Trade Liberalisation and the Environment: The Case of the Uruguay Round

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1. INTRODUCTION

ALTHOUGH a growing body of literature now exists on the relationship between trade liberalisation and the environment, few studies have attempted to quantify the environmental impact of a specific trade agreement. Those that have (see for example Beghin and Potier, 1997; Grossman and Krueger, 1993; and Beghin et al., 1995) tend to concentrate on the impact of three mechanisms associated with trade liberalisation, namely the *composition* effect, the *scale* effect and the *technique* effect. The composition effect refers to the fact that trade liberalisation is likely to change the composition of industry as countries specialise to a greater extent in those sectors in which they enjoy a comparative advantage. This change may have either a positive or negative impact on the environment. The scale effect stems from the expansion in the scale of production which is likely to occur as markets expand due to trade liberalisation. Taken in isolation, the scale effect is likely to prove damaging to the environment. Finally, the technique effect refers to the fact that following trade liberalisation, a nation may have greater access to resource efficient production methods whilst at the same time individuals may begin to demand a cleaner environment as they experience increasing incomes. Thus, the manner of production may change as a result of trade liberalisation, to the benefit of the environment.

This paper estimates the impact of the Uruguay Round of trade negotiations, in terms of these three effects, on five air pollutants for a number of countries/regions. The five pollutants are nitrogen dioxide, sulphur dioxide, carbon monoxide, suspended particulate matter and carbon dioxide. In this paper the scale and technique effect are combined into one effect, hereafter referred to as

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the combined scale and technique effect. Where the composition effect *and* the combined scale and technique effect are estimated for a pollutant, these are aggregated to provide the *total impact* of the Uruguay Round on that pollutant. From these estimates, the likely monetary cost associated with a change in pollution emissions is also estimated. As far as we are aware, no other study has quantified the environmental impact of the Uruguay Round, though Grossman and Krueger (1993) estimate the composition effect resulting from the North American Free Trade Agreement.

The remainder of the paper is organised as follows; Section 2 sets out the framework which has been adopted to examine the relationship between trade liberalisation and the environment; Section 3 provides results and Section 4 concludes the paper.

2. FRAMEWORK

François et al. (1995) estimate the impact of the Uruguay Round on the structure of world production and on the world level of income, using 13 regions and 19 sectors. This paper estimates the Uruguay Round's impact on air pollution for nine major regions. In order to quantify composition and combined scale and technique effects in terms of air pollution, it is necessary to estimate the relationship between per capita income and per capita pollution emissions. This relationship is encapsulated in environmental Kuznets curves (EKCs).[1]

With regard to the composition effect, the Uruguay Round is expected to change the global composition of industry, thereby also changing sectoral and aggregate pollution intensities. By increasing or decreasing the pollution intensity of each unit of GDP, the composition effect causes the EKC to shift. The extent of this shift is estimated by applying the regional sectoral output changes of François et al. to the local air pollution intensities from Hettige et al. (1994). Hettige et al. estimate pollution intensities for each ISIC sector for the US in terms of pounds of pollution per million 1987 US dollars of output. These pollution intensities were estimated by merging manufacturing census data from over 200,000 factories throughout the US with US Environmental Protection Agency data on air pollution emissions. Intensities are estimated for nitrogen dioxide, sulphur dioxide, carbon monoxide and suspended particulate matter, but not carbon dioxide. As yet, Hettige et al. do not estimate sectoral pollution intensities for any country other than the USA. However, rather than apply US intensities to all other countries/regions, US sectoral intensities have been scaled for each country/region according to the difference between that country/region's *total* pollution intensity (for each pollutant, for 1990) and that of the USA.

[1] Further details of the estimation of EKCs can be found in Cole et al. (1997a and 1997b).

Whilst the composition effect causes a *shift* in the EKC, the scale and technique effects result in a *movement along* the curve. As income increases as a result of the Uruguay Round, EKCs combine the increase in emissions stemming from the increase in production with the decrease in emissions which occurs as individuals begin to demand a cleaner environment. To estimate the resultant change in emissions, the new level of per capita emissions which arises from the increased per capita income is simply multiplied by 1990 population levels to obtain total emissions in the presence of the Uruguay Round. The level of total emissions in the absence of the Uruguay Round is then subtracted from this new level of emissions to provide the change in emissions. This estimate of the difference between 1990 emissions with and without the Uruguay Round is referred to as scenario 1. A second scenario considers the difference between emissions in the year 2000 with and without the Uruguay Round if, as a result of the Uruguay Round, income had grown each year by 0.5 per cent above the growth rate projected by the World Bank (1994). UNEP (1993) population forecasts are used to obtain total emissions from year 2000 per capita emissions. This link between the Uruguay Round and the actual rate of growth is discussed by François et al. (1993). The choice, in this paper, of a 0.5 per cent addition to the rate of growth is not intended to be an estimate, but merely serves to illustrate how a change in the rate of growth can affect pollution.

3. RESULTS

a. Composition Effect

Given the Uruguay Round Final Agreement, François et al. (1995) predict that the largest output shocks will result from the phaseout of the Multi-Fibre Agreement (MFA). Their model indicates that the liberalisation of the MFA will result in a significant contraction of textile and clothing production in developed countries, matched by an expansion of these sectors in the developing world, particularly East and South Asia. As the Asian developing countries shift resources into textiles and clothing, the manufacturing sectors contract, particularly transport equipment, steel, non-ferrous metals and other machinery. This contraction thereby allows an expansion of these sectors in the developed economies. Tables 1 and 2, summarise the estimated composition effects for the developed regions and the developing and transition regions, respectively. Table 2 also reports global estimates.[2]

[2] Cole et al. (1997b) provide composition effects for seventeen separate sectors, for each region. Tables 1 and 2 aggregate these sectoral effects to provide the total composition effect for each region and each pollutant.

For all four pollutants, the largest sectoral changes occur in the textile sector. For the developed world they represent the largest sectoral decreases, and for East Asia and South Asia the largest sectoral increases. These changes in pollution occur despite the relatively low pollution intensities associated with the output from the textile and clothing sectors.

In contrast, many of the heavy industry sectors possess large pollution intensities, with the iron and steel and non-ferrous metals sectors having particularly high sulphur dioxide and carbon monoxide intensities. Typically, the direction of the output change in these sectors dictates whether the region as a whole will experience an *overall* increase or decrease in pollution, as a result of compositional changes. As Table 1 illustrates, the predicted expansion of heavy industry in the developed economies is, thus, expected to raise total compositional pollution for these regions, for all four pollutants. Conversely, most developing regions are predicted to experience a fall in total compositional pollution due to the

TABLE 1
Composition Effects, Combined Scale and Technique Effects and the Aggregate Impact of the Uruguay Round for the Developed Regions (Thousand Tonnes (italicised) and Percentage of Total 1990 Emissions)

	Composition Effect (%)	*Combined Scale and Technique Effect (%)*		*Aggregate Impact (thousand tonnes and %)*			
		Scenario 1 1990	*Scenario 2 2000+0.5%*	*Scenario 1 1990*		*Scenario 2 2000+0.5%*	
Nitrogen Dioxide							
EU	0.1	0.2	0.9	*36*	0.3	*145*	0.9
USA	0.1	0.05	−0.3	*23*	0.1	*−60*	−0.2
Japan	0.3	0.1	0.3	*10*	0.4	*18*	0.6
Sulphur Dioxide							
EU	0.3	−0.4	−4.4	*−8*	−0.1	*−602*	−4.1
USA	0.4	−0.7	−5.4	*−103*	−0.3	*−1,473*	−5.0
Japan	2.0	−0.6	−5.8	*20*	1.4	*−65*	−3.8
Carbon Monoxide							
EU	0.2	−0.3	−3.9	*−129*	−0.1	*−1,951*	−3.7
USA	0.1	−0.6	−4.4	*−590*	−0.5	*−5,007*	−4.3
Japan	0.3	−1.0	−10.7	*−97*	−0.7	*−1,393*	−10.4
Suspended Particulate Matter							
EU	0.2	−0.3	−3.6	*−7*	−0.1	*−143*	−3.4
USA	0.2	−0.8	−7.1	*−45*	−0.6	*−426*	−6.9
Japan	0.3	−0.5	−4.6	*−4*	−0.2	*−91*	−4.3
Carbon Dioxide							
EU		0.4	2.4				
USA		0.3	1.8				
Japan		0.4	2.3				

TABLE 2
Composition Effects, Combined Scale and Technique Effects and the Aggregate Impact of the Uruguay Round for the Developing and Transition Regions (Thousand Tonnes (italicised) and Percentage of Total 1990 Emissions)

	Composition Effect (%)	*Combined Scale and Technique Effect (%)*		*Aggregate Impact (thousand tonnes and %)*			
		Scenario 1 1990	*Scenario 2 2000+0.5%*	*Scenario 1 1990*		*Scenario 2 2000+0.5%*	
Nitrogen Dioxide							
China	−0.3	1.6	6.3	*118*	1.3	*1,179*	6.0
East Asia	−0.1	2.0	4.0	*60*	1.9	*218*	3.9
South Asia	−0.5	1.0	6.6	*9*	0.5	*237*	6.1
Africa	0.2	2.0	7.8	*21*	2.2	*160*	8.0
Latin America	0.6	0.9	3.7	*59*	1.5	*232*	4.3
E.Europe	0.2	0.06	2.0	*13*	0.2	*139*	2.2
Global	0.04	0.5	2.6	*349*	0.6	*2,267*	2.6
Sulphur Dioxide							
China	−1.8	2.1	7.0	*18*	0.3	*1,026*	5.2
East Asia	−3.1	1.8	3.8	*−190*	−2.2	*79*	0.7
South Asia	−0.6	1.3	8.0	*31*	0.7	*729*	7.4
Africa	−0.08	2.8	9.7	*57*	2.7	*486*	9.7
Latin America	0.5	0.7	1.9	*124*	1.2	*317*	2.4
E.Europe	−0.07	0.003	−1.1	*−9*	−0.07	*−154*	−1.2
Global	−0.3	0.2	0.5	*−64*	−0.1	*343*	0.2
Carbon Monoxide							
China	−0.1	1.8	8.5	*569*	1.7	*5,322*	8.4
East Asia	−1.9	1.9	5.3	*9*	0.03	*521*	3.4
South Asia	−0.5	1.3	8.9	*67*	0.7	*1,467*	8.4
Africa	−0.05	2.4	10.1	*107*	2.4	*963*	10.0
Latin America	0.2	0.8	2.5	*184*	1.0	*588*	2.7
E.Europe	0.07	0.2	2.9	*38*	0.3	*641*	3.0
Global	−0.05	0.1	0.4	*158*	0.1	*1,151*	0.4
Suspended Particulate Matter							
China	−0.9	2.0	10.0	*21*	1.1	*325*	9.1
East Asia	−3.0	1.7	3.7	*−26*	−1.3	*36*	0.7
South Asia	−0.4	1.4	10.0	*10*	1.0	*201*	9.6
Africa	0.02	2.7	10.7	*15*	2.7	*130*	10.8
Latin America	0.4	0.6	2.4	*31*	1.0	*92*	2.8
E.Europe	0.07	0.002	−1.0	*5*	0.07	*−67*	−0.9
Global	−0.1	0.1	0.3	*−2*	−0.0005	*56*	0.2
Carbon Dioxide							
China		1.4	6.2				
Rest of Asia		1.7	8.9				
Africa		1.8	7.4				
Latin America		1.0	4.6				
E.Europe		0.08	3.1				
Global		0.5	3.3				

contraction of heavy industry. Latin America is the exception and is predicted to experience an *increase* in total compositional pollution, for all four pollutants, whilst Africa and Eastern Europe also experience an increase for some pollutants.

b. Combined Scale and Technique Effects

As Tables 1 and 2 indicate, for nitrogen dioxide and carbon dioxide, the combined scale and technique effects are estimated to increase emissions for all regions. Nitrogen dioxide emissions in the USA are the only exception since under scenario 2 per capita income has become sufficiently high for the EKC turning point to have passed. Emissions therefore begin to fall. For the other pollutants, combined scale and technique effects are estimated to lower emissions for most regions in the developed world, for both scenarios, and raise emissions for most developing regions.

c. Aggregating Composition and Scale and Technique Effects

Since both composition effects *and* combined scale and technique effects have been calculated for nitrogen dioxide, sulphur dioxide, carbon monoxide and suspended particulate matter, it is possible to aggregate the two effects to estimate the aggregate impact of the Uruguay Round on these pollutants. Thus, the combined scale and technique effect is added to the composition effect, with results provided in Tables 1 and 2.

With one exception, all nations are predicted to experience an increase in nitrogen dioxide emissions. With regard to sulphur dioxide, carbon monoxide and suspended particulate matter, emissions are predicted to increase in the developing world and fall in the developed world, the only exception being sulphur dioxide emissions in Japan and some pollutants for East Asia and Eastern Europe. For these three pollutants, the developed regions are typically predicted to experience large negative combined scale and technique effects which more than offset positive composition effects. For other regions the direction of the different effects depends on the pollutant, although many experience small negative composition effects which are offset by larger positive combined scale and technique effects.

Pollution changes for scenario 2 are considerably greater than those for scenario 1. The impact of the increased growth rate is therefore notable.

d. A Monetary Evaluation of the Change in Environmental Damage

It is possible to provide rough monetary estimates of the impact of the Uruguay Round (from both composition effects *and* combined scale and technique effects) on nitrogen dioxide, sulphur dioxide, carbon monoxide and suspended particulate matter emissions. For carbon dioxide, monetary estimates are possible only for combined scale and technique effects, since composition effects have not been estimated.

Monetary estimates of the damage resulting from one tonne of nitrogen dioxide, sulphur dioxide, carbon monoxide and suspended particulate matter have been made by several authors. These estimates are generally made by estimating the likely impact of a tonne of pollution, on the locale in which it is emitted, in terms of factors such as the cost of resultant illness amongst the population exposed to the pollution; the cost of mortality; and damage to buildings. Fankhauser (1995) provides estimates of the monetary impact associated with one tonne of nitrogen dioxide and sulphur dioxide of $5,000 and $2,500 respectively. Pearce (1993) provides estimates of the impact of a tonne of carbon monoxide and suspended particulate matter of $15.23 and $14,283 respectively. Fankhauser and Pearce obtain these figures by averaging the results from a number of other studies or by simply reporting the results of the study they consider to be most accurate. In the absence of any superior estimates, these figures are used in this paper. To amend these figures for developing regions they are scaled according to differences in income, following Fankhauser. Specifically, Fankhauser estimates damage costs in middle income and low income regions to be one-fifth and one-tenth of those in developed regions, respectively.

Fankhauser (1995) also provides an estimate of the global mean value of the marginal social cost associated with carbon dioxide emissions. He estimates this to be $20.3 per tonne of carbon emitted. This figure stems from a global estimate of the cost incurred if carbon dioxide concentrations were to double, which in turn is an aggregation of the regional costs associated with such an increase in concentrations. In the case of carbon dioxide, the source of the emissions is not relevant as the resultant impact is globally distributed. The same marginal social cost estimate is therefore applied to emissions from all regions to estimate the monetary cost of the increase in carbon dioxide emissions stemming from the combined scale and technique effect.[3]

Tables 3 and 4, provide the air pollution damage estimates associated with the Uruguay Round for the developed regions and the developing and transition regions, respectively. Table 4 also presents estimates at a global level. It can be seen that all regions are estimated to suffer a monetary cost of many millions of dollars due to increased nitrogen dioxide emissions, with the exception of the USA for scenario 2. With regard to sulphur dioxide, carbon monoxide and suspended particulate matter, the developed regions are predicted to experience a monetary benefit as emissions fall, whilst the developing and transition regions generally suffer a monetary cost due to rising emissions. The low unit damage costs attached to emissions in developing regions means that the direction and magnitude of the *global* monetary impact reflects the impact experienced in the

[3] These points were clarified by personal correspondence with Samuel Fankhauser.

TABLE 3
The Monetary Cost/Benefit Associated with the Change in Air Pollution Emissions for the Developed Regions —Based on Table 1 (Millions of 1985 US$)

	Scenario 1 1990	*Scenario 2 2000+0.5%*
Nitrogen Dioxide		
EU	180	724
USA	117	−302
Japan	50	91
Sulphur Dioxide		
EU	−19	−1,506
USA	−257	−3,682
Japan	49	−162
Carbon Monoxide		
EU	−2	−30
USA	−9	−76
Japan	−2	−21
Suspended Particulate Matter		
EU	−105	−2,038
USA	−647	−6,090
Japan	−62	−1,299
Carbon Dioxide		
EU	77	567
USA	107	672
Japan	23	212

developed regions, despite the higher levels of total emissions experienced in the developing regions.

All regions are estimated to experience a monetary cost as a result of increased carbon dioxide emissions. The largest monetary cost occurs in the developing and transition regions, more specifically in Asia. It should be noted that the interpretation of the monetary costs associated with carbon dioxide emissions should be different to those from the local air pollutants. For carbon dioxide, a region's monetary cost does not represent the cost incurred by that region, but rather that region's contribution to global costs. This stems from the fact that damage from carbon dioxide emissions is likely to be shared globally.

Although this is only a partial evaluation of the Uruguay Round's impact on carbon dioxide emissions, it is likely that the composition effect on carbon dioxide emissions will follow a similar pattern to that associated with nitrogen dioxide, sulphur dioxide and suspended particulate matter, since all four pollutants stem largely from energy use. Thus, it is possible that the composition effect will add to emissions, and hence to the monetary cost, for the developed

TABLE 4
The Monetary Cost/Benefit Associated with the Change in Air Pollution Emissions for the Developing and Transition Regions — Based on Table 2 (Millions of 1985 US$)

	Scenario 1 1990	*Scenario 2 2000+0.5%*
Nitrogen Dioxide		
China	59	590
East Asia	60	218
South Asia	4	118
Africa	10	80
Latin America	59	232
E.Europe	13	140
Global	553	1,890
Sulphur Dioxide		
China	5	257
East Asia	−95	40
South Asia	8	182
Africa	13	121
Latin America	62	159
E.Europe	−4	−77
Global	−240	−4,668
Carbon Monoxide		
China	1	8
East Asia	0.03	1.6
South Asia	0.1	2.2
Africa	0.2	1.5
Latin America	0.6	1.8
E.Europe	0.1	1.9
Global	−11	−110
Suspended Particulate Matter		
China	30	464
East Asia	−75	104
South Asia	14	287
Africa	21	186
Latin America	90	263
E.Europe	13	−191
Global	−721	−8,317
Carbon Dioxide		
China	125	1,177
Rest of Asia	286	2,249
Africa	63	527
Latin America	55	388
E.Europe	11	495
Global	747	6,287

regions and Latin America, whilst emissions may fall in the Asian regions. The effect of compositional changes on Africa and Eastern Europe is difficult to predict since they vary depending on the pollutant.

The monetary impacts associated with these five air pollutants can be seen to form only a small proportion of the estimated Uruguay Round benefits. For example, for China, Africa and Latin America, the monetary costs associated with the above five pollutants form approximately 1.2 per cent of their estimated income gain for 1990. For the European Union this figure is only 0.4 per cent whilst the USA's environmental *benefit* represents 1.8 per cent of the initial estimated gain.

Monetary damage estimates of this nature are subject to much uncertainty, however, as is the appropriate mechanism with which to scale costs for the developing regions. The sensitivity of the results to this scaling mechanism can be illustrated by allowing the developing regions to be subjected to the same monetary cost, per unit of pollution, as the developed regions. In this situation, China, Africa and Latin America would experience pollution costs equivalent to between 5–6 per cent of their estimated gains from the Uruguay Round for 1990. Furthermore, pollution costs for the developing regions would then be larger than any savings estimated for the developed regions resulting in a global environmental cost for both scenarios.

4. CONCLUSION

This paper has attempted to estimate the impact of the Uruguay Round of trade negotiations on emissions of carbon dioxide and four local air pollutants. Results indicate that most developing and transition regions will experience an increase in emissions of all five pollutants as a result of the Uruguay Round. In the developed regions, emissions of three local air pollutants are predicted to fall whilst nitrogen dioxide and carbon dioxide emissions generally rise.

The analysis of the composition effect associated with the Uruguay Round highlights the sectors which may require additional abatement efforts. The expansion of the textile sectors in virtually all developing regions is predicted to lead to an increase in emissions of all four local air pollutants. In the developed regions it is the heavy industrial sectors which are predicted to expand as a result of the Uruguay Round, again leading to increases in emissions of all four local pollutants. These increases are particularly large due to the high pollution intensities associated with the output from these sectors.

The results also highlight the effect of a change in the *rate* of economic growth on pollution emissions. If the Uruguay Round were to increase this rate of growth, the level of emissions in the year 2000 is likely to be considerably different from that predicted in the absence of the Uruguay Round. For example, the increase in emissions of local air pollution for the developing regions for the year 2000 is generally 5 to 10 times higher if the growth rate were increased by 0.5 per cent, with some emissions predicted to increase by up to 10 per cent.

With regard to the monetary costs associated with these changes in pollution, it would appear that, compared to the estimated gains from the Uruguay Round, these costs are small. It is, nevertheless, important that the existence of such costs is recognised. Furthermore, it is important to note that the above analysis is only a very partial estimate of the environmental impact of the Uruguay Round. Indeed, the monetary cost estimates consider only five air pollutants at the expense of other local air pollutants, greenhouse gases, CFCs, water pollutants and numerous other environmental indicators which may also be affected.

It should, of course, be pointed out that the estimates contained within this paper depend, not only on the estimated EKCs, but also on the computable general equilibrium income estimates of François et al. Nevertheless, this analysis indicates that trade liberalisation may result in some degree of environmental damage, particularly in the developing regions as a result of increased emissions of local air pollutants and perhaps globally for carbon dioxide emissions.

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