5. Reducing Uncertainty Through Dual-Intensity Targets

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Introduction

Under the Kyoto Protocol, developed countries committed to reduce their emissions from 2008 through 2012 to approximately 5.2 percent below their emissions in 1990. Under this approach, emission constraints of individual countries take the form of *fixed* greenhouse gas (GHG) targets. Such a fixed-target approach may be excessively rigid in the face of shifting economic situations, particularly for developing countries. In unstable developing country economies, reliably forecasting future economic and GHG emission growth is especially difficult. Because of these twin uncertainties, a fixed emission target approach could result in "hot air" in the case of lower-than-expected economic growth or potentially severe constraints on economic development in the case of higher-than-expected economic growth.

This chapter explores two distinct ideas—dynamic targets and dual targets—and their combination, each of which might help reduce these uncertainties. First, *dynamic targets*, where an emission target adjusts in response to another variable, have been proposed for developing countries as a possible future alternative to the Kyoto Protocol's fixed target approach (CCAP 1998, Baumert et al. 1999, Argentine Republic 1999, Philibert and Pershing 2001). Dynamic targets may perform better than fixed targets for economies facing considerable uncertainty, particularly in developing countries. Second, rather than a single target, a *target range* could be established; this approach is called *dual targets*. This chapter examines the viability of *dual-intensity* targets—which combine the ideas behind both dynamic and dual targets. Operating together, dual-intensity targets could further reduce the dangers (e.g., severe reduction burdens or unintended "hot air") stemming from the economic uncertainty in emission target-setting. This approach might also improve the likelihood of reaching a consensus in the climate change negotiations.

Section I of this chapter illustrates the concept and rationale for dynamic targets in general and dual-intensity targets in particular. Section II analyzes economic and emission uncertainties and investigates what these uncertainties imply for dual-intensity targets. It includes a regression analysis illustrating the application of dual-intensity targets for the Republic of Korea (South). Section III discusses several implementation issues, including an analysis of the compatibility of dynamic targets with international emissions trading and other advantages and disadvantages of dynamic targets (and dual-intensity targets specifically).

I. The Dual-Intensity Target Approach

To understand the concept and mechanics of dual-intensity targets, it is necessary to first explore the more general notion of dynamic targets. This section explains several kinds of dynamic targets and elaborates on one kind of dynamic approach—dual-intensity targets. In doing so, this section makes frequent comparisons between *dynamic* targets and *fixed* targets, such as those established in the Kyoto Protocol.

The Concept of Dynamic Targets

The most salient feature of dynamic targets is that they do not establish an absolute cap on a country's allowable emission level. Instead, the allowable emission level for dynamic targets is a function of a predetermined variable; in other words, instead of being fixed, allowable emissions fluctuate in response to some other measure. One can envision the use of numerous variables—including population, previous emissions, and exports. However, economic growth, expressed as gross domestic product (GDP), is the most likely variable because of its substantial influence on a country's overall GHG emissions output. The extent of GDP's influence on overall emissions depends on factors such as the structure of an economy (e.g., predominance of services or industry) and energy mix.

GHG intensity targets

There are at least two kinds of dynamic targets. One is often termed an emission "intensity target" (Baumert et al. 1999). Here, the target itself is expressed not in terms of an absolute measure, such as tons of GHGs, but in terms of an emissions intensity—a ratio between GHG emissions and economic output:

$$\text{Intensity Target, } I = \text{Emissions/GDP}^{\alpha}$$

where *I* is the emissions intensity target—a constant, expressed in tons of GHGs per unit of GDP. *Emissions* is the country's allowable emission level during the target period. *GDP* is the country's aggregate gross domestic product during that period, and α is a multiplier that determines the manner in which the allowable emission level changes in response to GDP. If α is equal to 1, then the relationship is linear: a 1 percent increase in GDP will increase the allowable emissions by 1 percent (because *I* is constant). In the case of Argentina (Chapter 6), α was set at 0.5 (i.e., the square root of GDP).

This formula can also be expressed as Emissions = $I \times \text{GDP}^{\alpha}$. Here, plugging the actual GDP value into the equation will yield the allowable emissions amount, because *I* and α are constants.

Indexed targets

A second kind of dynamic target uses indexing to adjust the allowable emission level (Frankel 1999). Like intensity targets, indexing adjusts the allowable emission level according to changes in GDP. Here, the agreed target (i.e., the allowable emissions) would be accompanied by an assumed annual average rate growth (AAARG) of GDP. Deviations from this assumed rate of GDP growth would trigger adjustments in the allowable emission level. For example, country Z adopts an emission target that limits its emissions to 100 units during a particular period. Z's target assumes that the average rate of GDP growth will be 4 percent annually (i.e., AAARG = 4 percent). If actual GDP growth exceeds 4 percent per year, the target is adjusted upward. An annual rate of GDP growth of, for instance, 6 percent (i.e., 2 percent in excess of the assumed rate) might enable the emission level to increase by 2 percent for every year between the negotiation and compliance dates. Conversely, if actual GDP growth is less than 4 percent per year, the target is adjusted downward.

For indexed targets, the adjustments do not need to be linear, just as, in the case of intensity targets, α does not have to equal 1. For example, GDP growth of 1 percent higher than the AAARG could result in an increase in emissions of 0.75 percent; growth of 1 percent *less* than the AAARG might result in a decrease of 0.50 percent in allowable emissions.

It is important to note that, while "intensity targets" and "indexed targets" may appear different, they are essentially the same. Under each, the

Table 5.1. Analyses and Proposals on Dynamic Targets

Source	Target indicator	Other characteristics
CCAP (1998)	Growth Baseline: Emissions/GDP	"Carbon efficiency" (C/GDP) target between BAU and a no-regrets baseline
Baumert et al. (WRI 1999)	Intensity target: Emissions/GDP	Reduction in intensity relative to BAU, measured from a historical base year
Argentine Republic (1999)	Emissions/$\sqrt{\text{GDP}}$	Reduction in emissions of between 2 and 10 percent relative to BAU (nine scenarios); legally binding if emissions trading is allowed.
Frankel (Brookings 1999)	GDP-indexed target	Target established at the BAU level or lower (approaching a "break-even" level, where gains from trade equal domestic costs).
Philibert (IEA/OECD 2002b)	GDP-indexed target	Possible use of price cap or other measures to enhance flexibility
U.S. Administration (2002)*	Intensity target: Emissions/GDP	Reduction in greenhouse gas intensity by 18 percent (relative to 2002) over 10 years; voluntary agreement
Lutter (2000)	Emission/[(lagged emission)$^{0.5}$×(lagged GDP)$^{0.6}$×(lagged GDP per capita)$^{0.06}$]	

* For U.S. administration, see White House 2002. **Abbreviations**: GDP (gross domestic product), BAU (business as usual).

allowable emission level fluctuates with economic activity. Table 5.1 summarizes the different dynamic targets that have been analyzed or proposed.

Economic uncertainty

Future GHG emission levels are highly uncertain in developing countries (a topic explored in greater detail below). This situation can lead to serious technical difficulties in establishing a future GHG emission limitation using a fixed target. Achieving a specific future level of GHG emissions might be very easy under conditions of low economic growth, industrial stagnation, and population decline. That same GHG goal, however, might be exceedingly difficult to reach if economic growth were instead robust and population were increasing. Thus, fixed GHG goals can entail widely varying levels of effort, depending on underlying socioeconomic conditions (especially GDP growth), which tend to have a powerful influence on emission levels.

This represents a serious problem. Experience suggests that when countries are proposing or evaluating a potential emission target, they are particularly concerned with economic impacts. In other words, countries want to know the impact that a particular emission control target will have on their domestic economy, including the overall costs and benefits, potential job losses and gains, and changes in international competitiveness. If a developing country were to agree to a fixed emission target, potential economic impacts are likely to be highly *uncertain*. Dynamic targets attempt to address this uncertainty by adjusting to economic reality and therefore reducing the economic uncertainty associated with taking a particular target. They allow faster-growing economies more emissions and contracting economies fewer emissions.

Governments are risk-averse with respect to economic considerations, such as growth, jobs, and competitiveness. This is especially the case in developing countries, where climate change is not a priority. If a developing country contemplates a GHG target, it will be important that this target does not unreasonably impinge on its development prospects. Given their risk aversion, developing countries might avoid GHG targets that have the *potential* to adversely affect economic growth, even if that potential is small.

Environmental uncertainty and environmental effectiveness

With dynamic targets, reduced economic uncertainty comes at the expense of environmental certainty. Unlike Kyoto-style fixed targets, dynamic targets do not guarantee any particular environmental outcome, although they will deliver environmental outcomes within a relatively predictable range.

It is important that the reduced upfront environmental certainty of dynamic targets is not equated with weaker environmental outcomes. Dynamic targets could actually facilitate more stringent emission limits, due to the reduced economic uncertainty of such targets, discussed above (Baumert et al. 1999, Philibert 2002a). Given governments' risk aversion, a fixed target could create an incentive for a developing country to settle only on a weak target that ensured no economic harm. Weaker emission limits are a serious drawback of fixed targets, especially given the links between emission targets and international emissions trading. Weak targets for one country (inadvertent or not) can reduce the environmental effectiveness of the entire regime by allowing other countries to purchase and use excess emission allowances that otherwise would not be used. Such excess allowances are often referred to as "hot air." Although hot air can be a political creation (from negotiating emission limits in excess of future needs), it can be enhanced by unexpected declines in economic activity after a fixed target has been negotiated.[1] Overall, dynamic targets do not eliminate the risk of negotiating hot air targets, but they do provide upfront transparency that will at least help Parties identify whether a target is likely to generate hot air.

In addition, dynamic targets could enhance environmental effectiveness by promoting wider participation in the international emission control system. Fixed targets might be simply unacceptable for many developing countries. Given the unsettling choice in the target-setting process—between weak targets (which would do little to help the global environment) and strong targets (which could have deleterious effects on their domestic economies), developing countries might opt for *no* commitment along these lines. Wider participation also supports environmental effectiveness by reducing the incidence of emission "leakage" from countries with emission constraints to those without.

Sustainable development

Another compelling feature of dynamic targets is their compatibility with sustainable development because they are geared toward achieving emission reduction *relative* to economic development rather than achieving absolute reductions in emissions (Baumert et al. 1999). Intensity indicators might better reflect the real climate challenge in developing countries—decoupling economic growth and emissions growth. Philibert (2002b) also states that dynamic targets could be considered most compatible with the environmental strategy adopted by the OECD, which is mainly based on the concept of "de-coupling environmental pressures from economic growth."

The Concept of Dual Targets

As discussed, dynamic targets are considered more appropriate than fixed emission targets with respect to accommodating uncertain economic growth rates, especially in developing countries. However, many difficulties and uncertainties remain in establishing emission targets for developing countries, whose economic growth is highly unpredictable.

Just as with fixed targets, a developing country would have an incentive to overestimate its "business-as-usual" (BAU) emissions intensity (to justify a weaker target) while other, rival negotiating countries would have the opposite incentive. In fact, if a country hypothetically tried to establish a target representing its BAU emission levels, even with a dynamic target there would likely be some degree of either hot air or economic burden. Thus, this section explores the possibility of establishing *dual* targets that, taken together, cover a range of future scenarios. This approach might improve the effectiveness of target setting and make consensus easier to reach.

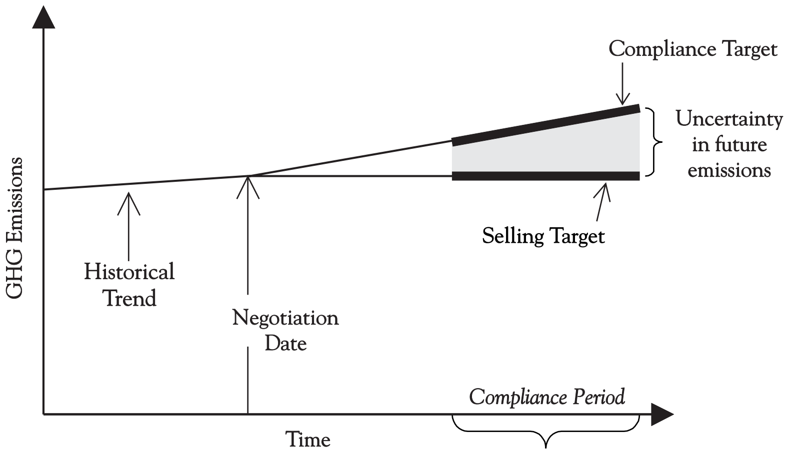
The concept of dual targets is not new. Philibert and Pershing (2000) proposed to establish two national targets with differing legal characters: one non-binding, the other binding. The binding target would allow a relatively high level of emissions to prevent the risk of undue constraints on economic growth. The non-binding target would be established at a more stringent level, in order to reduce the risk of hot air. This non-binding target would be the "selling target," while the binding target would be a "buying target." Although Philibert and Pershing did not consider the dual-target concept as an option for dynamic targets, it deserves to be extended and generalized to a wider policy design context. Dual targets could be applied to either fixed or dynamic targets. The *dual-intensity* target proposal in this chapter effectively combines the intensity-target approach and dual-target concept.

Combining the Concepts: Dual-Intensity Targets

Under the dual-intensity target approach, two emissions-intensity targets are established for a single country. The two targets have separate purposes. The lower (more stringent) target provides an incentive to reduce emissions: reductions below this target would enable the country to sell emission allowances. The higher (less stringent) target would have a punitive function: Exceeding this target would require the country to purchase excess emission allowances in order to remain in compliance. Thus, the lower target would be the "selling target" and the higher one termed the "compliance target." No penalty applies if the emissions intensity of the country lies between the selling and the compliance targets. That is, there is a "safe zone" in which the country is neither out of compliance nor able to sell allowances through international emissions trading. This approach is illustrated in Figure 5.1 (the "safe zone" is the dark shaded rectangle between the selling and compliance targets). Mathematically, the two formulas would take a form similar to the intensity formula described above:

Selling Target: $Emissions = I_1 \times GDP^{\alpha}$
Compliance Target: $Emissions = I_2 \times GDP^{\alpha}$, $I_1 \leq I_2$

Figure 5.1. Graphical Illustration of Dual-Intensity Target



I_1 denotes the lower (selling) intensity target and I_2 the higher (compliance) intensity target. This formulation is general enough to encompass a wide range of alternatives. If we set "$I_1 = I_2$," it is identical to a single intensity target. If we set "$I_2 = \infty$," it implies an incentive-only intensity target where there is no obligation to limit emissions (but also no trading, unless the selling target is reached). Therefore, the concept of dual-intensity targets gives us a general and flexible framework for commitments.

II. Analysis of Uncertainties and Implications of Dual-Intensity Targets

An underlying premise of dual-intensity targets is that uncertainty in future GHG emission levels impairs the process through which emission targets are set. Thus, it is worth illustrating the underlying economic and emission uncertainties in more detail and showing how dual-intensity targets help policymakers manage this uncertainty. This section analyzes historical and projected data in an attempt to derive implications for the performance of dynamic targets, particularly dual-intensity targets. First, the uncertainties in future projections of both emissions and emissions intensities are compared. Also, examples of past longer-term projections are scrutinized to see how those forecasts tend to change significantly over time. Finally, the result of a regression analysis for the case of Korea is presented and a potential application of dual-intensity targets is described.

Uncertainty of Forecasts: Experiences from Past Projections

One can evaluate different indicators by analyzing the reliability of past forecasts and the uncertainty of future projections. Table 5.2 shows CO_2 emissions and intensity (i.e., CO_2/GDP) projections to 2020. These projections, undertaken by the U.S. Energy Information Administration (EIA), include three scenarios: a reference scenario (i.e., BAU), a high GDP-growth case, and a low GDP-growth case. The table shows the range between the high and low emissions and intensity scenarios. This

Table 5.2. Summary of Energy Information Administration (EIA) Projections for CO_2 Emissions and Gross Domestic Product (GDP), 2020

	Uncertainty Range between High and Low Projections, 2020 (*percentage points, relative to the reference case*)		Change in Projections, EIA 2001 v. EIA 1999 (*percentage point difference*)		
Country	**CO_2**	**Intensity**	**GDP**	**CO_2**	**Intensity**
United States	13.6	27.4	30.6	3.3	–20.9
Canada	21.1	20.0	5.7	–1.1	–6.4
United Kingdom	16.1	24.8	5.7	6.1	0.4
France	20.0	21.1	4.1	8.9	4.6
Germany	16.5	24.8	–7.3	–6.6	0.7
Japan	24.4	17.1	–9.9	–1.4	9.5
Former Soviet Union	42.0	48.4	35.5	14.9	–15.2
China	56.1	29.1	9.2	–17.1	–24.1
India	40.0	19.9	13.5	–3.8	–15.3
Korea (South)	36.6	26.9	2.0	–23.9	–25.4
Mexico	27.1	13.0	6.6	28.5	20.6
Brazil	45.8	14.7	8.1	13.4	4.9
Total Industrial	**16.7**	**24.4**	**9.0**	**3.5**	**–5.1**
Total Developing	**47.7**	**17.8**	**9.8**	**–5.4**	**–13.8**
Total World	**34.0**	**16.0**	**9.5**	**–0.6**	**–9.2**

Source: Compiled from EIA (2001b and 1999).
Notes: The uncertainty range is the percentage point gap between the high growth scenario and the low growth scenario compared to the reference scenario. EIA's change in GDP projections for the United States is not a typographical error. Long-term growth rates were increased from 2.2 to 3.0 percent per year.

"uncertainty range" is the percentage point gap between the high-growth and low-growth scenarios, compared with the reference scenario.

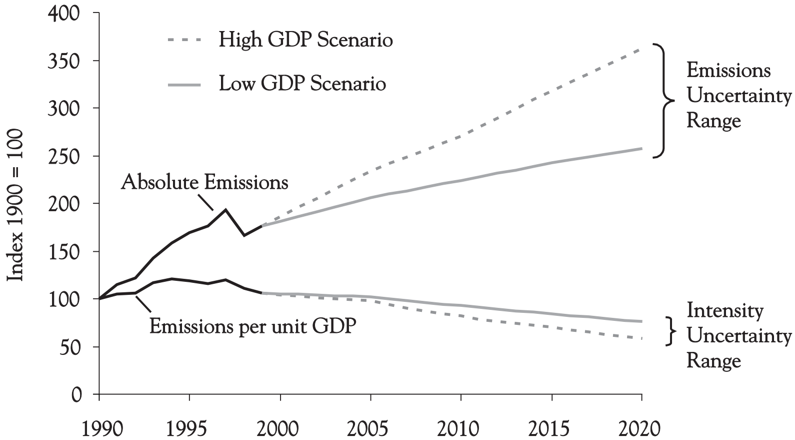
Future emission uncertainties (for the year 2020) are extreme in developing countries, with an uncertainty range of about 48 percentage points. This means that in 2020, according to EIA, emissions in developing countries could be anywhere between 3,490 and 5,697 million tons of carbon—a band of uncertainty that is larger than all developing country emissions in 1999 combined. When forecasts are expressed using an intensity indicator, this uncertainty is lowered to about 18 percentage points. In the case of Korea, the uncertainty (or range of forecasts) in absolute levels of CO_2 emissions is 36.6 percentage points, while the uncertainty range for the emissions intensity of CO_2 relative to GDP is 26.9 percentage points, a reduction of 9.3 percentage points. Figure 5.2 shows a comparison of the uncertainties, expressed in absolute levels of emissions and emissions intensities, for various developed and developing countries.

Future emission levels in industrialized countries, on the other hand, are less uncertain. Table 5.2 shows an uncertainty range of about 17 percentage points between the high and low CO_2 scenarios (relative to the reference case). It is interesting that future uncertainty in industrialized countries is actually greater when expressed using an intensity indicator than an indicator based on absolute emission levels (about 24 percentage points versus 17 percentage points, respectively).

Future projections for a given year (e.g., 2020) are also subject to continual, and sometimes major, revision over time. Lutter (2000) analyzes EIA's past projections of U.S. emissions and finds that nearly 87 percent of the forecasts turned out to be too low. Although the forecast errors are not that significant in the U.S. case, the situation for developing countries is different, as shown in Table 5.2. In the case of Korea, EIA forecasted GDP 2 percent higher in 2001 than in 1999, while the projection of CO_2 emissions decreased by 23.9 percent between the 2 years. As a result, the forecast of Korea's intensity decreased by more than a quarter. This phenomenon is not unique to EIA projections. In 1990, the Korea Energy Economics Institute (KEEI 1990) predicted that CO_2 emissions from the energy sector in 2010 would be 126.5 million tons of carbon. A decade later, KEEI (2000) predicted 2010 emissions to be about 170.6 million tons, an increase of about 35 percent.

Analysis of these forecasts—and comparisons between indicators—suggests several policy implications. First, CO_2 intensity targets (and dynamic targets in general) are likely to be superior to fixed CO_2 targets for developing countries, due to the reduced risk that the target would turn out to

Figure 5.2. Projected CO_2 Uncertainty in the Republic of Korea: Absolute Emissions versus Emissions per unit of GDP



Source: World Resources Institute, compiled from data in EIA (2002a).
Abbreviations: GDP (gross domestic product).

be overly stringent. Second, fixed targets could be better for some industrialized countries or economies in transition. For industrialized countries, future projections of intensities tend to be even more uncertain than for emissions. Furthermore, analysis by Lutter (2000) shows that CO_2 emissions in larger economies are less variable from year to year. A 10-fold increase in the size of the economy leads to a decrease in variability of approximately 7 percentage points. On the basis of this, Lutter shows that forecast errors decline as the size of an economy grows.[2]

Finally, and more generally, uncertainties persist using both indicators and in all countries. There seems to be considerable uncertainty that is unavoidable, even with the intensity approach. Such uncertainties indicate that negotiators and advocates should be very cautious about using a BAU forecast as a benchmark or a baseline for determining targets, whether fixed or intensity.

In spite of the large uncertainties, future forecasts are indispensable in negotiating emission targets. The reduction burden of any given target is the gap between BAU and that target; this is related not to past performance but to the future commitment period. Therefore, the inherent uncertainty of BAU forecasts may harm the negotiations due to differing perceptions or estimations, not to mention possible strategic misrepresentation by Parties. Because dual targets accommodate a *range* of BAU forecasts, rather than a singular BAU point estimation, they might perhaps help negotiators reach agreement more quickly and easily. This topic will be revisited in Section III.

Regression Analysis: Case of the Republic of Korea

Using data from the Republic of Korea (South), this section illustrates the potential formulation of a dual-intensity target. Regression analysis is helpful because it assess how much certain factors (independent variables), in this case GDP, explain changes in emissions (the dependent variable).[3] Specifically, regression analysis is used here to determine the two intensity formulas (I_1 and I_2) as well as the GDP coefficient (α).

We derived a regression equation to relate emissions to GDP over the same time period. The results are summarized in Table 5.3. The R-squared value is 0.974, meaning that there is a strong relationship between the dependent (CO_2 emissions) and independent (GDP) variables. (An R-squared value of 1.00 would mean that 100 percent of the variation in emissions is explained by changes in GDP.) The coefficient for the GDP variable is estimated to be about 0.955, indicating an almost linear relationship between GDP and emissions. The equation derived produces a typical form of target emissions under the intensity approach as follows:

$$Emissions\ (t) = 1.239 \times GDP(t)^{\ 0.955}, \quad (1)$$

where t is the time frame for the commitment period, emissions(t) are the allowable emissions during the commitment period, and GDP(t) is the actual GDP during the commitment period. The above formula shows a GDP multiplier of 0.955, which is close to 1. The multiplier would be

Table 5.3. Regression Analysis of CO_2 Emissions in South Korea

Regression Formula:

$$Ln(Emissions) = Constant + \alpha \cdot Ln(GDP)$$

Adjusted R^2	Standard Error	constant	α
0.974	0.0664	0.2144 p-value (0.3170)	0.9554 (2.78×10^{-14})

Note: The regression analysis covers the years 1981 to 1998.

Box 5.1. Calculating the Values of the "Dual" Intensities

The standard error (difference between the realized emissions and the BAU forecast) from Table 5.3 is 6.6 percent. Assuming the forecast error has a normal probability distribution where the mean equals zero and the standard deviation equals the standard error, the 95 percent confidence interval for the model is then calculated as follows:

$$\text{projected emission} \times [1 \pm 1.96 \times (\text{standard error})]$$

An equation for the dual-intensity target can be derived from equation (1). Let us consider a situation in which a dual-intensity target for 2008 is predicted in 1998 on the basis of equation (1) and we want to limit the possibility of emissions turning out to be either higher than the compliance target or lower than the selling target by less than 5 percent. In other words, the possibilities of hot air and unintended reduction burden should not exceed 2.5 percent, respectively. By applying equation (1), we get the following result:

$$\textit{Emissions}\ (2008) = 1.239 \times \textit{GDP}\ (2008)^{0.955}, \quad (2)$$

An interval for the dual-intensity target for 2008 can be described as follows:

$$\textit{Intensity}\ (2008) = \frac{\textit{Emissions}\ (2008)}{\textit{GDP}\ (2008)^{0.955}} = 1.239 \times [1 \pm 1.96 \times 0.0664]$$

Intensity targets for compliance and selling can be derived from equation (2). The former equals 1.369 and the latter 1.109. In other words, Korea would be allowed to sell extra permits if the intensity defined in equation (2) turns out to be lower than 1.109 and is obliged to buy emission permits from abroad to ensure its intensity does not exceed 1.369. The number of permits Korea is allowed to sell in 2008 can be calculated as "actual GDP powered by 0.955 and multiplied by 1.109" minus "actual emissions." And the number of permits Korea is obliged to buy in 2008 is calculated by "actual emissions" minus "actual GDP powered by 0.955 and multiplied by 1.369."

different depending on different countries' economic situations. It is 0.5 in case of the Argentine Republic (1999, and Chapter 6 of this volume), and Lutter (2000) proposes a value of 0.6 for universal application to all countries. The multipliers could be developed and applied through in-depth, country-specific studies. Box 5.1 indicates how values for the dual-intensity targets are calculated. (Note that this box is not indicative of any future commitment by Korea and should be understood as a hypothetical example only. Furthermore, the year 2008 used in this example also should not be understood as any indication of the appropriate timing of commitment.)

Above, we derived dual-intensity formulas using *historical* data (1981–98) in a regression analysis. An alternative methodology might be to investigate the pattern between emissions and GDP under various *future* scenarios. According to EIA (2001b) projections, the rate of emission change tends to be larger than GDP in the low, reference, and high economic growth scenarios. This implies that the multiplier on GDP in the intensity formula is likely to be higher than 1 and that the GDP elasticity of emissions is greater than 1. However, this is not true in the case of the Argentine Republic (1999) and other countries. Therefore, additional in-depth analysis of the appropriate form for the intensity formula is needed.

III. Implementation Issues

As discussed in Section I, the main advantage of dynamic targets in general and dual-intensity targets in particular is that they can reduce economic uncertainty in the target-setting process, especially for developing countries where future uncertainties are more significant. However, the absence of a fixed environmental outcome under dynamic targets can create several implementation challenges. These challenges include interactions with international emissions trading, monitoring and verification of GDP, and complexity of the negotiating process. Except where noted, these issues are associated with dynamic targets in general and are not specific to dual-intensity targets.

Linkage to International Emissions Trading

To ensure environmental effectiveness and cost-effectiveness, a smooth interaction between emission targets and international emission trading is needed. Thus, the dual-intensity approach (and dynamic targets in general) needs to be fully compatible with emissions trading. It is also important for trades to be possible between countries (or private entities) using fixed targets and those using dynamic ones. Two key issues are associated with the compatibility of dynamic targets and international emissions trading.

The first issue concerns the overarching stability of the emissions trading system. Some of the "risks" of international emissions trading are systematically under-appreciated in climate change policy debates and may be challenging to manage in the future (Baumert et al. 2002). For instance, overselling of allowances, excessive uncertainty over market prices, and trading ineligibility could plague a trading system.

Given these risks, dynamic targets could offer an advantage over fixed targets, mainly in that dynamic targets are less prone to creating hot air, as discussed earlier. Lowering the risk of hot air (or, conversely, of overly stringent carbon constraints) could reduce the volatility of market prices by better balancing supply and demand, thus increasing liquidity. Dynamic targets also enhance market stability, in that some countries, under extreme circumstances, might be unwilling to comply with fixed targets that do not accommodate their economic realities.

The second compatibility issue between dynamic targets and trading is defining and managing the tradable unit. The tradable unit with dynamic targets is identical to that of fixed targets—"allowances" denominated in units of CO_2 (or carbon) equivalent. However, the quantity of these units available to a country is not known until the *end* of the compliance period because the allowable emission level is linked to actual GDP levels. This system differs from fixed targets, where the number of allowances is determined ahead of time and does not change. Thus, dynamic targets can add uncertainty and complexity to the emissions trading system.

There are several ways to enable trading to take place with dynamic targets. First, and most obvious, is a post-verification trading system, whereby transfers take place *after* emissions and GDP are verified (during a "true-up" period, such as the one adopted under the Kyoto Protocol). Here, some of the dynamic cost-reducing benefits of trading could be lost. However, earlier trades could take place through various derivatives (e.g., futures, options) and insurance contracts. A second way of addressing trading shortcomings is by determining the country's allowable emissions just prior to the commitment period, based on GDP projections for the commitment period. These projections could, in turn, be updated annually during the commitment period, and then reconciled at the end of the commitment period so that allowable emission levels reflect actual GDP changes.

Contrary to conventional wisdom, however, fixed targets encounter similar uncertainty: Countries do not know the total number of allowances available to sell (or needed to buy) ahead of time. Indeed, this uncertainty is structural. Because of time lags in determining actual emission levels, a country will not know its surplus or shortage of allowances until 2014 or later. Philibert and Pershing (2001) even state that, if the link between emissions and GDP holds, "the uncertainties on both will essentially compensate. In fact, the uncertainty regarding the availability of [allowances]…would likely be reduced, not increased, by dynamic targets in comparison to fixed targets."

Furthermore, the 2001 Marrakesh Accords contain numerous provisions suggesting that, with respect to emissions trading, targets are *already* dynamic. First, the Marrakesh Accords established a "commitment period reserve" system to guard against the risk of overselling. This commitment period reserve already envisions annual adjustments to a country's reserve level.[4] Second, the Accords created a "removal unit" (RMU) that can be issued annually on the basis of a net removal of GHGs that results from an approved set of activities (UNFCCC 2002, 59–60). RMUs will essentially increase a country's allowable emission level, yet the quantity of RMUs created will be known only *ex post* and will be subject to myriad requirements.[5] Provisions for RMUs and commitment-period reserves demonstrate that the amount of GHGs a country is allowed to emit and trade can already shift *during* the commitment period.

Given the wide-ranging uncertainties with respect to availability of tradable allowances, it is not clear that dynamic targets will pose additional problems, other than adding complexity. It is likely that a significant amount of trading activity will take place during the so-called "true-up" period during which emission quantities are known, RMU units have been issued, commitment-period reserves are solidified, and (in the event of dynamic targets) GDP values are established.

Finally, it should be noted that dynamic targets in general—and dual-intensity targets in particular—can also be used for S-CDM initiatives (see Chapter 3), should they be allowed under the Protocol. Under a sectoral dual-intensity approach, selling targets could serve as a baseline for generating tradable "certified emission reductions," which would make a compliance target unnecessary.

Gross Domestic Product: Choice of Currency

Along with emissions trading, the use of GDP as part of an emissions target has sparked some criticisms and concerns that should be taken seriously. The first relates to choosing a currency.

There are several ways to measure GDP. It is measured primarily in local currency; once this is done, it can then be converted into U.S. dollars (using market exchange rates) or international dollars (using purchasing power parities) to facilitate comparisons *across countries*. Also, each of these currencies (with the usual exception of PPP) can be measured in either "constant" or "current" terms (i.e., adjusted for inflation or not adjusted for inflation). The purpose of using constant currency is to facilitate comparisons *across time*.

Dynamic targets would, in all likelihood, express GDP in terms of *domestic* currency (Baumert et al. 1999). The first reason for this is that there is no need to compare intensities across countries. Comparisons of intensity levels across countries are not suggestive of the relative stringency of commitments, just as absolute emission levels were not used in Kyoto to gauge stringency. Rather, *percentage reductions* for each country, relative to historical levels or BAU, are typically compared to gauge relative stringency. The second reason is that values expressed in other currencies (such as U.S. and international dollars) are derivative of domestic currencies. Converting domestic currency would create unnecessary controversy regarding the proper exchange rate and PPP conversion factors. Also, the domestic currency would be expressed in *constant* terms because of the need to compare across time. The proposal by the Argentine Republic (1999, see Chapter 6, this volume) used constant domestic currency (1993 pesos) for calculating GDP.

Finally, what really matters for dynamic targets are annual rates of change, rather than absolute levels of GDP.[6] Rates of change are not strictly tied to currencies and might be easier to agree on and verify, since different measurement methodologies might yield the same rates of change. There is no need to engage in debates about what constitutes the "true" GDP of a country.

Gross Domestic Product: Monitoring and Verification

A second concern about GDP relates to monitoring and verification of GDP. Dynamic targets increase the data requirements for participating countries. Greenhouse gas emissions are already subject to a wide range of measurement standards, reporting requirements, and review provisions. If GDP were used to adjust emission targets, GDP would also need to be subject to scrutiny.

Generally, most countries and international institutions have more expertise on and experience with national economic statistics such as GDP than they do with measuring GHG emissions. The standards and methods for national income accounting have been developing for more than 50 years and are periodically updated by international institutions, such as the International Monetary Fund (IMF) and the United Nations Statistical Commission. The table in Appendix 5A offers a comparison of the systems for measuring, reporting, and verifying GHG emissions and GDP.

For each system that has been set up to account for GHGs, one or more analogous systems for GDP accounting are already in place. These systems need not be duplicated by the Climate Convention. In fact, the Conference of the Parties may, according to the Climate Convention, "seek and utilize, where appropriate, the services and cooperation of, and information provided by, competent international organizations and intergovernmental and non-governmental bodies."[7] The IMF, for example, could play a role in providing GDP data or verifying the data provided by countries through its existing "surveillance" and oversight processes.

Despite the availability of standards and oversight systems, many countries still do not report timely, internationally reliable GDP estimates (similar to the gaps in GHG reporting). The Milestone Assessments of the System of National Accounts show that many developing countries are not reporting GDP data. In addition, some countries, especially China, have been accused of purposefully inflating their GDP statistics. The mainstream press has repeatedly reported experts' suspicions that China overstates its economic growth (typically reported as 7 percent per year or more) to promote foreign direct investment.[8] In many countries, including China, statistical agencies are not functionally independent and can be subject to political influence.

Intentionally inflating, or "gaming," GDP is a legitimate concern because it would weaken emission targets. However, it is difficult to imagine that climate change policy could motivate such actions. GDP is used for a myriad other purposes, including by international organizations to determine eligibility for loans, aid, or other funds. GDP and derivatives of GDP (such as debt/GDP ratios) are used frequently as part of the terms and conditions for obtaining commercial loans. GDP also is used to determine financial contributions that support international institutions, such as the UNFCCC Secretariat. If a country wanted to cheat using a dynamic target, it would probably be more tempting to purposefully *understate* emissions rather than *overstate* GDP.

Overall, most emission reporting (under Article 12 of the Convention) is now insufficient to support binding emission targets; the same is true for GDP. If a country were to adopt a dynamic target, better reporting and independent verification (for which guidelines and institutions already exist) would be required for both emissions and GDP. This suggests the need to improve in-country capacity in both areas.

Inclusion of Non-CO_2 Gases and Non-Energy-Related Sectors

The analysis in Section II of this chapter includes only CO_2 emissions from fossil fuel consumption. For these emissions, correlations with GDP typically are extremely high. However, if a target included other gases and/or sectors (e.g., methane from agriculture), dynamic targets might not be as effective in reducing uncertainty. This is illustrated in Chapter 6, as Argentina's emissions from the agricultural sector typically did not adjust in response to GDP changes. Similarly, CO_2 from land use change (a major source in some developing countries) would likely correlate poorly with GDP.

This poor correlation suggests that precision in target setting will be even more elusive and uncertainty even harder to reduce. It also suggests a greater need for a dual-target approach to better account for these rampant uncertainties in the target-setting process.

Complexity and Capacity in the Target-Setting Negotiating Process

Generally, dynamic targets may make negotiations more complex, especially when attempting to differentiate commitments among many countries. Not only might counties adopt different percentage reduction commitments (as in Kyoto), they might also adopt different GDP adjustment provisions for targets (in other words, different α coefficients, in the case of intensity targets, or different emission adjustment percentages, in the case of indexed targets). Negotiations might become exceedingly complex, to the point that non-specialists, or indeed anyone other than the negotiators themselves, would have difficulty understanding proposed commitments.

With respect to *dual-intensity* targets, it is difficult to predict how the added complexity would affect the negotiating process. Using a *dual-target* concept might actually help countries reach agreement more easily. Negotiations would not need to reach a consensus on a *single* target; instead, they would focus on agreeing to the selling and compliance target intensities described above (I_1 and I_2). One can conceive of a two-step negotiating process under which a country proposes its own compliance target and the Protocol Parties collectively (or representatives from other countries) suggest the country's selling target.[9] Because the Convention requires consent from the country in question as well as Protocol Parties collectively, the distance between the two targets may converge to a reasonable level. Overall, dual-intensity targets make assumptions and political decisions more transparent during initial target-setting. This reduces the likelihood of surprises that might lead a country to defect from its commitment, possibly improving the prospects of agreement.

Complexity also points to capacity needs. Country delegations would need the training and skills to understand and assess various dynamic-target options. Thus, this approach might be best suited to the more advanced developing countries. To make things simpler, the negotiation process might benefit from an initial agreement on several different dynamic-target formulas to provide some standardization in methodologies (e.g., a few different GDP coefficients, α).

Determining the Stringency of Reduction Commitments

Some approaches to target setting, such as the Brazilian Proposal and per capita entitlements, include provisions for determining the proportionality of emission limitation requirements among countries (Chapters 7 and 8). (For the examples noted above, these provisions are based on relative responsibility for existing climate change and on population size, respectively.) In other words, the stringency of a country's reduction commitment is partially[10] determined by the approach itself. Dynamic targets are different in that the stringency of the reduction target is separate from the approach. Generally, the stringency of such a target is an equity issue. This topic begins to exceed this chapter's scope, not because it is less important, but because it is more political than theoretical and could be considered independently without altering the essential elements of this approach. In principle, a variety of equity criteria could be applied to an intensity-target approach in order to determine the stringency of country targets. This approach, however, would most likely be employed through a pledge-based process, whereby countries suggest their own target(s), and negotiate this target(s) with the rest of the Parties.

Nevertheless, several proposals for dynamic targets do address the issue of how to determine the stringency of short-term reduction targets. CCAP (1998) suggested a growth baseline where the target intensity is set to be lower than the BAU level but higher than an intensity that can be achieved through "no-regrets" measures. They also suggested that countries of similar circumstances could be grouped together, with a common rate of intensity improvement required of all countries in a particular group. Four criteria would be considered in defining the groups: fuel mix, economic growth, technology level, and policy framework.[11] Frankel (1999) points out that a dynamic target set at BAU levels would have environmental and economic benefits for all countries involved (assuming, of course, the existence of an international market for emission reductions). He suggests that negotiations could settle near a "break-even" level, where overall gains from trade equal overall domestic costs, and that richer developing countries could take deeper targets than poorer ones.

In the case of Argentina (see Chapter 6), the target implied an emission reduction between 2 and 10 percent across the assessed scenarios. Besides Argentina, the United States is the only country to propose a dynamic target, albeit a non-binding one that is not linked to international emissions trading. The U.S. proposal of an 18 percent voluntary reduction in GHG intensity, announced in 2002, suggests future emission levels that are similar to historical trends (WRI 2002), implying little, if any, additional effort.

Internationally, it is unlikely that a single rule could guide the target-setting process. To make it fair, polluter-pays and egalitarian principles could play a role in burden sharing, and therefore cumulative and per-capita emissions could be used to help determine target intensities. Ability to pay and capacity to reduce could also play a role in target setting; thus, per capita GDP and marginal abatement cost characteristics would be considered. Marginal abatement costs are widely known to vary significantly among countries.

IV. Conclusion

The usefulness of dynamic targets and dual targets depends on the problem to be solved. In the past, countries have been extremely concerned with the magnitude and attendant economic impacts of taking an emission target. Yet, determining the economic impact of a fixed target is hard. Targets are negotiated 10 to 15 years in advance of their implementation, making it extremely difficult to gauge the level of effort inherent in any single target. Negotiating emission controls is challenging precisely because of pervasive uncertainties: Countries do not actually know what they are agreeing to. Dynamic targets and dual targets (perhaps combined) may have compelling advantages over fixed targets in that they can help reduce the problem of *uncertainty*.

Similarly, in negotiating future emission targets, a developing country might want to be protected from the possibility of having to be a net buyer of emission reductions.[12] Here, dual targets could be especially useful and could be combined with fixed or dynamic targets. The compliance target, on the one hand, could be set conservatively (or not at all) to ensure that under most any scenario, the country's BAU emissions would not exceed that level. The selling target, on the other hand, could be set more stringently to create an incentive to reduce domestic emissions (and capture benefits through international emissions trading).

An inevitable consequence of using dynamic or dual targets is a lack of environmental certainty. Considering the long-term nature of the climate change issue, however, short-term environmental certainty may be less important than the overall stringency of the reduction target. If an intensity target could provide more stringent reduction objectives, it may be more desirable to have such a stringent target even with the attendant lack of environmental certainty.

Key conclusions of this chapter include the following:

- Dynamic targets can be more effective than a fixed target in reducing the risk of "hot air" from weak targets or of non-compliance from unintentionally burdensome targets. This conclusion holds primarily for many developing countries, although not necessarily for industrialized countries. In industrialized countries, projecting *absolute* emission levels might be more reliable than projecting intensities.
- Dual targets could further reduce the risk of undesirable hot air or non-compliance. The concepts of dual and dynamic targets can be combined through the use of dual-intensity targets, for example. Dual targets could also be used with fixed targets.
- Dual-intensity targets would increase the complexity of the negotiations. Paradoxically, however, they might also facilitate a ratifiable consensus. Again, this conclusion applies primarily to negotiating developing country targets and not necessarily industrialized countries.
- Dual-intensity targets address only one part of a climate protection architecture. Other elements also are integral to the overall framework. They include monitoring and verification of both GDP and emissions data. International emissions trading which, we believe, is sufficiently compatible with dynamic targets, is also critical to an international policy framework.
- Dynamic targets are not a burden-sharing approach. Rather, they are a way of shaping a target. To promote the real application of this approach, additional decisions would need to be made on the acceptable stringency of country targets.
- As with almost any approach, to make dynamic targets operational, serious country-level analysis is required (including decisions on gases and sectors to be covered), as Chapter 6 of this volume illustrates.

For many developing countries whose unstable and uncertain economic growth exacerbates emission uncertainties, dual-intensity targets may be the best option—a low-risk strategy for participating fully in global climate protection.

Appendix 5A.

Table 5A. Measurement, Reporting, and Review of Information: Greenhouse Gases and Gross Domestic Product

	Greenhouse Gases	Gross Domestic Product
METHODOLOGIES AND STANDARDS	**Kyoto Protocol (Art. 5, par. 2)**: Requires the use of emissions (and absorption) estimation methodologies that are accepted by the Intergovernmental Panel on Climate Change and agreed on by the Conference of the Parties. **Intergovernmental Panel on Climate Change (IPCC)** provides guidelines and good practice methodologies for estimating greenhouse gas emissions.	**System of National Accounts (SNA)** • SNA is a common set of concepts, definitions, classifications, and accounting rules used in economic analysis and policymaking for all countries. The SNA provides a comprehensive conceptual and accounting framework for analyzing and evaluating economic performance. • Updated periodically through a working group that, to ensure consistency and comparability, includes the United Nations, Statistical Commission, the International Monetary Fund (IMF), the Organization for Economic Cooperation and Development (OECD), Eurostat, and the World Bank. **IMF Article IV consultations**. Data gathering through Article IV consultations relies on an internal IMF process and it responds to specific informational needs of the IMF such as for data on gross domestic product (GDP). **IMF's Special Data Dissemination Standards (SDDS)** guides countries in the dissemination of financial statistics (in order to promote access to international capital markets). The SDDS includes standards in the following areas (1) data: coverage, periodicity, and timeliness (or reporting); (2) public access to data; (3) integrity of the disseminated data; and (4) quality of the disseminated data.
REPORTING	**United Nations Framework Convention on Climate Change (Art. 12).** Periodic reporting of national communications, including a national emissions inventory **Kyoto Protocol (Art. 7).** Annual emissions inventories and necessary supplementary information to ensure compliance.	**SNA.** The U.N. Statistical Commission sends an international questionnaire to be filled out by members voluntarily on an annual basis. **IMF Article IV Consultations** (surveillance), contrary to the 1993 SNA, a member country (of the IMF) has the obligation to provide the information requested by the IMF's staff as stated in IMF's Article IV. The country itself, though, decides the public availability of this information to avoid the disclosure of sensitive information. IMF surveillance activities are conducted annually. **SDDS**. See above.

continued next page

Table 5A. *continued*

	Greenhouse Gases	Gross Domestic Product
MONITORING, REVIEW AND VERIFICATION	**Kyoto Protocol (Art. 8).** The information submitted by each Annex I Party shall be reviewed by expert review teams	**IMF Article IV Consultations.** See above. IMF **Reports on the Observance of Standards and Codes** assess the extent to which countries subscribing to the SDDS observe international standards **Milestone Assessment of the Implementation of the SNA** is a system for monitoring and assessing the performance of countries. The system includes six milestones that indicate different levels of national accounts development. Generally, the **SDDS** promotes dissemination, transparency, and public access to data. These data can then be reviewed and assessed by financial institutions (e.g., creditors) and others.
CAPACITY BUILDING	**National Communications Support Programme.** Provides technical support to enhance the capacity of non-Annex I parties in preparing their initial national communications, including in the preparation of greenhouse gas inventories. **CC:Train.** Jointly created by the Climate Convention Secretariat and the United Nations Institute for Training and Research in 1994.	The IMF's **General Data Dissemination Standard** (GDDS) focuses on education and training to improve data quality. GDDS includes a process for needs evaluation for data improvement and priority setting. Nine regional seminars for country officials have been held to date. IMF **Reports on the Observance of Standards and Codes** aim to assist countries in identifying areas where transparency can be further enhanced. **IMF Article IV Consultations.** See above.

Notes

1. The case of Russia under the Kyoto Protocol illustrates both kinds of hot air—intentional and inadvertent. At the time of negotiation, it was probably envisioned that Russia's economy would recover more rapidly.
2. Lutter (2000) argues that for forecast errors that are one period ahead, a 1 percent increase in GDP is associated with a reduction in the forecast error of about 0.1 percent.
3. This analysis uses "reduced form" regression models of the log-linear equation, using data from the IEA (2000) on two key variables, CO_2 emissions and GDP, for the period 1971 to 1998.
4. UNFCCC (2002, 54): "Each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest."

5. UNFCCC (2002, 62–63). Regarding restrictions on RMU eligibility, consider the uncertainty inherent in the following chain of conditional requirements: "Each Party included in Annex I shall issue in its national registry RMUs equivalent to the net removals of anthropogenic greenhouse gases resulting from its activities under Article 3, paragraph 3, and its elected activities under Article 3, paragraph 4, accounted in accordance with decision -/CMP.1 (Land use, land use change and forestry) as reported under Article 7, paragraph 1, following completion of the review in accordance with Article 8, taking into account any adjustments applied in accordance with Article 5, paragraph 2, and resolution of any questions of implementation related to the reported net removals of anthropogenic greenhouse gases. Each Party shall elect for each activity, prior to the start of the commitment period, to issue such RMUs annually or for the entire commitment period."
6. Indexed targets explicitly use rates of change, and intensity target formulas could be algebraically rewritten to use rates of change.
7. Article 7, paragraph 2(l).
8. For example, see Waldron (2002).
9. From the game-theoretic perspective, one can see a strong incentive for a country to increase both selling and compliance targets. A game rule needs to be designed to mitigate such strategic behavior. The proposed rule is one example where the bargaining power is distributed such that the country in question is given a primary opportunity to set its compliance target (which may determine the financial burden in case of lower performance) and other countries (e.g., the COP/MOP) have the role of setting the selling target.
10. Of course, the stringency of the targets also is partially determined by the overall environmental goal.
11. CCAP (1998) classifies 12 high-emitting developing countries into five categories. China and Iran are included in the group with "high no-regrets potential" and South Africa is classified in the "medium-high" group. India, Indonesia, Saudi Arabia, South Korea, Taiwan, and Thailand are classified in the "medium" potential group, and Mexico and Venezuela are evaluated as having "medium-low" potential. Brazil is classified in the "low potential" group.
12. This scenario is, of course, only viable if industrialized countries are likely to be net sellers.