E C O N O M I C S B U L L E T I N

The Montreal Protocol: Developing Countries Import of Halons

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Abstract

Base on the model of legal and illegal trade in CFC from Ivanova (2007), this paper empirically analyzes the affects of the Montreal Protocol on imports of Halons, and hence their consumption, in developing countries. We show that countries with high income level have decreased their import of Halons, but ratifiers of the Protocol import more Halons than non-ratifiers.

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1. Introduction

The Montreal Protocol was ratified[1] by over 191 countries in 2007. The Protocol requires countries to reduce and eventually ban the consumption and production of the main ozone depleting substances (ODS)- Halons, Chlorofluorocarbons (CFC), Hydrofluorocarbons (HCFC), Carbon tetrachloride, Methyl chloroform and Methyl bromide- because they resulted in the thinning of the stratospheric ozone layer. The thinning increases the intensity of UV rays reaching the surface of the Earth, and adversely affects human health and ecosystems. The timelines for ODS phase-out differs between Non-Article 5 (developed[2]) and Article 5 (developing) countries, and among the ODS, but they have proceeded according to schedule as detailed in the Protocol. However, in the mid 1990's, illegal trade in ODS has caused a serious concern which was not anticipated in the initial stage of the Protocol. The importance of the Protocol in reducing ODS emissions has also been been questioned. Barrett (1994) and Murdoch and Sandler (1997) show that non-cooperative instead of cooperative behavior is more important in reducing CFC emission. Nevertheless, Cole *et al*. (1997), and Mason and Swanson (2003), in measuring the turning point for the environmental Kuznet's curve, show that the Protocol is important for CFC emission reduction, especially for developing countries.

Given the harm caused by the ODS, the problems of trade in illegal ODS, and the two different viewpoints on the benefit of the Protocol, the objective of this study is to empirically analyze the import, and hence consumption, of the ODS, specifically Halons, in developing countries. We choose Halons even though its consumption is smaller[3] than CFC, because Halons are the "most dangerous" of the ODS covered by the Protocol. Halons' ozone depleting potential are about six times greater than CFC (UNEP, 2000). Moreover, economic studies on the Montreal Protocol have focused on CFC. The study also will indicate whether the affect of the Protocol differ across substances, and whether we can generalize the results from CFC to the other ODS. This is important because there are numeorus ODS governed by the Protocol. Developing countries are chosen because developed countries have had zero Halons consumption since 1994.

2. Halons in the Montreal Protocol

Halon 1211 (Bromochlorodifluoromethane), Halon 1301 (Bromotrifluoromethane) and Halon 2402 (Dibromotetrafluoroethane) are in Annex A, Group II of the list of controlled substances under the Montreal Protocol. They are mostly used in fire extinguishing agents around highly valuable materials. The Protocol required Non-Article 5 and Article 5 countries to stop their production and consumption of Halons in 1994 and 2010, respectively. Specifically, by 1992, Non-Article 5 countries ratifiers' annual consumption and production of Halons cannot exceed that of 1986 levels, except for production for Article 5 countries' essential use. By 1994, Non-Article 5 countries are not allowed to consume or produce Halons. For Article 5 countries, they are required to reduce Halons consumption and production to 50 per cent of 1995-97 average levels in 2005, and eventually to zero consumption in 2010. Table 1 summarizes the phase-out timelines and control measures for Halons.

[1] Source: http:\\ozone.unep.org. Not all of the amendments are ratified by all 191 countries.
[2] Also include East european counties which are in transitions.
[3] 1081968.4 tonnes for CFC, and 217517.4 tonnes for Halons in 1986.

Table 1: Summary of Control Measures for Halons

	Years and the applicable control measures (% change relative to corrsponding baseline year)		
	1992	1994	
Non Article 5	Freeze to 1986 level	100% Phase Out	
	Years and the applicable control measures (% change relative to corrsponding baseline)		
	2002	2005	2010
Article 5	Freeze to average 1995-97 level	50% of average 1995-97 level	100% Phase Out

Baseline year for Non-Article 5 countries is 1986
Baseline year for Article 5 countries : average for 1995-97.

With regard to Halons production and consumption, UNEP (2005) shows that, except for Russia, Non-Article 5 countries' productions are zero from 1994 onwards. For consumption, Russia and Kazakhstan have positive consumption from 1994 onwards. Azerbaijan's consumption of Halon is positive in 1996 and 1997, Turkmenistan in 1995 and Uzbekistan in 1996. For Article 5 countries, only China, India, South and North Korea report the production of Halon, which means that any consumption of Halons by Article 5 countries is imported. For consumption, on average, it has decreased since 1986, except for a period between 1995-1997 as shown in Table 2.

Table 2: Article 5 Countries Simple Average
For Halons Consumption (1986-2004) in ODS tonnes

Halons consumption in 1986	44797.70
Average Halons consumption from 1989-1994	34964.93
Average Halons consumption from 1995-1997	46434.00
Average Halons consumption from 1997-2004	18756.60

3. Theoretical Background & Empirical Analysis

Model Specifications

The theoretical and empirical background of this study is based on Ivanova (2007),[4] who analyzes legal and illegal trade[5] of CFC. Following Ivanova (2007), we estimate the model (1) using the two-ways fixed effects[6]:

$$I_{it} = \alpha + \mathrm{X}_{it}^{'}\mathrm{B}^{x} + \beta^{h} h_{it} + \beta^{\tau}\tau_{it} + \beta^{f} f_{it} + \beta^{hf} h_{it} f_{it} + \beta^{h\tau} h_{it}\tau_{it} + \beta^{f\tau} f_{it}\tau_{it} + \varepsilon_{it} \qquad (1)$$

[4] The model is based on Martin and Panagariya (1984).
[5] Ivanova (2007) used the results from legal import to infer about illegal import.
[6] Hausman test show fixed effect is the appropriate model.

where I is imports of Halons in ODP tonnes for country i in period t; α is a constant; X_{it} is a vector of control variables; h_{it} is the country level of honesty; f_{it} is the expected fine if smuggling activities are caught; τ_{it} is the average tariff for Halon; B^x is a coefficient vector for control variables; β are coefficients scalar for honesty, tariff, expected fine and their interaction terms; and ε_{it} is the error term. Control variables used are the countries' income (GDP), squared of GDP, import of Halons in 1986 and the ratification of the Montreal Protocol. GDP is used to take into account the level of economic development and the demand for environmental quality in different countries. GDP squared is used to allow for the possibility of an inverted-U relationship (Environmental Kuznet curve) between Halons consumption and income. The 1986 level of Halon imports is also used as a control because countries with high initial import levels will incur greater cost in complying with the Protocol. The dummy for Montreal Protocol is used because ratifiers are bound by the Protocol, hence they are forced to reduce consumption.

Ivanova (2007) shows that even though tariff decreases legal imports, the size of its effect depends on both the level of corruption and the expected fine. However, the interaction between tariff and expected fine, and honesty, cannot be determined a priori. She also shows the coefficients for honesty and expected fine to be positive, and their interaction to be negative.

Data

The data for Halons imports[7] is from the Ozone Secretariat United Nations Environmental Program (UNEP) report on the "Production and Consumption of Ozone Depleting Substances under the Montreal Protocol 1986-2004." We do not include negative imports, as the theoretical model is for import. To measure honesty, we use the index for corruption from the International Country Risk Guide (ICRG). The index ranges from 0 to 6 where higher value represents less corruption or, in this case, a more honest country. To measure the expected fine, we use the index for law and order from the ICRG. The law and order index measures the strength of the court system. A lower value indicates a weak court system, where disagreements are settled by physical force or other illegal means. We expect countries with strong court systems to impose higher penalties if smuggling is caught. Instead of a tariff for Halons, we use tariff data taken from the Worlds Bank's "Trends in Average Applied Tariff Rates in Developing and Industrial Countries, 1981-2005" as a proxy for average tariffs on Halons. The proxy is used even though the tariff data for Halons is available from the Trade Analysis and Information System (TRAINS) database maintained by the United Nations Conference on Trade and Development (UNCTAD) because the time period covered by the database is short and has gaps. One of the concerns for using an average tariff for an aggregate of goods is that environmentally conscious countries may have high tariffs on environmentally harmful goods but low tariffs on other goods. However, our tests on the available data show that the correlation between the two tariffs are very high, hence it is a good proxy. The data for GDP is from the World Development Indicators. Data for the Montreal protocol ratification is from the UNEP[8].

[7] The report contains production and consumption of Halons, hence import is consumption minus production.
[8] http://ozone.unep.org/Ratification_status/

Results

Table 3 reports the results[9]. The coefficients for honesty and the expected fine are positive, and the coefficients for their interaction are negative, which is as predicted by the theory. However, the expected fine is not significant. These mean that honest countries import more legal Halons, and that the affects of honesty and expected fine are interdependent. The coefficients for tariff are negative but they are not statistically significant and hence the use of tariff alone may not help in reducing Halons import. The significant interaction between honesty and tariff suggests interdependency between the two variables, which means that a higher tariff reduces import if a country is honest. The negative sign for GDP means that countries with high levels of economic development import less Halons, i.e they have substituted Halons for other alternatives. GDP squared are not significant, meaning that there is no environmental Kuznets affect. The positive and significant coefficients for Halons import in 1986 mean that the amount of imports reduction depends on the benchmark year. The dummy for Montreal ratification is positive, meaning that countries which ratify the Protocol import more legal Halons, which suggests that the Protocol may not be important in reducing Halons emission.

Table 3: Fixed Effects Model Estimates

	Model 1	Model 2	Model 3	Model 4
Honesty	212.824**	204.767**	210.356**	203.315**
	(63.559)	(63.739)	(63.447)	(63.639)
Honesty*Expected Fine	-30.892**	-28.865**	-32.789**	-30.878**
	(14.641)	(14.693)	(14.643)	(14.707)
Expected Fine	68.677	70.531	70.781	72.316
	(50.149)	(50.126)	(50.062)	(50.052)
Expected Fine*Tariff	1.202	1.063	0.877	-0.771
	(1.463)	(1.465)	(1.469)	(1.470)
Tariff	-0.299	-1.016	-0.117	-0.767
	(3.969)	(3.995)	(3.962)	(3.990)
Honesty*Tariff	-3.442*	-3.341*	-3.092*	-3.021
	(1.904)	(1.904)	(1.908)	(1.908)
GDP	-4.944**	-8.493**	-4.969**	-8.130**
	(0.603)	(2.454)	(0.602)	(2.457)
GDP Squared		0.004		0.003
		(0.003)		(0.003)
Halons Import in 1986	0.179**	0.244**	0.177**	0.235**
	(0.044)	(0.062)	(0.044)	(0.062)
Montreal			136.116**	128.531*
			(67.051)	(67.262)
Constant	-383.216	-416.402	-440.491	467.291
	(303.018)	(303.603)	(303.765)	(304.270)
Observations	918	918	918	918
R^2	0.605	0.606	0.607	0.608

Country and Time Fixed Effects not reported.
Standard errors in parenthesis.
*, **: Denote significance and 10% and 5% level respectively.

[9] We also use OLS and random effects regression. The results from the OLS are significantly different from the fixed and random effects. For example, the coefficients for honesty, GDP and the Montreal Protocol dummy have different signs. We focus the discussion on the fixed effects model because panel data is used and, hence they are more reliable, and the Hausman test suggests the use of fixed effects model.

4. Conclusion

The results show that tariffs alone cannot reduce the import of Halons as the level of corruption in a country will affect the level of legal import. The results also show that the Montreal Protocol is not significant in reducing the import for Halons for developing countries. It is GDP and the interaction between honesty, tariffs and expected fine, which are the more important coefficients.

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