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Summary

There has been a recent economic literature arguing that international environmental agreements (IEAs) can have no real effect, on account of their voluntary and self-enforcing nature. This literature concludes that the terms of IEAs are the codification of the noncooperative equilibrium, and recent empirical work has supported this conclusion in the context of the Montreal Protocol. This paper reaches the opposite conclusion, by means of the comparison of the CFC emissions implicit within the cooperative and noncooperative management paths. The cooperative path is implicit within the terms of the Montreal Protocol. The noncooperative path is implicit in countries' behaviour during the period of unilateral management of CFC emissions. This study estimates the relationship between countries' propensities to produce CFCs and income per capita over the period 1976-1988 (prior to the entry into force of the Montreal Protocol). It then extrapolates this path of unilateral management beyond 1988, and compares it to the obligations adopted under the cooperative regime. This comparison of the projected noncooperative path with the obligations adopted under the Montreal Protocol allows a qualitative test of theories on the economic foundations of self-enforcing IEAs. We find that, in the absence of the Protocol, CFC production (and hence emissions) would have increased by a factor of three over the next fifty years. This study also supplements existing environmental Kuznets curve analyses by providing estimates for the unilateral management for a global externality. In this manner we are able to assess the distributive impacts of the Protocol, in addition to its effectiveness. Using dynamic estimation methods on a panel of around 30 countries over 13 years, the turning point in the relationship between CFC production and income is found to lie around (1986) US$16,000. This implies that developing countries bear the greatest costs in the implementation of the Montreal Protocol.

Keywords: IEA, CFC, Montreal Protocol, Kuznets curves

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1. Introduction

This study surveys the three distinct relationships that have existed between society and the chemical group known as the chlorofluorocarbons (CFCs). Initially and up until the early 1970s, the marketing success of these chemicals was virtually unprecedented. From their initial synthesis in the 1930s[1] their uses as inexpensive refrigerants, aerosols and solvents rendered them unrivalled in their markets, and their growth in sales was geometric after the war years.[2]

It was their unprecedented stability as a chemical group that rendered them useful, and it was this same characteristic that led to their management and later prohibition. In the late 1960s chemists (concerned with the phenomenon of chemical accumulation witnessed with other synthetic chlorine-based compounds such as DDT) began to query where these very stable chemical compounds might ultimately react with their surrounding environment. Atmospheric chemists identified the outer reaches of the earth's atmosphere as the point at which such chemicals would degrade, in response to the intense ultraviolet radiation present in that region. It was hypothesised that these chemicals might indeed react with the surrounding ozone in these outer reaches in the course of their photo-degradation, and it was this chemical reaction that was initially observed in the early 1970s and then documented as the depletion of the ozone layer. From the time that this first information began to become publicly available in the early 1970s, pressure was brought on governments to ban various uses of these chemicals in order to halt depletion of the ozone layer.[3] This was the era of unilateral management with regard to these chemical sustances (1975 to 1988).

The Montreal Protocol on Substances that Deplete the Ozone Layer was first signed on 16th September 1987 and came into effect on January 1, 1988. This international environmental agreement initially mandated 50% cuts from 1986 levels in both the production and consumption of the five main chlorofluorocarbons (CFCs) by 1999. Subsequent adjustments and amendments have increased the number of substances controlled by the Protocol, brought many more (particularly developing) countries into the fold of the agreement, and speeded up the phase out of many chemicals thought to be responsible for the increasingly well-documented "ozone holes". Following the recent meeting of the Protocol signatories in Vienna in 1995, 95 substances are now controlled, with production of the main five CFCs phased out in developed countries by 1996;[4] developing countries face a deadline of 2010. The Montreal Protocol ushered in the era of cooperative management of CFC uses and their impacts.

A total of 150 countries had ratified the Montreal Protocol (as of October 1995), leading many to conclude that it is one of the most effective international agreements in existence. (See Brack (1996) and Benedick (1991) for further discussion of the Protocol.) Despite this impressive record of international action, there is substantial academic debate concerning whether this agreement, or any other international environmental agreement (IEA), has any real impact or effect. The argument against the effectiveness of IEAs is that individual states considering the value of joining a coalition of states in support of the IEA's restrictions will also perceive the benefits to be derived from joining the coalition of states "free riding" upon the coalition's efforts. Viewing the IEA in this way means that the only states which join the IEA coalition are those for whom it is in their individual interests to meet the terms of the IEA. Key

[1] By the same chemist who later gave the world leaded petrol as an anti-knock compound.
[2] See section below.
[3] For example, the US instituted a unilateral ban on the use of CFCs as a propellant in aerosols during this era.
[4] Some production of the substances is allowed for use as chemical feedstock, process agents; and in medical and military applications.

papers in this vein include Barrett (1990, 1994), Maler (1990) and Carraro and Siniscalco (1992, 1993). The conclusions from this work can be summarised in the following three statements: (i) for the number of signatories to an agreement to be large, the ratio of abatement costs to the benefits from pollution reduction for each country must be small; (ii) when this ratio is small, there is little gain to be had from international cooperation, since countries would unilaterally have undertaken pollution abatement (i.e. the cooperative and non-cooperative outcomes are very similar); (iii) therefore international agreements with large numbers of signatories can do no more than codify non-cooperative behaviour. Barrett (1994) therefore states that the theory of international environmental agreements "suggests that the Montreal Protocol may not have increased global net benefits substantially compared with the non-cooperative outcome"(p. 892).

The results of this paper can be seen as the second attempt to test this theory. The Montreal Protocol has clearly attracted substantial support; current theory predicts that this is because countries' unilateral incentives are to reduce CFC emissions. The first study, by Murdoch and Sandler (1997), confirmed these predictions and found support for the hypothesis that the case of ozone depletion is an example of "the private provision of a public good". In our approach we attempt to provide the link between this body of work and a second literature based on the analysis of the relationship between national income and environmental management, collectively known as the "environmental Kuznets curve debate". Holtz-Eakin and Selden (1995) (CO2 emissions) Grossman and Krueger (1995) (water and air quality) Selden and Song (1994) (water quality). These papers are concerned with the hypothesis that there may be a general relationship between national income and environmental management which is indicated by a "turning point" in environmental degradation at higher levels of income. The question of a turning point in countries' emissions of pollutants is clearly of importance in the assessment of the effectiveness of the Montreal Protocol. The existence of a sufficiently low turning point in the relationship between income and CFC emissions would render the Protocol superfluous (in line with the theoretical predictions above). If the critical income level is very high, however, CFC emissions in the absence of the Protocol would continue to grow for most countries over the foreseeable future.[5] Then the Protocol is necessary in order to achieve emission reductions, and it imposes the greatest costs on developing countries, whose CFC emissions would have increased for many years before the critical level of income was reached.

Therefore, we test the "private provision hypothesis" by reference to the empirical relationship between income and CFC emissions. For the current rate of CFC abatement to be the result of unilateral (i.e. noncooperative) management, the turning point in the Kuznets curve for CFC abatement must occur at a sufficiently low income level for a large number of countries to want to manage CFC emissions unilaterally. If the observed turning point occurs at a high level of income, then the hypothesis that unilateral management will supply this public good (in the absence of cooperation) cannot be correct. We test this hypothesis explicitly by projecting the noncooperative pathway into the future and comparing it to the path of emissions dictated by the cooperative regime.

The contribution of this paper is three-fold. First, it extends the set of Kuznets curve results to another, global pollutant and refines the methodology of existing studies by using dynamic estimation techniques, rather than the simple static models found in existing studies. Secondly, it provides a second test of the theory of international agreements: do they

[5] This is the case, for example, at US$8 million as Holtz-Eakin and Selden estimate for carbon dioxide emissions. It is unlikely that there would be any interest in joining an effective CO2 management regime for any reason other than to secure the cooperative gains.

merely codify the path that would be taken by states in the noncooperative equilibrium? Finally, it is the first attempt to provide an explicit link between these two developing literatures: the empirical literature analysing the relationship between national income and unilateral management, and the economic theories of self-enforcing international environmental agreements.

The next section of the paper discusses the methodology used in this study. Section 3 describes the data used in the analysis, and the econometric models that are estimated. Section 4 present results from these estimations. Section 5 makes projections based upon these estimates and demonstrates the anticipated impact of the terms of the Protocol. Section 6 discusses the distributional implications of the Protocol, and relates it to the amounts available under the Multilateral Fund. Section 7 concludes.

2. Methodology: Induced Management and Global Public Goods

The methodology utilised here combines the approaches taken within two distinct literatures: that concerning the induced management of environmental goods and services (the so-called environmental Kuznets curve debate) and that concerning the expected impact of international environmental agreements. The former literature states that national interests, and especially incomes, drive the adoption of more rigorous environmental management regimes regarding environmental resources. The latter literature analyses the framework within which states determine the management that will be accorded a shared resource. Combining these two literatures it is possible to construct the framework within which the gains from cooperative behaviour occur, and the baseline against which they are measured.

Framework for Estimating Contributions to the Management of a Global Public Good

The first step to the estimation of the benefits from cooperation is the identification of the correct "conflict point": the counter-factual that would have occurred if cooperation had not. In a dynamic framework this would equate not with a point but with an equilibrium path based on Nash noncooperative behaviour: the *baseline path*. There is a recent literature that has utilised a dynamic approach to the problem, by constructing paths for the noncooperative and cooperative management of a shared resource. (Chandler and Tulkens, 1992; Dockner and Long, 1993; Hughes Hallet, 1986; Long, 1992; Van der Ploeg and de Zeeuw, 1992). Any gains from cooperation, would then be ascertained relative to this baseline, i.e. the Nash noncooperative *path*. (For the analysis of such a path, and its distributive implications in the context of climate change, see Escapa and Guitierrez, 1997).

The impact of the Montreal Protocol must be discerned by reference to the *terms* of that agreement – these terms are taken to be the codification of the cooperative solution to the ozone management problem – and in comparison to the path that would have occurred in the absence of that agreement. The terms of the Protocol provide the pathway of CFC use (production and consumption) that must be taken by all parties from the time of its initiation (in 1988) until the global prohibition of CFCs (in 2010) and from then afterwards. The difficult question is the counter-factual: the ascertainment of the pathway that would have been elected in the absence of the cooperative management regime.

The Noncooperative Path – Relationship between Unilateral Management and Income

The noncooperative pathway for CFC usage may be reconstructed by reference to the general relationship displayed between a nation's development status and its environmental good provision during a period of unilateral management. Across a wide range of environmental resources, empirical studies have revealed a fundamental relationship between national income and environmental good provision. These regularities may be used to reconstruct the counterfactual as to how various countries would have managed CFCs given their income levels, if they were doing so within a noncooperative rather than a cooperative management regime.

In the empirical literature on the national provision of environmental public goods, the relationship that has been discerned between income and the environmental good is one that is linear in the *decline* of the environmental good, but quadratic in its provision. The similarity between this phenomenon and that of income inequality/development has lead to the "inverted-U"s being called "Kuznets curves". Grossman and Krueger (1995) investigate the relationship between per capita income and four local pollutants: urban air quality, and three types of river contamination. Using similar methodology to Holtz-Eakin and Selden, they find uniformly lower turning points, the highest being no more than US$11,600, and most being below US$8,000 (1985 values). Selden and Song (1994) also examine air quality, but concentrate on aggregate emissions, rather than urban pollution. Consequently, they find higher turning points than Grossman and Krueger, with all four pollutants studied have critical income levels in excess of US$8,500. (This is not an exhaustive list of such studies; see Stern, Common and Barbier (1996) and Ecological Economics (1998) for critical surveys.)[6]

There is at least one other Kuznets curve analysis of a global public good.[7] Holtz-Eakin and Selden (1995) estimate a Kuznets curve for carbon dioxide emissions (on a panel of 130 countries over the period 1951 to 1986). They find that the turning point of the curve—the critical income per capita level at which emissions per capita start to decrease—lies

[6] In general the criticism levelled at the environmental Kuznets curve case studies is well-deserved, but inapplicable to the study undertaken here. Much of that criticism concerns the problems associated with using reductionist approaches to explanation - in the case of environmental management, the attempt is to endogenise environmental management by reference only to prevailing income levels. The dangers of oversimplification and spurious correlation are obvious, and now well-documented. See Ecological Economics (1998). With this paper we are adding to neither the environmental Kuznets curve literature nor that literature that is critical of it. We make no claims regarding causation in our correlations. Instead, we merely observe that, irrespective of the motivating force or explanation, any regularity in the relationship between income levels and unilateral environmental management (here, CFC management) should be taken as an upper bound on what should be demanded of others under a global management regime. That is, developed countries should not have the right to demand of less developed countries a greater sacrifice for the management of the ozone layer, simply because of the order in which development occurs.

[7] The global public goods case is a very different approach to Kuznets curve analysis than has usually been the case in the domestic pollutant literature. In that literature the point of the environmental Kuznets curve analysis often has been to provide an explanation for the emergence of the management that is required to produce the public good. In the case of a global public good this is an unlikely proposition, since the public good by definition can only be provided through universal agreement. For example, in the absence of an agreement to fully cooperate in management, unilateral efforts may have perverse impacts on the overall efficiency of the management of the public good. (Hoel,M. 1992) Therefore, the Kuznets curve analysis applied to a global public good must be focused more on the distributional implications of a *given global management regime*, rather than the explanation of how that management regime came into being.

at US$35,000 (in 1986 values) if the model is in levels, and at over US$8 million if the model is in logs; both values are far above income levels of any of the countries in the authors' sample. The first step in our approach will be to replicate the Holtz-Eakin and Selden (1995) approach to provide a "Kuznets curve" analysis of CFC production, in order to ascertain the sort of management applied to this environmental problem by countries acting unilaterally and at various income levels.

Determining the Baseline Path for CFCs

In order to estimate the relationship between unilateral management and income, it is necessary to construct a data base that consists of countries' CFC emissions during the period before the cooperative regime was implemented. For CFCs, there are in fact three distinct stages of management: *Stage I*) when there was no known environmental impact from CFC usage (and hence no incentives for any form of management); *Stage II*) when there was known environmental impact but no legal basis for cooperative management of the resource (and hence incentives for only unilateral management within a noncooperative regime); and, *Stage III*) the adoption of the cooperative regime and joint management of CFCs.

In the context of CFCs it is possible to be remarkably precise regarding the dates that define these periods. CFC production commenced in the 1930s but remained at very low levels until the post-war years. There could have been no information on the ozone-depleting potential of these substances prior to the early to mid-1970s when the first scientific discoveries concerning ozone depletion were announced.[8] Thereafter there would have been a substantial range of uncertainty concerning the extent of and potential damages from ozone depletion, but there certainly was information on the existence of a relationship between CFC use and ozone depletion. Hence the point of demarcation between the period of non-awareness and the period of unilateral management would lie in about 1975.

The point of demarcation between the period of unilateral management and cooperative management is also readily definable. Prior to 1985 there was no legal basis for the cooperative management of ozone depletion. In March 1985 the Framework Convention on the Protection of the Ozone Layer (the "Vienna Convention") was signed, but this agreement carried no obligations other than the agreement to continue negotiations over a management regime – this is the meaning of a "framework" convention. The later ratification of this convention meant that it did not enter into force until September 1988. In the meantime the first Conference of the Parties to the Vienna Convention adopted the Montreal Protocol in September 1987, and this Protocol contained specific agreements concerning the restrictions on the production and consumption of specified ozone-depleting substances but it did not enter into force until it received sufficient ratifications. The Montreal Protocol finally entered into force on the *1st of January 1989*, and ushered in the era of joint management of the ozone layer.[9]

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[8] The publication by Molina and Rowland (1974) is often cited as the first scientifically argued case concerning the link between CFC usage and ozone depletion.

Stages of Ozone Management and Regimes:

Stage I	**Stage II**	**Stage III**
Non-Management	**Unilateral Management**	**Joint Management**
	Non-coop. Behavior	**Cooperative Behavior**
1930s	Mid-1970s	1/1/89
Invention of CFCs	Discovery of Ozone Depletion	Management under Montreal Protocol

This timeline breaks up the history of ozone depletion and management neatly into the three distinct periods: I) non-management (1930-1973); II) unilateral management (1974-1988); and III) joint management (1989 onwards). And these periods provide the basis for determining baseline behaviour. The impact of a change of regime is then straightforward: It is the difference between the actual choices countries are making in any given period and those that they would have made in that period *if they had continued to choose as they had done in the period before.*

In the remainder of this paper we will estimate the relationship between income and CFC production in the era of unilateral management, and then extrapolate this behaviour into the era of joint management. In this manner we will be able to compare the effects of projected behaviour along the noncooperative pathway to actual behaviour under cooperative management.

Distinction between Noncooperative and Cooperative Models of Behaviour

The impact of the Montreal Protocol was one of the questions addressed in a recent paper by Murdoch and Sandler (1997). Their results confirm the theoretical predictions of Barrett (1994) to the effect that the rates of abatement undertaken by the various states at the time of the Montreal Protocol were consistent with the hypothesis of the "private provision of a public good". Specifically, they tested for the existence of a linear relationship between national incomes and abatement levels, and found this to exist (consonant with the private provision hypothesis). Thus, they argued that the levels of abatement undertaken by states at the onset of the Protocol were consistent with the noncooperative model of state behaviour under international environmental agreements.

It is important to note that, even prior to their empirical analysis these authors had concluded that a cooperative model of behaviour was inapplicable to the changes in emissions that occurred between their two points of observation - 1986 and 1989. [10] This conclusion they deduce from: 1) the small number of ratifications occurring during their period of

[9] It is important to emphasise that the adoption of an international agreement carries no legal force against any of its parties until such time as a sufficient number of contracting parties (as specified within the agreement) have ratified their signatures.

[10] The data base they use is based on data constructed by the World Resources Institute from the same sources as we use. We have constructed our own dataset (rather than rely on the WRI dataset) in order to develop a consistent panel data set for the entire era of unilateral management, something not previously undertaken. See the next section and Appendix A for a fuller description of the CFC databases available for these analyses.

observation; 2) the relatively large reduction in emissions (41% on average) among countries *not ratifying* the Protocol during that period; 3) the large variation in emission reductions across countries despite the uniformity of its strictures; and 4) the relatively large CFC reductions by developing countries (>45%), when the Protocol required less of them. These facts they find to be so much at odds with any contractual approach that they reject out of hand the role of cooperation as an explanation for the management of CFC emissions in this period.

In fact, the explanation for Murdoch and Sandler's four observations is relatively simple, and demonstrates the importance of cooperation behaviour in generating these results; all of their observations were immediate results of the contracting process that was then taking place. This is attributable to the fact that the Montreal Protocol specified that there would be preferential treatment (via the implementation of a "financial mechanism") for all developing countries joining as "Article 5(1) countries", but that developing countries could only be listed as such if they *reduced their CFC usage below 0.3 kg per capita*.[11] With this additional information, the explanation for Murdoch and Sandler's observations is that: 1) most of the developing countries were postponing their ratification of the Protocol until the outcome of negotiations over the financial mechanism was known, and to maintain pressure on these negotiations; 2) the relatively large *average* reductions in emissions in the interim were attributable to the reductions by developing countries to meet the requirements for entry as Article 5(1) countries ("large" relative to a low base level); 3) the large variation in emissions reductions was attributable to the fact that only developing countries could qualify as Article 5(1) countries, so others had little incentive to undertake substantial reductions; and 4) the incentives provided to developing countries resulted in their reductions being greater than the average.[12] The observations cited by Murdoch and Sandler is some of the strongest evidence in support of the contractual model of behaviour being evidenced during the construction of the ozone management regime, but it is only evidence of its immediate and short term impacts of cooperation (i.e. the engagement of the developing countries within the contractual process). The real, long term impact of the Montreal Protocol requires a broader view of the processes at work.

Conclusion- Methodology for Determining the Impact of the Montreal Protocol

In the remainder of this paper we use the methodology developed above to estimate the impact of cooperative management as compared to unilateral management of CFC production (Stage III as compared to Stage II-based

[11] Article 5(1) listed specified "developing countries" with a per capita consumption of 0.3 kg. CFC per capita. These listed "Article 5 countries" were entitled under the terms of the Protocol to delay compliance with the control measures of the Protocol for ten years. The Protocol also promised continued negotiation over compensation measures and transfer of technology; it was the London Amendments of 1990 that specified the nature of the compensation mechanism. Center for International Environmental Law (1997).

[12] At the time of the adoption of the text of the Montreal Protocol in 1986, the 1990 Amendments to the Montreal Protocol were in preparation for adoption at the Second Conference of the Parties in London. These amendments were primarily concerned with the nature of the multilateral financial mechanism provided for but unspecified within the Protocol. The London Amendments of 1990 enabled "Article 5 countries" to access a newly created Multilateral Fund for compensation of the "incremental costs" of their compliance. The large average reductions by poor countries between 1986 and 1989 were made in anticipation of the adoption of this financial mechanism, and the potential benefits it might afford those countries entering as Article 5 countries. The huge incentive to reduce CFC usage in order to qualify under the London Amendments is evidenced by the fact that only 29% of the countries ratifying the Protocol prior to the Amendments were developing countries, while 88% of the countries ratifying after the Amendments have been so classified. In short, 111 of the 156 parties to the Montreal Protocol are developing

forecasts) over the long run. In this way we hope to demonstrate that real cooperation is in fact occuring within the context of negotiations over international environmental agreements and, at least in some instances, a cooperative rather than a noncooperative model of state behaviour is more appropriate to understanding the outcome of these negotiations.

In the remainder of this paper we first assess the relationship between income and unilateral (noncooperative) management in sections 3 and 4, and then we extrapolate these paths of unilateral management into the era of cooperative management in section 5 for comparison with the terms of the Protocol. The difference in aggregate CFC production (and the distribution of that production) between the two pathways represents the impact of the Montreal Protocol.

3. Data and Empirical Model

3.1 Data and Sources

An immediate problem confronting any empirical research of CFC use is a lack of data.[13] Global CFC production figures are produced by the industry association AFEAS (see AFEAS (1995)); commercial confidentiality means, however, that country-level production is not available for any reasonable time period.[14] In addition, trade data (so that consumption can be calculated) are available only at an aggregate level. The appendix describes how these problems have been tackled in this paper, and the limitations of the final data sets that have been constructed. Our approach is based on disaggregation via the use of observable surrogates for the unobservable CFCs; this approach is consistent with that which has been used in the only other attempts to construct a CFC database (WRI 1990, 1992). The second major problem confronting the researcher is how to convert consumption (of raw chemicals or end-products containing CFCs) into emissions. The chemical stability of CFCs means that all CFCs produced will, eventually, reach the stratosphere. But there will be a lag between consumption of the chemical (either in raw or end-product form) and release to the environment. For the purposes of this analysis, this lag (which can be substantial) will be ignored. It is assumed that a country "cares" about the impacts of its current emissions in the year in which their production or consumption occurs.

A data set was constructed: production and prices of the raw chemicals CFCs 11 and 12, and income for 58 countries over the period 1976 to 1988 inclusive[15]. Details of the data and sources are contained in Appendix A. Summary statistics are shown below. Historic population and income data are taken from the Penn Mark V.6 World Tables (see

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countries, and only 2 of these 111 have failed to qualify as Article 5(1) countries by maintaining low per capita CFC consumption levels. CIEL (1997), at 26.

[13] To our knowledge the only other attempt to create a database of CFC emissions has been undertaken by the World Resources Institute. (WRI 1990, 1992) In discussions with the authors of that data base, we have found that they have used the same sources and conducted the same exercises to reconstruct the data. We have redone these exercise in order to create a consistent and current data base and in order to be transparent concerning the manner in which it was constructed. See Appendix A.

[14] Production and consumption figures are collected at a country level by the United Nations Environmental Program (UNEP) as part of the Montreal Protocol monitoring system. Only one year's data (1986) are available before the signing of the Protocol. The confidentiality requirements of UNEP do not allow the public dissemination of disaggregated data.

[15] Gaps in the data mean that regressions can be performed on only 29 countries.

Summers and Heston (1991)). The series on real per capita GDP is used to allow real comparisons between countries over time.

Table 1: Summary Description of Production Dataset (see appendix A for detail)

Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
CFC Production Dataset (29 countries)				
GDP per capita 1986 USD 1000s	7.4088	4.5571	1.1240	17.7100
CFC Production p.c. Tonnes ODP	4.6403	4.8571	0.0667	34.1161
Source: See Appendix A	ODP stands for ozone depleting potential.	CFC 11 and 12 have equivalent ODPs (1).	Note that the countries in data set 2 are not the same as in data set 1.	

Estimated Model

We estimate a reduced-form model using only the most important variables determining national CFC production and consumption. The estimated parameters of this model can then be used (with forecasts of the independent variables) to produce forecasts. The reduced-form model that is used in existing Kuznets curve literature is usually static, but we formulate a dynamic model:

Estimation of Dynamic Model of CFC-Income Relationship: (1)

$$cfc_{it} \ ? \ ?_{i} \ ? \ ?_{t} \ ? \ ?_{3} y_{it} \ ? \ ?_{4} y_{it}^{2} \ ? \ ?_{5} cfc_{i,t?1} \ ? \ ?_{it}$$

Where:

cfc_{it} is CFC consumption or production per capita for country i in year t;

y_{it} is GDP per capita for country i in year t;

$?_{i}$ is a fixed effect for country i[16]

[16] This might include exogenous factors such as the climate and geography of each country. For example, ozone depletion is of greater concern for countries which lie close to the poles; and so alpha i should be smaller for these

?t is a fixed effect for year t;[17]

? $_{1,2}$ are the independent variable coefficients.

and ?$_{it}$ is a white noise error term for country i and year t.

Equation (1) is known as a two-way error component model; see Hsiao (1986). Most notable about the equation is the inclusion of income y as the only explanatory variable. The underlying assumption is that only income is truly exogenous—all other potentially relevant variables (such as the composition of output, political structure, etc.) are endogenous consequences of income growth. (Any other factors which might affect CFC consumption will be picked up in any event by the constants alpha i and gamma t. The functional form used—a quadratic in income—reflects the hypothesis that production/consumption per capita will grow at low income levels, and decline at higher wealth. It is expected that beta 1 will be greater than zero and beta 2 < 0; the critical level of income then equals beta 1 divided by twice beta 2. The specification includes lagged CFC production/consumption as a regressor in order to capture the effects of business cycles and feedback effects. Estimation of equation (1) using standard panel data techniques (the Within estimator) would yield biased and inconsistent results for panels of finite length; see Nickell (1981). Consequently, instrumental variable methods must be used. Following Arellano and Bond (1991), the orthogonality conditions between lagged values of y it and the disturbances ?it are used to construct 'internal' instruments.[18] This study reports the estimation of equation (1) for CFC production.[19] Since it is anticipated that there will be correlation between the country fixed effects (?i) and the regressor x_{it} (since rich countries tend to be non-equatorial), only fixed effects estimation is performed.[20]

4. Estimation Results

All regressions reported in this section were performed on CFC production data over the period 1976-1988 for 29 countries. The dependent variable is total production of CFCs 11 and 12 (in tons), divided by population. Income variables are per capita in 1986 US$000s. The details of the data are given in appendix A.

Table 2 reports the results of estimating equation (1) using the instrumental variable method of Bond and Arellano (1991). (The data are first-differenced, so there are no country dummies.) The variable CFC1 is CFC production lagged one period. The results show that this variable is highly significant, with a coefficient of 0.3 and a t-statistic of 7.8. The

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countries than for equatorial nations. Inclusion of this term avoids the biasedness and inconsistency problems that would result if the assumption of homogeneity across countries were used (see Hsiao (1986)).}

[17] This will capture year-specific factors, such as oil price shocks.

[18] The estimations are performed using DPD, a set of programs written in GAUSS by Arellano and Bond. We are grateful to Steve Bond for providing the programs and assistance.

[19] The data quality for CFC prices and consumption do not warrant a fuller reporting of those results, but the estimations were conducted on these data as checks on the production model. The results were consistent with those reported in this study. For a more complete report on the empirical analysis of this problem involving both static and dynamic estimations and production and consumption data, see Mason and Swanson (2000).

[20] Random effects estimation can yield biased and inconsistent results in this setting; see Greene (1993).

coefficients on the linear and quadratic income terms are significant at the 92% and 87% levels, respectively. The improved statistical significance of the regression provides a justification for the use of a dynamic, rather than static, model. The critical income level in the Kuznets curve is *US$16,050* (which is just within-sample—see table 1). As discussed in the introduction, existing studies have found lower turning point values (of around US$8,000 or less) for domestic pollutants, with much higher values for global pollutants such as carbon dioxide. The value found in this paper fits well with this trend. The income elasticity of production, calculated at the average values of the variables in the model (see table 1) is 3.0633 (short-run) and 4.3929 (long-run). The Sargan test indicates that the instruments are valid, and that the regression is not over-identified.[21]

Table 2: Estimation of Dynamic Panel Model (Equation 1)

Variable	**Estimate**	**Standard Error**
Constant	-0.3357	0.2229
CFClag1	0.3027	0.0390
GDP per capita	3.5643	2.0266
GDP per capita (squared)	-0.1111	0.0736
D79 (year dummies)	0.4988	0.2200
D80	-0.6699	0.2495
D81	1.3999	0.4524
D82	-0.2298	0.3442
D83	0.6079	0.1929
D84	0.8755	0.7467
D85	0.4868	0.1600
D86	-0.4493	0.6922
D87	-0.8419	0.3743
D88	0.3070	0.2502
Regression Diagnostics:		
Wald Test (joint significance)	173.314868 (3)	
Wald Test (Significance of dummies)	43.954346 (11)	
Test for first order serial correlation	-1.517 (29)	
Test for second order serial corr.	-1.008 (29)	
Sargan Test	302.097070 (60)	
Number of countries	29	
Number of observations	316	

The results indicate the importance of undertaking a dynamic estimation for a Kuznets form of relationship.[22] In addition, the results from our analysis of the production data indicate a couple of interesting results. First, the existence of an "inverted U" relationship between income and CFC production cannot be rejected, and the turning point in this

[21] Both the static and dynamic models were run with variables in natural logarithms. Statistical significance was not improved in either, so the results are not reported here

[22] The significance of the estimation and the estimators were vastly improved by using this technique.

relationship exists at the high income end of the dataset (i.e. around 16,000 1986 US$ per capita). Secondly, the dynamic analysis of the panel data indicates that the year dummy in 1987 has a large, negative and statistically-significant coefficient, while most years preceding it have positive or insignificiant ones. Combined with the observation that most of these reductions that occurred in 1987 were undertaken by developing countries (see footnote 12), this coefficient captures the initial, short term impact of the Montreal Protocol. As noted by Murdoch and Sandler (1997), the initial impact of the Protocol was to induce developing countries to reduce CFC production (in order to qualify for admission as Article 5 parties to the agreement) and this is captured by the coefficient corresponding to the variable D87 in Table 2. The long run impact of the Montreal Protocol is the subject of section 3.

Conclusion

The short run impact of the Montreal Protocol is captured in the immediate reductions in CFC production undertaken by developing countries to qualify for admission to the Protocol as such. The longer term impact of the IEA requires a broader frame of reference than a single year. For this purpose we must consider how the projected unilateral management of CFC emissions would have differed from that resulting under cooperative management into the distant future.

The analysis of the relationship between income and CFC production during the period of unilateral management provides support for two assertions: 1) there is clear evidence of an "inverted U" sort of relationship between income and CFC emissions; 2) this relationship does not indicate that unilateral management alone would have halted ozone depletion, as evidenced by the fact that the "turning point" in the estimated function does not occur until relatively high levels of income (somewhere around 1986 US$16000 per capita).

In short, it is plausible that the estimated relationship between income and CFCs provides an explanation for the downturn in CFC production (in actual amounts and relative to the forecast production) that is seen in Figure A1 above. The knowledge of the relationship between CFC use and ozone depletion did indeed brake expansion in the use of these chemicals in the period after the early 1970s, certainly far less than the geometric growth experienced prior to that time. This change - from the pre-1970s era of geometric growth in production to one (post-1974) of continued growth at reduced rates (up through 1987) - is coincident with a period of "unilateral management". In order to ascertain the distributive impact of the ensuing period of joint management, it is now necessary to extrapolate the rates of CFC production occurring in the era of unilateral management into the future (beyond 1988). This is the task to which we turn in section 5.

5. The Impact of the Montreal Protocol - Comparing Cooperative and Noncooperative Paths

The object of the previous sections was to estimate the relationship between income and CFC use over the era of unilateral management. In sections 3 and 4 this task was accomplished at the level of individual countries across a period of a dozen years. This section uses the results of section 4 to produce forecasts of CFC production along these same baselines up to the year 2050.[23] Results are reported in aggregate terms and with the countries grouped into income quintiles. The comparison of the requirements of the Protocol with the forecasted CFC production along the noncooperative pathway indicates that the international environmental agreement has had a substantial impact on CFC usage, and that most of this impact has been achieved by altering the options available to the poorest countries.

CFC Production

The forecasts are summarised in figure 1, which shows global (i.e. summed over the countries which were producing in 1988) production of CFCs 11 and 12 for each year over the period 1989 to 2050.[24] Three growth scenarios are presented. 'Medium growth' assumes that growth occurs according to equation; 'fast growth' adds 0.005 to the growth rate for each country in each year; 'slow growth' subtracts 0.005. Alternative growth scenarios are analysed below.[25] The figure shows that there is little difference over the entire period between the medium and slow growth scenarios; the fast scenario departs from the other two during the periods 2000-2010 and 2038 onwards, when the quadratic income term causes production to fall sharply. Despite these differences, total production over the period in the three scenarios is very similar: 3.317, 3.439, 3.475 billion tons of ODP in the fast, medium and slow scenarios respectively. Global production in 2050 is a factor of between 2.3 (fast) and 2.8 (medium and slow) greater than its 1988 level. In short, the forecasted levels of CFC production in fifty years (under the assumption of unilateral management) are a factor three times their levels at the time of the agreement. Clearly, this level of management in itself was incapable of solving the problem of ozone depletion.

Insert Figure 1

Figure 2 shows how shares in global production vary over the forecast period for income quintiles. These quintiles are countries grouped together by income levels in 1988. The highest quintile includes countries whose incomes lie in the top 20% of the global income distribution; the fourth quintile includes countries whose incomes lie below the top 20% but above the top 40% of the income distribution; and so on.

Insert Figure 2

[23] The method for forecasting individual country populations and incomes is taken directly from Holz-Eakin and Selden (1993).

[24] .An important omission is that production from new countries, not included in the original number, is not modelled. The effect of this omission is to bias downwards not only future CFC production, but also the production share of the lowest income countries (see figure 2).

[25] The year-specific fixed effects coefficients in equation (2) were not forecast, but set equal to their 1988 levels.

Table 4 shows which countries are in which quintiles[26], and also gives summary statistics for each.

Table 4: Countries in Production Data set and their Income Groupings

Quintile	**Country**	**CFC Prod per capita (tonnes)**	**GDP per capita (000s 1988 US$)**	**Population (000s)**
Lowest	Algeria	0.2025	2.7690	23758
	Brazil	1.7365	4.208	143803
	Colombia	1.1954	3.231	31189
	India	0.4413	1.729	171994
	Thailand	1.0013	2.972	54536
	Turkey	1.4046	3.419	53764
	Chile	0.6361	3.989	12748
	Nicargua	0.0667	1.719	3401
	Peru	0.3218	2.724	20654
	Philippines	0.1572	1.676	58721
Second	Argentina	1.2415	5.349	31536
	Greece	3.7753	6.459	10004
	Korea	6.297	5.607	41975
	Mexico	6.0418	5.349	78933
	Portugal	4.0659	6.01	10287
	Yugoslavia	0.1283	4.944	23566
Third	Spain	5.1387	8.759	38809
Fourth	Denmark	0.1812	13.571	5130
	Finland	12.8623	13.377	4951
	France	10.5613	13.259	55884
	Germany	13.3336	13.456	61474
	Hong Kong	2.7864	13.969	5627
	Italy	7.998	11.918	57452

[26] Quintiles were defined by taking the largest income level in the sample and dividing it into five equal parts – countries are then listed with those that fall within the same income grouping. This definition preserves income proportionality, but allows populations in each quintile to vary. Despite this, each of the quintiles is relatively proportionate to its representation in the global population, except that the absence of China from the data set (and the disproportionate representation of western countries) provides an imbalance in world population toward the higher quintiles.

	Japan	9.0302	13.156	122613
	Sweden	9.7743	14.408	8436
	UK	1.658	12.969	57065
	Norway	9.1505	14.674	4209
Highest	USA	7.5677	17.710	246307
	Canada	7.6776	17.258	25950

Figure 2 explains, for the medium growth scenario, the shape of the curve in figure 1. For example, the share of the lowest income quintile increases from under 20% at the beginning of the period to over 75% by the end; the highest two income quintiles account for over 65% of global production in 1988, but produce nothing by 2050. The monotonic fall in production by the higher income countries causes the fall in global production during 2007-2015; the relentless rise in production by the lower income countries maintains the overall upward trend. It is the low incomes and high populations of those countries in the lowest income groups that drives the continued use of CFCs throughout the forecast period.

The Impact of the Montreal Protocol

The impact of the Montreal Protocol can be illustrated by considering figures 3 and 4, which are the analogues of figures 1 and 2 with countries' production replaced by their Protocol obligations. Figure 3 (in which the 'medium growth' scenario is assumed) shows that global production drops sharply in 1994, when the high income countries are obliged to reduce production to one-quarter of 1989 levels; by 1996, developed countries' production[27] is zero, and all remaining production is due to developing countries. This comes under Protocol control in 2005, when production must fall to 50% of 2002 levels. All production is banned by the year 2010. CFC production under the terms of the Protocol is shown in figure 4, grouped by income quintiles. The highest income quintile would have produced, in the absence of the Montreal Protocol, approximately 10 million tons of CFC 11 and 12 in the year 2000; under the Protocol, its production is required to be zero. By roughly 2020, Protocol obligation and unilateral management coincide for the richest countries. In contrast, the poorest countries (the lowest income quintile), unregulated in the year 2000, would have produced about 20 million tons of CFCs in 2020, compared to the zero production level required under the Protocol, and their production would have continued to expand through the end of the simulation (i.e. 2050). This is a clear indication that the burden of the Protocol in the future will fall increasingly on the poorest countries.

Therefore, the comparison of these figures demonstrates that the Montreal Protocol has a pronounced aggregate and distributive impact. The difference in aggregate impact is the difference between the areas under Figure 1 (CFC production under unilateral management) and that under Figure 3 (CFC production under the Protocol). The distributive impact is evidenced by the difference between the production by the various income groupings in Figures 2

[27] To be precise, 'non-article 5 countries', defined as those countries with high national incomes **or** CFC production per capita in excess of 0.3 kg of ODP.

and 4. Clearly, the Montreal Protocol as designed has a substantial effect, and this is attributable primarily to the additional abatement required of the poorest countries.[28]

Insert Figures 3 and 4

6. Financing the Protocol: Production Values and Multilateral Funds

Under Article 10 of the Montreal Protocol a Multilateral Fund was established. This fund has been created for the purpose of funding the "incremental cost" of substituting new technologies for ozone-depleting ones in developing country member states. The Fund was initiated with $240 million in 1991 and then replenished with $500 million in 1994 (to cover the three years through 1997), and recently renewed. Therefore, developing countries are able to receive some financial assistance in their transition from ozone depleting substances to others. Are the amounts being made available to the developing countries adequate for the purpose of sharing the burden of the provision of this public good? The aggregate amount placed in the fund to date is about $0.7 billion and this may be put into perspective when compared to a few of the claims placed upon it. Korea estimated its own incremental costs at $1.9 billion and India presented an estimated range of $1.4-2.4 billion of incremental costliness. Clearly the level of funding available and the claims placed upon it have not been in balance.

This section estimates production value losses occasioned by the Montreal Protocol. The figures are discounted sums of flows of values over the forecast period, in 1986 US$. The calculations have been performed for various combinations of the model parameters: income and price growth rates, and the discount rate. Naturally, the absolute values of the losses involved change with the different parameter values. But the distribution of losses between countries (grouped by income quintiles) has the same qualitative features in many of the scenarios.

Table 5 give the discounted sum of value and surplus changes over the forecast period for three different real price growth rates (constant real price, 2.5% per annum and 5% per annum price growth) and three different discount rates (1%, 5% and 10%).[29] Table 5 gives production value losses for each of the five income quintiles as well as the total

[28] Two notes. First, it is important to acknowledge that the obligations under the Montreal Protocol and reality are two different things; however, the issue addressed here is whether joint management under the Protocol (as designed) confers additional responsibilities over those that would be adopted unilaterally, and upon whom these responsibilities are conferred. Second, it is important to acknowledge the implicit ethical assumption here that those countries developing after 1989 have the same rights to CFC-based development as those developing between 1970 and 1989. This is debatable as there is a different information base available to these later countries, and they are less likely to have sunk investments without that information. However, the response to this contention is the same as that to the first point – the only issue here is whether countries are being assigned responsibilities in excess of those that countries undertook unilaterally in the period 1975-1988.

[29] Varying these parameters captures the importance of two different assumptions that must be made regarding the nature and rate of technical change. The rate of real price growth captures the importance of technical change in creation of non-accumulating CFC substitutes. If technical change in the creation of CFC-substitutes advances at a rate equal to or in excess of the rate within the general economy, then the appropriate real price path would be at or below the 0 rate in the table. If, on the other hand, it is difficult to find substitutes for CFCs that do not have the same capacity for environmental damage, then the higher price paths are the more relevant ones. The discount rate assumption concerns the general rate of growth and change within the economy, and the capacity for these changes to

losses (at mid-range assumptions). Note that the greatest losses are being experienced by the poorest countries, and that these losses are highly sensitive to the discount rate assumptions imposed. These observations illustrate that the Montreal Protocol is being financed by the elimination of development opportunities in the distant future - for the poorest of the world's countries.

Table 5: Estimated Production Value Lost Due to Montreal Protocol (millions 1988 US$)

Development Status of Country (Income Quintile)	**CFC Price Growth Path Assumption**	**<u>Production Value Lost:</u> Discounted @1%**	**Discounted@ 5%**	**Discounted@ 10%**
Lowest	0%	1,540	347	85
	2.5%	5,644	1,029	194
	5%	31,210	4,537	611
Second	0%	362	81	19
	2.5%	1,289	238	44
	5%	6,814	1,008	138
Third	0%	49	18	7
	2.5%	124	35	11
	5%	471	95	22
Fourth	0%	373	134	54
	2.5%	1,012	275	89
	5%	4,594	846	182
Highest	0%	5	2	1
	2.5%	11	4	1
	5%	24	8	3
Total	**2.5%**	**8,067**	**1,581**	**339**

Note also that present value of the aggregate losses being imposed are not far off the amounts being transferred via the Multilateral Fund for the implementation of the Montreal Protocol. Hence it is at least possible that the foregone development opportunities of developing countries are being purchased at approximately their present value. Another example of the real impact of this international environmental agreement.

7. Conclusions

This paper has examined the relationship between countries' propensity to produce CFCs and income per capita in the period before the adoption of the Montreal Protocol but after the identification of the ozone-depleting capacity of CFCs (i.e. 1975-1988). In this way we have been able to ascertain the relationship between income and unilateral

substitute or ameliorate for the impact of ozone depletion. If there is a high rate of ozone-augmenting change, then the management for ozone depletion. In doing so it has applied more powerful econometric techniques than previous studies of environmental Kuznets curves. This proved particularly useful for estimating production income and price elasticities. Regression analysis estimated the turning point in the "inverted U" relationship between income and CFC use occurs around US$16,000 for production (depending on the model estimated). The income elasticity of production is approximately 3.1 (short-run) and 4.4 (long-run), while the price elasticity is 0.3 and 0.5 in the short- and long-run, respectively.

These results are particularly useful for assessing the impacts of the Montreal Protocol. They demonstrate what unilateral management would have achieved in the absence of the Protocol. Comparison of Figures 1 and 3 shows that the results could not be more clear-cut. The agreed reductions codified under the Montreal Protocol will dramatically reduce ozone depletion over what would have been predicted to occur under unilateral management, based on the experience with unilateral management that occurred between 1975 and 1988. This conclusion counters Barrett's (1994) statement that the Protocol has achieved nothing more than to codify countries' non-cooperative actions, and contradicts the empirical findings of Murdoch and Sandler (1997) in this regard. Clearly, the Montreal Protocol has had a substantial impact on the management of CFCs.

The distributive impact of the Protocol is also clear. There is clear evidence that the Protocol imposes the largest production value losses on the poorest countries—many (poorer) countries which are signatories to the Protocol will suffer significant losses from their participation. This is because their incomes are far below the unilateral management-based turning point of $16,000 per capita, and their population levels are relatively high. It is the impact of the Protocol on the future production possibilities of these – the poorest of all countries – which gives it its effectiveness. The forecasts of production, and comparison with levels mandated by the Montreal Protocol, meant that the value of production losses of the Protocol could be calculated. These were found to be in the region of $1-8 billion, depending upon the assumptions used. These figures are not far off the aggregate values being used to compensate countries for foregoing the use of CFCs. Contrary to much of the theoretical and empirical literature, the impact of the Montreal Protocol has been to provide the framework for the provision of this global public good, and to provide for the mechanism to finance it publically.

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higher rates of discount are applicable; if not, then the lower rates would be applicable.

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Appendix A

Data set 1: CFC Production

Lengthy time series production data exist only for CFCs 11 and 12; this is not a serious limitation, since these two chemicals account for approximately 78% of CFC use in 1988. The data problems outlined in section 2 mean that country-level CFC production figures must be estimated by using several proxies.

There are three major steps:

1. Global production of CFC 11 and 12 (taken from AFEAS (1995)) is allocated to countries using countries' share in world production of the related chemicals polyvinyl chloride (PVC) and trichloroethylene (TCE), both chlorinated hydrocarbons.[30] PVC and TCE production figures are taken from the United Nations Industrial Commodity Yearbook;
2. Countries' income and populations are obtained from the Penn Mark V.6 World Tables (see Summers and Heston (1991));
3. U.S. CFC prices are taken from Chemical Marketing Reporter; country CFC prices are calculated by deflating using country- and year-specific price deflators taken from the Penn World tables.[31]

These calculations have been checked against U.S. production figures, which can be obtained directly from the International Trade Commission (ITC). They have also been checked against 1986 production figures reported to UNEP. Both checks show that the production estimates are reasonable.

The period of the study is truncated at 1976 due to changes in trade classifications that make it impossible to get sufficiently disaggregated data prior to that date. In any event, the analysis would have to start no earlier than 1974, since this is the year in which scientific results first suggested a link between CFCs and ozone depletion. The end year of 1988 coincides with the start of the Montreal Protocol obligations. Full data can be obtained only for 29 countries, which are listed in Table 4 above.

[30] The best proxy for this purpose would be countries' shares in world production of carbon tetrachloride, 90\% of which is used in the manufacture of CFCs. Unfortunately, these data are not collected, and only figures on PVC and TCE are available.

[31] Strictly speaking, transportation costs from exporting to importing countries should also be included in this calculation. These can be significant for CFCs, since pressurised containers must be used, particularly for CFC 12. Prices were not adjusted for costs, since this factor should be captured in the country-specific dummies of the panel estimation (provided transportation costs have stayed roughly constant over time).

FIG 1

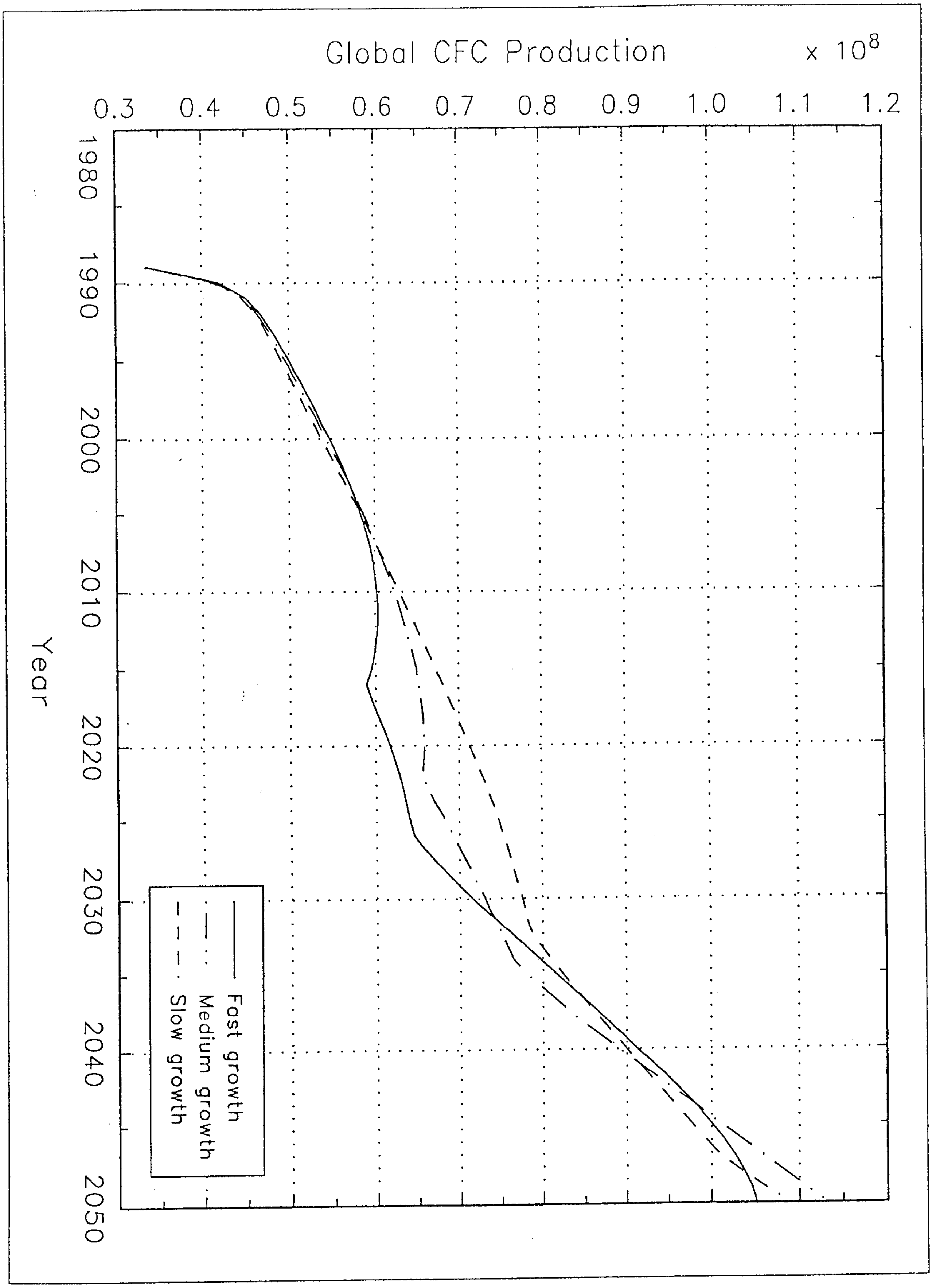

Global CFC Production
x 10^8
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1980
1990
2000
2010
2020
2030
2040
2050
Year
Fast growth
Medium growth
Slow growth

FIG 2

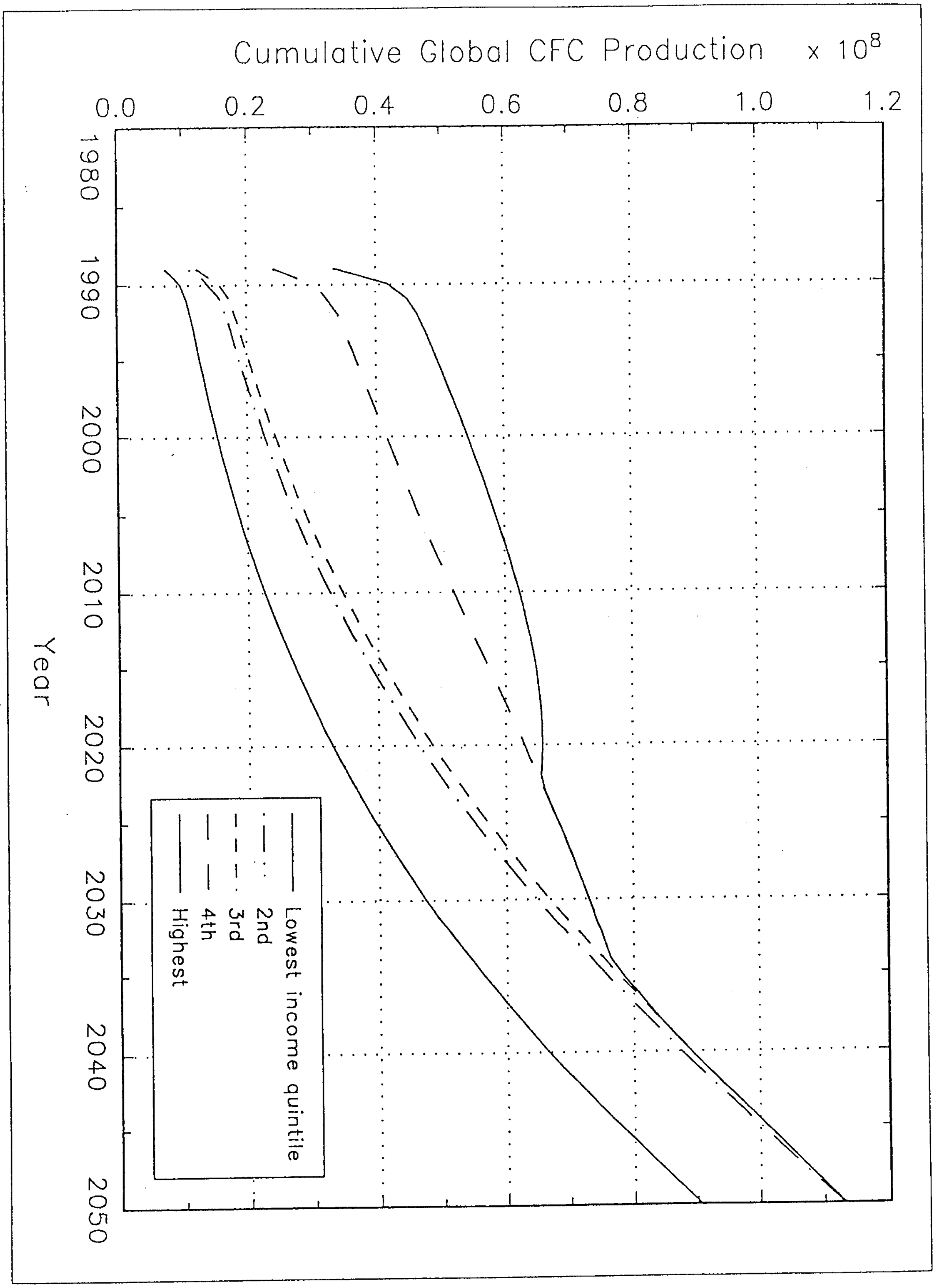

Cumulative Global CFC Production x 10^8
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
2010
2020
2030
2040
2050
Year
Lowest income quintile
2nd
3rd
4th
Highest

FIG 3

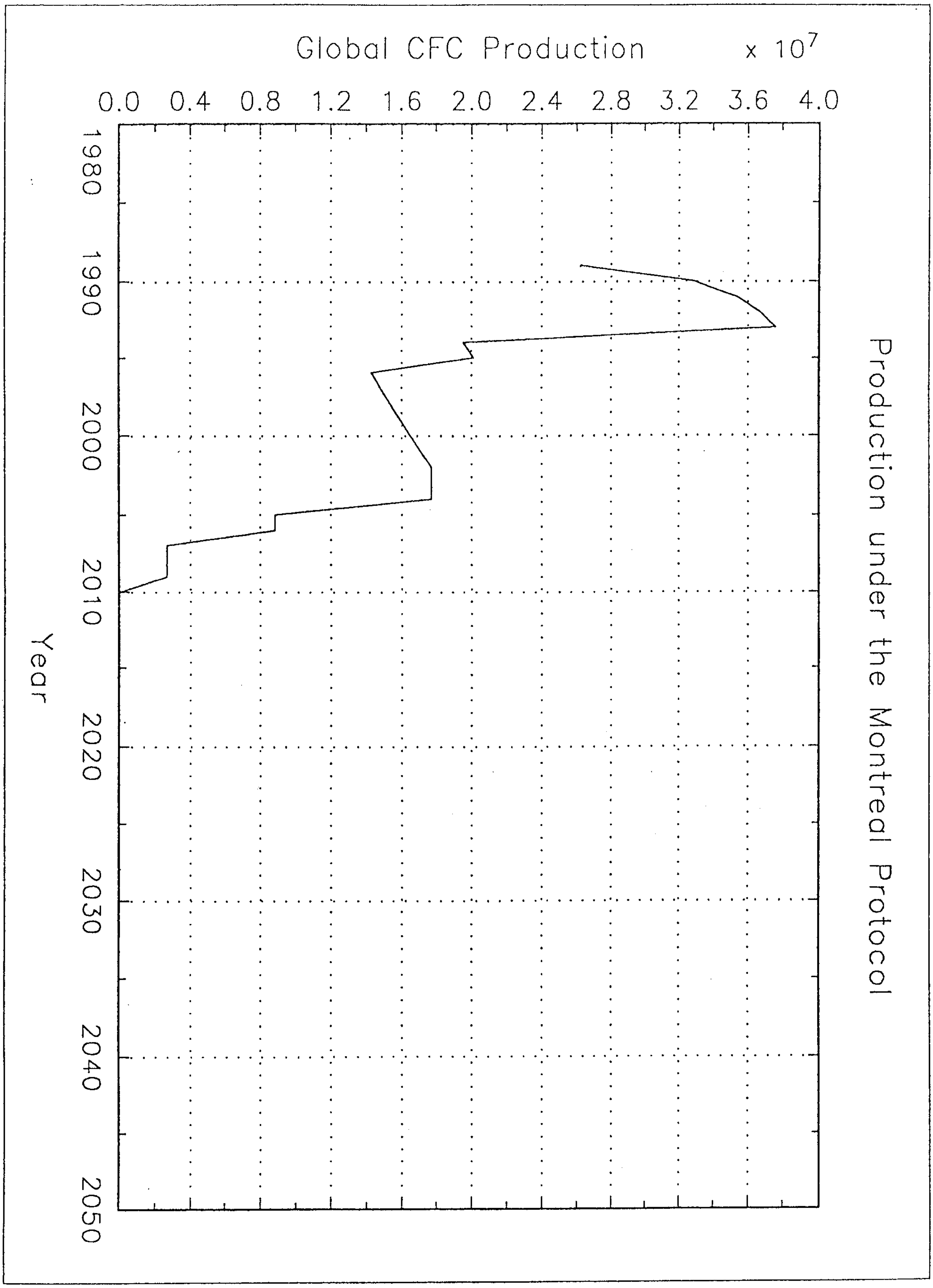
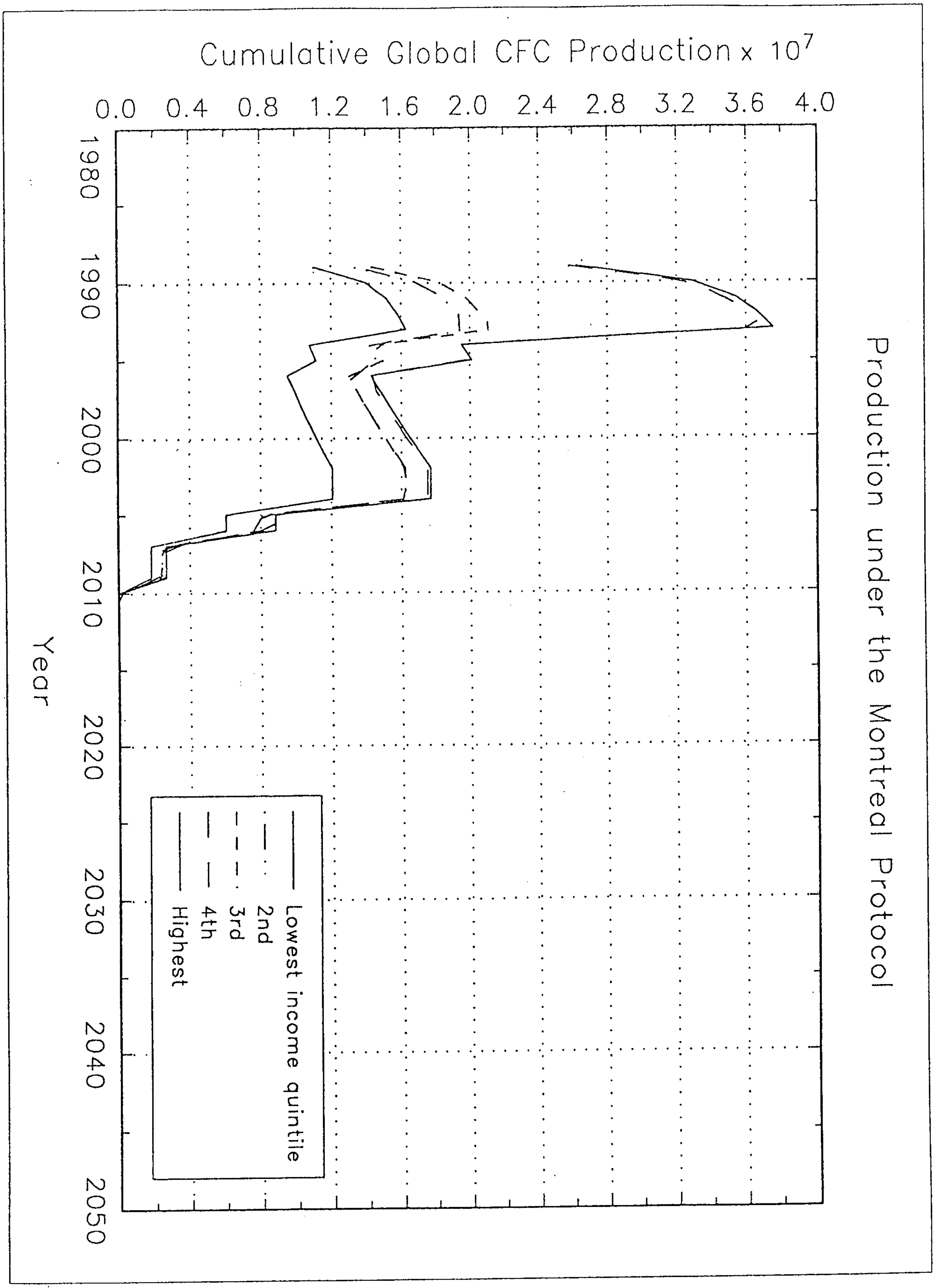

Global CFC Production
x 10^7
0.0 0.4 0.8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
1980
1990
2000
2010
2020
2030
2040
2050
Year
Production under the Montreal Protocol

FIG 4


Production under the Montreal Protocol
Cumulative Global CFC Production x 10^7
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
Year
1980
1990
2000
2010
2020
2030
2040
2050
Lowest income quintile
2nd
3rd
4th
Highest

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(xlix) This paper was presented at the International Conference "Knowledge as an Economic Good", organised by Fondazione Eni Enrico Mattei and The Beijer International Institute of Environmental Economics, Palermo, April 20-21, 2001
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(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001
(lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001
(liii) This paper was circulated at the International Conference on "Climate Policy – Do We Need a New Approach?", jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001
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(lvii) This paper was presented at the First Workshop of "CFEWE – Carbon Flows between Eastern and Western Europe", organised by the Fondazione Eni Enrico Mattei and Zentrum fur Europaische Integrationsforschung (ZEI), Milan, July 5-6, 2001

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