Climate Change Policy for India*

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ABSTRACT

While the global environment waits for the world to reach some form of agreement on climate policy, developing countries such as India are entering a phase of higher economic growth. The decisions on investment in energy systems that will be made in India in coming years will have an important impact on global climate change over the coming century. This paper explores how action could be undertaken in India today, in a way that commits India to longer run goals for greenhouse emissions but does not raise the short run cost to the development process in India. The approach proposed is a modification of the McKibbin-Wilcoxen Blueprint for climate policy which relies on establishing property rights and markets in both short term and long term emission permits. The goal is to encourage long term investment decisions to move towards less carbon intensive activities. This approach could be unilaterally implemented in India. If successful it would not only reduce Indian carbon emissions but it would be an example for the entire developing world to follow and it might remove a key obstacle preventing the United States from implementing policies based on the argument that developing countries are not committed to taking action to reduce greenhouse emission.

This paper outlines the recent history and prospects for carbon emissions in India. It also explores the various alternative economic instruments that might be used. The paper presents illustrative results for the consequences of a rise in the price for carbon in India based on a new version of the G-Cubed multi-country model that includes India. This simulation illustrates that an immediate increase in the price of carbon either through taxes or from entering a Kyoto style permit trading market could be very costly for India. Thus a credible commitment such as would be possible under the Blueprint is the best way to change investment incentives in India while at the same time give India time to develop before contributing to the cost of global greenhouse abatement.

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1. Introduction

The global community has been struggling with the issue of how to effectively respond to the threat of climate change for several decades. In 1992, the United Nations Earth Summit in Rio de Janeiro produced a landmark treaty on climate change that undertook to stabilize greenhouse gas concentrations in the atmosphere. By focusing on stabilization, however, the treaty implicitly adopted the position that the risks posed by climate change require that emissions be reduced no matter what the cost. The agreement, signed and ratified by more than 186 countries, including the United States, spawned numerous subsequent rounds of climate negotiations aimed at rolling back emissions from industrialized countries to the levels that prevailed in 1990. To date, however, the negotiations have had little effect on greenhouse gas emissions and have not produced a detectable slowing in the rate of emissions growth[1]. The treaty's implementing protocol, the 1997 Kyoto agreement, has stalled after being heavily diluted at subsequent negotiations in Bonn and Marrakesh[2]. The survival of the Kyoto Protocol in its current form is waiting for ratification from Russia. More than a decade of negotiations has produced a policy that is very strict in principle but completely ineffective in practice.

The problem at the international level is actually worse than it appears from the stalled process of Kyoto ratification. Even if the Kyoto Protocol entered into force, it only places restrictions on the industrial economies excluding the world's largest greenhouse emitter, the United States. Developing countries, including India, have ratified the agreement but have not taken on any responsibilities for reducing emissions except those that emerge from mechanisms such as the Clean Development Mechanism (CDM) and joint implementation (JI). Thus in a real sense a majority of the future global greenhouse

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1 See McKibbin and Wilcoxen (2002) for a summary of the negotiations and critique of the approach.

emissions are not bound by the current international agreement. Indeed, the fact that developing countries are not taking on commitments is one of the reasons claimed by both the United States and Australia for not ratifying the Kyoto Protocol. The fact that the world largest emitter, the United States, is not involved in climate policy substantially dilutes global action even further. The fact that there are no binding commitments by the key developing countries of China, India, Brazil and Indonesia (amongst others) means that effective action against possible climate change is still a hypothetical debate.

Yet developing countries have a valid point in their argument that while they are prepared to be part of regime to tackle climate change, they should not be required to bear a disproportionate part of the costs of taking action. Current concentrations of greenhouse gases in the atmosphere are primarily the result of economic activities in the industrial economies since the Industrial Revolution. Because it is the stock of carbon in the atmosphere that matters for temperature changes, any climate change in the near future will be largely the result of the activities of industrial economies. Why should developing countries not be able to follow the same energy intensive development paths of the currently industrialized economies? The answer to this question has inevitably lead to an expectation of compensation paid for by the industrialized economies for action taken in developing countries. One of the biggest dilemmas for developing countries is not just the reality that at some stage they need to make some form of commitment to curbing greenhouse gas emissions but the fact that most estimates of the damages from climate change are borne by developing countries[3].

Standing back from the intensity of international negotiations it is worth clarifying several important facts about the costs and benefits of climate policy and exploring whether

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2 Direct comparisons of the COP3 and COP7 versions of the protocol, can be found in Bohringer (2001), Buchner et al (2001), Kemfert (2001), Löschel and Zhang (2002) and McKibbin and Wilcoxen (2004).

3 See IPCC (2001).

there are approaches possible in Developing Countries that are not being considered because of the standard refrain that "Kyoto is the only game in town". This mindset has already hindered effective action for the past decade as countries and industries postpone action until agreements are clarified. Given the uncertainties of climate change and the decisions on energy systems being made in the regions of the developing world that are growing rapidly, this delay in providing clear incentives for moving away from fossil fuel based systems, may ultimately prove to be extremely costly.

One of the largest sources of anthropogenic greenhouse gas emissions is the burning of fossil fuels. The cheapest means of changing of the global energy system to be less reliant of fossil fuels, is to remove these emissions from future energy systems rather than from existing energy systems. There are huge investments in physical and human capital surrounding existing energy systems which are costly to change. However, future investments (largely to occur in developing countries) are much cheaper to change before they are undertaken. Technology will ultimately be the source of reductions in emissions whether through the development of alternative sources of energy or through ways of sequestering carbon released from burning fossil fuels. Developing countries have huge potential to avoid the pitfalls in terms of carbon intensities, experienced by industrialized economies in their development process. The key issue is how to encourage the emergence of energy systems in developing countries that are less carbon intensive over time. Ultimately if climate change does emerge as a serious problem, developing countries will have to move towards a less carbon intensive future. It is likely to be significantly cheaper to do this over time than to face a massive restructuring at some future period – the sort of problems being faced within industrialized economies today.

This paper proposes a policy for India (the McKibbin-Wilcoxen Blueprint[4]) that will

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4 See McKibbin and Wilcoxen (2002a).

assist in moving India towards a less carbon intensive future while at the same time minimizing the short term economic costs. It is argued that the type of climate policy proposed could well increase the rate of economic growth by providing crucial institutions that enhance investments in energy technologies and economic development in India.

The paper is structured as follows. Section 2 gives a brief overview of carbon emissions in India both historically and the outlook to 2025. It also explores the approach India has taken to date in addressing climate change. There have been significant changes in India over the past two decades but these largely relate to development objectives rather than being directly related to climate policy. India is a key developing country both in terms of its size and potential emissions of greenhouse gases but also through its intellectual contributions to the global debate from a developing country perspective. By promoting alternative measures to tackle greenhouse emissions within a developing country context, it is an important case study to explore alternatives that are viable across the developing world (or at least in those key large developing countries that are potentially large greenhouse emitters). Section 3 examines a number of standard economic instruments for tackling greenhouse, exploring their strengths and weaknesses. Carbon taxes and conventional permit trading are outlined. The McKibbin-Wilcoxen Blueprint is also outlined with a focus on how it would be modified for India. Section 4 presents some preliminary results from a new climate policy model of India developed within the G-Cubed framework[5]. Using this model we explore the impact of a $US10 per ton carbon tax in India. These results illustrate the current cost to the Indian economy of a rise in the price of carbon – whether directly as a tax or as part of a Kyoto-Style permit trading system. This suggests that short term action in pricing current emissions might be expensive for India and therefore a better strategy would be to price future carbon emissions and encourage investment in less fossil fuel intensive activities in the future. A summary and conclusion are presented in Section 5.

2. Indian Emissions History and Future Climate Projections

a. Recent History

There are a number of studies on greenhouse emissions in India. A good summary is provided by Parikh and Parikh (2002) and papers in Toman et al (2003). India ratified the Kyoto Protocol in November 2002 yet the debate in India appears to be focused on the role of the Clean Development Mechanism (CDM) within the Kyoto Protocol framework and how to make CDM more widely applied within the country. This is unfortunate since the CDM is unlikely to have an important impact on India's future emissions.

Figure 1 show the profile of fossil fuel carbon emissions by energy source in India (from the US Energy Information Agency greenhouse gas database). Total emissions from fossil fuel use have risen more than 300% over the past two decades. The primary source of fossil fuel emissions is from the burning of coal (largely for electricity generation) followed by petroleum (largely from transportation) and natural gas. It is interesting that since 1995 there appears to be a slight change in the trend of emissions. This coincided with reforms within the Indian economy although more research is needed to further explore this issue and the impact of the reform process on likely trends greenhouse emissions.

b. Future projections

Projecting carbon emissions is difficult since as discussed in section 4 below, it depends on the range of assumptions about input growth and changing relative prices in the global economy. This section provides a summary of projections from the US Energy

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5 This model is one on the major international economic models used for climate policy analysis. See the survey in Weyant (1999) and McKibbin and Wilcoxen (1998) for an overview of the model.

Information Agency new 2004 report ‘International Energy Outlook 2004. Figure 2 shows a snapshot of the composition of global emissions in 2001 and again in the forecast year of 2025. The share of global emissions by developing countries is projected to rise from 44% in 2001 to 53% by 2025. India’ share in the total is projected to rise by 50% from 4 percent of global emissions to 6% of global emissions. The level of carbon emissions is projected to be 500 million metric tones of carbon (1,834 MMT carbon dioxide) in 2025 which is a doubling from the level in 2001. This is a growth rate of 2.9% over the period from 2001 to 2025.

c. Current Policies In India

India signed the United Nations Framework Convention on Climate change (UNFCCC) on June 10, 1992 and ratified it on November 1, 1993. It ratified the Kyoto Protocol in on August 26, 2002 and hosted the eighth Conference of the Parties to the UNFCCC in October 2002 in Delhi. There are a number of projects under way directly aimed at reducing greenhouse gas emissions, funded by the Global Environment Facility although these relate to small projects largely on renewable energy sources such as Biomass. The Indian government is also about to release the first national communication on sources of greenhouse gas emissions (NATCOM).

The role of the Clean Development Mechanism (CDM) and other mechanisms of the Kyoto Protocol in India’s energy future are unclear. The CDM allows developing countries to generate Kyoto permits that can be traded in an international market for projects that otherwise would not have been undertaken and which reduce emissions below a baseline. A CDM project must be voluntary, generate “real, measurable, and long term benefits related to the mitigation of climate change” and generate “reductions in emissions that are additional to any that would occur in the absence of the certified project"[6]. The main problem with the CDM is the problem of determining the baseline emissions that would otherwise have occurred as well as the amount of administrative cost involved in having CDM projects evaluated and approved. Probably the most attractive aspects of the CDM approach is the application to changes in land use practice and afforestation of degraded areas. However India is already spending resources on reforestation independently of the CDM mechanism and it may be unclear what is additional to baseline.

Parikh and Parikh (2002) point to a number of areas where India has reduced greenhouse gas emissions because of policies aimed at other goals. The gradual removal of energy subsidies and move towards world pricing for energy sources has been important in scaling back demand for coal with a 370% rise in the price of coal between 1980 and 1995. Electricity prices have risen even more over this period. Increase openness has meant that energy efficient imported goods from white goods to motor vehicles have driven innovation in more energy efficient Indian products.

The noticeable improvement in energy efficiency has been driven partly by policy and partly by price induced incentives to conserve energy. The government of India has long promoted renewable energy sources. Parikh and Parikh (2002) point out that by the end of the Ninth plan, the use of renewables in energy generation is likely to reach 6500 MW. Other policies aims at reducing air pollution in the transport sector will also likely reduce greenhouse gas emissions.

Despite all of these initiatives it is hard to see how greenhouse gas emissions in India will not continue to rise especially as economic reforms raise the potential rate of economic growth. It would seem that more direct policies aimed at changing the future composition of energy generation in India need to be considered.

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6 Page 12 of the test of the Kyoto protocol. See http://unfccc.int/resource/docs/convkp/kpeng.pdf

3. Economic Instruments for Climate Policy In India

a. Taxes and Permit trading

Economic theory provides guidance about the structure of a possible climate change policy for India[7]. Since greenhouse gases are emitted by a vast number of highly heterogeneous sources, minimizing the cost of abating a given amount of emissions requires that all sources clean up amounts that cause their marginal cost of abatement to be equated. To achieve this, the standard economic policy prescription would be a market-based instrument, such as a tax on emissions or a tradable permit system for emission rights. In the absence of uncertainty, the efficient level of abatement could be achieved under either policy, although the distributional effects of tax and emissions trading policies would be very different.

Under uncertainty, however, the situation becomes more complicated. Weitzman (1974) showed that taxes and permits are *not* equivalent when marginal benefits and costs are uncertain, and that the relative slopes of the two curves determine which policy will be better8. Emission permits are better than taxes when marginal benefit schedules are steep and marginal costs are flat: in that situation, it is important to get the quantity of emissions down to the threshold. A permit policy does exactly that. In the opposite situation, when marginal costs are rising sharply and marginal benefits are flat, a tax would be a better policy. The potential inefficiency of a permit system under uncertainty is not just a theoretical curiosity: it is intuitively understood by many participants in the climate change debate by the expression of the concern about a policy that "caps emissions regardless of cost."

Applying this analysis to climate change shows that a tax is likely to be far more efficient than a permit system under the uncertainties surrounding climate change. All

7 See McKibbin and Wilcoxen (2002a) for a survey.

evidence to date suggests that the marginal cost curve for reducing greenhouse gas emissions is very steep, at least for developed countries. Although there is considerable disagreement between models on how expensive it would be to achieve a given reduction in emissions, all models show that costs rise rapidly as emissions targets become tighter. At the same time, the nature of climate change indicates that the marginal benefit curve for reducing emissions will be very flat.

Although a tax would be more efficient than a permit system for controlling greenhouse gas emissions, it has a major political liability in that it would induce income transfers from firms to the government. This would likely be perceived as unreasonably large. In particular, firms would end up paying far more in taxes than they spent on reducing emissions because a tax is levied on all emissions and not only those that are removed at the margin. As a result, the transfers would dominate the political debate and would give firms a powerful incentive to fight the proposal. The political problem is not just that firms dislike paying taxes; rather, it is that the transfers would be so much larger than the abatement costs that they would completely dominate the political debate. The problem is not unique to climate change and is probably the most important reason that Pigouvian taxes have rarely been used to control environmental problems.

Given the advantages and disadvantages of the standard economic instruments is it possible to combine the attractive features of both systems into a single approach? Secondly, is it possible to develop a system which is common in philosophy across developed and developing economies but in which developing economies do not incur the short run costs to the economy in the form of higher energy prices until they have reached a capacity to pay?

There are a number of goals that should be at the core of any climate change regime. These involve the recognizing the tradeoff between economic efficiency and equity within

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8 See also Pizer (1997) for a more recent discussion of the issue.

and between countries. The policy should also be based around clear property rights over emissions and clear long run emission targets but near certainty in the short run costs to the economy. A sensible climate policy should also create domestic institutions that allow people to self-insure against the uncertainties created by climate change. There should be market mechanisms that give clear signals about the current and expected future costs of carbon. There should be coalitions created within countries with the self interest of keeping climate change policy from collapsing rather than creating a system of international sanctions in order to sustain the system.

a. McKibbin Wilcoxen Blueprint

The McKibbin Wilcoxen Blueprint was created to attempt to explicitly deal with these issues. It is a Hybrid system that blends the best features of taxes and emission permit trading9. It is a system that can be applied across developed and developing countries but which recognizes that developing countries should not bear the same economic costs as industrial countries in the short run, The basic approach will be presented first and then the application to a developing country such as India outlined.

The key innovation of the MW proposal is that in order to achieve the targets of long run targets as well as guaranteed short run costs we would create *two emissions-related assets* and associated markets for both in each country. These markets are not linked internationally and therefore there is no international trading of these assets. The two assets are designed to set a long run goal for emissions and to limit the short run costs. Fortunately the two markets also create a mechanism for managing risks associated with climate change policy within each economy so that very little else needs to be done to implement a consistent and simple market-based approach to tackling the climate change issue.

The first asset is an ***emission permit***. This certificate would entitle its holder to produce a unit of carbon each year (each permit would have a date stamp and be valid only in the year issued). These emission permits are to be held by producers of carbon to acquit for each unit of carbon produced each year. The holder of the permit and the ultimate owners who supply the market need not be the same people.

The second asset is an ***emission endowment,*** which is a certificate that entitles the holder to an emission permit *every year forever*. The emission endowment is like a government bond that pays a coupon of an emission permit every year. Another way to think about the two assets is that the emission endowment is like stock in a corporation whereas the emission permit is the dividend the corporation pays each year to people who hold the shares. The stock value is the expected value of future dividends.

There is a critical difference between the two asset markets. The endowment market, which is a long-term market, would be one in which the supply of carbon is fixed (the goal of policy) but the price is flexible. The market supply curve if shown in figure 3. The government cannot issue more endowments after the initial allocation but can buy back endowments in future years if the target for emissions is to be tightened. Because the endowment is the perpetual lived asset, its price will reflect the expected future price of emission permits in each year (analogously to the stock price and the dividends of a company).

We treat the market for annual emissions quite differently. The demand for permits will be by industry that requires a permit for producing carbon. The supply of permits in any year will be composed of the permits generated by the emission endowments. We also introduce a supply of permits by the government of a sufficient amount to hold the price of permits at an internationally agreed level. Thus the price of permits is fixed and the number of permits (equal to the amount of carbon emissions in any year) is allowed to vary. The

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9 The intellectual idea actually dates back to Roberts and Spence (1976) for general environmental policy and

supply of annual permits by the government is shown in the right hand panel of Figure 3. The aggregate supply for annual permits is the combination of the supply from perpetual permits and the government supply and shown in Figure4. Every ten years there would be a negotiation between all countries in which the price for emission permits is agreed to and fixed for ten years. The price of permits would be fixed in each economy by governments selling additional permits into the market after the permits generated by the endowments have been fully utilized. Thus a producer that wants to produce a unit of carbon for domestic use can get a permit in a given year by either having an existing emission endowment, purchasing an emission endowment in the endowment market (this would be sold by another private holder of an endowment), or purchasing an emission permit in the permit market that is either supplied by a private owner of a permit or from the government.

The perpetual permit market is like the market for long term government bongs whereas the annual permit market in like the short term interest rate market in which a central bank controls the price of money (or the interest rate). The two markets are linked because the bond market prices the expected future path of short term interest rates controlled by the central bank as well as the long run demand and supply of capital. For the same reasons that central banks control the short term interest rate, the government would control the short term price of permits except that commitments on the price of several years into the future would be made in advance give some certainty on the cost of carbon in production.

In several papers McKibbin and Wilcoxen have proposed that the initial price of the annual permits – which would determine the marginal cost of emitting carbon -- be set at $US10 per ton of carbon (in 1990 dollars). The price cap would be the same in all markets in all participating countries, and thus the cost of removing carbon at the margin in each economy would be identical in the short run, if the cap was reached (note in the discussion

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McKibbin and Wilocxen (1997) for climate change policy.

below developing countries would have zero annual prices for a period because of the large supply of perpetual permits). No complicated system of international trading in permits or global monitoring would be required – addressing a central flaw in the current Kyoto Protocol. Moreover, the value of permits in the United States or Australia or India would not depend on how permits are generated in other countries.

In contrast, the price of endowments would be flexible, reflecting the outcome of market forces, the period of fixed permit prices in the near future, as well as the expectations of private actors as to what is likely to happen after the current negotiation period. Industry and consumers would be expected to respond to both the short run price signals (which are known for ten year periods) as well as the long run price signals (which are market determined) in making spending and investment decisions.

The purpose of separating the endowment market from the emissions market is to ensure that, over the long run, emissions do not exceed a given limit. The annual emissions permitting process cannot accomplish this objective since it operates on the basis of a fixed price (the emissions fee), not a fixed quantity.

The initial allocation of endowments would be up to each government. We propose giving a significant portion to every person in an economy at a point in time. We would also give a large amount to fossil fuel industries and fossil fuel intensive industries as compensation to shareholders for the capital losses of significant structural change as well as to workers in these industries. The initial allocation of endowments will create a natural constituency supporting climate change policies because the value of the endowments in future years will depend on the commitment of the government to pursue sound environmental policies. This would create a mechanism for enforcement of the agreement that is internal to each country.

The actual outcome in any year in an industrial economy facing a binding short run constraint would depend on the functioning of demand and supply in the annual market and the perpetual market. Figure 5 illustrates two possible outcomes in the annual permit market. In the case illustrated by the left hand pnael of Figure 5, marginal abatement costs are low and the perpetual permits are sufficient to meet the short run demand for annual permits. The price in the nnaul market is P and the revenue going to the pertual permit owners in the single year is P^*Q_T. In the right hand panel the marginal abatement costs turn out to be high so the perpetual permits are insufficient to meet the demand for emissions in the given year. Thus the owners of perpetual permits can rent their permits for $P^* Q_T$ and the government sells additional permits in that year to keep the price at PT. The revenue to government is the rectangle shown. Thus emissions are above the long term target but the price is known.

It is important in this example to distinguish between the way industrial countries would be treated under this approach and the treatment of developing countries. Failure to do so could unduly inhibit the growth of the developing world and would not attract their support for a global system that is absolutely crucial for a successful policy.

Accordingly, it is appropriate in the case of industrial countries (Annex B countries) to use the Kyoto targets as the perpetual permit allocation within each economy. For developing countries such as India, however, it is only reasonable to allow perpetual permit allocations well in excess of current requirements (the precise levels being subject to international negotiation or unilateral goals). With endowments greater than requirements for permits over the next several decades, the price of annual permits in a developing country would be zero, and thus there also would be no short run costs. In contrast, the price of perpetual permits in developing economies would be positive, since the price would reflect the expected future price of permits. Thus a price signal can be introduced into a developing country like India that will affect current investment plans without entailing short run costs.

A developing country can therefore begin to contribute to a reduction in emissions with a firm commitment in the form of perpetual permits. This reduction will be realized, however, only when emissions actually bump up against the perpetual permit limit. The faster a country's economy grows, and thus the faster pace at which emissions are growing, the more rapidly the endowment constraint will become binding.

Meanwhile, carbon intensive industry will have fewer incentives to shift from Annex B countries into developing countries in order to avoid the carbon charge in industrial countries because they would need to consider the fact that all countries will be participating in the overall emissions reduction program (of which endowments would play an important role). The differential endowment system – one for industrial countries, another for developing countries – also would have the added benefit of factoring in the cost of emissions in decisions by foreign private investors when deciding whether to commit funds to developing countries. Another important issue that our approach avoids relative to Kyoto is that under Kyoto if a developing country joins the Annex B trading system they will immediately face the new higher price of carbon (which could be costly as shown in section 4 below), which will lead to immediate structural change within that economy. Even though compensation could be made through giving a large allocation of permits, it is not clear that the officials who receive the permits will be the same people who are impacted by the jump in carbon prices.

The attractiveness of the Blueprint for creating institutions to aid in economic development in developing countries should not be underestimated. The ability of investors in energy systems to effectively hedge their investment over long period of time should be very attractive for the development of energy systems in developing countries. The length of the assets created by committing to global climate systems is currently unparalleled. India could use this new asset as a way of attracting foreign investment and enhance the development process by creating what is effectively a future market in energy. This is far more likely to induce foreign investment that the CDM or other similar mechanisms that face very high administrative costs.

An example of the differential effects of the policy in India relative to Annex B countries is given in figures 6 and 7. Figure 6 contains a stylized example for annual permit prices in which the Blueprint is introduced in Annex B countries and India in 2004 with a renegotiation of the permit price at ten years steps. This is a case in which information arrives over time about a worsening climate problem and authorities decide to tighten the climate constraint progressively by raising permits price each decade until they are expected to be $US140 per ton 2044 and stay there forever. India on the other hand faces permit prices of zero for two decades before the constraint given by the allocation of perpetual permits begins to bind in 2024. Gradually over time the price in the annual permit market rises to the same price as in Annex B countries by 2030. This long period of adjustment will still have an impact on energy investments in India. Figure 7 shows the value of the perpetual permits in both markets under the assumption of a discount rate of 5%. The value of perpetual permits in India are substantial and a strong incentive in that the future price of carbon is priced even though the actual constraint on industry is not binding for several decades.

Clearly this example is illustrative only. If the commitment of India was not credible then the value of perpetual permits would be discounted and if the future price of annual permits was expected to be low then the value of perpetual permits would also be low. However once distributed and traded the former example would be unlikely to be observed because the enormous wealth generated for the recipients of the perpetual permits would create a powerful constituency for the current and future governments to stick with the policy. Reneging would be equivalent to abolishing real estate contracts or the Indian stock exchange. It would be highly unlikely to occur.

4. Some Preliminary Results for India

In exploring the impact of policies that price carbon in the short term in this section results a re presented for the impact of a carbon tax in India using a new model of India developed within the G-Cubed Multi-country model. First the model is summarized (full details can be found at www.gcubed.com) and then results presented.

a. The G-Cubed Model

The G-Cubed model outlined in McKibbin and Wilcoxen (1999), is ideal for undertaking global projections having detailed country coverage, sectoral disaggregation and rich links between countries through goods and asset markets. A number of studies—summarized in McKibbin and Vines (2000)—show that the G-cubed model has been useful in assessing a range of issues across a number of countries since the mid-1980s.[10] A summary of the model coverage is presented in Table 1. Some of the principal features of the model are as follows:

- The model is based on explicit *intertemporal* optimization by the agents (consumers and firms) in each economy[11]. In contrast to static CGE models, time and dynamics are of fundamental importance in the G-Cubed model.

- In order to track the macro time series, however, the behavior of agents is modified to allow for short run deviations from optimal behavior either due to myopia or to restrictions on the ability of households and firms to borrow at the risk free bond rate on government debt.

[10] These issues include: Reaganomics in the 1980s; German Unification in the early 1990s; fiscal consolidation in Europe in the mid-1990s; the formation of NAFTA; the Asian crisis; and the productivity boom in the US.

11 See Blanchard and Fischer (1989) and Obstfeld and Rogoff (1996).

For both households and firms, deviations from intertemporal optimizing behavior take the form of rules of thumb, which are consistent with an optimizing agent that does not update predictions based on new information about future events. These rules of thumb are chosen to generate the same steady state behavior as optimizing agents so that in the long run there is only a single intertemporal optimizing equilibrium of the model. In the short run, actual behavior is assumed to be a weighted average of the optimizing and the rule of thumb assumptions. Thus aggregate consumption is a weighted average of consumption based on wealth (current asset valuation and expected future after tax labor income) and consumption based on current disposable income. Similarly, aggregate investment is a weighted average of investment based on Tobin's q (a market valuation of the expected future change in the marginal product of capital relative to the cost) and investment based on a backward looking version of Q.

● There is an explicit treatment of the holding of financial assets, including money. Money is introduced into the model through a restriction that households require money to purchase goods.

● The model also allows for short run nominal wage rigidity (by different degrees in different countries) and therefore allows for significant periods of unemployment depending on the labor market institutions in each country. This assumption, when taken together with the explicit role for money, is what gives the model its "macroeconomic" characteristics. (Here again the model's assumptions differ from the standard market clearing assumption in most CGE models.)

● The model distinguishes between the stickiness of physical capital within sectors and within countries and the flexibility of financial capital, which immediately flows to where expected returns are highest. This important distinction leads to a critical difference between the *quantity of physical capital* that is available at any time to produce goods and services, and the *valuation of that capital* as a result of decisions about the allocation of financial capital.

As a result of this structure, the G-Cubed model contains rich dynamic behavior, driven on the one hand by asset accumulation and, on the other by wage adjustment to a neoclassical steady state. It embodies a wide range of assumptions about individual behavior and empirical regularities in a general equilibrium framework. The interdependencies are solved out using a computer algorithm that solves for the rational expectations equilibrium of the global economy. It is important to stress that the term 'general equilibrium' is used to signify that as many interactions as possible are captured, not that all economies are in a full market clearing equilibrium at each point in time. Although it is assumed that market forces eventually drive the world economy to a neoclassical steady state growth equilibrium, unemployment does emerge for long periods due to wage stickiness, to an extent that differs between countries due to differences in labor market institutions.

Table 1: Overview of the G-Cubed Model

Regions
United States
Japan
Australia
Canada
New Zealand
Europe
Rest of the OECD
China
India
Brazil
Mexico
Rest of Latin America
Oil Exporting Developing Countries

Eastern Europe and the former Soviet Union Other Developing Countries
Sectors
Energy: (1) Electric Utilities (2) Gas Utilities (3) Petroleum Refining (4) Coal Mining (5) Crude Oil and Gas Extraction Non-Energy: (6) Mining (7) Agriculture, Fishing and Hunting (8) Forestry/ Wood Products (9) Durable Manufacturing (10) Non-Durable Manufacturing (11) Transportation (12) Services (Y) Capital Good Producing Sector

The policy assumptions in place are important. For monetary policy we assume that the Reserve Bank Of India follows a Henderson-McKibbin rule12 setting short term nominal interest rates based on the previous period short term interest rate and the gap between the actual and desired inflation target and the gap between the actual and potential growth rate of real GDP with weights of 0.5 on inflation and output growth. For fiscal policy we assume that the central government exogenously determines the ratio of spending on each type of good to GDP and has an exogenous rate of employment. Corporate and household income tax rates are assumed to be constant along the baseline. Fiscal deficits are allowed to emerge but changes in the interest servicing costs of a federal fiscal deficit are financed by a lump sum tax on households. This is sufficient to eventually stabilize the ratio of government debt to GDP in the long run.

12 See McKibbin and Singh (2003)

b. The Results for a Rise in the Price of Carbon

In this section we use the G-Cubed model to explore the impacts on the Indian economy of a rise in the price of carbon in 2004 and maintained permanently. There are a number of ways this could arise, whether as part of a carbon tax, a domestic permit trading system or an international permit trading system under the Kyoto Protocol. The difference between these regimes is the issue of who receives the revenue from the payments for carbon rights. In the case of a carbon tax the payments would go to the government. In the case of a domestic permit trading regime the payments would go to the owners or generators of the permits, which could be the government in an auction setting, or individuals or companies who receive an allocation of permits from the government. In the case of the Kyoto system it could be any of these or if India became a net importer of permits it could be transfers to foreigners. It is very unlikely given the various studies on the marginal abatement costs of reducing carbon that India would be a net importer of carbon rights.

In McKibbin and Wilcoxen (2004) we simulate the Kyoto Protocol as if it was implemented as at the Marrakesh agreements of 2002 but without the participation of the United States or Australia. In that study we found that the permit price of a Kyoto trading system would rise from close to $US4 per ton in 2008 to $US10 by 2020 under a range of specific assumptions. Although we could include India into a Kyoto style scenario in the new model, in this paper we first explore the impact of a carbon tax of $US10 per ton to illustrate the impacts on the Indian economy. This is illustrative of the impacts of joining a Kyoto trading system where the price of carbon in India would rise to the global market price. The main difference between this scenario and the permit trading scenario is that the transfers from foreigners to India, is not modeled. Thus the income effects would be smaller than that shown in these results.

We first need to generate baseline projection for the world economy. The assumptions about the inputs into growth projections are from the fundamental sources of growth in the G-Cubed approach. There are two key inputs into the growth rate of each sector. The first is the economy wide population projection. The second is the sectoral productivity growth rate. In Bagnoli et al (1996) we modeled economy wide productivity and then used the historical experience of differential growth across sectors to apportion the aggregate productivity projections to each sector within an economy.

We now assume that each sector in the US will have a particular rate of productivity growth over the next century. We then assume that each equivalent sector in each other country will catch up to the US sector in terms of productivity growth, closing the gap by 2% per year. The initial gaps are therefore critical for the subsequent sectoral productivity growth rate. We follow a two step process in determining the initial size of the gap. The first step is to specify the gap between all sectors and the US sectors equal to the gap between aggregate PPP GDP per capita between each country and the US. We can't use sectoral PPP gap measures because these do not exist. Thus the initial benchmark is based on the same gap for each sector as the initial gap for the economy as a whole. If we then have evidence that a particular sector is likely to be closer to or further away from the US sectors than the aggregate numbers suggest, we adjust the initial sectoral gaps attempting to keep the aggregate gaps consistent with the GDP per capita gaps. We then assume that productivity growth in each sector closes the gap between that sector and the equivalent US sector by 2% per year. The productivity growth is calculated exogenously to the model. We then overlay this productivity growth model with exogenous assumptions about population growth for each country to generate two of the main sources of economic growth.

Given these exogenous inputs for sectoral productivity growth and population growth, we then solve the model with the other drivers of growth, capital accumulation, sectoral demand for other inputs of energy and materials all endogenously determined. Critical to the nature and scale of growth across countries are these assumption plus the underlying assumptions that financial capital flows to where the return is highest, physical capital is sector specific in the short run, labor can flow freely across sectors within a country but not between countries and that international trade in goods and financial capital is possible subject to existing tax structures and trade restrictions.

Thus the economic growth of any particular country is not completely determined by the exogenous inputs in that country since all countries are linked through goods and asset markets.

Carbon emissions are determined in the model by the amount of fossil fuels (coal, oil, natural gas) that are consumed within each country in each period. These primary factors are endowed within countries but can also be traded internationally subject to transportation costs (captured implicitly through the elasticities of substitution between each good in the model). Thus economic growth can occur within a country, without any particular pattern implied for energy use. The pattern on energy use will be dependent on the underlying inputs into the growth process.

After generating the baseline we then impose a shock of a carbon tax in India of $US10 (real in 2002 prices) per ton of carbon. Results in the figures are presented as percent deviation from the underlying baseline.

The results are contained in figure 8 and figure 9. Figure 8 contains the percent deviation in gross domestic product (GDP), Gross National Product (GNP) and carbon emissions. Figure 9 contain results for the output of each sector relative to baseline.

Imposing a price of carbon of $US10 per ton of carbon from 2004 reduces GDP in India by up to 0.75% by 2012. In the longer run there is substitution on the supply side away from carbon based energy and changes in consumer behavior as well as increased investment in non fossil fuel technologies. This endogenous response halves the initial GDP loss after three decades. The GNP loss is larger than the GDP loss because of payments to foreigners for the increase borrowing by India in an attempt to smooth consumption over time. The carbon tax is effective in reducing carbon emissions by 16% in the first year and then by up to 10% after 30 years.

There is a differential impact on sectors of the Indian economy as shown in Figure 7. Clearly the hardest hit sector is the coal sector. Because coal is roughly 60% carbon and tax on carbon substantially raises the price of coal. This reduces the demand for coal and coal based products. There is initially a 25% fall in the output of the coal sector. Other energy related and energy intensive products also experience a decline in demand as their price rises. The service sector on the other hand experiences a gradual rise in output because of its low energy intensity. Over time the economy moves away from fossil fuel based consumption to less carbon based products as well as less energy intensive products which is focused in the service sector. Despite the longer term changes in Indian economic structure, the GDP losses are not completely unwound.

These results can also be considered in the context of India joining a permit trading system within the Kyoto Protocol. Unless India can quarantine the domestic and foreign markets in permits it will be the case that domestic opportunities to reduce emissions will emerge where these reductions costs less than the world permit price. The main difference between these results and the results of a Kyoto permit system trading at $US10 per ton of carbon would be that India would likely be a net exporter of permits and thus there would be transfers through the balance of payments to India. The GDP profile is unlikely to change a great deal but the GNP profile would be less negative due to the income transfers from overseas.

The key point is that it is difficult in any international trading systems to isolate a country such as India from facing the short run structural adjustment shocks while achieving the gains from trading permits. This is a risky strategy for a developing country unless it can be sure it has the ability to domestically transfer resources and to deal effectively with the structural issues that would emerge from a change in comparative advantage from labor intensive manufacturing to generate carbon abatement credits. In contrast the MW Blueprint enables the price of future carbon to be priced into the investment decisions of firms and households but at the same time the short run structural shock can be quarantined because the short run price of carbon would be zero for at least a decade. Just as the results show that over time GDP can be stimulated through investment and incentive within India, there is no need for India to be part of a global carbon trading system. Therefore managing the shift to a less fossil fuel intensive economy over time is less costly and more feasible under the Blueprint than through a Kyoto permit trading scheme.

5. Summary and Conclusion

This paper has summarized the climate policy issues currently facing India at a time when the global climate debate has stalled around the lack of progress in the Kyoto Protocol. It is particularly important to have this debate in India when more than a billion people are poised to enter a new phase of higher economic growth. It is argued in this paper that there are policies such as the McKibbin Wilcoxen Blueprint which could be implemented in India as part of a broader strategy of action that both prices future carbon emissions and encourages economic development. The development of institutions to manage risk as well as the clear commitment to taking effective action against future carbon emissions has the potential to be an attractive option for a country like India. If it was shown to be successful in both stimulating foreign investment in energy development and reducing the trend of greenhouse emissions through market based incentives based on the clear establishment of property rights, the demonstration effect across the developing world would be powerful. It would certainly remove the complaint by countries like the United States and Australia against taking action because of lack of binding commitments by developing countries. That alone would reduce greenhouse gas emissions significantly in future decades.

The alternative strategy for India is to wait for a resolution of the stalemate over the Kyoto protocol and wait for large sums of financial assistance to accompany the transfer of energy technology from the industrial economies though some other Kyoto like endeavor. I believe that this will be a very long wait if past historical experience of is any guide. But in waiting to take action, decisions are already being made in India on long term investments with very few incentives to move away from reliance on the abundance of low cost fossil fuels within India. Thus in delaying the creation of a framework for committing to taking action on climate policies, the Indian economy could suffer unnecessary future structural shocks caused by an eventual need to adapt to the realities of a world with serious climate problems. The Blueprint could be implemented unilaterally in India without an international agreement although it could be made consistent with Kyoto style systems over time if necessary. As Parikh and Parikh (2002) argue "The need for an approach to mitigating the threat of climate change that is equitable and one that can accommodate differing perspectives on risk need to be elaborated". This paper attempts to provide one approach that has many advantages including a great deal of flexibility to adapt as the world learns more about the threats and challenges of climate change.

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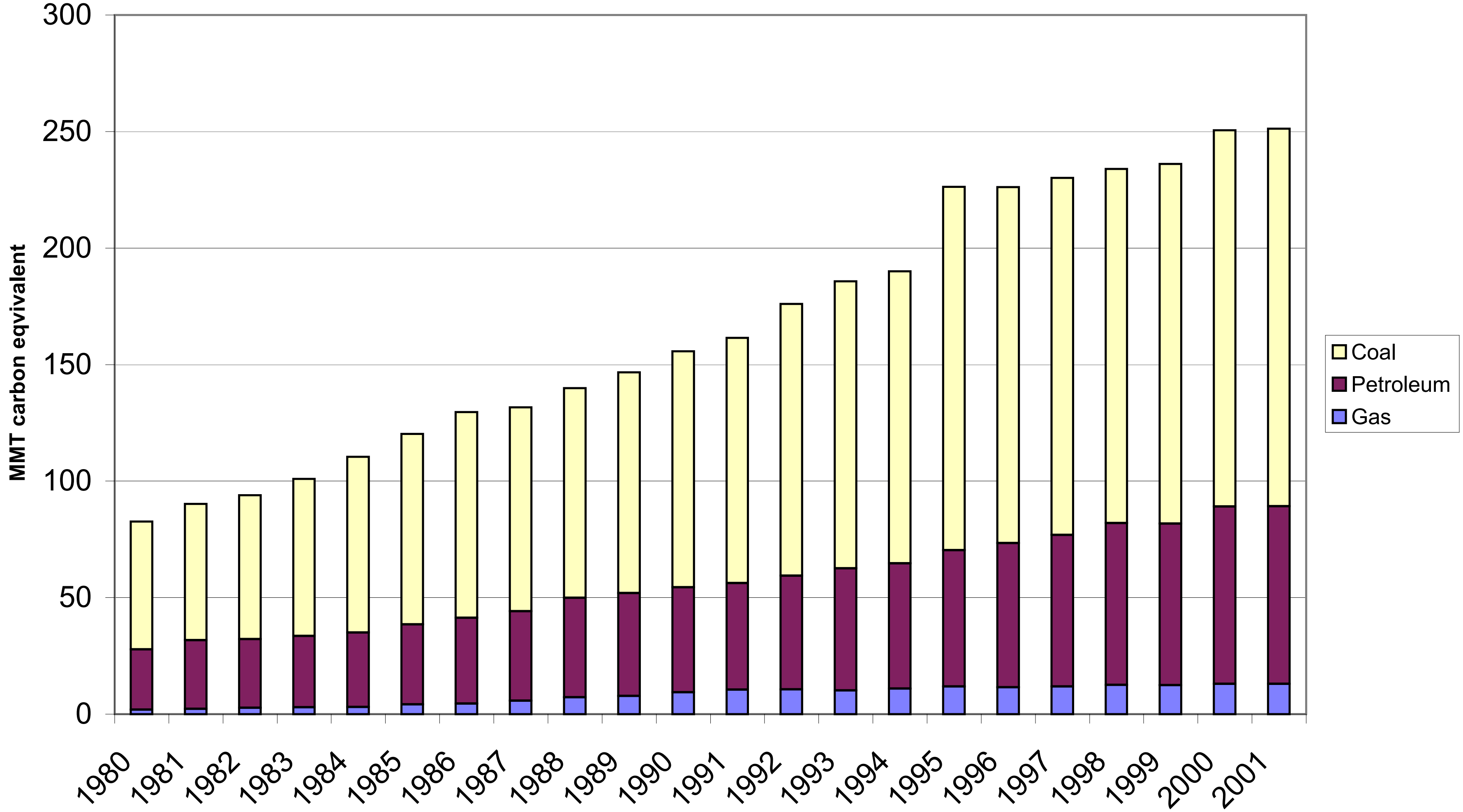
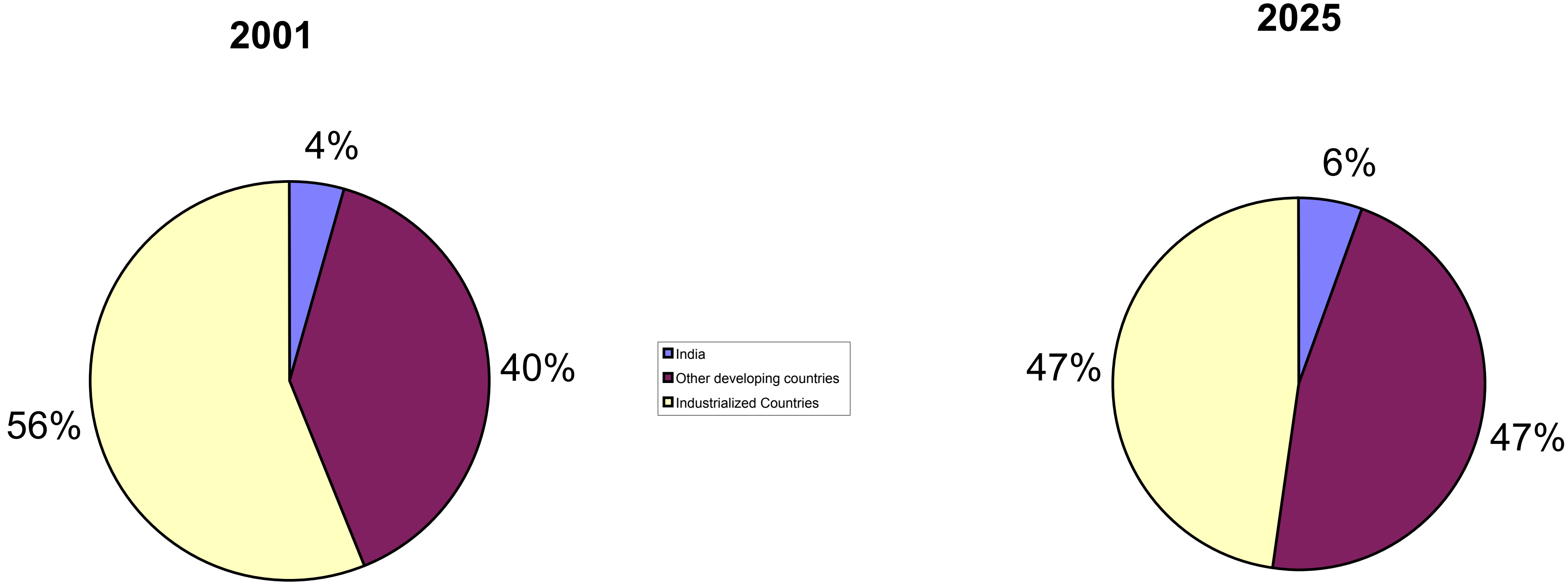
Figure 1: Indian Carbon Emissions by Source 1980-2001



Source: US Energy Information Agency (2004)

Figure 2: India's Share of Global Carbon Emissions from Fossil Fuels 2001 and 2025



Source: US Energy Information Agency (2004) "International Energy Outlook 2004"

Figure 3: Market supply in the perpetual and annual permit markets

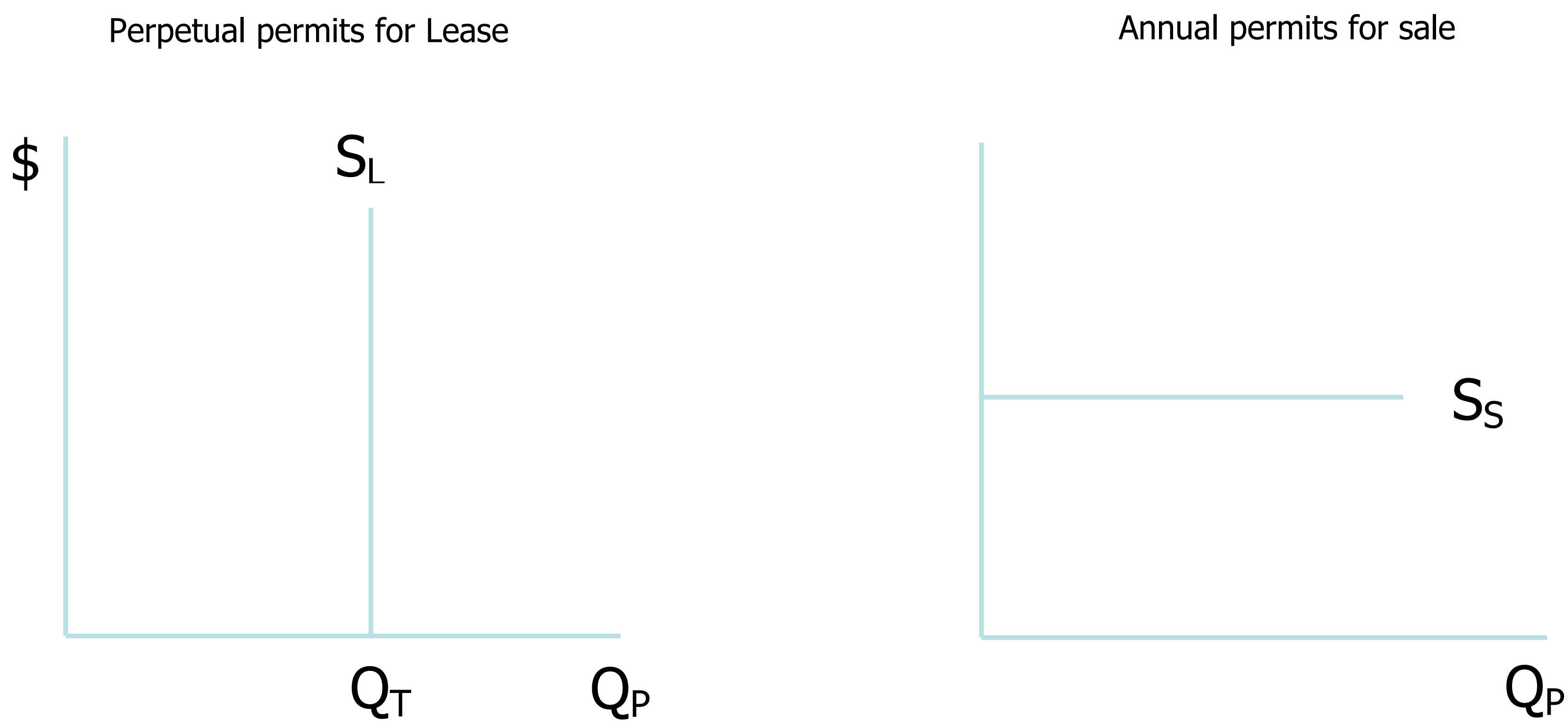


Figure 4: Overall Supply of Annual Permits in a Given Year

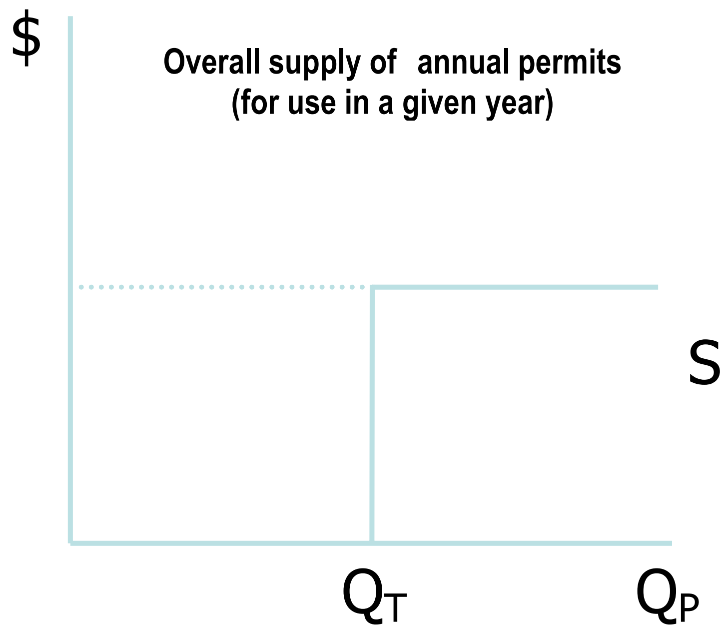


Figure 5: Alternative Marginal Abatement Cost Outcomes

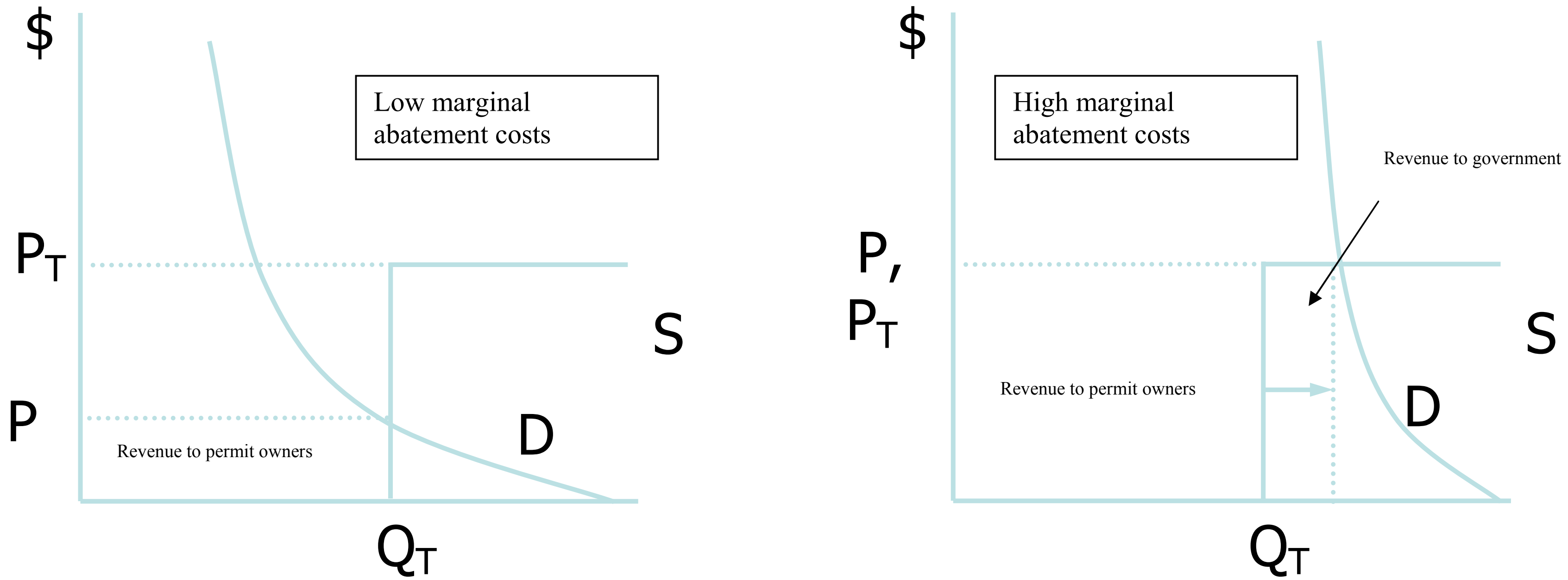


Figure 6: Stylized Annual Permit Price

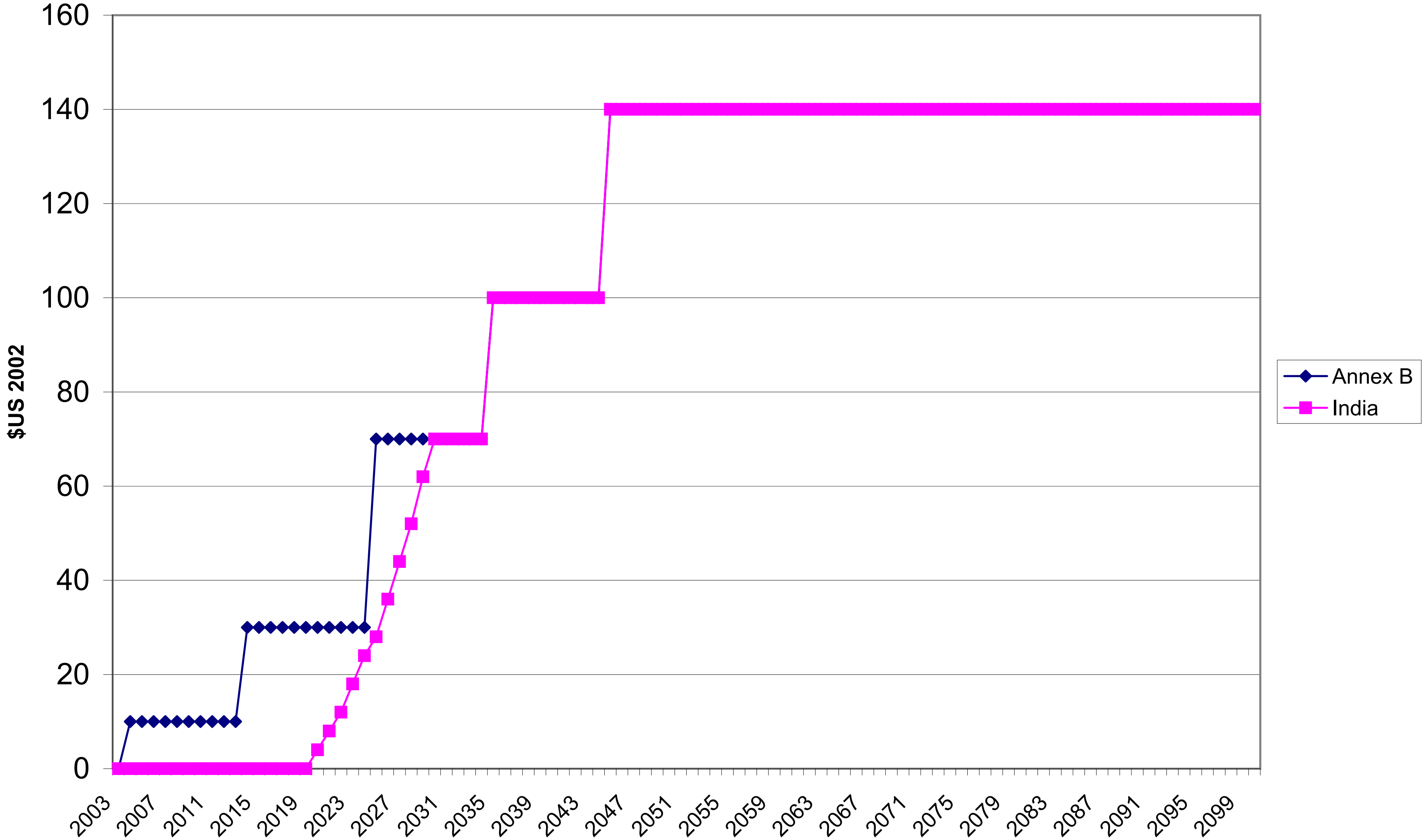


Figure 7: Stylized Value of Perpetual Permits

(Assuming r=5%)

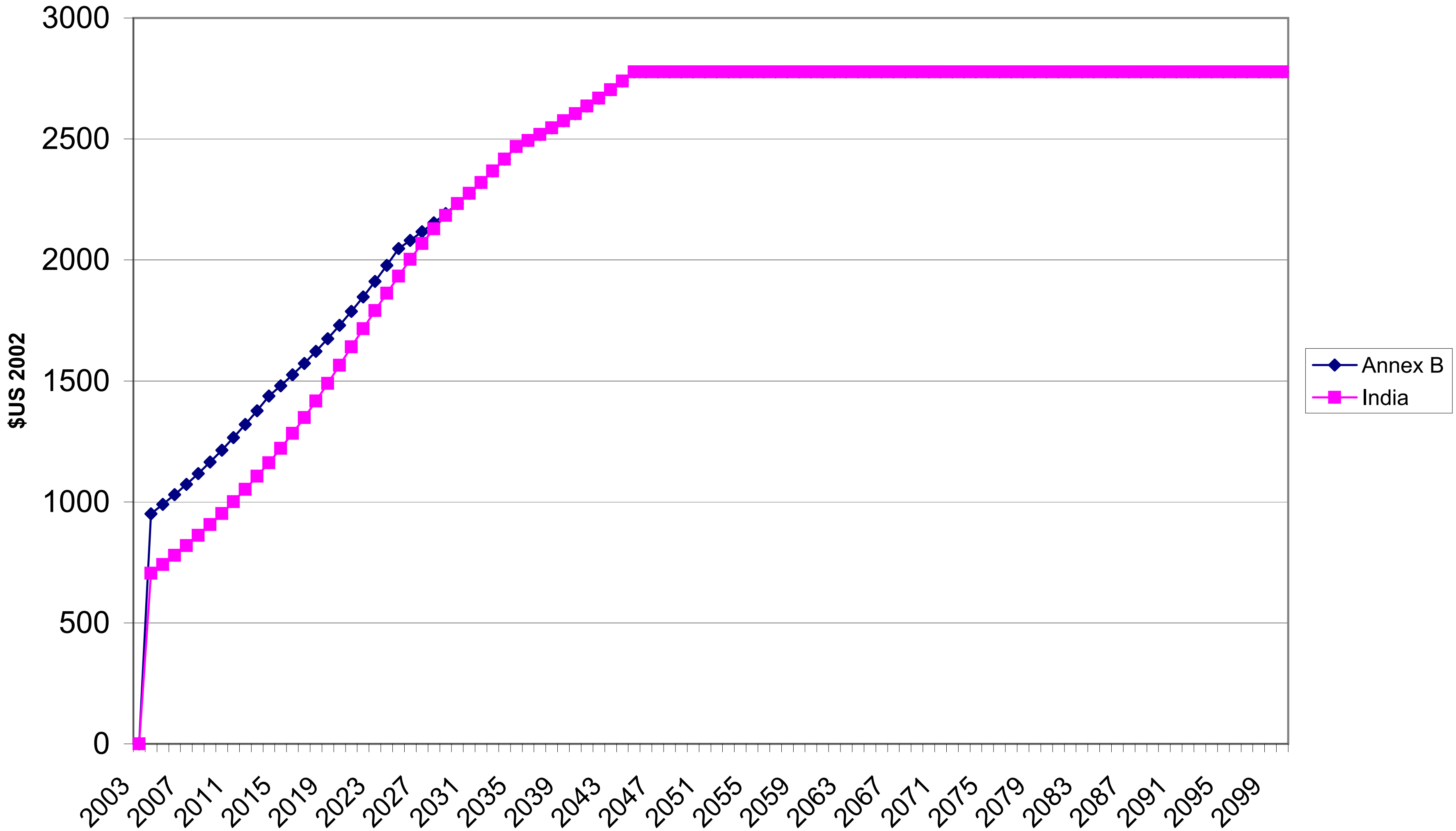
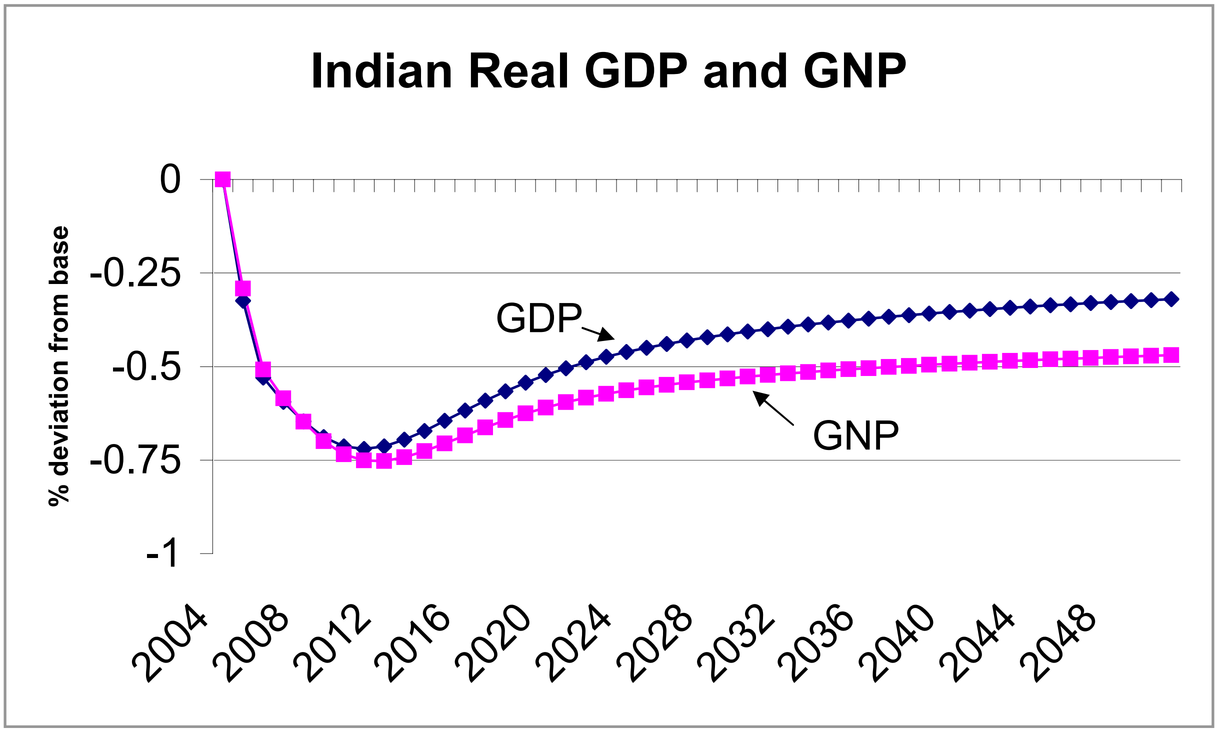
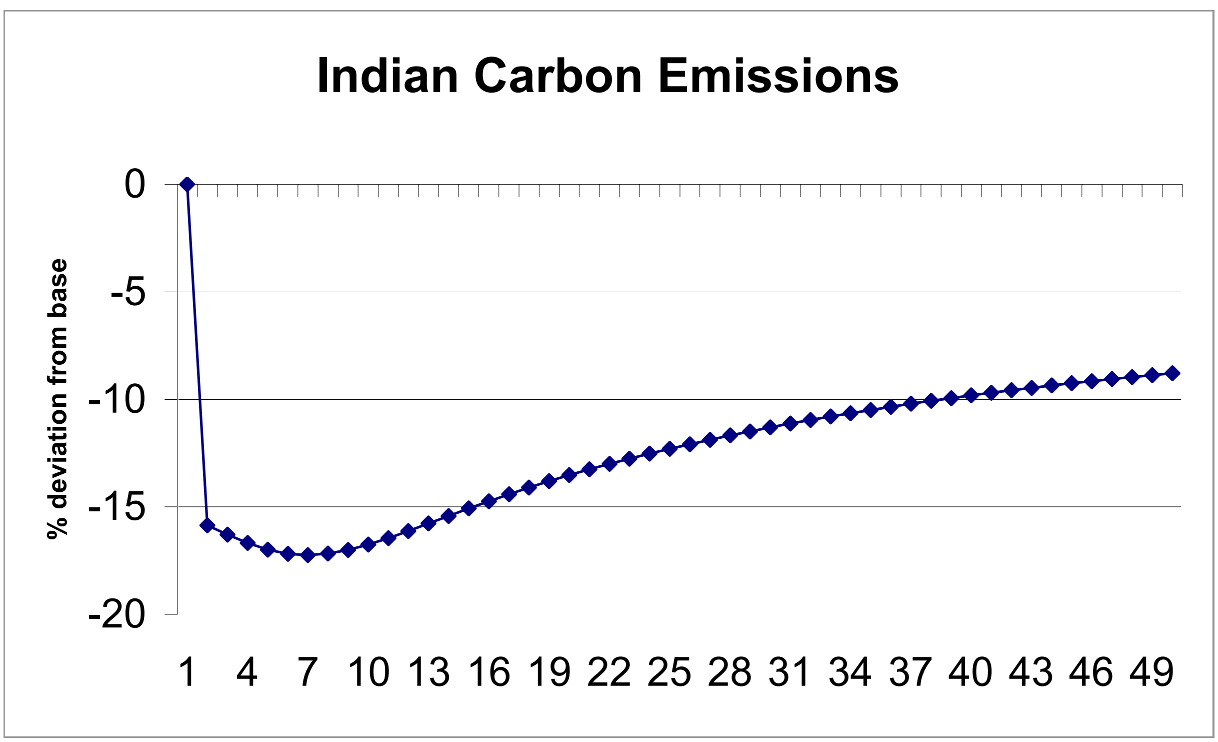


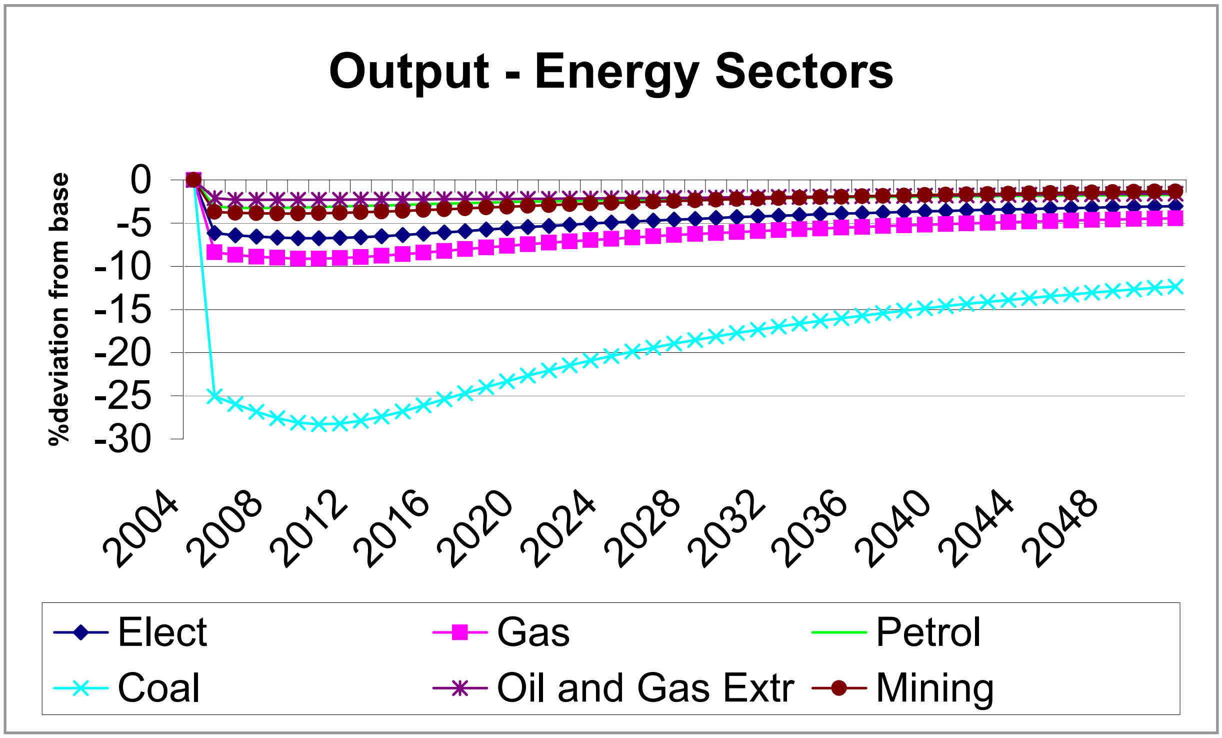
Figure 8:Impacts on India of a $US10 per ton of Carbon

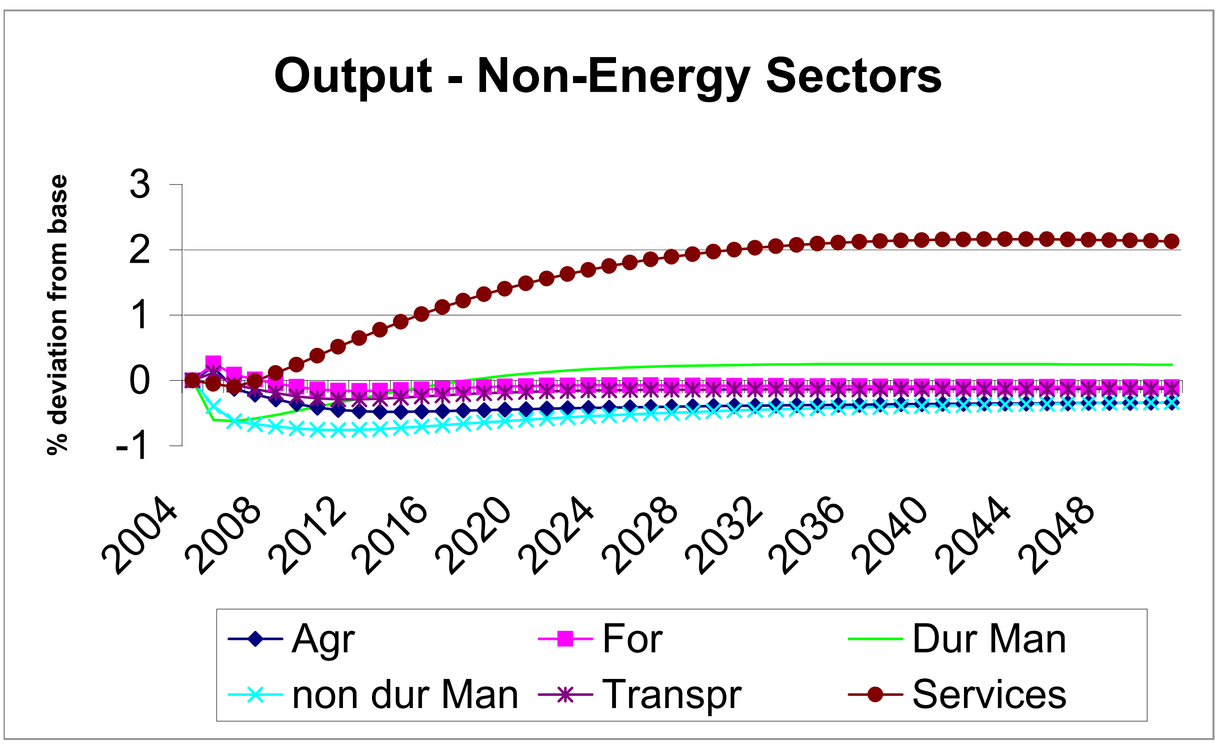




Source:G-Cubed model version 55I

Figure 9 :Impacts on Indian sectors of a $US10 per ton of Carbon





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