable livelihoods and evaluated climate resilience in three current development models.

The paper has two central findings. First, aspects of climate resilience are embodied in each of the three models. The neo-liberal globalization model emphasizes the importance of mobilizing global capital for development, especially FDI. The sustainable globalization model highlights the importance of global carbon regulation, the potential role of business in reducing poverty, and the benefits of multi-stakeholder, tri-sector partnerships in designing and implementing industrial development projects and governance (Figure 7).

The second finding is that two elements of the new developmentalist model—the overarching objective to build endogenous productive capacity and its embrace of a strong role for government in industrial development—make it the most robust of the three models as a starting point for the design of climate resilient development paths. Without these two elements, it is highly unlikely that developing economies will develop on a low-carbon trajectory or that they will significantly reduce their vulnerability to intensifying climate instability.

A strong role for government in industrial development will require institutional reform and capacity-building, at both national and global levels. World trade rules have been built to facilitate the neo-liberal globalization model. WTO reform is urgently needed to define "policy space" for climate resilient industrial development, not least to avoid global trade wars. Nationally, governments need to invest in building the state managerial capacities of pro-active industry policies, especially in countries that have adopted the neo-liberal globalization model.

These two elements, however, are merely starting points. None of the models puts climate risk into the center of development planning. Global climate instability will have highly differential impacts, both spatially and temporally. Industrial development policies will need to be flexible and adaptive to local natural and institutional conditions. Climate-resilient development, in short, points not towards a singular "model" but a plurality of development paths. The work of understanding the theory and praxis of such paths has only just begun.

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2 A large literature has found little evidence that FDI generates "horizontal" knowledge spillovers, that is, to firms in the same industry, and mixed evidence that it generates "vertical", that is local supply chain, spill-overs (for a review, see Gallagher and Zarsky 2007:Paper 1). Pointing towards a more nuanced approach, a number of studies have found that local "absorptive capacities" are needed to capture FDI spillovers, including well-developed financial markets (Alfaro et. al. 2003), and technological capabilities in local supplier firms (Chudnovsky and Lopez 2010).

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