MIT Joint Program on the Science and Policy of Global Change

The Effects of Changing Consumption Patterns on the Costs of Emission Restrictions

Supriya Lahiri, Mustafa Babiker and Richard S. Eckaus

Report No. 64
August 2000

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To inform processes of policy development and implementation, climate change research needs to focus on improving the prediction of those variables that are most relevant to economic, social, and environmental effects. In turn, the greenhouse gas and atmospheric aerosol assumptions underlying climate analysis need to be related to the economic, technological, and political forces that drive emissions, and to the results of international agreements and mitigation. Further, assessments of possible societal and ecosystem impacts, and analysis of mitigation strategies, need to be based on realistic evaluation of the uncertainties of climate science.

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The Effects of Changing Consumption Patterns on the Costs of Emission Restrictions

Supriya Lahiri, Mustafa Babiker and Richard S. Eckaus†

Abstract

Models with time horizons of 100 years are customarily used to predict anthropogenic greenhouse gas emissions and to inform the different climate-change policy dialogues. Historical evidence indicates that over this time span the current consumption patterns in developing countries are likely to change substantially and to converge to the present patterns in developed countries. The implications of such changes on emissions profiles and on the costs of policies to curtail them in developing countries are crucial aspects of a comprehensive climate-change policy agenda. This study deals with modeling this type of non-homotheticity in consumption functions within the EPPA framework based on econometric estimation and the above assumption of convergence in consumption patterns.

We find that the composition of consumption and the consequent implications for the sources of emissions would be different in the model with static consumption-function coefficients from that in the model with dynamic coefficients, even though the regional emissions profiles are virtually the same in the two cases. The differences have significant implications for the costs of emissions restrictions in developing countries. Our results suggest that the costs of emissions restrictions in developing countries would be higher if the changes in consumption patterns are taken account of than if they are ignored in the simulation model.

Contents

1. Introduction

The economics of global emissions and climate change deal with processes that take place over substantially long periods of time, a century or more. Thus we need long-term economic models that also span this time horizon to evaluate the impact of alternative climate change policies. All the behavioral relationships in such very long-run models may be expected to undergo substantial changes during their time horizons. In particular, the behavior of consumer demands, especially in relatively rapidly growing developing countries will not remain the same in the very long-term. While long horizon projections are uncertain it is reasonable to expect that, as growth takes place, the consumption behavior of developing countries will change and can be expected to move toward the consumption patterns of developed countries. These structural changes will

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take place due to income growth, urbanization, technical change and other long-term social as well as economic transformations. This is confirmed by empirical estimates of consumption function parameters that have shown that consumption function parameters are, in fact, very different for developed and developing countries.[1] The objective of this study is to investigate the effects of long-term changes in consumption patterns of developing countries on levels of global emissions of greenhouse gases and the resulting costs of emissions restrictions.

2. Overview of the Study

The principal objectives of the MIT Emission Prediction and Policy Analysis Model (EPPA) are to predict the levels of total emissions for the global economy at a disaggregated and regional level and to determine the costs of emissions restrictions. EPPA is a recursive dynamic, multi-regional general equilibrium model of the world economy. The current version of EPPA (EPPA version 3, Babiker *et al*., 2000)[2] is built on a comprehensive energy-economy data-set (GTAP-E)[3] that provides a consistent representation of energy markets in physical units as well as detailed accounts of regional production and bilateral trade flows. The base year for the model is 1995 and the model is solved recursively through 2100 in 5-year time intervals.

The model includes eight production and consumption sectors, plus energy backstop sectors, with the world divided into 12 regions. Description of these sectors and regions is provided on **Table 1**. The model's equilibrium framework is based on final demands for goods and services arising from a representative agent in each region. Final demands are subject to an income balance constraint with fixed marginal propensity to save. Investment is savings-driven, and capital is accumulated, subject to vintaging and depreciation. Consumption within each region is financed from factor income and taxes. Taxes apply to energy demand, factor income and international trade, and are used to finance an exogenously determined growth in the level of government spending on goods and services. International capital flows in base year accounts are phased out gradually, and the government budget is balanced each period through lump-sum taxes.
Based on DOE/EIA statistics (DOE/EIA, 1998) fossil energy resources are calibrated to an exogenous price path for fuels) through 2010. After 2010, a long-run resource depletion model determines energy prices. Energy goods and other commodities are traded in world markets. Crude oil is imported and exported as a homogeneous product, subject to tariffs and export taxes. All other goods, including energy products such as coal and natural gas, are characterized as regionally differentiated products that can move in international trade, with an explicit representation of bilateral trade flows calibrated to the reference year, 1995.

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[1] See Lluch, Powell and Williams (1977).

[2] For a brief description of the EPPA model version 2, see Yang *et al*. (1996); for a brief description of the EPPA version 3 model, see Babiker *et al*. (2000).

[3] This special database is provided by the Global Trade Analysis Project (GTAP) along with release 4 of their economy-trade database. For further information on GTAP see McDougall *et al*. (1998).

Table 1. Dimensions of the EPPA Model, Version 3

Production Sectors	**Countries and Regions**
Non-Energy	*Developed Countries (Annex B)*
1. Agriculture (AGRIC)	1. USA United States
2. Energy-Intensive Industries (ENERINT)	2. JPN Japan
3. Other Industries & Services (OTHIND)	3. EEC European Union[a]
Energy	4. OOE Other OECD[b]
4. Crude Oil (OIL)	5. FSU Former Soviet Union
5. Natural Gas (GAS)	6. EET Central European Associates
6. Refined Oil (REFOIL)	*Developing Countries (Non-Annex B)*
7. Coal (COAL)	7. CHN China
8. Electricity (ELECTRIC)	8. IND India
Future Energy Supply (Backstops)	9. BRA Brazil
10. Carbon Liquids	10. DAE Dynamic Asian Economies
11. Carbon-Free Electric	11. EEX Energy Exporters
Primary Factors	12. ROW Rest of World
1. Labor	(only selected regions are listed above)
2. Capital	
3. Fixed factors for fuel and agriculture	

Notes: [a] Includes the 15 nations of the European Union, as of 1995
[b] European Free Trade Area (EFT), Australia, New Zealand, Canada, Turkey

Energy products (refined oil, coal, natural gas, and electricity) are sold at different prices to industrial customers and final consumers. All existing energy subsidies are phased out gradually. The intermediate production structure of EPPA is based on a static Leontief input-output framework. The behavioral relationships on both the demand and production sides are captured in Constant Elasticity of Substitution (CES) systems.[4] The model is solved with a very efficient algorithm, MPSG. While the algorithm is efficient, it requires the assumption of homotheticity throughout the model. Given the static characteristics of a Leontief structure of the input-output model and the homothetic characteristics of the demand functions, the shares of the different sectors in output remain virtually constant over time in the EPPA solutions. We develop an approach that allows more realistic changes in consumption shares over the long term. Our main interest here is to examine the implications of this respecification for the predictions of total CO_2 emissions and costs of emission restrictions.

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[4] Earlier versions of the EPPA model used a Linear Expenditure System (LES) to represent the behavioral relationships on the demand side. The version 2 EPPA model has the following utility function: $\Pi_C (Y_c - \theta_c)^{\mu c}$. Each region has a representative consumer who maximizes a utility function in consumption Y_c and a minimum level of consumption Q_c subject to the budget constraint. A monotonic transformation of the utility function takes the form $U = \Sigma \log \mu_c (Y_c - \theta_c)$ where μ_c and θ_c are the parameters of the function. θ_c can be interpreted as some absolute minimum level of consumption of commodity. μ_c, or "marginal expenditure shares," tell us how consumers allocate their income above the floor level when their income goes up by an additional dollar. Given the above utility function and a budget constraint, a complete set of consumer demand equations, known as the LES, can be derived. The principal problem with this specification is that the parameters μ_c and θ_c remain unchanged over time. They may vary over regions and commodities but are unchanged over time. The other disadvantage of the LES is that it always implies an income elasticity of close to one for all commodities.

However, the data for the past hundred years indicate that the shares of output of the different sectors have changed significantly in growing countries. For example, in the United States the share of agricultural output declined from about 17% in 1900 to around 2% in 1990. In Japan the agricultural share declined from 34% to 3% over the same period.[5] If agricultural prices had risen during this time period, such changes could be consistent with a homogenous consumption function, with the decline in share driven by price substitution. In fact, agricultural product prices have fallen substantially, at least in relative terms. These patterns are compatible instead with more conventional demand functions, which are non-homogeneous. For example income elasticities of luxury goods are greater than one, whereas for basic necessities like food, they are less than one. Exogenous changes in labor productivity, capital accumulation, and the existence of limited resources, such as those in land and fossil fuels, are sources of structural change and create relative price changes in EPPA. Yet, alone they do not generate, for example, the reductions in the share of agriculture to be expected with economic growth in countries like in China and India.

In order to simulate the changes in sectoral shares we would ideally, make two changes in the model's formulation. First, we would use nonhomothetic demand functions to reflect the changing structure of consumer final demands as the income of a country increases over time. Second, we would allow the inputs of intermediate as well as primary factors, that are now determined endogenously in the model, to reflect structural changes in the production structure of the economy. Both types of changes would involve nonlinearities and would be computationally difficult to solve given the dimensions of the EPPA model.

In this paper we concentrate on the demand side alone. However, since models with non-homothetic demand functions are relatively difficult to solve computationally in a large CGE framework, we have devised a rather simple procedure to simulate the consequences of using such functions. We assume that consumption patterns in developing countries will converge overtime to those in developed economies and we emphasize the evolution of the consumption behavior in the two largest developing economies, namely China and India.

As pointed out by Sato (1972) a number of econometric studies have used an interesting relationship proposed by Frisch (1959) to estimate demand systems. Sato has shown that when the utility function is a generalized CES type, and σ is the overall average elasticity of substitution parameter, the Frisch parameter, which is considered to be a measure of the flexibility of the marginal utility, is simply the inverse of the overall average elasticity of substitution. Given the data on Frisch parameters for of a set of countries around the world, as well as their per-capita incomes, we estimate a regression relationship with the inverse of the Frisch parameter as the dependent variable and per-capita income as the independent variable.[6]

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[5] Mitchell, B.R. (1993), *International Historical Statistics, The Americas, 1750-1988*, Second Edition, Stockton Press, pp. 776-777; Mitchell, B.R. (1993), *International Historical Statistics, Africa, Asia, & Oceania*, Second Edition, Stockton Press, p. 1028.

[6] The Frisch parameter is the income elasticity of the marginal utility of income.

This formulation allows consumption in EPPA version 3.0 to be determined by a CES function but without the implied limitations on changes in consumption shares over time. The modification introduces changes both in terms of elasticity measures as well as consumption shares as illustrated in the following paragraphs.

The CES Specification for the utility function in EPPA is:

$$U = \Sigma (\beta_i \, q_i^{-\rho})^{-1/\rho}$$

and σ is the overall average elasticity of substitution among commodities,

$$\rho = (1 - \sigma)/\sigma ,$$

where U is the utility and q_i is the amount consumed of commodity i. In order to make the β_i (shares) and σ_I (elasticities) region specific, we first estimate relationships for β_i and σ_i based on per capita income. We then use these relationships to adjust β_i and σ_i as income changes over time. To assess the significance of these changes we then compare the results of the EPPA model with varying β_i and σ_i to the cases where these are invariant over time.

The values of σ that are included in the GTAP data set varies by region, as shown in **Table 2**. As expected σ is larger at higher income levels because expenditure shares of more demand elastic goods increase with income levels. The value of σ is low for low-income developing countries because the expenditure shares of necessities or less elastic goods are large in these economies.

In other words σ should have both a time subscript and a region subscript in a new utility function. Neglecting price-induced changes, we can express σ as a function of per-capita income. With the values in Table 2 for σ in the base year (1995) and the associated per-capita GNPs for that year we estimate a linear-log equation of σ on GNP. Since the regions are of varying sizes, the method of weighted least squares (WLS) is used to estimate the coefficients of the regression equation. The regions' populations are used as weights. The weighted linear-log form regression equation of σ (SIGMA) against per-capita income is:

$$\text{SIGMA} = 0.485829 + 0.104019 * \text{LOG (PER-CAPITA GDP)}.$$

This equation is used in the model to determine the values of σ_t for each region as its per capita income changes, except for the mature developed regions of the world namely USA, Japan, EEC and OOE. The values of σ_t generated for the twelve different regions by the EPPA model based on the above estimated equation are reported in **Table 3**.[7]

Putting aside the mature, developed regions, the values of the elasticity of substitution change substantially for the poorer of developing countries and regions, like China, India and ROW (rest of the world developing countries). Yet the changes in the parameter for DAE, FSU and EET are also sizeable.

[7] Our results seem to be in line with Houthakker's results for the US. If real income doubles, σ rises from 0.5 to 0.559 and, if trebled, it rises to 0.596 (Sato,1972).

Table 2. Regional variation of GNP and the elasticity of substitution

	GNP *in million dollars*	**Population** *in millions*	**GNP per capita** *million $/ million population*	**SIGMA** *elasticity of substitution*
Australia	346636.7	18.1	19151.20	0.5848
New Zealand	58665.2	3.6	16295.89	0.5128
Japan	5091655	125	40733.24	0.7092
Korea	451163.3	44.9	10048.18	0.4237
Indonesia	199178	193.3	1030.41	0.1845
Malaysia	95963	20.1	4774.28	0.3165
Philippines	70259.1	68.6	1024.19	0.1969
Singapore	67399.1	3	22466.37	0.5882
Thailand	165890.6	58.2	2850.35	0.2674
China	712002.1	1220.9	583.18	0.1739
Hong Kong	101364.6	6.2	16349.13	0.5780
Sri Lanka	13196.7	18.1	729.10	0.1667
Bangladesh	29110	120	242.58	0.1613
Pakistan	66490	130	511.46	0.1667
India	329324.9	928.6	354.65	0.1667
Canada	574321.5	29.6	19402.75	0.6173
USA	7126432	267.3	26660.80	0.6536
Mexico	279290.6	91.8	3042.38	0.3401
Argentina	257017.8	34.7	7406.85	0.4202
Brazil	712801.2	159	4483.03	0.2994
Chile	63531.3	14.2	4474.04	0.3175
EEC	8197050	349.6	23446.94	0.6211
OOE	1628311	133.6	12187.96	0.6452
EEX	1800193	584.1	3081.99	0.2355
FSU	483815	298.5	1620.82	0.2762
EET	298486	117.9	2531.69	0.2755
DAE	761212	180.3	4221.92	0.3745
ROW	856993	1318	650.22	0.2493

Table 3. Values of the elasticity of substitution parameter generated by EPPA

	USA	**JPN**	**EEC**	**OOE**	**EEX**	**CHN**	**FSU**	**IND**	**EET**	**DAE**	**BRA**	**ROW**
1995	0.65	0.69	0.62	0.59	0.320	0.300	0.260	0.250	0.310	0.380	0.410	0.250
2000	0.65	0.69	0.62	0.59	0.360	0.231	0.293	0.142	0.346	0.399	0.404	0.203
2005	0.65	0.69	0.62	0.59	0.359	0.246	0.286	0.153	0.349	0.404	0.408	0.203
2010	0.65	0.69	0.62	0.59	0.360	0.265	0.293	0.168	0.358	0.413	0.414	0.206
2015	0.65	0.69	0.62	0.59	0.363	0.286	0.306	0.186	0.373	0.424	0.421	0.210
2020	0.65	0.69	0.62	0.59	0.368	0.307	0.318	0.205	0.388	0.436	0.430	0.216
2025	0.65	0.69	0.62	0.59	0.373	0.329	0.331	0.224	0.404	0.449	0.439	0.223
2030	0.65	0.69	0.62	0.59	0.379	0.352	0.344	0.244	0.421	0.463	0.450	0.231
2035	0.65	0.69	0.62	0.59	0.386	0.375	0.360	0.264	0.439	0.477	0.461	0.240
2040	0.65	0.69	0.62	0.59	0.395	0.398	0.373	0.281	0.456	0.490	0.471	0.245
2045	0.65	0.69	0.62	0.59	0.406	0.420	0.387	0.298	0.473	0.502	0.481	0.251
2050	0.65	0.69	0.62	0.59	0.415	0.440	0.400	0.312	0.489	0.514	0.490	0.256
2055	0.65	0.69	0.62	0.59	0.425	0.460	0.412	0.326	0.505	0.525	0.501	0.264
2060	0.65	0.69	0.62	0.59	0.436	0.479	0.425	0.342	0.520	0.537	0.512	0.275
2065	0.65	0.69	0.62	0.59	0.446	0.497	0.438	0.358	0.535	0.549	0.523	0.285
2070	0.65	0.69	0.62	0.59	0.456	0.514	0.451	0.372	0.549	0.561	0.534	0.296
2075	0.65	0.69	0.62	0.59	0.466	0.531	0.464	0.386	0.563	0.572	0.543	0.307
2080	0.65	0.69	0.62	0.59	0.477	0.546	0.476	0.398	0.576	0.582	0.554	0.317
2085	0.65	0.69	0.62	0.59	0.487	0.560	0.488	0.410	0.589	0.593	0.564	0.328
2090	0.65	0.69	0.62	0.59	0.498	0.574	0.500	0.422	0.601	0.604	0.575	0.340
2095	0.65	0.69	0.62	0.59	0.508	0.588	0.512	0.433	0.613	0.614	0.586	0.351
2100	0.65	0.69	0.62	0.59	0.519	0.601	0.524	0.445	0.625	0.624	0.596	0.362

To simulate the changes in consumption shares that would take place in developing countries as income changes over time, we also estimated a regression relationship based on GTAP data on consumption budget shares and per-capita income for the different countries and regions of the world. We again use weighted least squares due to the differences in the sizes of the different regions. The regions' populations are used as weights in the estimation procedure to counteract the problems of heteroscedasticity.

The weighted regression relationship for Agricultural, Other Industry and Energy Intensive sectors are shown below:

CONS. SHR. AGR. = 0.336348 – 0.499258 ∗ PER-CAPITA(GDP)
CONS. SHR. OTHR. = 0.572121+ 0.460912 ∗ PER-CAPITA(GDP)
CONS. SHR. ENINT. = 0.062746 + 0.025724 ∗ PER-CAPITA(GDP)

As expected the slope coefficient in the regression equation for agricultural consumption share has a negative sign on per capita GDP, because, as per-capita income rises, the share of agricultural goods in the consumption basket falls. The slope coefficients in the Other Industry sector and the Energy Intensive sectors are positive, indicating that the consumption shares of these goods rise as their demand grow with income. The above regression relationships are incorporated in the EPPA Version 3 to simulate the changes in consumption behavior in developing countries over time.

3. Results with EPPA and the New Consumption Specifications

The increases in the per-capita income levels of China and India as projected by the EPPA model using the new consumption specifications, are depicted in **Figure 1**, showing the substantial growth expected over the next century. **Figure 2** shows that for India the consumption shares of agricultural goods fall from 35% of total consumer budgets in 1995 to 6% in 2100. The reductions in the Agriculture budget shares in China for the similar period are from 20% to 5%. The discontinuities in the graphs reflect the assumption that the changes in shares stop after the shares reach the levels of the developed countries. Overall the changes mirror changes that have occurred in developed countries during the course of their development.

We also observe in **Figures 3** and **4** the rising shares of consumption of industrial goods and energy consumption that are consistent with the changing pattern of budget shares of developed countries.

The next question is: what impact do changing budget shares have on the projections of gross output over the 100-year period? To consider this question, we compare the EPPA results with changing budget shares and elasticities to a version of EPPA that is identical in all ways except that budget shares and elasticities are constant over time. In the EPPA model, with static consumption coefficients, the shares of gross output in Agriculture, Energy Intensive Industry and Other Industry, remained virtually unchanged, as shown for China and India in **Figures 5** and **6**.

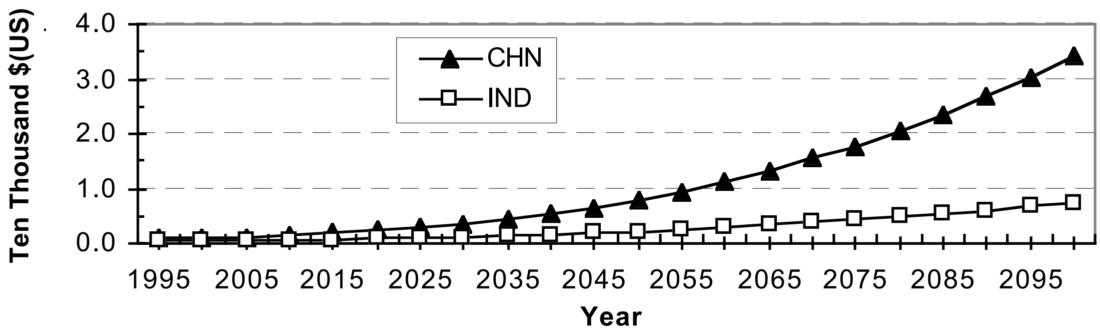

Figure 1. *EPPA model projections of per capita income*.

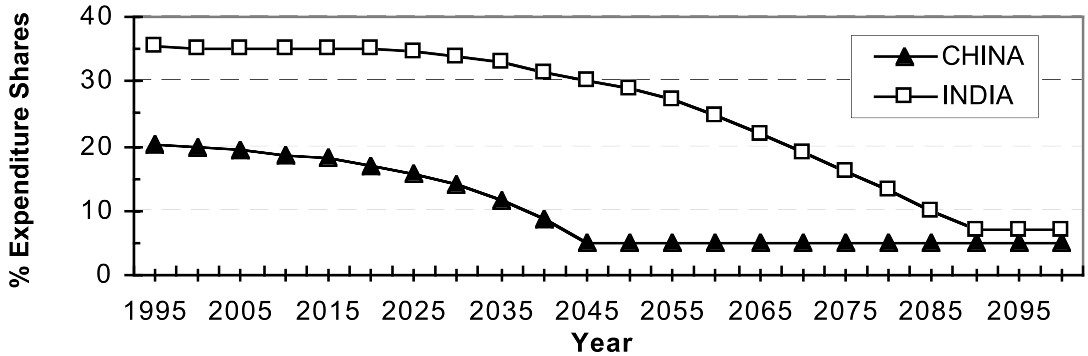

Figure 2. *Consumption shares of Agricultural goods with dynamic consumption coefficients*.

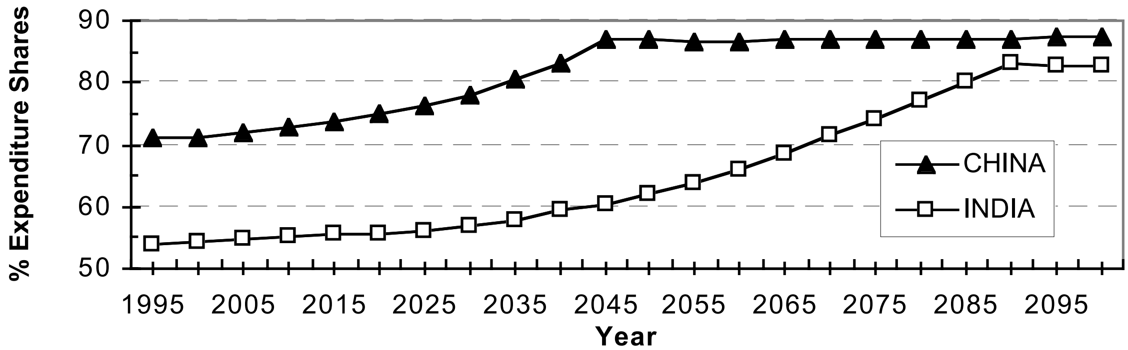

Figure 3. *Consumption shares of Other-Industry Goods with dynamic consumption coefficients*.

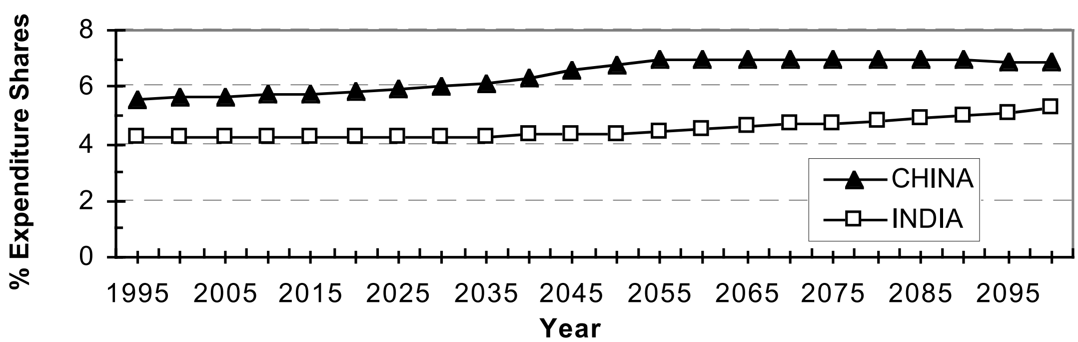

Figure 4. *Consumption shares of Energy-Intensive Goods with dynamic consumption coefficients*.

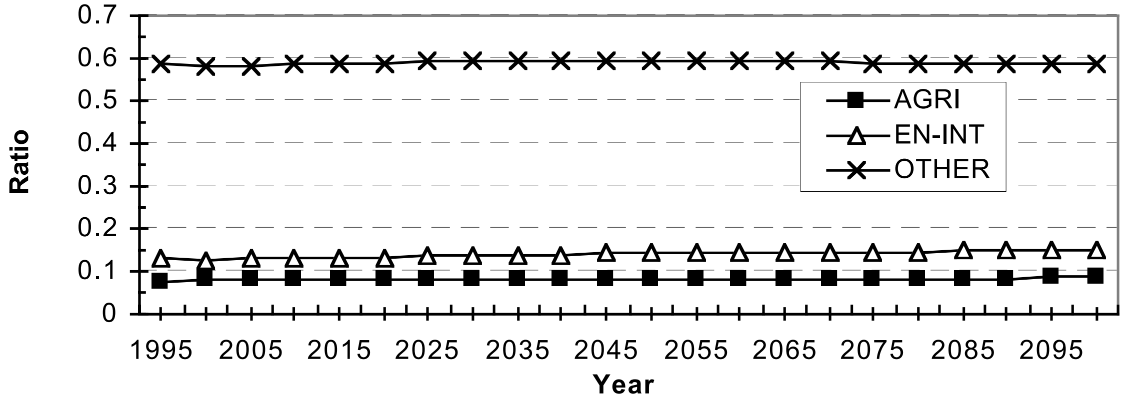

Figure 5. *Shares in gross output in China with static consumption coefficients.*

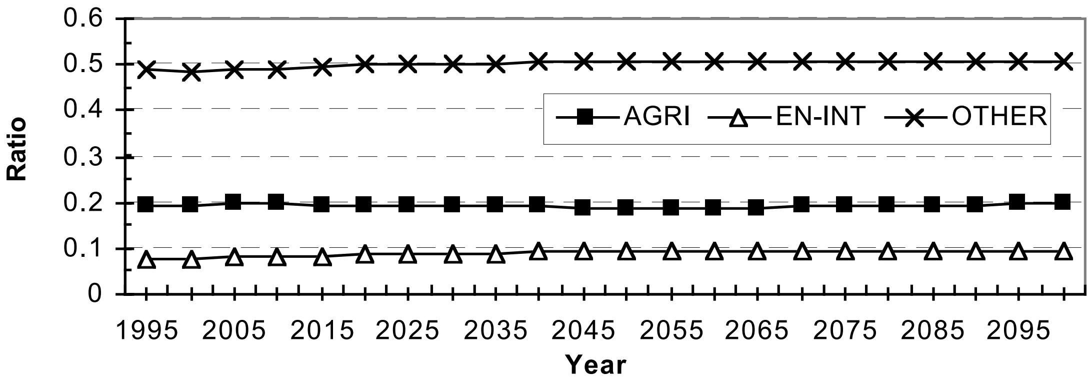

Figure 6. *Shares in gross output in India with static consumption coefficients.*

By comparison, production shares in the EPPA version with a dynamic consumption coefficients change significantly for India and to a considerable extent for China (**Figures 7** and **8**). The greater shifts in the production patterns in India compared to China are the result of differences in the degree of economic openness as well as the differences in the technological aspects of production the two countries. In particular China is relatively more active in international markets than is India, and therefore the production patterns in the former are derived not only by domestic demand but also by international demand.

We turn now to the impacts of these changes in consumption and sectoral output patterns in developing countries on their generation of total carbon dioxide emissions and the costs of emissions restrictions. As depicted in **Figure 9**, we find that the total emissions over the entire planning horizon (1995–2100) of China and India remain virtually unchanged despite the changes in the sectoral composition of output. An increase in fuel consumption, resulting in an increase in CO_2 emissions due to the substitution of some of the consumption of Agriculture's products by those of Other Industries, would have been a plausible expectation. However, that is not the case as there are several counteracting influences. First, a large part of the Services sector is included in the Other Industry sector classification in the EPPA model thus the Other Industry

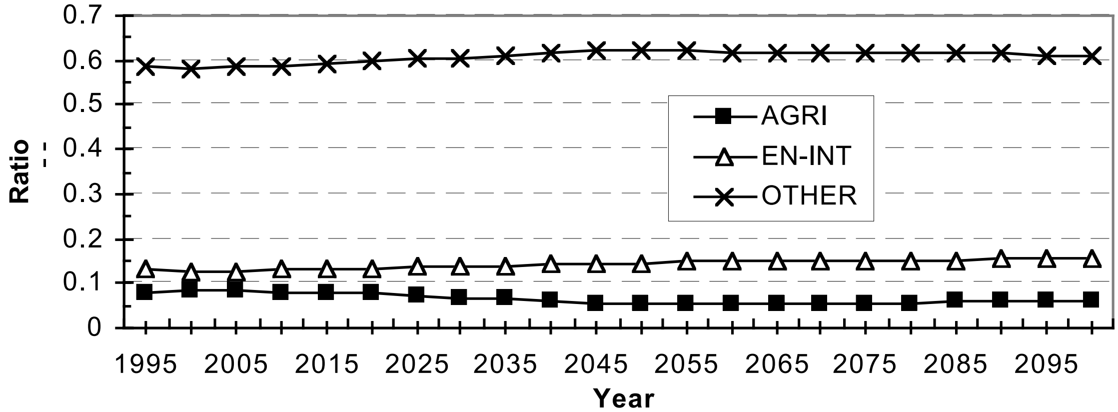

Figure 7. *Shares in gross output in China with dynamic consumption coefficients.*

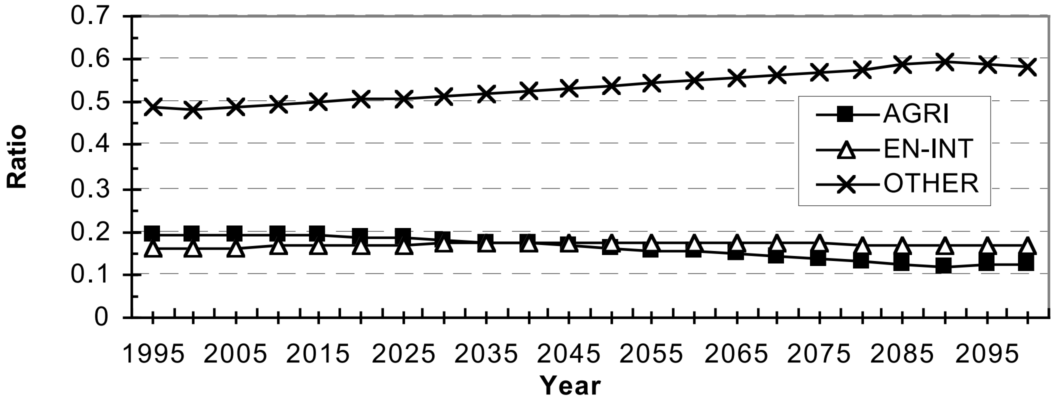

Figure 8. *Shares in gross output in India with dynamic consumption coefficients.*

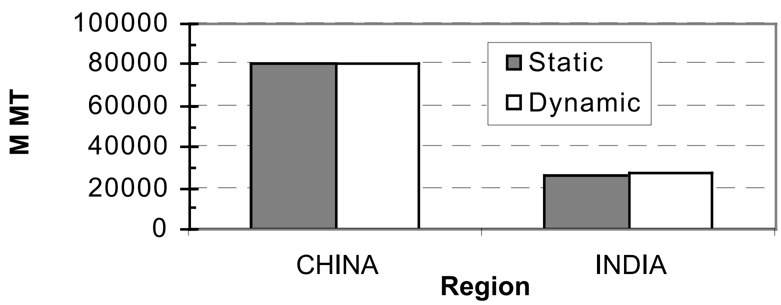

Figure 9. *Total emissions with static and dynamic consumption coefficients.*

sector is not particularly more energy intensive than agriculture. Second, with augmentation of energy saving technology in the developing countries' manufacturing sectors, a shift from agriculture to other manufacturing sectors may not result in an increase in energy consumption and, hence there is no substantial additional generation of emissions. Finally, the results suggest that the fixed coefficients of intermediate input in production may be a more important factor affecting energy use and emissions than are, the sectoral the consumption shares. However, this last suggestion cannot be verified without further investigation.

Another relevant issue is whether the new consumption specifications change the costs of the emission restrictions for developing countries that would result if they were to accept reductions in CO_2 emissions that are similar to those of the developed countries. For example, what would be the impact on shadow prices of carbon if the developing world were asked to enter the Kyoto type agreement at a later date?

To answer this question, we simulate EPPA for a scenario capping carbon emissions in developing countries at 2020 reference levels with the static (fixed consumption shares) structure in one case and with the dynamic (changes in consumption patterns) structure in the other case. The results of theses two runs were then compared. The relative changes in shadow prices of carbon that result from the imposition of the new consumption patterns are presented in **Figures 10** and **11** for China and India respectively. The shadow prices of carbon are up to 5.5% higher for China and up to 15% higher for India in the run that simulates the change in the structure of final demand as opposed to where these changes are ignored.

The higher costs associated with the dynamic consumption coefficients model as compared to the static consumption coefficients version are due to the fact that the scope for substitution away from energy consumption is more limited in the first case than in the second case. For example, in the dynamic-coefficients model, as consumers' income rise they start to consume more energy and less of agricultural goods in the reference scenario. Thus it is more difficult for them to substitute away from the former into the latter goods when emissions restrictions are imposed.

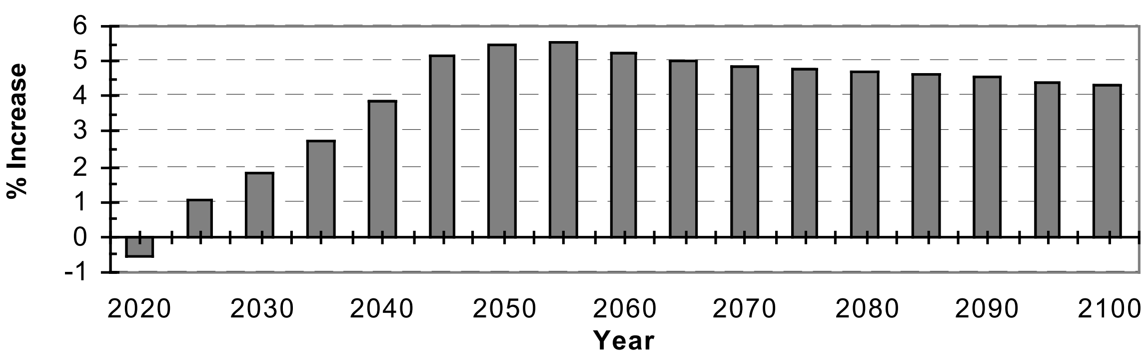

Figure 10. *Relative changes in the shadow price of carbon in China with dynamic consumption coefficients (capping carbon emissions at 2020).*

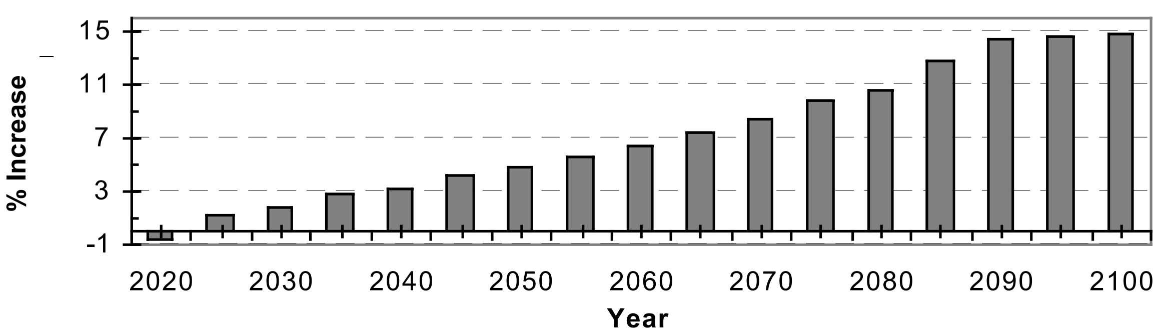

Figure 11. *Relative change in the shadow price of carbon in India with dynamic consumption coefficients (capping carbon emissions at 2020).*

Consequently the costs of restricting carbon emissions are higher with the change in the pattern of consumption that favors energy and energy-intensive products over agricultural ones. This effect becomes evident even when we look at the behavior of prices, which reveals the weight that the consumer attaches to the different commodities as income changes. The prices of agricultural goods are lower in the version that simulates the change in the structure of final demand as compared to those in the version that simulates the static-coefficients-specification of the consumption function. The results are shown in detail in **Figures 12** through **17**.

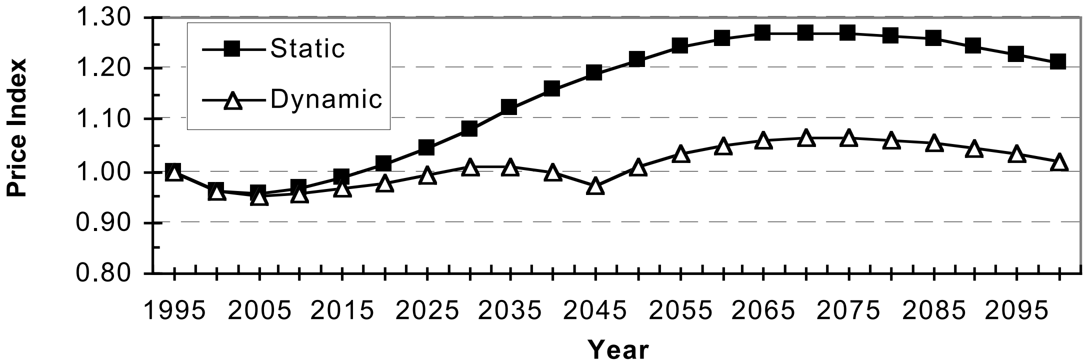

Figure 12. *Consumer prices of Agricultural Goods in China with static and dynamic consumption coefficients.*

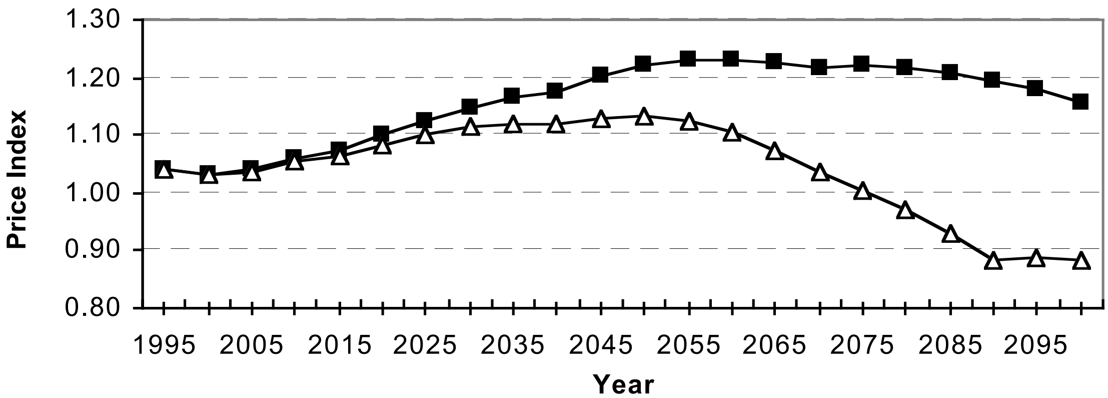

Figure 13. *Consumer prices of Agricultural Goods in India, with coefficients as in Fig. 12.*

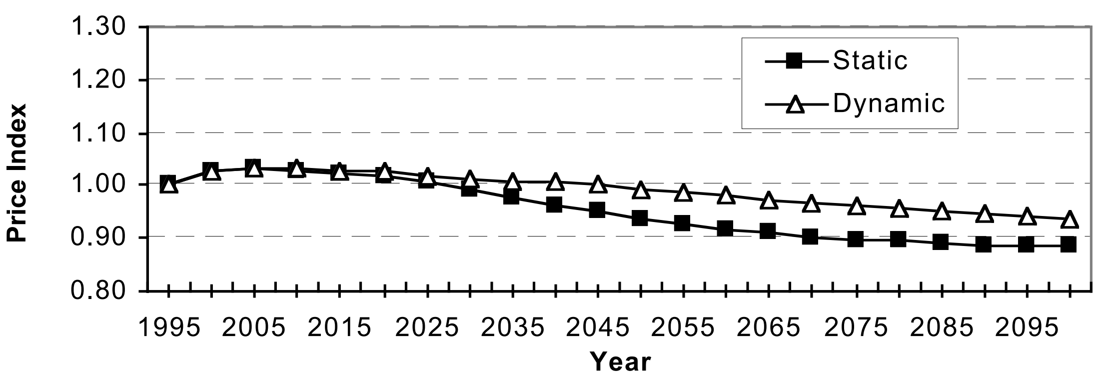

Figure 14. *Consumer prices of Energy-Intensive Goods in China with static and dynamic consumption coefficients.*

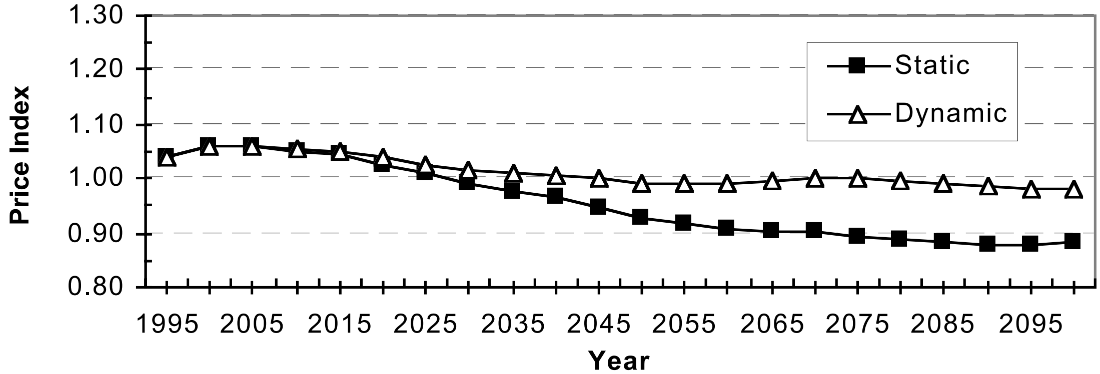

Figure 15. *Consumer prices of Energy-Intensive Goods in India with static and dynamic consumption coefficients*.

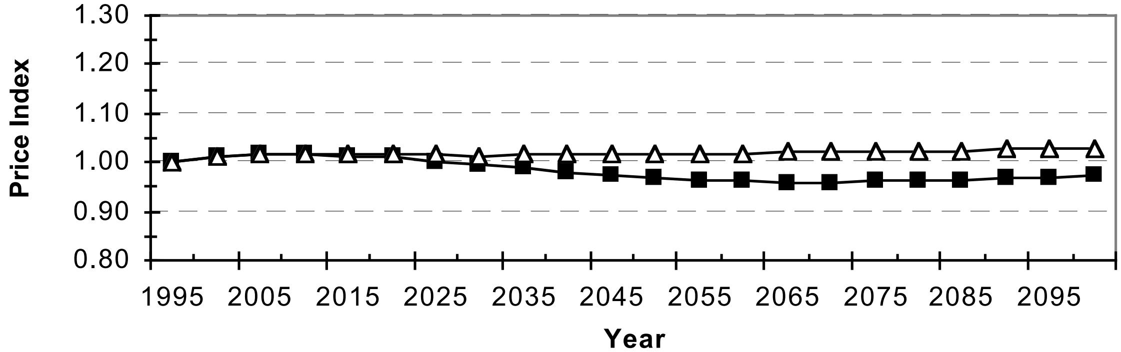

Figure 16. *Consumer prices of Other Goods in China with static and dynamic consumption coefficients*.

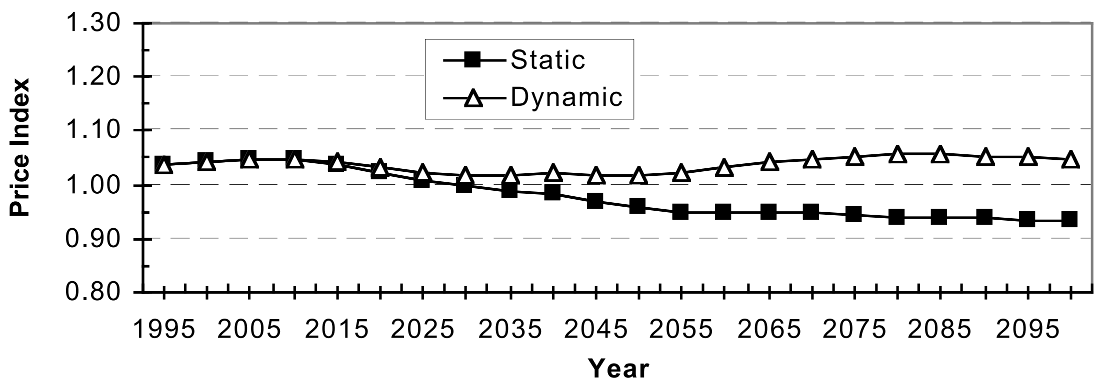

Figure 17. *Consumer prices of Other Goods in India with static and dynamic consumption coefficients*.

The final moral of the story is that the more realistic specification of consumption behavior leads to a higher estimate of the costs for developing countries that would be entailed if they entered a Kyoto-type agreement.

4. Concluding Remarks

Models with time horizons of 100 years are customarily used to predict anthropogenic greenhouse gas emissions and to inform the different climate-change policy dialogues. Historical evidence indicates that over this time span the current consumption patterns in developing countries are likely to change substantially and to converge to the present patterns in developed countries. The implications of such changes on emissions profiles and on the costs of policies to curtail them in developing countries are crucial aspects of a comprehensive climate-change policy agenda. This study deals with modeling this type of non-homotheticity in consumption functions within the EPPA framework based on econometric estimation and the above assumption of convergence in consumption patterns.

We find that the composition of consumption and the consequent implications for the sources of emissions would be different in the model with static consumption-function coefficients from that in the model with dynamic coefficients, even though the regional emissions profiles are virtually the same in the two cases. The differences have significant implications for the costs of emissions restrictions in developing countries. Our results suggest that the costs of emissions restrictions in developing countries would be higher if the changes in consumption patterns are taken account of than if they are ignored in the simulation model.

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