Evaluating the CDM in a changing world:

The global economy and emissions since 1997

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List of abbreviations

BAU	Business-as-usual
CDM	Clean Development Mechanism
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
PPMV	Parts Per Million by Volume

The Clean Development Mechanism (CDM) is the child of a different era. Much has changed since the Kyoto Protocol was adopted in 1997, and the Panel must consider whether the CDM is still relevant, and – if it is – which features of the CDM should be retained, reinvented or retired. Economic circumstances, including the magnitude and distribution of economic growth, are an important contextual consideration. This short paper outlines key changes to the economic context since 1997.[1,2]

1. The mitigation challenge

To fully appreciate the importance of mitigation policy, it is useful to quickly review the scale of the climate change challenge.

When the Intergovernmental Panel on Climate Change (IPCC) wrote its 2007 report, it noted that of the twelve years between 1995 and 2006, eleven were among the hottest on record (according to global surface temperature) (IPCC, 2007c). More recently, the National Oceanic and Atmospheric Administration observed that the eleven years between 2001 and 2011 rank among the 13 warmest in the 132 years on record (NOAA, 2011). These trends in global average temperatures highlight the growing urgency of the mitigation challenge.

The measures required to mitigate climate change involve dramatic changes to our global emissions profile. The most ambitious scenarios considered by the IPCC could limit mean global temperature increases to 2-2.4 degrees Celsius above pre-industrial levels. Using 'best estimate' assumptions about climate sensitivity, the IPCC suggest that a target of 2 degrees warming requires stabilisation at around 450ppmv CO_2-equivalent and for global emissions to peak by 2015. By 2050, global emissions need to be equivalent to 50 percent of 2007 levels. Limiting the expected temperature increase to 2.4-2.8 degrees Celsius requires emissions to peak by 2020, and for emissions to be 30 percent below 1997 levels by 2020 (IPCC, 2007b).[3]

CO_2 concentration at stabilisation	**CO_2-e concentration at stabilisation**	**Peaking year for CO_2 emissions**	**Change in global CO_2 emissions (% 2000 emissions)**	**Global ave. Temp increase above pre-industrial**
ppm	**ppm**	**Year**	**Percent**	**Degrees Celsius**
350-400	445-490	2000-2015	-85 to -50	2.0-2.4
400-440	490-535	2000-2020	-60 to -30	2.4-2.8
440-485	535-590	2010-2030	-30 to +5	2.8-3.2
485-570	590-710	2020-2060	+10 to +60	3.2-4.0

Table 1: Greenhouse gas concentrations and associated expected temperature increases
Extract from IPCC, 2007b, p 198.

Radical CO_2 emissions cuts are required to achieve Parties' 2 degrees objective and to avoid dangerous climate change.[4] In 2007 the IPCC argued that existing mitigation measures under the UNFCCC and Kyoto Protocol are inadequate if we wish to reverse overall greenhouse gas emission

[1] This paper is a review of other work, and the analysis is not always tailored exactly to the 1997-2012 timeframe.
[2] References are provided for those Panel members who wish to pursue calculations and methodologies in more detail.
[3] This analysis does not factor in the possibility of climate feedback. Climate feedback occurs when the absorption and release rates of carbon sinks are altered by changes in the physical environment. The climate feedback process is expected to increase the concentration of carbon in the atmosphere.
[4] Parties to the Copenhagen Accord pledged their support for a target to limit global warming to 2 degree Celsius.

trends (IPCC, 2007a). The following sections of this paper suggest that global economic growth is aggravating the gap between "business as usual" (BAU) greenhouse gas (GHG) emissions and an emissions trajectory that avoids unacceptable and dangerous warming of the earth.

2. Why economic circumstances matter

There is a positive correlation between countries' per capita income and per capita emissions.

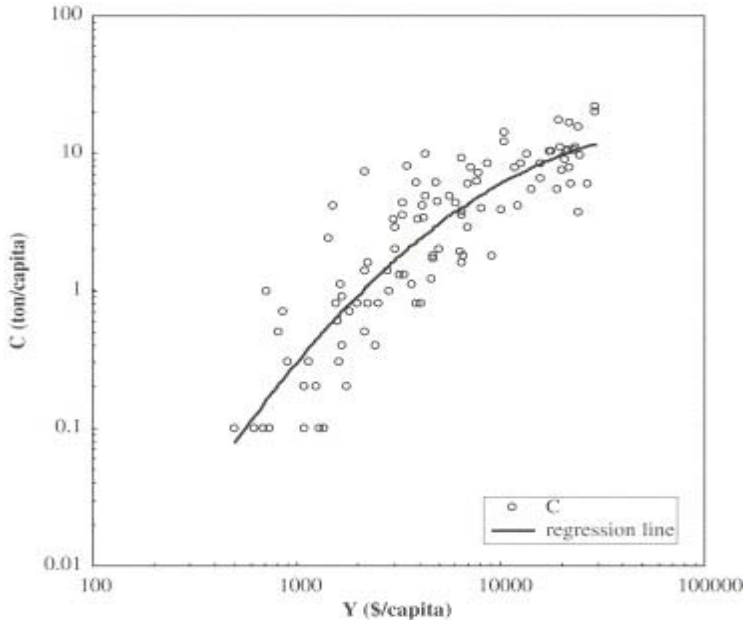


Diagram 1: Correlation between income and carbon emissions per capita
Source: Ang and Liu (2006)

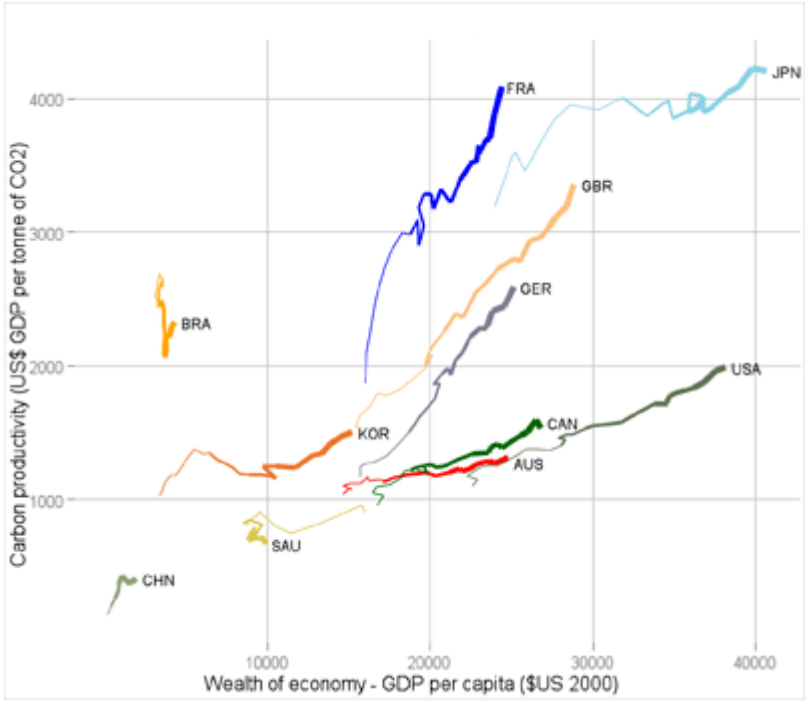
Although the correlation is clear, the relationship between economic growth and emissions is complex. Emissions are often described as a function of population levels, peoples' wealth, and technology (as per the IPCC, 2000).[5] 'Technology' describes the carbon intensity of production, which is determined by of the energy intensity of production, and the carbon intensity of the energy supply. Emissions are therefore a function of compounding pressures, and the balance of pressures can change through time. During the last three decades of the 20th Century, energy consumption and greenhouse gas emissions were driven by economic growth and population growth. These factors outweighed the effects of declining carbon intensity of production, and so global emissions continued to rise (IPCC, 2007c). Between their Third and Fourth Assessment Reports (in 2001 and 2007 respectively), the IPCC revised their population projections downwards, but in the Fourth Assessment predicted that other drivers of emissions will largely offset the impact of reduced population growth (IPCC 2007b; IPCC 2007a).

Economic growth is essential to the quality of life for most citizens of developing countries. If we wish to reduce global emissions and encourage growth, we rely heavily on adjustments to the GHG-intensity of production. If net global growth exceeds our expectations, or if economic growth occurs in populous countries (such that 'population' and 'affluence' interact), we will need to demand even more radical changes to the GHG intensity of production than we expected. Since 1997 it has become

[5] The IPCC (2007 presents the simple 'IPAT' equation to illustrate how economic growth affects the environment, including GHG emissions: Impact (I) = Population (P) × Affluence (A) × Technology (T). The IPAT equation is overly simple, but is a useful conceptual device for structuring analysis of greenhouse gas emissions. This relationship is also known as the Kaya Identity.

increasingly clear that we are experiencing both phenomena, and it is likely that these circumstances will persist in the immediate and medium-term future.

There is an extensive body of research that explores the relationship between growth and GHG emissions. There have been many attempts to econometrically establish the direction of causality between economic growth and emissions, with different empirical techniques and data sets yielding conflicting results (see Chiou-Wei et al, 2008, for a summary). Other research focuses on estimates of the relationship between per-capita income and per-capita emissions at a national or global level, often motivated by the concept of the Kuznet's curve (see Müller-Fürstenberger et al (2004) for a summary and critique of this econometric literature)[6]. Researchers have also documented and explored the variation in countries' or sectors' emissions intensity of production.[7]



Carbon productivity = Energy productivity (GDP/unit energy) × Carbon intensity (unit energy/tonne CO_2)

Diagram 2: Variation in carbon productivity across selected countries
Reproduced with minor adjustments
Source: Vivid Economics and Norton Rose, 2011

A higher level of carbon productivity helps alleviate the tension between economic growth and climate change mitigation, and is therefore critical if the global community wishes to pursue both goals.[8] Researchers can exploit variations across countries to isolate and study structural influences on carbon productivity. The sectoral composition of growth strongly influences production patterns, and

[6] The Carbon Kuznet's Curve is a hypothesised relationship between per capita income and emissions, and traces out an inverted-U shaped arc. This suggests that beyond some income thresh-hold, carbon emissions per capita start (and continue) to decrease.
[7] For a summary of carbon intensity of sectors and across countries, see Appendix Table 7 in Mattoo et al, 2008.
[8] Michaelowa and Michaelowa (2009) suggest an alternative conceptual framework, in which Human Development Indicators (HDI) are adopted as a policy goal, rather than growth in Gross Domestic Product (or Income). They demonstrate that moderate levels of HDI can be achieved with minimal growth in emissions. They suggest that growth in HDI (up to a point) can be more effectively decoupled from emissions growth than growth measured in GDP. This is because HDI improvements are possible without a "consumption age" and heavy industry.

therefore the carbon intensity of growth. In particular, an expansion of the industrial sector has historically been linked to dramatic increases in GHG emissions (Michaelowa and Micahelowa, 2009).

Given the relationship between economic growth and GHG emissions, it is useful to summarise key features of the global economy since 1997. If the distribution of growth and wealth is changing, this has implications for emissions profiles and for the broader political discussion about climate change and mitigation. Article 3 of the UNFCCC states that "parties should protect the climate system... in accordance with their common but differentiated responsibility and respective capabilities. Accordingly, developed countries should take the lead in combating climate change and the adverse effects thereof." The Kyoto Protocol – and the CDM – reflect the global economic structure in 1997. It is important to evaluate the CDM and countries' mitigation commitments in light of changes to the global economy.

3. The global economy since 1997

Since 1997 the global economy has been characterised by one dramatic trend and one dramatic event. The strong growth of middle-income countries was already evident in 1997, but this has become even more pronounced over the 1997-2012 period.[9] For some middle income countries this trend - like broader global growth - was interrupted by the 2008-09 Global Financial Crisis.

3.1 The continuing rise of middle-income countries

By 1997, many middle-income countries had enjoyed a period of solid growth. Industrial development had played an important role in the economic growth of countries including China, Taiwan Province of China (Taiwan) and Indonesia (UNDESA, 2007).

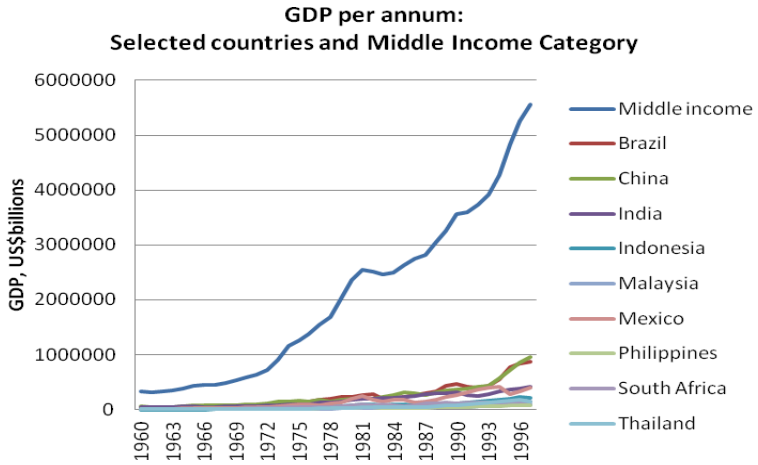


Diagram 3: Growth in Middle-Income countries' GDP, 1960 to 1997
Source: World Bank Indicators, accessed May 2012

This trend was interrupted in South East Asian countries between 1997 and 1999, when the Asian Financial Crisis had a major impact on growth rates. Thailand, South Korea, Indonesia and Malaysia were the most adversely impacted (Haggard, 2000).

[9] Unless otherwise specified I will use the World Bank's categorisation of countries according to annual Gross National Income (GNI, 2010 data), which is measured in $USD. Countries are classified as follows: low income: $1,005 or less; lower middle income, $USD 1006-$3975; upper middle income $3,976-$21,275; high income: $12,276 or more.

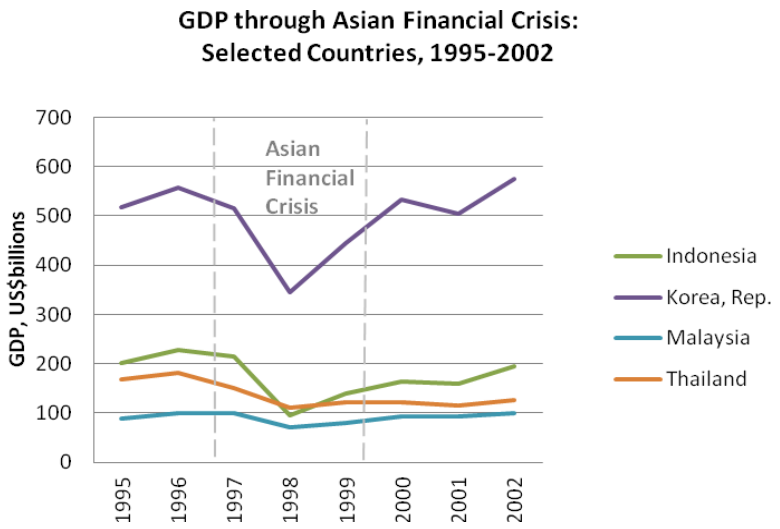


Diagram 4: The impact of the Asian Financial Crisis, selected countries.
Source: World Bank Indicators, accessed May 2012

However, the effects of the Asian Financial Crisis were reasonably well contained geographically, and through the late 20th Century growth recovered. The early years of the twenty-first century brought the most widely based and rapid economic growth that the world has experienced (Garnaut, 2009). This economic expansion was driven by growth in populous countries, led by China, with Indonesia, India and others following suit. Across the cusp of the twentieth and twenty-first centuries, more people were elevated from poverty than ever before, and in a relatively short period (Garnaut, 2009).

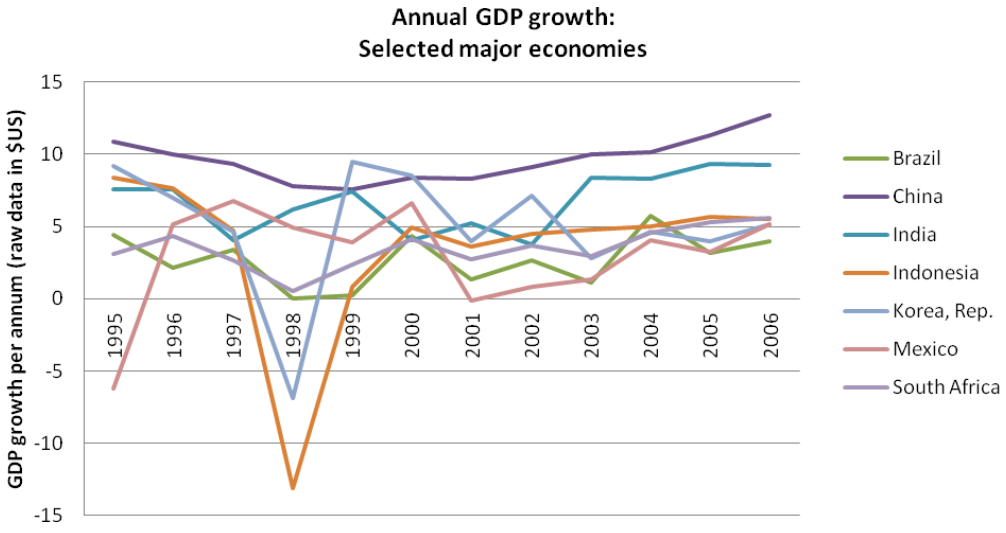


Diagram 5: Before and after the Asian Financial Crisis:
Positive growth in substantial middle-income countries and Korea
Source: World Bank Indicators, accessed May 2012

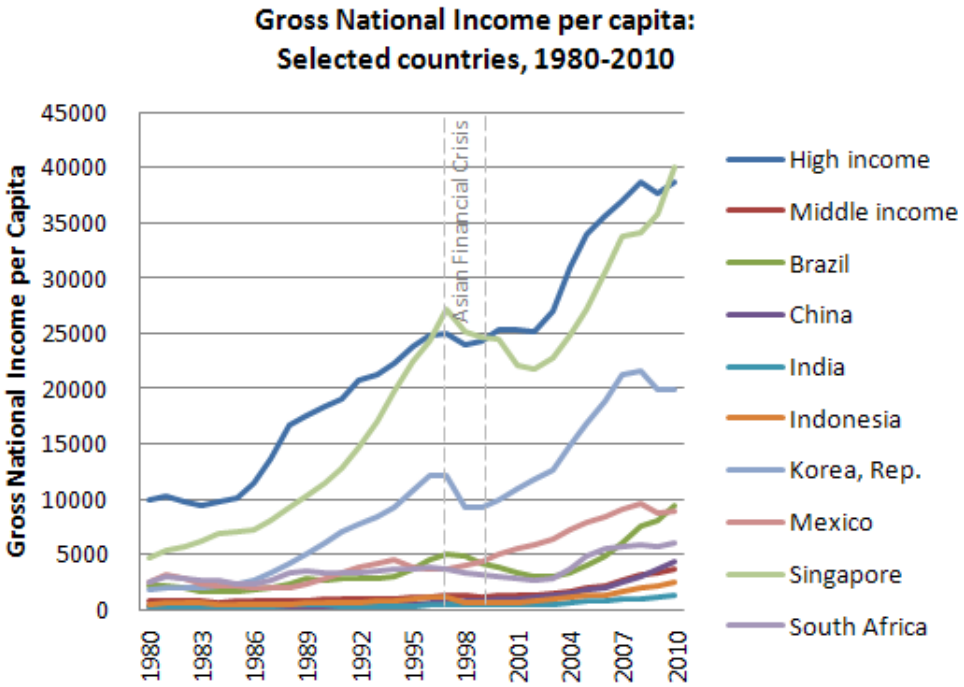


Diagram 6: Income per capita, 1980 - 2010: selected countries and country groups
Source: World Bank Indicators, accessed May 2012

China, India, Indonesia and Brazil are four of the five's most populous countries, and in 2010 represented nearly 3 billion of the world's approximately 6.8 billion people. Between 1997 and 2010 average annual economic growth across these four middle-income countries exceeded 3 percent per annum. However, even stronger growth was concentrated in the two most populous countries. China and India's joint population approximates 2.5 billion people, and in both countries average Gross Domestic Product (GDP) growth exceeded 7 percent per annum between 1997 and 2010: China's average growth was 9.8 percent per annum over this period; India's was 7.3 percent. In India, this lifted gross national income per capita from US$400 per capita in 1997 to US$1270 in 2010. In China the impact was even more pronounced, with an increase in per capita income from US$750 to US$4270 over the same period. Across middle-income countries more generally, an average growth rate exceeding 5 percent per annum saw gross national income per capita climb from US$1282 to US$3726.

The continued growth of middle-income economies stands out as the defining trend of the period since 1997, with many millions of people lifted from poverty as these economies have expanded.

3.2 The Global Financial Crisis

Through the early 21st Century, some of the savings from the rapidly growing middle-income countries, together with savings from oil exporting countries, were supplied as credit to north America, Europe and Australia. As a proportion of these economies, the surpluses and deficits were the largest in modern history. Coinciding with these new patterns of lending and borrowing was an emerging era of 'shadow banking,' characterised by financial instruments designed to carve up and shift around risk (Garnaut, 2009). Before they emerged as Collateralised Debt Obligations (and other, more complex products), these instruments were sub-prime (high-risk) mortgages.

In 2007, global output grew by 5.2 percent, with developing countries growing at an impressive 8.3 percent. China's output grew at 13 percent, and India's at 9.3 percent (Garnaut 2009).

Macroeconomic variables appeared consistent with strong growth in upper-middle income countries, and moderate growth in high-income countries. However, with benefit of hindsight, America's National Bureau of Economic Research points to the end of 2007 as the beginning of a US recession, although output did not decline until early 2008. Output in Japan and parts of Europe also began to fall at the close of 2007, although this was also disguised by strong growth up to that point. On September 7 2008, two US government-sponsored mortgage associations - Fannie Mae and Freddie Mac - were taken into conservatorship. One week later, Lehman Brothers Holdings declared bankruptcy. As market uncertainty grew, the global movement and supply of capital seized up. During 2008 and 2009 the global economy experienced a significant contraction, widely referred to as the Global Financial Crisis or the Great Crash (Garnaut, 2009).

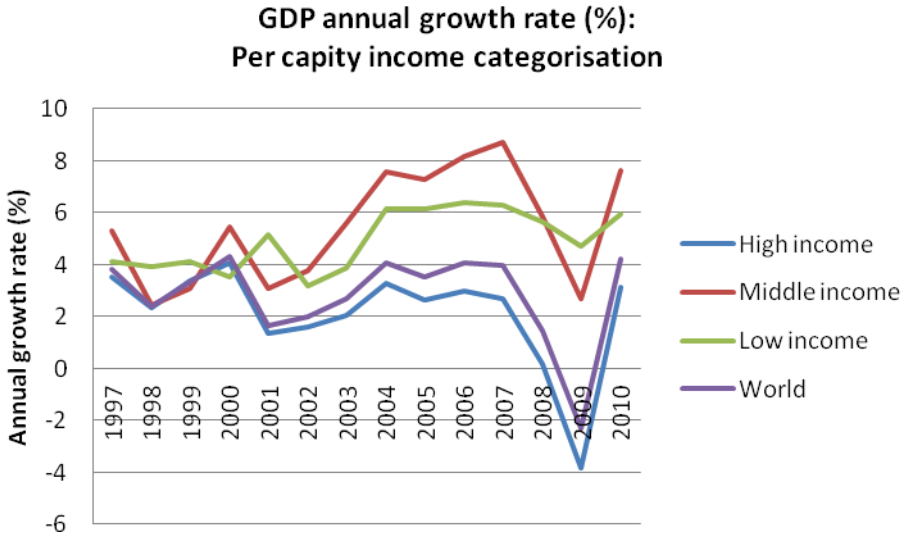


Diagram 7: Growth rates classified according to countries' income per capita, 1997-2010
Source: World Bank Indicators, accessed May 2012

From September 2008 through to mid-2009, the decline in global production exceeded any measured global decline over a comparable period, including the early stages of the Great Depression. Between 2007 and 2009, economic output in developed countries contracted by 2.7 percentage points (Garnaut, 2009). The economic slowdown was particularly pronounced in Japan and the European Union. Governments incurred huge costs to prop up non-bank and bank lenders through North America, Europe and Australia, and these costs have reduced, and will continue to reduce, governments' scope to employ fiscal stimulus measures. The high cost of credit has triggered a deeper malaise through the Euro Zone, and in 2012 the United Kingdom formally entered a double-dip recession. The US economy is currently managing low levels of GDP growth, but investor and business confidence is shaky, and unemployment remains high at 8.2 per cent (versus 4.4 per cent in October 2006) (U.S. Bureau of Labour Statistics, 2012).

In East Asia, the economic decline over the first six months after September 2008 was more pronounced than over the equivalent period of the Asian Financial Crisis (World Bank, 2011). However, despite the fall in middle-income growth rates, the contraction did not impact as deeply or for as long as in high-income economies. Indeed, as a group, growth remained positive, with Indonesia maintaining a growth rate of about 5 percent throughout the Crisis. Led by China and India, the middle-income economies returned to strong growth, with Brazil and other large economies following suit (Garnaut 2009; Garnaut 2011). In East Asia, the post-Crisis rebound was faster than the

recovery from the Asian Financial Crisis, and in 2011, real GDP and industrial production exceeded pre-Crisis levels in East Asia (World Bank, 2011).

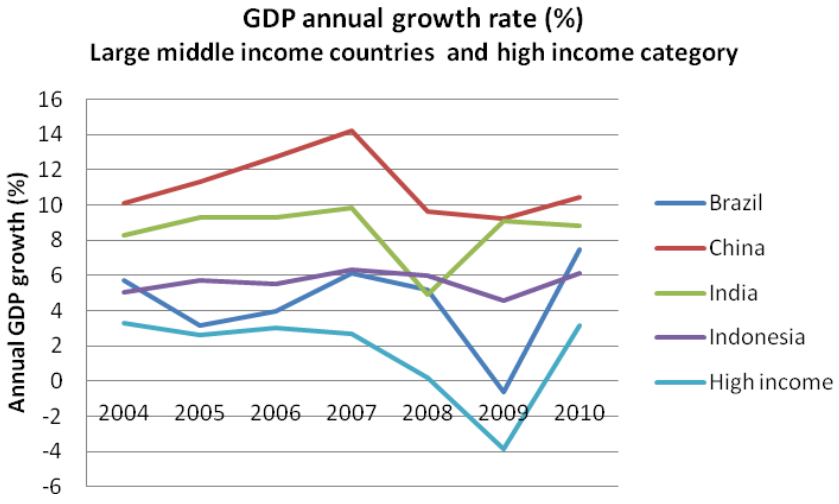


Diagram 8: Growth rates for selected large middle-income countries and high-income countries
Source: World Bank Indicators, accessed May 2012

The Global Financial Crisis further redistributed the balance of growth from high-income countries to populous, middle-income countries, and developing countries' share of global GDP continues to rise steadily (World Bank, 2011).

4. Emissions trends since 1997

The growth in global emissions since 2000 has exceeded the most fossil-fuel intensive scenario considered by the IPCC in the late 1990s (Raupach et al, 2007). During the 1990s the annual average growth of $C0_2$ emissions from fossil fuel was 1.3 percent per annum. Between 2000 and 2007, the average annual growth rate of emissions jumped to 3.3 percent per annum. This was driven by growth in the world economy and an increase in the carbon intensity of production (Canadell et al, 2007). Between 1970 and 2000, the carbon intensity of gross world production declined from 0.35 kilograms of carbon per dollar (1970) to 0.24 kilograms per dollar (2000). This promising trend was reversed between 2000 and 2007, when carbon intensity increased approximately 0.3 percent per annum (Canadell et al, 2007). The carbon intensity of energy has remained nearly constant or has increased slightly in both developed and developing countries (Raupach et. al, 2007).

These aggregate figures obscure substantial shifts in the global distribution of GHG emissions, which mimicked the redistribution of economic growth. The rising carbon intensity of production reflects the industrialisation of middle-income economies and their dependence on carbon-intensive energy supplies: many of the rapidly developing economies are well endowed with emissions-intensive coal (Garnaut, 2009). The relocation of energy-intensive sectors of production from developed to developing countries has thus contributed significantly to the reallocation of the global emissions share (Raupach et. al., 2007). Some of the rapidly developing countries are among the World's most populous, and their rapid and GHG-intensive growth has interacted with the population effect to increase GHG emissions (Canadell et al, 2007, Raupach et al, 2007).

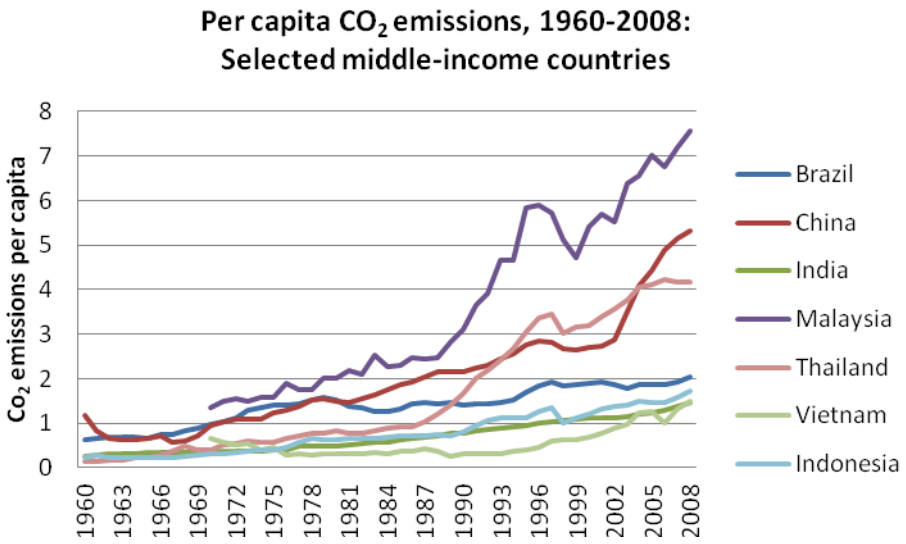


Diagram 9: Per capita $C0_2$ emissions
Source: World Bank Indicators, accessed May 2012

During and after the crisis, GHG emissions fell in those countries most adversely impacted, while countries that were not affected as badly, or recovered more quickly, generated increasing emissions profiles. In 2009 the emissions of Annex-1 countries fell by 6.5 percent, equivalent to about 6.4 percent below collective emissions in 1990. For those countries participating in the Protocol, emissions were approximately 14.7 percent below 1990 levels. Within non-Annex-1 countries, emissions grew at 3.3 percent (IEA, 2011). Recent research published in *Nature: Climate Change* suggests that global emissions trends have returned to the trajectories established prior to the Global Financial Crisis (Peters et. al., 2011). The global carbon intensity of production also continues to rise, but at a lower rate than CO_2 emissions (Peters et. al., 2011).

The recent strength of emissions growth in middle-income countries has more than offset the decline and slowdown in others. This growth is partly due to the post-Crisis economic recovery, and partly due to the emissions intensity of economic expansion.

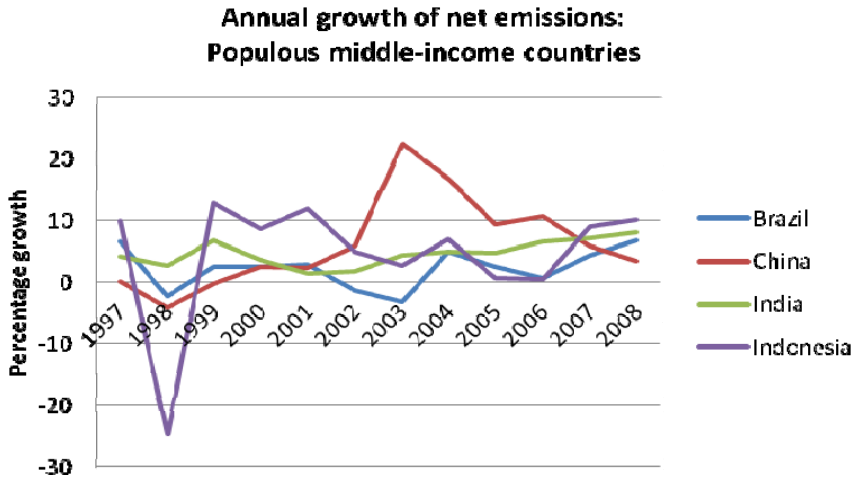


Diagram 10: Annual emissions growth, selected countries.
Source: World Bank Indicators, accessed May 2012

Experts expected that developed-country emissions would continue to exceed developing-country emissions until about 2015 (Peters et. al, 2012). However, in 2009, total emissions from non-Annex-1 countries increased to 54 percent of the global total (excluding bunkers) (IEA, 2011), and developing nations came to represent the majority of the carbon footprint of global consumption (Peters et. al, 2012).

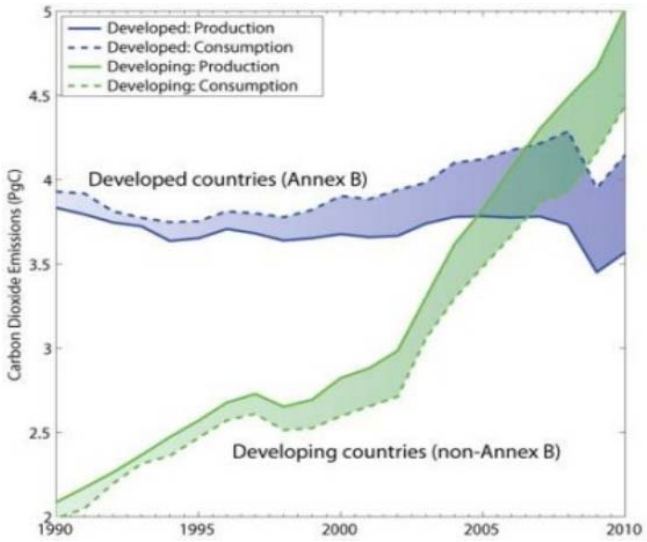


Diagram 11: Carbon dioxide emissions for developed and developing countries, 1990-2010
Source: Peters et al, 2012

Developing economies now contribute the majority of the world's emissions, in net terms. Per capita emissions are well below those of developed countries, but are rising.

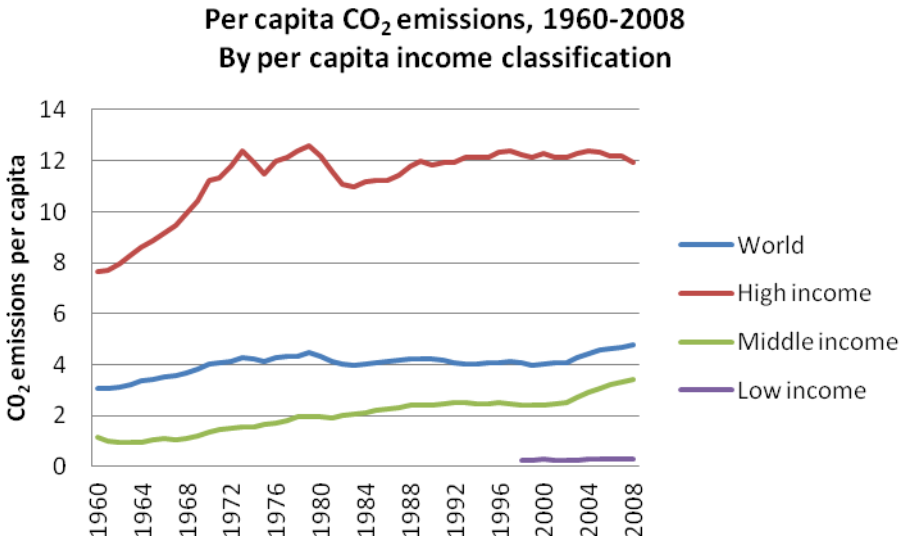


Diagram 12: Per capita carbon emissions: per capita income classification
Source: World Bank Indicators, accessed May 2012

With the majority of net emissions and emissions growth concentrated in large middle-income countries, it is no longer possible to achieve the necessary reductions to global emissions without

serious participaton by these countries. The costs of mitigation can be reduced if middle-income countries can act early enough to avoid the 'lock-in' effects of GHG-intensive infrastructure; there are therefore economic as well as environmental reasons to undertake mitigation efforts sooner rather than later (IPCC, 2007b).

Per-capita emissions in high-income countries vastly exceed those of the middle income countries. Despite the recent drop in per-capita emissions in high-income countries, this decline is marginal relative to the reductions that are required to avoid dangerous climate change. The Global Financial Crash and subsequent recession has reduced BAU predictions for high-income economies. This potentially reduces the opportunity costs of introducing processes and infrastructure that are consistent with a lower emissions trajectory. Just as middle-income countries can sieze the opportunity to avoid future costs, high-income economies can capitalise on the unexpected opportunities that exist during anotherwise difficult economic period.

5. Trends in the longer term

The central growth projections of the US Department of Energy, the International Energy Association and the World Bank all expect average global growth rates of around 1.5-1.9 percent to 2030, which is an estimate that falls in the middle of the range of the IPCC's Special Report on Emissions Scenarios.

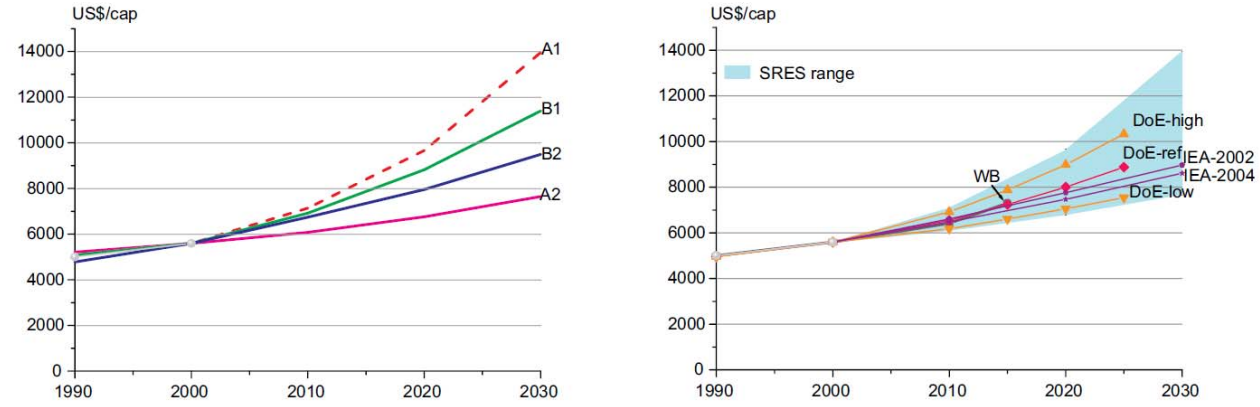


Figure 3.3: *Comparison of global GDP growth per person in the SRES scenarios and more recent projections.*
Notes: SRES = (Nakicenovic *et al*., 2000), WB = World Bank (World Bank, 2004), DoE = assumptions used by US Department of Energy (USDOE, 2004), IEA assumptions used by IEA (IEA, 2002 and 2004); (Van Vuuren and O'Neill, 2006).

Diagram 13: Predictions of per capita income
Source: IPCC 2007

It is expected that the middle income countries will continue to grow, and that their volume and share of the global greenhouse gas emissions will continue to rise. The World Bank (2011) notes that if developing countries continue to grow at current rates, developing countries will come to represent one half of the global economy during the 2020s. China is expected to become the world's largest economy at about the same time, and the World Bank expects that regional integration in East Asia will continue to support growth in other rapidly growing economies. The World Bank predicts that Chinese output growth will moderate to 6.8 percent between 2016 and 2020 and to 5.1 percent between 2026 and 2030.

Table 3. The share of developing countries in global GDP is rising steadily

in percent of GDP

	2010	2030	2030 (current prices)	
		(2010 prices)	low	high
High income	66.4	52.4	49.1	40
U.S.	23.6	20.5	19.2	15.7
Other	42.8	31.9	29.9	24.4
Low & middle income	33.6	47.6	50.9	60
China	9.5	17.1	18.8	23.6
India	2.3	4.6	5.1	6.7
Other	21.9	25.9	27	29.7

Sources: World Bank, IMF, Consensus Economics, and World Bank staff estimates.
Note: Low appreciation: 0.8 percent a year vs. the U.S. dollar, high appreciation is 1.5 percent a year. See chapter IV.

Table 2: World Bank predictions for 2030: Share of global GDP by income category
Source: World Bank (2011)

Garnaut projects that productivity growth can support China's rapid growth until the late 2020s, and that by 2030, average incomes will be more than half of those in advanced industrial countries. China's economy is expected to rival the combined economies of the US and European Union combined. Garnaut projects that India has stronger long-term growth prospects than China, with growth from a lower base. Garnaut anticipates 9 percent annual growth through to 2015, and 8.5 percent average growth for the years 2015-2030. Growth is predicted to be underpinned by the steady rise in the post-Crash savings rate and by the "demographic dividend," as India's young population matures into a workforce. India is likely to continue growing rapidly after Chinese growth slows during the late 2020s. Indonesia is expected to experience 6.5 percent annual average growth between 2009 and 2015, which is consistent with revised short-term predictions by the IMF, with this growth rate maintained through to 2030.

According to these projections, developing countries will account for 70 per cent of global carbon dioxide emissions by 2030, with China's share of global emissions expected to rise to 41 percent and India's contribution expected to rise to 11 percent.[10] Other developing countries are projected to contribute an estimated 19 percent of global emissions. Developed country emissions are expected to remain approximately constant between 2005 and 2030 (Garnaut, 2011).

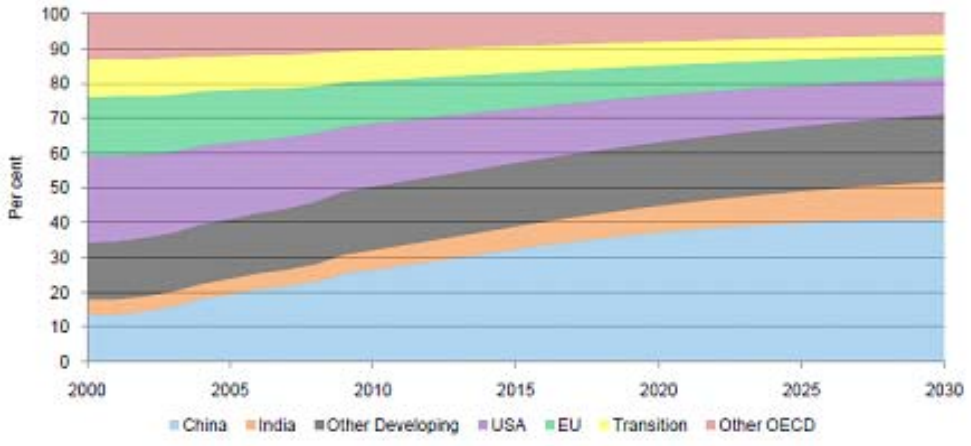


Diagram 14: Global business as usual emissions shares by region, 2000 to 2030
Source: Garnaut (2011)

[10] Garnaut classifies high-income countries according to the World Bank per capita income threshold of US$11,000, 'least developed' as per the United Nations, with remaining countries described as 'developing.' This broadly accords with the WB description of 'middle income' countries.

The World Bank argues that it is “technically and economically feasible” for East Asian carbon emissions to peak by 2025, but notes that this will require a dramatic shift in energy supply from coal to sources with negligible carbon emissions (renewables and nuclear). This peaking profile will also require substantial increases in energy efficiency.

6. Discussion

Since 1997 the increase in global emissions has outpaced the IPCC’s projections under the scenario of strong, fossil-fuel dependent growth. The economic expansion of middle income countries has been accompanied by strong growth in greenhouse gas emissions. This reflects the carbon intensity of the energy supply in many middle income countries, and is also driven by the sectoral composition of growth. Since 2009 non-Annex 1 countries have produced the majority of the World’s emissions. The Global Financial Crisis and mitigation policies have driven Annex-1 emissions below 1990 levels, however per capita emissions in these countries remain well above the levels consistent with Parties’ 2 Degrees Celsius objective.

The net increase in emissions, together with the redistribution of global economic growth and emissions, provide a backdrop to the Panel’s evaluation of the CDM. The economic context has changed dramatically since 1997, and the Panel must evaluate the CDM – and the broader implications for countries’ mitigation efforts – in light of changes to the global economy. The Panel’s recommendations should also account for the likelihood that the trends observed since 1997 will persist into the immediate and medium-term future.

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