climate policy

synthesis article

Is industrialization still a viable development strategy for developing countries under climate change?

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The implications of climate change for economic development strategies in developing countries are explored, in particular whether industrialization still represents a viable development strategy in the context of climate change. Synthesizing the relevant literature and drawing insights from a comparison of Chinese and Indian experiences, it is argued that industrialization still represents an effective and, to some extent, indispensable development strategy, especially for those low- and low–middle-income countries that are affected by deindustrialization.

Keywords: climate change; deindustrialization; developing countries; development strategies; economic development; industrialization

L'incidence du changement climatique sur les stratégies de développement économique dans les pays en développement est examinée, à savoir en particulier si l'industrialisation représente toujours une stratégie de développement viable pour ces pays dans le contexte du changement climatique. Il est soutenu, à travers une synthèse de la littérature pertinente et d'aperçus tirés d'une comparaison entre expériences chinoises et indiennes, que l'industrialisation représente toujours une stratégie de développement efficace, et d'une certaine mesure indispensable, surtout dans les pays à revenus faibles et intermédiaires bas touchés par la désindustrialisation.

Mots clés : changement climatique; désindustrialisation; développement économique; industrialisation; pays en développement; stratégies de développement

1. Introduction

The implications of climate change for economic development strategies in developing countries are explored, in particular, whether industrialization – a traditional pathway of economic development and a focus of development economics – is still a viable development strategy for them. Prima facie, climate change appears to have made industrialization less desirable and viable in developing countries due to the emissions intensity of industrial activity. Despite appearances, it is argued, on the contrary, that climate change makes industrialization even more desirable for developing countries and, moreover, it remains viable if the right path is taken. Indeed, industrialization has a great deal of potential for building a low-carbon future, and wider and beneficial effects on other development goals (including those associated with climate change adaptation).

Since the publication of the IPCC Third Assessment Report (IPCC, 2001), there has been a growing consensus that climate change needs to be integrated into long-term development planning and policymaking due to the close links between climate change and development patterns (as demonstrated by studies such as the Special Report on Emission Scenarios (SRES) (Nakicenovic et al., 2000)). Often

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referred to as 'the mainstreaming challenge', this requires an understanding of the implications of climate change for development planning and strategies.

Part of the mainstreaming challenge lies in the fact that there is a lack of critical assessment of what is at stake. For instance, mainstreaming of mitigation is often treated separately from mainstreaming of adaptation (e.g. Agrawala, 2005; Adger et al., 2007; Sathaye et al., 2007). Existing works have focused on disparate and, arguably, marginal development issues. For example, an OECD (2005) study on mainstreaming examined such diverse areas as water resource management on the Nile in Egypt, coastal mangroves in Fiji and Bangladesh, glacier retreat and water resource management in Nepal, economic development and natural resource management on Mount Kilimanjaro in Tanzania, and forestry and agriculture in Uruguay. Such a fragmented and piecemeal approach is unlikely to help the cause of mainstreaming climate change, given the scope and magnitude of climate change and sustainable development challenges. Past experience of mainstreaming (e.g. of a gender perspective in development) shows that effective mainstreaming requires both an agenda setting (i.e. aiming to transform the development agenda itself) and an institutionalization (i.e. focusing on adapting institutional procedures to achieve the policy objective) approach (Reeves and Baden, 2000), and highlights the importance of addressing issues that are at the core of development strategies in developing countries.

With these issues in mind, the article proceeds as follows. Section 2 discusses three reasons why industrialization may be neither a desirable nor a viable development strategy. These include the significance of industry-related emissions, the implication of an emerging global carbon market and the current trend of deindustrialization among developing countries. Section 3 considers the effects of climate change and the challenges it poses for these countries in their pursuit of sustainable development. Three key policy issues are identified: the reduction of (i) emissions intensity, (ii) vulnerability and (iii) poverty. Section 4 gives a detailed assessment of the potential of industrialization to address these issues. It is concluded that industrialization, even for those that are affected by premature deindustrialization, still represents a viable and, to some extent, indispensable development strategy for developing countries in the context of climate change.

Before embarking on these discussions, however, it is necessary to make the meanings of our terminology clear. 'Industrialization' refers to a process in which the share of an industry (especially manufacturing) in both national income and employment increases within an economy (Dasgupta and Singh, 2006). Following Sen (1988), development is characterized by an all-encompassing improvement in the standard of living of the population, whereas sustainable development is, according to WCED (1987), the kind of development that meets the needs of the present generation, especially those living in poverty, without affecting the ability of future generations to meet their needs. In comparison, economic development is a particular aspect of the process of development, a means to development. It is characterized by sustained economic growth (therefore increased income and resources), transformation of the economic structure, improved technology and significant reduction of poverty (Schultz, 1953; Sen, 1983; Meier, 1995). Further elaboration of their relations is provided in Section 4.1.

2. Climate change, industrialization and development

The worry that industrialization may no longer be a viable development strategy, in the context of climate change, stems from three sources, as described in the following.

First, industry in developing countries may represent their single largest source of emissions. Developed countries are thus concerned about the rising level of these emissions. Table 1 shows that although industry's share in non-agricultural greenhouse gas (GHG) emissions in these countries has declined since 1970, it still accounted for 49.8% in 2000. This share is projected to rise to 51% in

TABLE 1 Historical and projected non-agricultural GHG emissions by developing countries

Year	CO_2 emissions (MtC)				Industry's share of total (%)	Developing countries' share in total non-agricultural emissions
	Industry	Building	Transport	Total		
1971	288	127	105	520	55.38	14.3
2000	1,016	593	430	2,039	49.83	34.5
2020 (A1)	3,147	1,361	1,668	6,176	50.96	53.2
2020 (B2)	2,001	833	1,019	3,853	51.93	44.0

Own calculation. 2020 (A1) and 2020 (B2) represent, respectively, projections for SRES A1 and SRES B2 scenarios. Developing countries here include centrally planned Asia, other Asia, Latin America, sub-Saharan Africa and Middle East/North Africa.
Source: Price et al. (2006).

2020 under the SRES A1 scenario family and 51.9% under the SRES B2 scenario family. Given the anti-industrialization sentiment among neoclassical economists (Pack, 1988), the growing pressure on developing countries to mitigate can easily be turned into pressure on them to slow down the rate of industrialization or indeed to deindustrialize.

Second, the emergence of a global carbon market – a result of either domestic legislations in developed countries (e.g. the US Climate Change Bill) or international treaties/agreements – is changing the trade environment for manufactured exports from developing countries. At the very least, complying with such legislation will increase the costs of these exports (*The Economist*, 2007). Successful industrialization in developing countries depends crucially on having access to markets in developed countries. Such access not only facilitates the transfer of technology and management skills, but also provides foreign exchange earnings for the purchase of necessary semi-components and capital goods, and creates substantial employment opportunities (e.g. Thirlwall, 2003). Currently, developing countries enjoy a significant comparative advantage in labour-intensive manufacturing because of their abundant, and relatively low-cost, labour resources. Because economic activities in developing countries are generally more emissions intensive (see Table 2), both their comparative advantage in emissions-intensive manufactured exports and their relative attraction for manufacturing activities in the domestic allocation of resources will be eroded by the introduction of a carbon price (Mattoo et al., 2009).

TABLE 2 Distribution of global GHG emissions[a] (2004)

Grouping	tCO_2e/cap	$kgCO_2e$/USGDP_{ppp(2000)}$	Share in global totals (%)		
			Population	GDP	Emissions
Annex I countries	16.1	0.683	19.7	56.6	46.4
Non-Annex I countries	4.2	1.055	80.3	43.4	53.6

[a]All Kyoto gases including those from land use.
Source: Rogner et al. (2007), p.106, Figure 1.4a and b.

Third, since the early 1990s, many developing countries have experienced deindustrialization, the opposite of industrialization. Of the 107 countries for which we could find data for an industrialization proxy indicator (i.e. change in manufacturing as a percentage of GDP), only 26 experienced positive industrialization. Eleven saw no change and the rest (70 countries) registered negative industrialization (i.e. deindustrialization). As Figure 1 shows, some of the most heavily deindustrializing economies are also the poorest ones. This phenomenon raises the question of whether industrialization is still a feasible strategy given the widespread deindustrialization among developing countries, especially poorer countries, as well as the need for mitigation.

These considerations raise prima facie doubt over the desirability and viability of industrialization.

3. Challenges for developing countries

3.1. The challenge of climate change

Climate change poses the challenges of mitigation and adaptation for mankind. With regard to mitigation, Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) states that the ultimate objective of the Convention is 'to achieve . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. In order to contain the costs of adaptation, constraining global mean temperature change to less than 2°C has been widely accepted as the most important climate protection goal (e.g. EC, 2007; UNDP, 2007). This requires stabilizing GHG concentrations at, or below, 400 ppm CO_2, or limiting global carbon emissions to about 3 billion tonnes by 2100 (equivalent to an 'emission budget' of 0.3 tonnes of carbon per capita or 1 metric tonne of CO_2e per capita) (Banuri et al., 2001:89). Consequently, global emissions levels must peak by 2015 and decline by 50–80% from 2000 to 2050 (IPCC, 2007). Such reductions will be impossible without drastic changes to the present mode of development: global GHG emissions have increased by 70% from 28.7 to 49 GtCO_2e between 1970 and 2004 (or 1.58% per annum on average).

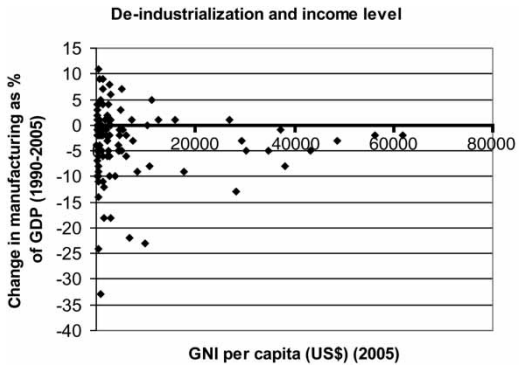

FIGURE 1 Trend of deindustrialization across countries, 1990–2005

Source: World Development Indicators. Own rendition.

So where should the changes be made? The influential Kaya identity states (Nakicenovic et al., 2000) that

$$\text{(KI1) } CO_2 \text{ emissions} = \text{population} \times (\text{GDP/population}) \times (\text{energy/GDP}) \times (CO_2 \text{ emissions/energy})$$

or, equivalently,

$$\text{(KI2) } CO_2 \text{ emissions} = \text{population} \times (\text{GDP/population}) \times (CO_2/\text{GDP})$$

The Kaya identity implies that the growth of CO_2 emissions is the sum of the rates of change in population, per capita income and the ratio of emissions to GDP (i.e. emissions intensity). To achieve a specific level of emissions reduction, increases in income level and population (which usually accompany economic growth) will need to be offset by decarbonization of at least the same magnitude.

From this perspective, mitigation represents a severe challenge for developing countries. As Table 2 shows, although their tCO_2e emissions per capita were only a quarter of those in Annex I countries as of 2004, these exceeded the 'emission budget' by a factor of 4 and were responsible for more than half of the total emissions. On the other hand, GHG emissions per unit of GDP (i.e. emissions intensity) were 50% higher in non-Annex I countries. This means that political and economic pressure on developing countries to mitigate climate change will grow. However, because their population and economic growth rates are generally higher than those in developed countries, to offset them, faster reductions in their emissions intensity will be needed in order to hold down the growth of total emissions.

Developing countries arguably face an even greater challenge in adaptation. Adaptation involves how we alter our behaviour in response to the effects of climate change and exploit potentially beneficial opportunities. Existing works on adaptation (e.g. Burton et al., 2006) tend to emphasize the reduction of vulnerability and the development of adaptive capacity. 'Vulnerability' is defined as 'the likelihood of injury, death, loss, disruption of livelihoods or other harm' (Eriksen and O'Brien, 2007:338), and has been formalized by Swart and Raes (2007) as the product of exposure and sensitivity to climate stimulus, divided by adaptive capacity. Adaptive capacity is itself dependent on economic resources, technology, information and skills, infrastructure, institutions and equity (Smit et al., 2001) – in other words, the level of development. Developing countries are at greater risk from climate change due to their geography (they are more exposed to climate change), their greater reliance on agriculture (they are more sensitive to climate change) and their lower adaptive capacity (due to their lower level of development) (Burton et al., 2006; McCarthy et al., 2001; World Bank, 2008a).

The above analysis supports the view that the expansion of non-agricultural activities and the process of development are generally beneficial for the reduction of vulnerability at the societal level. At the individual and household level, vulnerability is a function of poverty (Moser, 1998), broadly thought of as the inability to make favourable choices (Sen, 1988). Thus, vulnerability disproportionately affects the people whose livelihood or well-being is already undermined by a high incidence of poverty. In a developing world in which, as of 2005, a quarter of the population still lives in extreme poverty (World Bank, 2008b), the obvious implication is that effective adaptation is impossible without economic development, especially poverty reduction.

3.2. Implications for economic development in the south

The preceding discussion shows that to effectively address the challenge of climate change, developing countries need to simultaneously pursue three key policy objectives: the reduction of (i) emissions intensity, (ii) poverty and (iii) vulnerability. What kinds of development strategies have the greatest potential to deliver these reductions?

The SRES is relevant to the objective of reducing emissions intensity. It outlines a set of four alternative scenario 'families' comprising 40 SRES scenarios and is guided by the Kaya identity. Building upon a common set of driving forces – including global population growth, economic development, technological diffusion, energy systems and land use – the model does not assume the implementation of specific climate policies such as the UNFCCC or emission targets of the Kyoto Protocol. The SRES scenarios indicate a wide range of global CO_2 emission possibilities, ranging from less than 10 $GtCO_2$ to almost 35 $GtCO_2$ by 2100. The corresponding CO_2 concentration and global mean temperature increase (from 1990 to 2100) vary, respectively, from 500 to 1,000 ppm and from 1.3 to 5.8°C, with the B1 scenario family offering the lowest emissions level.

Table 3 summarizes the six illustrative SRES scenarios highlighted in the SRES and their drivers, and demonstrates a striking range of future possibilities. Four observations are appropriate. First, all other thing being equal, the A1 scenario family, which is characterized by fast economic and population growth, depends on the nature of the energy systems leading to either an extremely high level of emissions or an intermediate-to-low level of emissions. Second, combining a service-based economy with cleaner energy produces the B1 scenario family, with very low emissions (lower than the level of 1990). Third, a combination of intermediate growth rates for the economy and population and a lower degree of global convergence results in the B2 scenario family, characterized by a relatively low emissions level (one higher, though, than the level of 1990). Finally, the worst scenario family is A2, characterized by slow economic growth, fast population increase, less global convergence and a high level of emissions.

These contrasting scenario families suggest one conclusion: the rate of economic growth is not a decisive factor for mitigation. Much depends on the kind of energy systems developed and the economic structure in place, hence the linkage to economic development.

However, it would be a mistake to conclude from the SRES that developing economies should bypass industrialization in pursuit of a service-oriented economy. The literature on economic development, energy use and adaptation strongly supports the view that industrialization is an important stepping stone to both economic development and achieving the three policy objectives identified above.

4. Industrialization as a climate-hedging economic development strategy for developing countries

4.1. Economic development and industrialization

The concept of economic development is distinct from that of economic growth. Economic growth is the rate of change in the production level of goods and services, which is typically measured by the rate of change in per capita GDP. Economic growth over time affects average income level. In contrast, economic development is concerned with the enhancement of living standards and what people can achieve with the benefits provided by economic growth (Sen, 1988). The concept of economic growth is often criticized for failing to take into account important issues such as distribution and externality. However, studies in ecological economics suggest that although growth in numerous developed countries is now 'uneconomic' (i.e. increases in production come at the expense of resources and well-being that is worth more than the commodities made), it is still 'economic' in developing countries due to the prevalence of unmet basic wants (i.e. extreme poverty) (Daly, 2007).

TABLE 3 Emissions scenarios and drivers

Illustrative emissions scenarios	Approximate CO_2e concentrations (ppm)	Best estimate temperature change[a] (°C)	Key drivers of emissions					Underlying theme
			Economic growth	Economic structure	Population growth	Global convergence	Energy systems	
A1FI	1550	4.0	Fast		Peaks in mid-21st century, then declines	Fast	A1FI Fossil energy intensive	Convergence and reduced regional gaps
A1T	700	2.4					A1T Non-fossil energy sources	
A1B	850	2.8					A1B Balanced energy sources	
A2	1250	3.4	Slow		Continuously increasing	Slow		Self-reliance and preservation of local identities
B1	600	1.8	Fast	Towards a service and information economy	Same as A1		Cleaner technology	Global solutions to sustainability
B2	800	2.4	Intermediate		Similar to A2, but at a lower rate	Slower, more diverse than B1 and A1		Emphasis on local solutions, including equity

[a]At 2090–2099 relative to 1980–1999.
Sources: Own elaboration on the basis of Nakicenovic et al. (2000:22) and IPCC (2007:45).

Sen (1988) suggests that the process of economic development can be seen as a process of expanding the capabilities of people (i.e. the ability to do this or that), which in turn is based on people's entitlement or 'the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces'. He points out that such entitlements and capabilities would depend not only on the ownership of commodities, but also on the availability of public goods and the possibility of using private goods freely provided by the state (i.e. property rights). In particular, using the contrasting experiences of famine in modern China and India, Sen highlights the importance of a free press and political institutions in delivering developmental outcomes. He emphasizes that although economic growth is important, it is not enough, on its own, to achieve development. Other variables such as income distribution, provision of public goods, property rights and politics are important too.

Another important difference between the concepts of economic growth and economic development is their respective emphasis on the quantitative and qualitative aspects of economic change. While growth is the gradual extension of capital apparatus and increased production, according to Schumpeter (1934), economic development can occur only when technical innovation at firm level introduces new production techniques, products or means of organizing production, that is, when production factors are utilized in new ways. This means that economic development is characterized by a process of structural transformation and improved techniques of production at a macro-economic level (Meier, 1995).

Several influential studies (e.g. Kuznets, 1966; Chenery and Syrquin, 1986; Syrquin, 1988) covering newly industrializing countries, as well as today's developed countries, demonstrate that at an aggregate level, economic development follows a well-established pattern of structural changes, marked by the initial rise and eventual decline of industries. This pattern includes the following three phases: (i) primary production (when the production of primary goods, typically agricultural products, dominates the economy), (ii) industrialization and (iii) developed economy. The last phase is characterized by deindustrialization, when manufacturing's share in employment and then in GDP declines, while the weight of service industries continues to increase. From a comparative study of 38 countries, Chenery et al. (1986) find that, on average, per capita income rose during the course of industrialization from US$400 to $2,100 in 1970 (equivalent to $1,734 and $9,127 in 2007 prices).[1] Moreover, this increase results, to a large extent, from the relocation of production factors (most importantly, labour) from (less productive) agriculture to (more productive) manufacturing and service industries. Finally, the change in economic structure is accompanied by urbanization, a building up of social overhead (i.e. infrastructure), and a demographic transition towards a low-birth and low-death pattern of population growth.

These studies acknowledge that the existence of such broad structural transformation does not preclude alternative pathways of development at a more disaggregated level, thanks to the differences in national circumstances and resource endowment. Nevertheless, they show that the universality of such a transformation is not accidental. On the contrary, it is the result of fundamental economic forces: changes to consumption and trade patterns as income rises, and the relative efficiencies of the three key branches of the economy (i.e. primary, secondary and tertiary sectors). In particular, the universal effects of Engel's law[2] are considered as the most important factor for the decline of primary production, whereas trade and technology are found to be more important for the shift towards manufacturing (Syrquin, 1988).

Overall, industrialization is considered in development economics as the most dynamic phase of structural transformation, because of economies of scale, learning by doing and positive externality, which are believed to be uniquely associated with the manufacturing industry (e.g. Kaldor, 1966, 1978; Hirschman, 1968; Jacobs, 1984; Grübler, 1995; Thirlwall, 2003). Industrialization has been

found to be a very effective means of achieving economic growth. For instance, examining the rate of economic growth and the share of industry in national GDP among low- and middle-income countries[3] for 1960–1980, Sen (1988) finds that the top economic growth performers in both groups also happened to be among the countries with the highest share of industries in GDP. (The picture at the other end, that of low growth, was not, however, as clear.) More recently, analysing the statistics of 45 African countries in the period 1980–1996, Wells and Thirlwall (2003) find that the rate of GDP growth is strongly and positively related to the degree to which manufacturing grows faster than agriculture or services.

Industrialization has been noted for its wider developmental effects, ranging from balancing the external account and productive employment, to the development of infrastructure and progressive social institutions. Dasgupta and Singh (2006) argue that the manufacturing sector is crucially important for the external balance. For a developing country, although agriculture may be able to contribute towards the external balance in earlier stages, as per capita income rises (and due to very high income elasticity for manufactured goods at these income levels), the lack of a domestic manufacturing sector that is able to meet these demands will put serious pressure on the external balance. Equally, services could also contribute to the external balance. However, services are inherently less tradable, except for those that are provided by a relatively small number of well-trained workers. Even if agricultural and service exports and remittances from migrant workers could help the external balance, their effects on the development of the economy and society are considered to be less favourable than manufacturing. This is because these earnings do not have the same salutary effects on the development of long-lasting assets such as infrastructure and technological and managerial skills (Hirschman, 1968; Jacobs, 1984). Industrialization has also been linked to the development of progressive social institutions such as unions and more efficient government (Hirschman, 1968; World Bank, 1993; Evans and Staveteig, 2006).

Thus, for any sizeable country, a productive service-oriented economy can only develop when industrialization has substantially improved the technical efficiency of goods production, raised income, and improved the physical and human capital of society. The implication is that skipping industrialization at an earlier stage of economic development deprives a developing country, especially a sizeable one, of many of the benefits that industrialization brings.

4.2. Industrialization and climate change

There are at least three reasons why industrialization is even more important in the context of climate change. First, industrialization plays a crucial role in laying the foundation for the development of a low-carbon economy in terms of more economic resources, better infrastructure and stronger technological and human capabilities, all of which are important for mitigation and adaption (IPCC, 2007; Rogner et al., 2007). On the one hand, Grübler (1995) argues that industry has built in an 'inherent incentive structure' to minimize factor inputs, enabled by technological change. Based on his analysis of the historical trends of energy intensity and carbon intensity during different periods of the post-World War II era in a number of countries – including the US, UK, Japan, South Korea, Brazil and Nigeria – he shows that, with a few exceptions (e.g. Nigeria), a rising level of industrialization (measured by industrial value-added per capita) has been accompanied by consistent declines in both energy intensity and industrial carbon intensity. Focusing on the relationship between industrial development and technological innovation, Grübler argues that industry inherently moves in the direction of dematerialization (i.e. to reduce resource inputs per unit of economic activity) and decarbonization (i.e. to reduce emissions impact per unit of economic activity), and the real issue is 'how to accelerate such trends' (Grübler, 1995).

There is also some evidence that the effect of industrialization is likely to be favourable for the future trend of decarbonization among developing countries. For instance, Table 1 shows that a scenario of a higher share of industrial emissions in developing countries is not matched by them having a higher share of global non-agricultural emissions. Thus, in the B2 scenario family, a 52% share by industry in total non-agricultural emissions in 2020 results in a 44% share by developing countries in global non-agricultural emissions. In contrast, under scenario family A1, the respective figures are 50.96 and 53.2%. This is prima facie evidence that an increased share of industrial emissions, a likely outcome of industrialization, does not have to raise the share of developing countries in global emissions. A possible reason for these scenario results is that industrialization enables the reduction of emissions elsewhere in the urban economy (e.g. in building and transport), presumably by promoting faster technological upgrading and speedier development and deployment of cleaner energy sources than would otherwise occur.

For reasons explained in Section 4.1, a pathway through industrialization tends to endow society with more resources, as well as stronger human and physical capabilities with which to deal with the effects of climate change. The contrasting development experiences of China and India illustrate this point. Starting at a similar level of per capita GDP (see Table 4), both China and India have seen substantial economic

TABLE 4 Selected economic development indicators of China and India

Indicators	Countries	1990	2000	2005
CO_2 emissions intensity ($kgCO_2/US\$GDP_{ppp}$)	China	2.65	1.14	1.04
	India	0.93	0.76	0.58
GDP growth (annual %)	China	3.8	8.4	10.4
	India	5.5	4.0	9.4
Industrial value added (% of GDP)	China	41.3	45.9	47.7
	India	26.9	26.2	28.8
Service value added (% of GDP)	China	31.5	39.0	39.7
	India	43.8	50.5	52.2
GNI per capita (ppp$)	China	800	2,330	4,100
	India	860	1,500	2,220
Improved sanitation facilities, urban (% of urban population with access)	China	61	69	–
	India	44	49	–
Road paved (% of total roads)	China	72.1	86.7	–
	India	–	47.5	–
Life expectancy at birth (years)	China	68.3	71.4	72.6
	India	59.7	62.5	64.0
Mortality rate, under 5 (per 1,000)	China	45.4	39.6	25.4
	India	116.6	91.2	76.9
Percentage of population living on less than 2005ppp$ 1.25 per day[a]	China	60.2	35.6[b]	15.9
	India	51.3	44.8[b]	41.6

[a]From World Bank (2008b).
[b]For 1999.
'–' indicates data not available.
Source: World Development Indicators, online database.

growth since the early 1990s, at annual rates of 9.7 and 6.5%, respectively, in the period 1993–2004 (Bosworth and Collins, 2008). However, industry has played a much more important role in China than in India (47.7%, compared with 28.8% of GDP in 2005). Bosworth and Collins (2008) show that continuing industrialization in China has generated many more job opportunities for former agricultural workers, attracted much larger amounts of foreign direct investment, and underpinned faster productivity rises in both industry and agriculture. In comparison, as Table 4 shows, although India has done slightly better in output per worker in services, the differences in development achievements – ranging from life expectancy and mortality rate to infrastructure and poverty reduction – are much greater than the growth differential would suggest. India is significantly behind China in almost every area, and such differences will no doubt affect their capacities to mitigate and adapt.

There is a second reason why industrialization is even more important, given climate change. Although climate change has increased the urgency and difficulty of reducing poverty, industrialization is arguably still the most effective means to do so (Fukunishi et al., 2006). International experiences have shown that to lift a large number of people out of poverty, one of the essential ingredients is to provide the poor with the opportunities to use their most abundant asset, labour (World Bank, 1990). In this regard, labour-intensive, manufactured exports-oriented industrialization (the type commonly found in East Asia) has been shown to be particularly effective, because it enables the exploitation of a market much larger than the domestic market and also creates jobs for a significant number of semi-skilled labourers (World Bank, 1993). The important underlying factors here are the links among growth, employment and poverty reduction.

Recent studies show that economic growth is still fundamental to poverty reduction. For instance, Kraay (2006) shows that, among a sample of 92 countries (1950–1999), there is a one-to-one correlation between economic growth and an increase in the poor's income (with an R^2 of 0.49); in the long run (on average 9.7 years within the sample), economic growth explains 97% of the variance in poverty reduction. Moreover, Kraay shows that, despite the apparent co-existence between economic growth and rising income inequality in some cases, the positive effects of economic growth on poverty reduction are overwhelmingly positive and dominant. Coupled with the discussion of the effectiveness of industrialization in achieving economic growth in the previous section, this supports the view that industrialization is still a desirable pathway out of poverty.

In this connection, UNIDO (2004) points out that the kind of economic growth required (on average, 4% of annual growth in per capita GDP) to halve income poverty in sub-Saharan Africa, the most important millennium development goal, is only achievable with substantial structural change in the economy, namely that provided by industrialization. The contrast between China and India, as presented in Table 4, is again illustrative of the efficacy of industrialization for poverty reduction. Starting with a lower per capita GDP in 1990, China has managed to achieve much faster economic growth and greater reduction in poverty through the development of labour-intensive manufacturing exports and the attraction of substantial amounts of foreign direct investment (Bosworth and Collins, 2008). In fact, during the period 1990–2005, the share of population living in extreme poverty fell from 60.2 to 15.9% in China and from 51.3 to 41.6% in India (see Table 4).

A third reason is that industrialization can also fundamentally reduce vulnerability by diversifying the economy and promoting socio-economic features that underpin adaptive capacity, as discussed in Section 3. A study by Roberts and Parks (2007) is illustrative. Analysing the effects of more than 4,000 climate-related disasters across the world over the past two decades, they found that, when other factors are held constant, per capita GDP does not explain the trends in deaths and homelessness. Indeed, five other variables (income inequality (+), urban populations (−), coastal populations (+), press freedom (−) and property rights (−)) are far more consistent predictors of such effects than per capita GDP. Testing the hypothesis that 'the way a country is 'inserted' into the world economy bears

heavily upon its ability to cope with climate related disasters', the authors find that a narrow export base explains about one-third of homelessness, from one-seventh to one-third of deaths, and about 40% of national patterns that were affected by climate-related disasters. Robert and Parks contend that such a correlation reflects the fact that a narrow export base is often a legacy of an extractive colonial past, with distinctive characteristics ranging from declining terms of trade and deteriorating infrastructure to degraded natural environments, and weak and corrupted political institutions. This study shows how industrialization may effectively help reduce vulnerability by broadening the range of exports of a developing economy, helping to develop infrastructure and institutions, and enhancing urbanization.

To sum up, industrialization is still an important development strategy in the context of climate change. In contrast, deindustrialization at a low-income level will have serious negative effects (discussed in the next section).

4.3. Deindustrialization in developing countries

Deindustrialization, evidenced by a fall in the share of manufacturing employment or by an absolute fall in such employment (Dasgupta and Singh, 2006), has a number of causes. These include changing consumption patterns accompanying income rises (cf. Engel's law), differential productivity increases between industry (faster) and services (slower), trade specialization, and reduced manufacturing investment (Rowthorn and Ramaswamy, 1999). Deindustrialization is generally considered a normal development trend and largely unproblematic in developed countries, because these economies have the necessary skills, infrastructure and institutions to expand into a knowledge-based economy.

However, Dasgupta and Singh (2006) find that many low- and middle-income developing countries are currently deindustrializing at a level of per capita GDP much lower than is the case for today's developed countries, a phenomenon they describe as 'premature deindustrialization'. They identify two ideal types of premature deindustrialization since the 1980s: 'the 'Indian' type (where manufacturing employment is not expanding in the formal sector but is growing within a large informal sector, although there is nevertheless expansion of manufacturing products) and 'the 'Latin American and African' type (where contraction in manufacturing stops the economy from achieving its full potential of growth, employment and resource utilization). Dasgupta and Singh find that although the former is not as harmful as the latter, it is nevertheless characterized by a slow productivity rise and a limited scope for growth.

Premature deindustrialization has numerous negative effects on developing countries. It prevents faster economic growth and productivity increases, and also the creation of much needed productive industrial jobs. Moreover, the affected developing countries are probably unable to compensate for this shortfall by the growth of knowledge-based and high value-added services due to weaknesses in relevant skills and resources. Pieper (2000) finds that negative rates of productivity growth in the industrial sector are strongly associated with negative productivity growth for the economy as a whole, and vice versa. Moreover, slow industrial growth tends to lead to 'low road development' (productivity growth trades off with employment growth), while fast industrial growth tends to be associated with 'high road development' (simultaneously expanding employment and overall productivity growth).

Finally, in the context of climate change, because industry plays a decisive role in the development of the energy system and infrastructure, including energy-related infrastructure, premature deindustrialization will reduce the ability of these countries to mitigate and adapt effectively. Thus, developing countries need to engage in more industrialization (and hence less deindustrialization) in order to address climate change.

While industry currently produces a large amount of emissions, its expansion (i.e. industrialization) arguably represents an irreplaceable pathway to higher productivity and income levels, faster

technological progress (with greater potential of mitigation), and effective reductions of poverty and vulnerability, all of which are essential goals of climate policies and sustainable development. How can we resolve this apparent conflict? The Kaya identity, briefly discussed in Section 3.1, indicates that the only way to constrain the growth of emissions while allowing income and population growth is decarbonization (i.e. the reduction of emissions intensity). Industrialization thus has to be combined with decarbonization to remain a viable economic development strategy. The feasibility of this approach is examined below.

4.4. Is decarbonizing industrialization feasible?

However challenging it may sound, decarbonizing industrialization is more feasible than it appears. As Grübler (1995) argues, industry has an inherent ability to decarbonize. On the other hand, an important insight in the clean production literature is that 'new paths are always pioneered outside the dominant regions' (Robins and Kumar, 1999:78). Similar precedents include the US's invention of mass production of automobiles and Japan's pioneering of lean manufacturing.

Evidently, decarbonization is already happening in developing countries. For example, a study of mitigation experiences in six large developing countries (Brazil, China, India, Mexico, South Africa and Turkey) by Chandler et al. (2002) shows that efforts undertaken by these countries (mostly unrelated to climate change policies) have reduced their emissions growth over the past three decades (1970s–1990s) by approximately 300 million metric tonnes a year. More importantly, these countries have significant scope for further mitigation: experts have estimated that India could reduce projected emissions over the next 30 years by nearly a quarter, for less than $25 per tonne of carbon equivalent. Indeed, developing countries are projected to continue to reduce energy intensity quicker than developed countries because of the greater scope for structural transformation and improvement in energy use (IEA, 2007). Another encouraging sign is that, according to a recent HSBC report (Robins et al., 2009), China and South Korea (in their fiscal stimulus packages), not the US, lead the green investment league table in response to the global financial turmoil begun in 2007–2008. Chinese investment is more than double that of the US.

In addition, the transfer of technology and financial resources through the Clean Development Mechanism (CDM) under the Kyoto Protocol could effectively facilitate decarbonization in developing countries. Owing to the low level of technical development, the scope for emissions reduction is generally bigger, and the marginal cost of emissions reduction lower, in developing countries. Developing countries thus have more potential to reduce emissions than developed countries and are therefore attractive to foreign capital intending to exploit the emerging global carbon market. It is noteworthy that although it is still in its infancy, the carbon market is expanding fast and has the potential to transfer a large amount of financial and technical resources from developed to developing countries. As shown in Table 5, from 2005 to 2008, the total volume of emissions trading rose by a factor of almost 10, whereas the value of the transactions grew by more than a factor of 12, to reach $126 billion by 2008. In particular, the value of primary CDM projects, which represents the revenue received by developing countries through CDM, rose from $221 million in 2005 to $6,519 million in 2008. A significant proportion of this flow has been spent on the development of cleaner energy sources (Capoor and Ambrosi, 2007, 2009).

The contrasting experiences of China and India may provide reassurance to those who worry that calling for decarbonizing industrialization underestimates the difficulties of simultaneously reducing emissions intensity while seeking industrialization. As Table 4 and Figure 2 illustrate, China has, to a large extent, maintained a substantial industrial sector, while India has followed a different path. However, although China's emissions intensity in 2005, at 1.04 ($kgCO_2/US\$GDP_{ppp}$), was significantly

TABLE 5 Global carbon market: volumes and values in 2005–2008

	2005		2006		2007		2008	
	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)
Allowance	328	7,971	1,131	24,620	2,108	49,361	3,276	92,859
EU ETS	321	7,908	1,101	24,357	2,060	49,065	3,093	91,910
Project-based	382	2,894	508	5,477	636	8,195	463	7,210
Primary CDM	341	2,417	450	4,813	552	7,433	389	6,519
Secondary CDM	10	221	25	444	240	5,451	1,072	26,277
Total	710	10,864	1,639	30,098	2,984	63,007	4,811	126,345

Sources: Capoor and Ambrosi (2007, 2009).

higher than India's, at 0.58, the former has managed to reduce CO_2 emissions intensity by 60.75% between 1990 and 2005, compared with a reduction of 37.85% by the latter. Even in India, emissions intensity fell more substantially in 2000–2005, despite industrialization, than in 1990–2000 when the share of industry hardly increased.

Nevertheless, it should be acknowledged that pursuing industrialization in a decarbonizing world is a huge challenge. Interestingly, however, there is evidence that this may be more feasible for low emissions intensity developing countries (e.g. sub-Saharan African countries) than for high emissions intensity countries such as China or India. Using a computable general equilibrium model developed by the World Bank, Mattoo et al. (2009) explore different scenarios of a 30% emissions cut on manufacturing output and exports in developing countries. Their results show that the effects will be significant for high-carbon-intensity countries. For instance, combined with emissions tradability and transfers, a 30% emissions cut relative to projected business-as-usual levels in China and India will reduce their manufacturing output by 6–7%, and manufacturing exports by 9–11%. In contrast, the

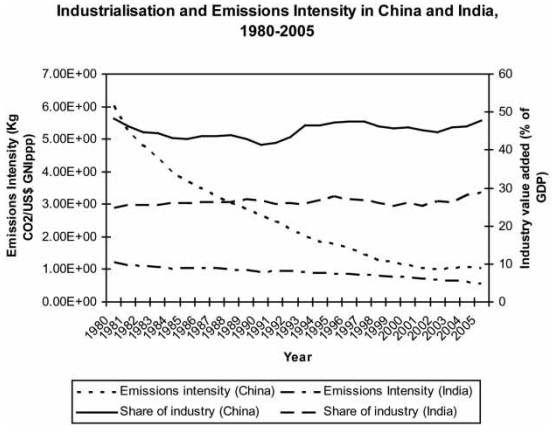

FIGURE 2 Changes in emissions intensity in China and India

Source: World Development Indicators, online database.

impact on sub-Saharan African manufacturing output and exports will be positive if the effects of the Dutch-disease type of mechanisms can be avoided.

5. Conclusions

The implications of climate change for economic development strategies in developing countries have been examined, focusing on whether industrialization is still a desirable and viable development strategy in the context of climate change. Through a synthesis of the literature and a comparison of Chinese and Indian (and other) experiences, it has been argued that industrialization does indeed constitute such a development strategy on the grounds that in a range of low- and low- to middle-income developing countries, industrialization has significant potential to simultaneously reduce emissions intensity, vulnerability and poverty, while deindustrialization reduces the prospects of doing so. Addressing climate change among developing countries does not require the abandonment of industrialization, nor indeed premature deindustrialization. On the contrary, if anything, the reality of climate change justifies the reversal of the current deindustrialization trends among lower- and middle-income countries. Indeed, the potential of industrialization for driving decarbonization, eliminating extreme poverty and minimizing vulnerability in developing countries needs to be explored further and more proactively than it currently is. Needless to say, more research is needed on this important issue. For the time being, the view that industrialization is a desirable and viable development strategy for developing countries is best treated as a hypothesis in need of further testing.

Notes

1. The 2007 amounts are calculated by using the GDP deflator provided on www.measuringworth.com/uscompare/.
2. Engel's law states that as income level rises, both food consumption and total private consumption as a percentage of GDP decline. These 'imply a shift in demand away from agricultural goods and to industrial commodities and nontradables' (Syrquin, 1988:231).
3. These include all countries listed in the World Development Report 1982's low- and middle-income categories, other than those with less than 10 million populations, members of OPEC, and countries without GNP or GDP growth figures.

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