Staff Working Paper ERSD-2010-04 **Date: January 2010**

World Trade Organization
Economic Research and Statistics Division

This paper appears in the WTO working paper series as commissioned background analysis for the World Trade Report 2010 on "Trade in Natural Resources: Challenges in Global Governance"

Trade and Deforestation: A literature review

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Manuscript date: December, 2009

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This document was prepared for the World Trade Organization.

* We are thankful to Alexander Pfaff for his comments and guidance while writing this document. We also thank Nadia Rocha and Michele Ruta for their valuable comments. Of course, all errors are our own.

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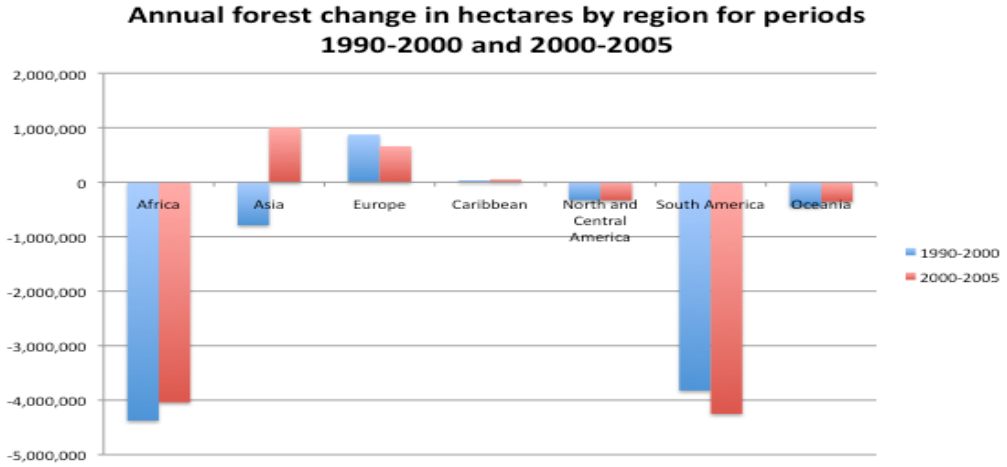
1 Introduction

Forest plays a significant role in the overall balance of carbon in the atmosphere mitigating or exacerbating the effects of global warming. Forest carbon sequestration can potentially reduce the accumulation of greenhouse gases in the atmosphere. The US Environmental Protection Agency reported that land-use-land-change and forest activities resulted in a 13 percent offset of total U.S. CO2 emissions between 1990 and 2003 (EPA 2005).

Moreover, when deforestation takes place, carbon is released to the atmosphere again. In Mexico, the resulting carbon balance from land use change represented approximately 40% of the estimated annual total carbon emissions for 1985 to 1987 (Masera et al. 1997). Globally, it has been estimated that about 11% to 39% of all carbon emissions from human origin come from the forest sector (Hao et al. 1990). Regarding global warming, the balance between forest conservation and deforestation can change forest sector activities from a solution to a problem and vice versa.

Currently, the amounts of greenhouse gasses emitted by deforestation are high. More than seven million hectares of forest were destroyed annually between 2000 and 2005 and more than eight million hectares between 1990 and 2000 (FAO 2009). Most of the deforestation has take place in less developed regions such as Africa and South America (see Figure 1). This has been attributed mainly to land conversion and agricultural expansion (IPCC 2007) and is expected that with business as usual deforestation will continue in the following years due to increases in global population and associated demands for food and agricultural products.

Figure 1



Source: FAO 2009.

Meanwhile, the number of Regional Trade Agreements (RTAs) has increased since the early 1990s. Some 421 RTAs have been notified to the GATT/WTO up to December 2008. At that same date, 230 agreements were in force (WTO 2009a). Taking into account RTAs which are in force but have not been notified, those signed but not yet in force, those currently being negotiated, and those in the proposal stage, there are close to 400 RTAs programmed to be implemented by 2010. This lead to a significant increase in trade flows in the last decades. Total world trade has been increasing since 2000 at an average rate of 12% (WTOb 2009), and is expected to continue growing in the following years due to these new agreements.

In this paper, we investigate what the literature has found by analyzing the relationship between trade liberalization and deforestation. Research that focuses on deforestation and trade is abundant. As Bulte and Barbier 2007 argue, the literature in trade and renewable resource can stand apart as a field for three reasons: the role played by institutions, the dynamic nature of resource management and the complexity of habitats that are affected. Our goals in this paper are to identify the areas where the literature has reached agreements, where it still has not, and the areas where more research is required.

Among the agreements, we find that deforestation is affected by agricultural output prices. Therefore, when trade affects these prices, it will also affect deforestation rates. The effect of trade will depend on the differential between world and local prices. If trade liberalization occurs and local agricultural prices increase, deforestation will also increase. But if trade liberalization occurs and local agricultural prices decrease because world prices are lower, deforestation will also decrease.

The effects of input prices on deforestation are ambiguous. So, even if trade affects prices, farmers might substitute one resource for another. If for instance the prices of fertilizer increases, one would expect that deforestation will decrease because profits will decrease, but if farmers substitute fertilizer for land, deforestation will increase. Evidence of both effects has been found in the literature.

Transportation costs play a key role in deforestation but these effects are context specific. Changes on transport costs allow trade. As discussed previously, this will increase or decrease deforestation depending on how prices will be affected. Empirical evidence shows that transport investments close to developed areas do not increase deforestation significantly, but as the distance increases, transport investment effects also increase. A point is reached where even if transport costs are reduced, deforestation does not increase. Conditions in these pristine areas do not allow people to engage in trading.

Also, it is agreed that opening for trade may not increase welfare. Trade can increase the depletion of the resource, which in the long run could lead to lower welfare. Also, institutions

play an important role. If institutions are not functioning correctly it is likely that trade will reduce welfare. Property rights, corruption and resource management regimes are deeply studied within the role of trade. There are some empirical attempts to address the magnitudes of the effects in resource extraction but certainly more empirical research in this direction is needed.

The literature is also consistent when concluding that conservation policies might be, to some extent, offset through trade by deforestation in other regions or countries. Some divergence in the magnitudes is found but agreement exists on the direction especially across regions and across countries. This is especially important for international agreements. Negotiations that only focus on countries with high deforestation rates, might not be effective as trade might generate deforestation in countries that are not part of the negotiations (low deforestation rate countries).

We found opposing positions in relation to the effects of timber extraction as a consequence of trade on deforestation. Researchers have found that for some countries, increase in prices of timber will lead to increases in deforestation. However, others have argued that the effect depends on different conditions. Other drivers of deforestation should be jointly relevant. Additionally, some researchers argue that high prices of timber might actually lead to increases in forest plantations. Finally, accessibility of standing natural forest plays a key role when discussing the effects of higher timber prices.

Researchers are also still discussing whether trade sanctions can be used for environmental purposes. Some argue that this can help global environmental efforts but other say that this can generate perverse incentives by reducing the value of the stock of the resource, which could lead to depletion. Certainly, the amount of environmental clauses has increased significantly in trade agreements. Cross-country empirical analysis of the effects of these types of restrictions might now be possible.

The paper is organized as follows. In section 2, we discuss the determinants of deforestation at the micro level and discuss how trade can trigger changes in these determinants. We then discuss at the macro variables that can affect deforestation and the theoretical models developed to take into account specificities of resource abundant countries. In Section 4, we discuss the relationship between environmental policies and trade. Finally, we present our conclusions in Section 5.

2 Trade and deforestation drivers

As Lopez 1992 points out, trade liberalization effects are hard to predict. Opening markets to trade will bring local and global prices closer together. Depending of the difference in prices, trade will increase or decrease local prices accordingly. Accordingly, deforestation in a given country can increase or decrease as a consequence of trade.

For instance, if local prices of a natural resource such as forest are lower in a country than in the rest of the world, one would expect that trade will lead to an increase in the rate of extraction. But if local prices are higher than world prices, one could expect that local extraction will decrease as imports of the resource increase. So, trade can reduce deforestation in some countries while having the opposite effect in others.

Trade also affects input prices such as wages and rents. These prices also affect profitability of extraction and/or of alternative land uses. The sum of these factors leads to a combination of uncertain changes in deforestation or extraction that even within a country is difficult to predict the effects of trade.

In this section, we discuss what drives deforestation and how these drivers could be affected by trade. An abundant quantity of research dealing with determinants of deforestation has been developed (see Kaimowitz and Anderson 1998 and by Wunder and Verbist 2003 for literature reviews). We focus on output and input prices but also discuss the effects of market access through transport cost investments as empirical evidence of trade effects.

2.1 Agricultural and timber prices

It is fairly easy to find literature arguing that agricultural prices and timber prices trigger deforestation rates (Kaimowitz and Anderson 1998, Wunder and Verbist 2003, Angelsen 1996, Barbier and Burgess 1996 and Deininger and Minten 1996). The opportunity cost of conserving forest increases. Farmers, then, decide to switch from forest to agricultural production or to selling timber. As Wunder and Verbist 2003 argue, farmers react to opportunity of more profitable cultivation by deforesting and this also attracts new comers. Moreover, higher prices help finance additional conversion of land from forest to agriculture (Kaimowitz and Anderson 1998).

As described in Table 1, evidence is found in different continents and for different agricultural products. Barbier and Burgess 1996 find that in Mexico maize and beef prices affect land conversion. Angelsen et al. 1999 find that annual crop prices lead to agricultural expansion in Tanzania. Katila 1995 and Panayotou and Sungsuwan 1994 find that timber prices lead to deforestation in Thailand. Morton et al. 2006 show that, in Brazil, the area deforested for cropland and the mean annual soybean price in the year of forest clearing are directly correlated, suggesting that deforestation rates could return to higher levels with a rebound of crop prices in international markets. McAlpine et al. 2009 also find that in Brazil, beef prices correlate well with the deforestation rates. They also state that the recent expansion in cattle in Australia has been partly due to rising beef prices. Pacheco 2004 presents similar results for Bolivia, where the area devoted to sugarcane has increased due to higher international prices.

Table 1

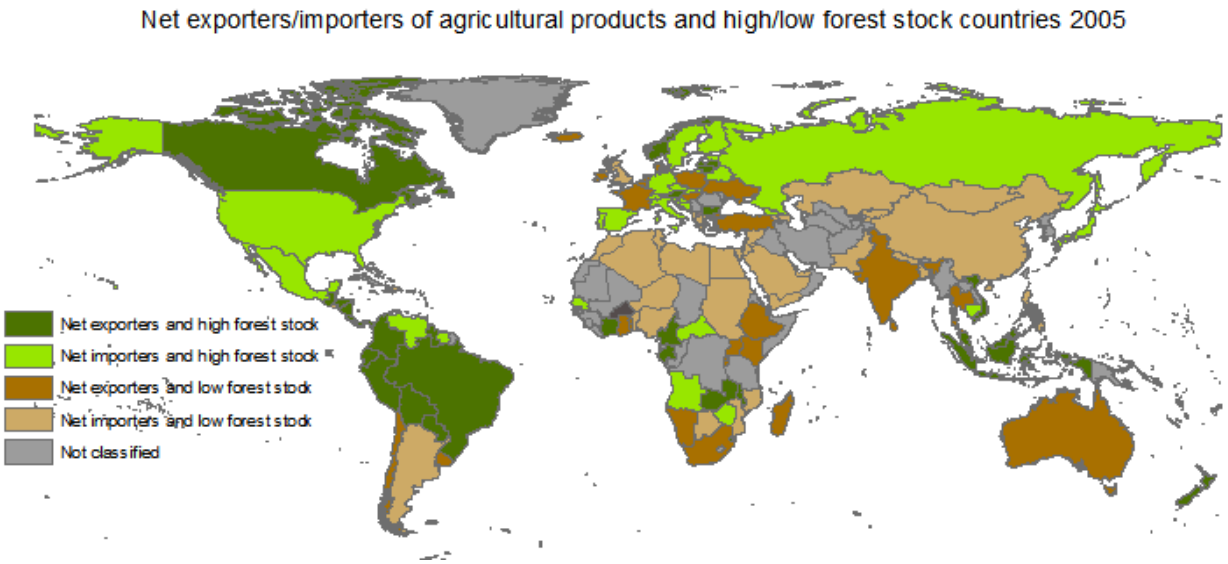
Studies that relate international prices with deforestation rates

Authors	Year	Country	Product
Barbier and Burgess	1996	Mexico	Maize and Beef
Angelsen et al.	1999	Tanzania	Annual Crops
Katila	1995	Thailand	Timber
Panayotou and Sungsuwan	1994	Thailand	Timber
Morton et al.	2006	Brazil	Soybean
Arroyo-Mora et al.	2005	Costa Rica	Beef
McAlpine et al.	2009	Australia	Beef
McAlpine et al.	2009	Brazil	Beef and Soybean
Pacheco	2004	Bolivia	Sugarcane

In Figure 2, we show countries that are net exporters in agricultural goods and have a high stock of forest (dark green), those countries that are net exporters in agricultural goods and have a low stock of forest (dark brown), those countries that are net importers of agricultural goods and have a high stock of forest (light green) and those countries that are net importers of agricultural goods and have a low stock of forest (light brown). This figure can shed some light on where deforestation could increase with trade.

It is likely that higher trade will lead to higher production of agricultural goods in net exporter countries. Therefore those that are in dark green are the countries that will most likely suffer higher deforestation rates with increase trade. Conditions are already set in these countries for the development of agriculture and land cover with forest is relatively abundant. In this category, we find countries like Brazil, most of the Andean countries, Central America, Canada, Indonesia and Malaysia. We should not expect large increases in deforestation in agricultural net-exporting countries with low forest stock but there will probably be increases in agricultural production. Substitution of agricultural products is highly likely given that trade will lead to specialization and little forest is left. However, if prices increase enough, it is likely that countries that are today net importers given that have abundant forest might increase agricultural production and increase deforestation too (light green). These will depend of course on the magnitude of the movement of agricultural prices and how trade also affects other economic activities.

Figure 2



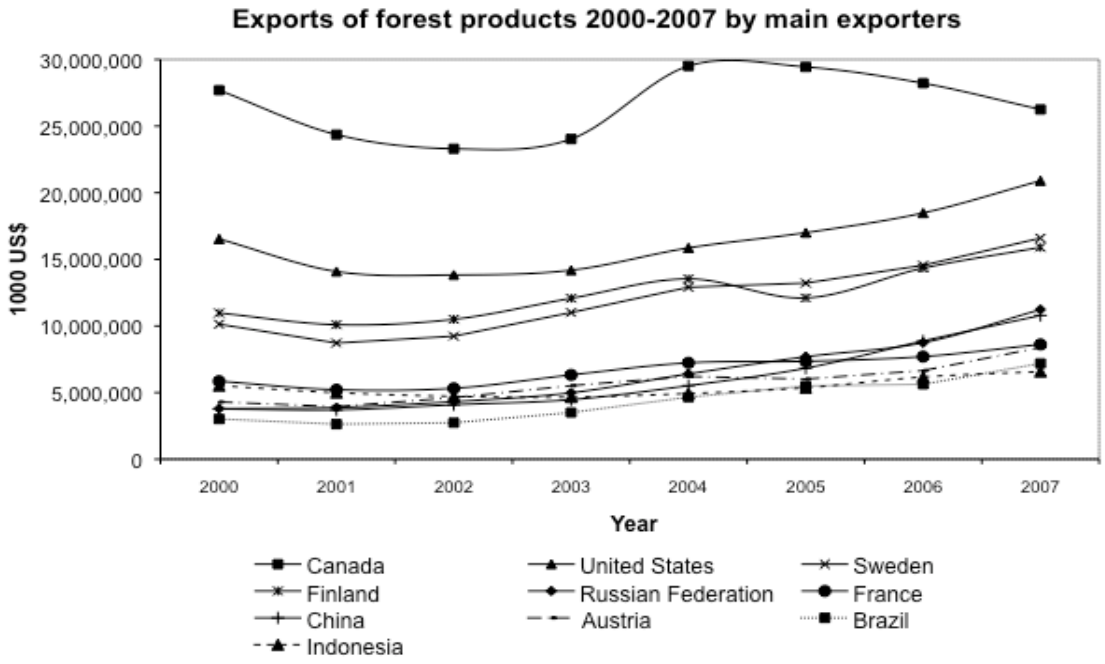
It is also important to mention that not necessarily all agricultural price increases will translate into increases in deforestation even in dark green countries. Lopez 2005 argues that trade effects depend on whether changes in prices will increase the threat of deforestation. If for example trade leads to increases in prices of agricultural goods that can easily produced in current forest areas, deforestation will increase. But trade might have little or no effect if trade increases the production of agricultural goods that would not be produced in forest areas. He finds that in Philippines, forest competing crops are essentially non-traded or import substitutes; in Brazil, forest competing crops are a mix of import substitutes and export goods. Therefore trade does not lead to deforestation. However, this is not the case in Malaysia and Indonesia where forest competing crops are export oriented.

Evidence of how trade could reduce deforestation or increase forest cover also exists. This is more likely in countries that after trade will specialize in producing non-land intensive goods. Pfaff 2000 and Pfaff and Walker 2009 found that when trade appeared as a consequence of the reduction in transport costs (the construction of the train between New England and the Midwest) deforestation in New England decreased significantly. Agricultural goods were shipped in from the Midwest at a cheaper price than what they were produced locally. Therefore, agricultural land was abandoned and the forest stock increased. Linking this evidence with Figure 2, one could also argue that increases in trade in the net importers (light green and light brown) will translate into reductions of deforestation rates or increases in forest cover. This will occur especially if trade in non-agricultural and non-timber goods increases (e.g. oil for Mexico, Venezuela and Russia).

Timber trade and deforestation

The world exports of forest products[1] increased steadily at an average annual rate of approximately 7 percent between 2000 and 2007. Developed countries are leading the global exports of forest products, with Canada, United States, Sweden and Finland at the top of the list. However, developing countries are gaining more importance in this market. This is the case of Brazil and Indonesia. Figure 3 shows these trends.

Figure 3



Source: FAO 2009.

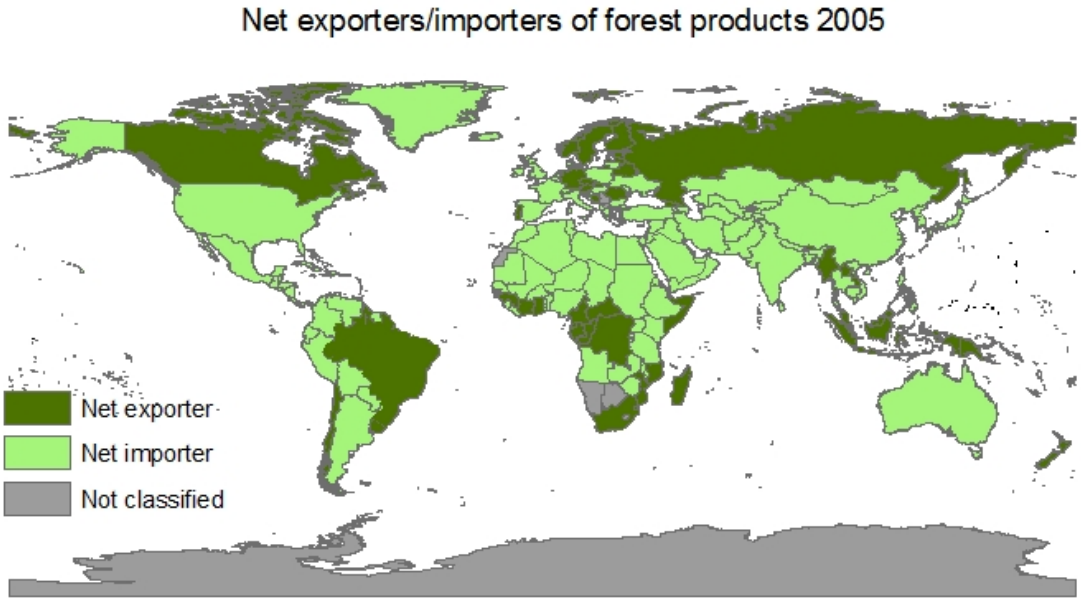
Figure 4 presents the countries that in 2005 were net exporters of forest products (dark green) and those that were net importers (light green). The Scandinavian countries, the Russian Federation, Canada, Brazil and Indonesia are countries with a domestic output large enough to satisfy their national demand. Some of these countries like Brazil and Indonesia have abundant natural forest stocks that could be under threat.

Others like the United States need to satisfy their consumption through imports. Developed economies are in fact the largest importers of forest products (FAO 2009). However, China is catching up with the developed nations in terms of the imports and consumption of forest products. The great recent growth of China, and to a lesser extent, Southeast Asia, has changed

[1] The category of forest products is formed by: roundwood, fuelwood, charcoal, industrial roundwood, sawnwood, wood-based panels, pulp, paper, paperboard and species.

the nature of the global forestry market, which is moving from west to east. (UNEP, FAO, UN, 2009).

Figure 4



Timber extraction can lead to deforestation as evidence has shown (see Table 1). Allen and Barnes 1985 show that wood exports are an important cause of deforestation. Cruz and Repetto 1992 and Lopez 1993 claim trade liberalization in the Philippines and in Ghana, respectively, can be expected to increase deforestation due to increasing logging activities.

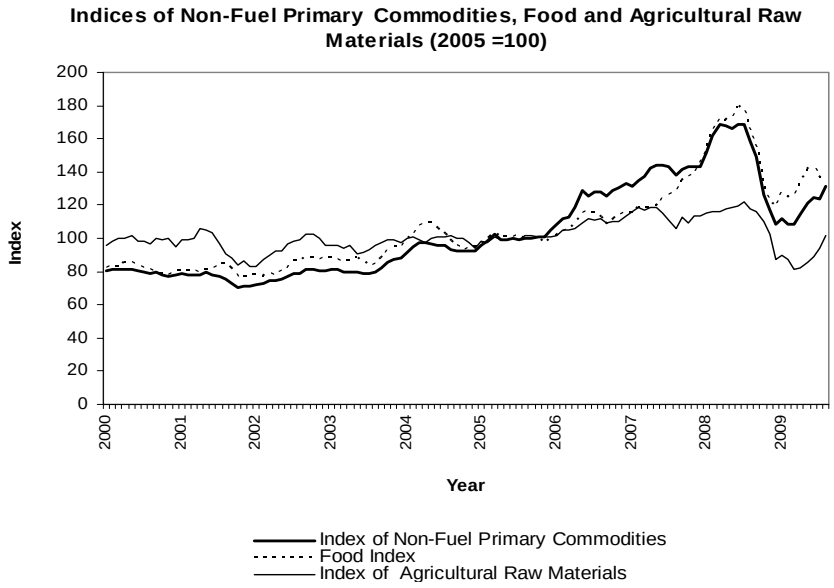
However, others argue that the effects are not always so clear (Wunder and Verbist 2003). The main impact of timber extraction is that it facilities deforestation for agricultural purposes. So, the effects of changes in timber production are not instantaneous or have to come together with other drivers of deforestation so that land actually changes use. Similarly, Barbier et al. 1995 using a simulation model concludes that logging is not the major cause of deforestation in Indonesia. Also, Burgess 1993 points out, after reviewing the literature extensively, that timber extraction is generally not the predominant driver of tropical deforestation. However, in relation to environment, timber extraction might not only be measured by its effect on deforestation. The thinning of the forest as consequence of logging directly affects habitats and carbon sequestration.

Timber price effects could also be ambiguous due to the length of timber production. For example, Sonhgen et al 1999 argue that increases in prices of wood could actually lead to an increase in plantations of forest and that the effects of primary forest will depend on timber productivity and access costs. Foster and Rosenzweig 2002 also argue that increases in demand for forest products associated with income and population growth could lead to forest growth.

World prices' movements

To establish the expected effects of trade at the local level, we need to understand the movements of agricultural prices globally. International prices of non-fuel primary commodities increased between 2000 and the first half of 2008. Then, there is a significant drop caused by the global financial and economic crisis. In 2009, prices appear to be increasing again. Indices for food products and agricultural raw materials present a similar evolution (see Figure 5).

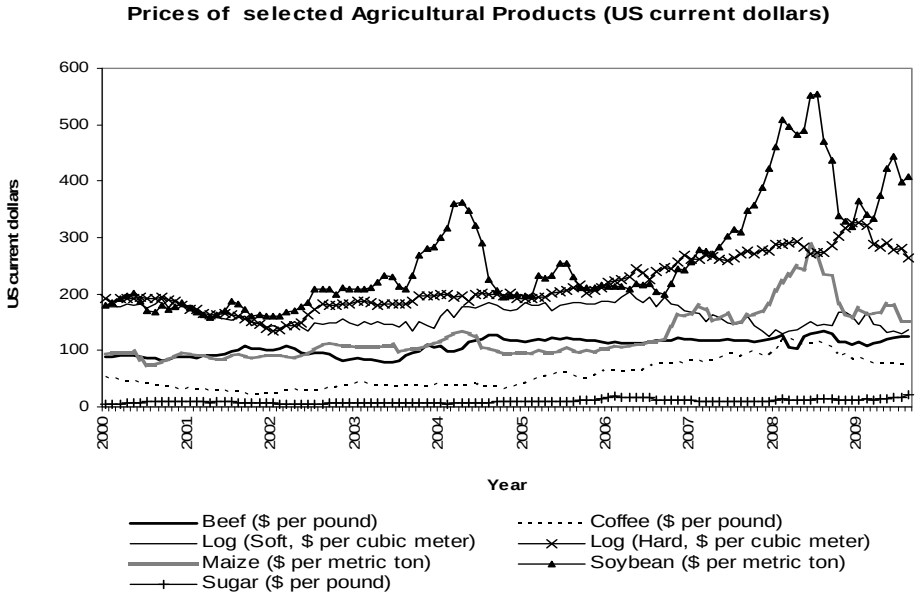
Figure 5



Source: IMFb 2009.

In Figure 6, we show the evolution of prices (in US current dollars) for beef, log, maize, sugar, coffee and soybean, which are some of the main changes in deforestation. Prices in general increased before the beginning of the crisis. However, the tendency is not clear during the last year. The prices of soybean and beef are recovering at a faster pace than the others.

Figure 6



Another important aspect is the variance of the prices of the outputs. If price variances increase, individuals might take one shot opportunities and deforest land. This is a problem if we consider the amount of years that takes forest to regenerate. Therefore, trade will also be a problem even if agricultural average world prices are low in long run low when international prices have a higher variance. Barret 1998 argues that market oriented reforms that increase the mean and the variance of food prices may stimulate deforestation. Roebeling et al. 2009 find that the value of farm increases with the variance in land prices due to the speculative returns from land. More empirical research is needed to connect variance of world prices and deforestation.

2.2 Agricultural input prices

Other important drivers of agricultural development are local input prices. However, the effects on deforestation are less clear (Kaimowitz and Anderson 1998). Within the analytical open economy models, it is argued, in general, that increases in input prices reduce the profitability of deforestation when inputs and land are complements in the production function of agricultural goods (Kaimowitz and Anderson 1998). Deininger and Minten 1996 find that in those municipalities with higher per capita income, deforestation is lower. Kaimowitz and Anderson 1998 argue that this finding can be explained by input costs. In high income areas, labor costs for agricultural activities are higher and therefore deforestation is lower. Chomitz and Griffiths 1996 argue that if agricultural production is labor intensive, increases in wages will significantly reduce pressures for conversion in Indonesia.

Walker et al. 2000 argue that forest clearing at the household level is the result of abundance of labor in areas with high in-migration rates. Muñoz 1992, Monela 1995, Godoy et al. 1996 and Pichón 1997 find that larger households deforest more. In these papers, the mechanism is also linked to the abundance of cheap labor.

However, the relationship between income and deforestation has been the focus of extensive debate. For example, Peterson 2007 finds that in Peru, lagged income is positively correlated with clearing but at a decreasing rate. Wunder 2001 concludes that income levels have an ambiguous effect on deforestation rates. Pfaff et al. 2009 explain that an increase in income might relax constrains to capital and therefore increase deforestation but an increase in income could also increase labor costs and therefore reduce deforestation. They find that for Costa Rica the poor tend to deforest more after controlling for a series of geographic variables that explain location. This implies that increasing incomes due to trade might not lead to increases in deforestation.

It is also important to note the relationship in the production function between inputs. If within the economic activity that leads to deforestation all inputs are complements, increases in any of the inputs will lead to reductions of deforestation. However, it is not clear what happens when inputs have some level of substitutability. For instance, if land and fertilizers are substitutes, an increase in the cost of fertilizer might lead to a substitution between land and fertilizer, and deforestation will increase as has occurred in Latin America (Kaimowitz and Anderson 1998).

When trade increases, one would expect that input prices will converge to international prices. All imported inputs related to agriculture might become cheaper. Export inputs might become more expensive locally. However, the effects on deforestation will depend on the relationship among inputs.

In relation to wages, the availability of labor might make an important difference in terms of trade as discussed before. If trade favors rural agricultural activities instead of urban industrialized activities, deforestation is likely to increase. But if trade promotes new economic activities and conglomeration in cities (Fujita et al. 1999), trade might actually reduce deforestation in some countries. Lack of availability of labor in the rural areas will push wages up and agricultural profits down. But if trade reduces industrial employment, the opposite might occur. For instance, a study by Boyd (1994) concludes that the North American Free Trade Association (NAFTA) is likely to reduce industrial employment in Mexico, swelling the ranks of the rural labor force and thus lead to greater deforestation.

2.3 Access and transport investments

It is well known that transport plays a key role in trade flows. Reductions in transport costs open the possibility for trade. So, transport costs investments generate evidence of what will occur when trade opens. In this section, we discuss how transport costs investment affects deforestation rates and how these results can change under different contexts. Similar conclusions can then be reached by opening trade in rural areas and context will determine the effects on resource extraction.

As mentioned previously, deforestation will only occur if profits from alternative uses are attractive enough in a specific hectare, farm or village. Not only national prices affect profitability in a given location, but also the availability of transport infrastructure. Evidence supporting that deforestation increases with lower transport costs is abundant (Southgate 1990; Angelsen 1996, Muñoz 1992; Ozório de Almeida and Campari 1995; Angelsen 1996; and Pichón 1997).

A large set of theoretical models based on von Thunen spatial analysis on the organization and distribution of agriculture activities argues that transport costs are one of most important drivers of deforestation. The basic idea behind these models is that agricultural production will take place in every location that is profitable given the current output prices. Therefore, increases (or decreases) in transport costs, will lead to increases (or decreases) in agricultural prices at farm gates, which in turn will lead to increases (or decreases) in deforestation rates. As Leamer and Levinsohn 1996 argue, transport costs measured with distances between markets is one of the most significant determinates of trade flows.

However, this is not the only effect of transport costs in the economic activity and deforestation. Transport costs will also ease migration between regions. Increases in population might lead also to increases in deforestation via lower wages or higher local demands of agricultural goods. Transport costs reductions together with increasing returns to scale might also lead to industrialization and agglomeration close to population centers. Therefore, reduction of transport costs can change the spatial configuration of production (Fufita et al. 1999). If trade favors urban development instead of agricultural activities, deforestation could decrease.

A large body of literature addressing the effects of transport costs on deforestation has been under development in the last decade. The relationship between transport costs and economic development has lead researchers and policy makers to advocate for transport cost investment, especially in poorer countries that are usually more forest abundant. The trade-off between environmental conservation and development has lead researchers to focus on the effects that transport cost investments such as road building have on deforestation rates. In Table 2, we

present the effect that transport costs reductions can have on agricultural prices, land prices and deforestation rates in different ways.

Transport costs reductions can lead to increases in the prices of agricultural goods, to facilitate access for logging, and to increase population flows. It is common to find in the literature, theoretical models and empirical evidence that conclude that forests closer to roads or areas where roads are more abundant, are more likely to be cleared. But it is also common to find that these effects might vary depending on the type of roads and the amount of forest originally present.

In North Thailand, Cropper et al. 2001 show that primary roads increase deforestation. They also argue that road building facilitates the access to markets and therefore, increases the probability of deforestation. In Belize, Chomitz and Gray 1996 also find that increased access to markets through the road network results in higher deforestation rates. Places with better access to markets receive better prices for their agricultural goods and therefore, these areas are more likely to be deforested. They argue that building roads in areas with agriculturally poor soils and low population densities may generate lose-lose situations, creating deforestation and low economic returns.

In the Brazilian Amazon, Laurance et al. 2002 find that the expansion of highways and network infrastructure are likely to increase deforestation significantly. Unpaved roads also increase deforestation, but the impact is lower. This is an expected result given that the effects on transport costs of unpaved roads have to be lower than of highways. This implies that the agricultural gain caused by unpaved roads will also be lower than the gain caused by paved roads.

Also for the Brazilian Amazon, Pfaff 1999 argues the abundance of roads increase deforestation at the municipality level. His results show that the impact caused by paved roads is higher than the one generated by unpaved roads, which is consistent to what was found by Laurance et al. 2002. Interestingly, he finds that the density of roads in neighboring counties has a higher effect on deforestation rates than own county roads. This shows the importance of roads as a network that facilitates trade and not as an isolated effort regarding deforestation effects. What drives deforestation are the changes in prices as a consequence of trading possibilities with other markets. If roads are not actually helping gain better agricultural prices by increasing trade with other places, these might not have important effects on deforestation rates nor development.

There is also evidence that a reduction in transport costs for a specific area can lead to decreases in deforestation rates. Sometimes a reduction in transport costs allow cheaper agricultural goods to be shipped in and the incentives for deforestation can be reduced. It becomes cheaper to import agricultural goods than producing them locally and deforestation is actually reduced.

Pfaff 2000 and Pfaff and Walker 2009 argue that this was the case for New England when railroads reached the Midwest. Railroads allowed importing agricultural goods that were previously produced locally. Abandonment of land allowed forest re-growth in New England. These results show that transport infrastructure effects are closely linked to trade.

Table 2
Literature on transport infrastructure and deforestation

Study	Region	Dependant Variable	Effects and contextual variables
Chomitz and Gray 1996	Belize	Deforestation rate	Roads increase deforestation
Pfaff 1999	Brazilian Amazon	Deforestation rate	Density of roads in neighboring counties has a higher effect than own county roads
Pfaff 2000	New England	Deforestation rate	The construction of the train between New England and the Midwest reduced the deforestation in New England
Cropper et al. 2001	North Thailand	Probability of deforestation	The closer to the markets, the higher the effect of roads on the probability of deforestation.
Laurance et al. 2002	Brazilian Amazon	Deforestation rate	The effect of unpaved roads is low compared to the effect of paved roads
Andersen et al. 2003	Brazilian Amazon	Growth of cleared land	The effects of paved roads decrease as the percentage of cleared area increases.
Weinhold and Reis 2004	Brazilian Amazon	Growth of cleared land	The effects of paved roads decrease as the percentage of cleared area increases..
Pfaff et al. 2009	Brazilian Amazon	Deforestation rate	Only in highly cleared areas paved roads do not have a significant impact.
Pfaff and Robalino 2009	Brazilian Amazon	Deforestation rate	The effects of paved roads depend on the distance to previously paved roads (developed areas)

Andersen et al 2002 argue that paving roads in already cleared areas might cause intensification of agriculture expansion and relieve the pressure for new land clearing. They argue that paved roads generate less deforestation than unpaved roads in relatively cleared areas. Weinhold and Reis 2004 go further, and state that road paving can actually decrease the rate of deforestation in partially cleared areas in the Brazilian Amazon. They explain the difference in their result as a consequence of their dynamic approach. They find that roads can also be explained by deforestation. This implies that the association between present roads and present deforestation can lead to biased estimates of causal effects due to endogeneity (the fact that deforestation could

also cause the presence of roads). They argue that the overwhelming evidence against their findings is due to this issue.

However, using also a dynamic model, Pfaff et al. 2006 and Pfaff et al. 2009 showed that past roads affect current deforestation. It can be argued that past roads can serve as an instrument for present roads and past roads are not affected by current deforestation. They differentiate state and federal roads as well as paved and unpaved roads, and test their effect at different periods (different lags). They show that the effect of roads built between 1976 and 1987 had an effect on deforestation between 1986 and 1992, but also between 1992 and 2000. For state unpaved roads, the effect increased as time went by. For federal unpaved roads, the effect decrease but was still positive and significant as time went by. For state paved roads, the effect first increased and then decreased. For federal paved roads, the effect started high and decreased as time went by. These results capture not only reductions in transport costs at different levels, but also the deforestation that follows the development as a consequence of opening access with roads as argue by the authors. Of all these combination of effects, they did not find one type of road that would decrease deforestation in the Brazilian Amazon.

Pfaff and Robalino 2009 examine whether the deforestation impact of a new road varies also by prior development. Specifically, first-decade impact of a new road is relatively low if prior roads are close or far (pristine areas). In between those bounds, new roads significantly raise clearing. The non-monotonicity of development's effect on first-decade impact highlights dynamics. These results are consistent with the fact that close to already developed areas, roads will not make a difference in terms of production. As distance increases, the combination of resources makes it profitable to engage in deforestation and ship to the population centers. Far away from developed areas, improving roads will not have an important impact in the short term because the conditions in those placed do not allow engaging in trade. This could be due to lack of access to other inputs or, as Lopez 1993 points out, in under developed areas production is for subsistence purposes and it might not meet the standards to start trading products with other regions.

While the empirical evidence of the effects of roads reducing deforestation rates is abundant for developing countries, it is always important to keep in mind that these results are generally average statements. Therefore, it is important to continue breaking down the samples in other dimensions (besides forest stock, distance to markets or type of roads) in order to find if the negative effects will be reduced in different circumstances. Roads can potentially generate intensification and ultimately reduce deforestation, as argued by Andersen et al 2002 and Weinhold and Reis 2004. Roads can actually reduce the price of agricultural commodities and reduce deforestation, as argued by Pfaff 2000 for New England. Roads can bring in more people and generate economies of scale and shifts from agriculture to industrial activities, which can also reduce deforestation.

The main challenge that these studies face is the endogenous nature of road building and investment as Chomitz and Gray 1996, Andersen et al 2002., Weinhold and Reis 2004 and Pfaff et al. 2007 point out. Does new deforestation allow the construction of new roads or do new roads allow new deforestation? Simple regression analysis would allow identifying these effects separately as noted by Chomitz and Gray 1996, Weinhold and Reis 2004 and Pfaff et al 2006. Some attempts to address this problem have been developed. Chomitz and Gray 1996 use topographic variables as instrumental variable for roads. Pfaff et al. 2007 use previous road paving instead of current road paving. Wenhold and Reis 2004 and Andersen et al. 2007 use a highly dynamic data set at the expense of large aggregation. However, there is still a heavy burden on the assumption of the instruments and or techniques used.

Further research and better data are required to address this issue. The best data one could imagine to test accurately the effects of roads on deforestation, would be generated by an experiment where roads would be randomly assigned. Then, the impact of roads can easily be measured without concerns of endogeneity or omitted variable biased. This type of data does not exist so far. Implementing a policy randomly just for the sake of evaluation is not politically viable besides being inefficient. However, the search of a better instrument or better empirical techniques continues.

Changes on transport costs allow trade. As discussed previously, this will increase or decrease deforestation depending on how prices will be affected. An inverted U shaped relationship is found between the effects of trade investments on deforestation and distance to urbanized population centers. Transport investments close to populations centers do not increase deforestation significantly, but as the distance increases, transport investment effects also increase. A point is reached where even if transport costs are reduced, deforestation does not increase. Conditions in terms of resources at these do not allow people to start trading.

3 Trade and deforestation in imperfect markets

Most of the effects discussed in the previous section assumed that local markets work well and that trade openness would lead to equalization of the local prices and international prices. This, however, is not always the case due to imperfect competition (see Helpman and Krugman 1985 and Fujita et al. 1999) and institutions (Levchenko 2004). In this section, we discuss this issue presenting theoretical findings of the effects of trade on resource use under different types of institutions and contexts. We also describe some of the empirical findings.

3.1 Exchange rates and biases towards specific economic activities

Variables that affect trade flows such as the exchange rate has also been studied as a driver of forest outcomes. Arcand et al 2008, using a theoretical model, argue depreciation of the real exchange rate increases deforestation in a developing country but decreases deforestation in a developed country. Deprecation incentives agricultural exports and reduces imports in developing countries. They argue that since the real exchange rate has been appreciating in developed countries and depreciating in the developing world, it may have contributed significantly to deforestation at the global level. They also argue that while institutions in developing countries reduce deforestation also exacerbate the effects of depreciation.

Along the same lines, Sunderlin and Wunder 2000 also discuss the effects of exchange rates on deforestation. They argue that agricultural activities might be affected by "Dutch disease". Countries with high proportion of petroleum or non-petroleum mineral exports experience relatively low deforestation rates. The argument is that non renewable resource exports lead to appreciation of the real exchange rate, which in turn disincentives the agricultural sector and therefore deforestation rates.

A similar argument is presented in Wunder and Verbist 2003. They find in the literature that consistently oil and mineral export countries have greater share of forest, a lower deforestation rate and deforestation increases when oil or mineral prices are down. They also explain this as a result of the effects of the real exchange rate. But they also mention that government spending increases and that favors urbanization attracting people to the cities.

Computable General Equilibrium models have also addressed the issue of how currency devaluations affect deforestation (see Kaimowitz and Anderson 1998). Wiebelt 1994 argues that a real devaluation in Brazil would lead to a significant short-run expansion of crop production in Amazon and that medium-term impacts are smaller. Aune et al. 1996 find similar results for Tanzania, both through increasing output prices, and by having land substitute for agricultural inputs in response to input price increases. Mwanawina and Sankhayan (1996) also conclude that real devaluations increase deforestation in Zambia, but not by much, since Zambian exports are inelastic.

In general, conditions which favor non-agricultural activities will have positive effects on forest cover. For instance, increasing returns to scale in the manufacturing sector can lead to agglomeration and concentration of industrial activities in a country (Fujita et al. 2000). This will lead to reductions in deforestation as labor will be mainly used in manufacturing activities.

Trade policies that favor the manufacture sector will have similar effects. Jones and O'Neill 1993 1994 argue that export taxes, tariffs and subsidies biased in favor of urban/manufacturing

activities and against activities associated with deforestation also affect forest cover positively. These types of policies reduce the profitability of agriculture by lowering the output price for agricultural goods, increasing rural wages and raising the costs of agricultural inputs. Mwanawina and Sankhayan 1996 and Lopez 1993 argue that increasing agricultural subsidies and reducing agricultural subsidies will increase deforestation in Ghana and Zambia.

3.2 Trade, welfare and institutions in resource abundant countries

One of the arguments to promote trade is that is welfare increasing. However, this conclusion has been challenged when considering natural resource exploitation. Brander and Taylor 1997 examine a small open economy with an open-access renewable resource. They show that there are instantaneous gains as trade opens but they are eroded by ongoing resource depletion. The present value of utility falls for appropriate discount rates and terms-of-trade 'improvements' may reduce welfare. Then, in Brander and Taylor 1998, the same authors argue explicitly that the basic 'gains from trade' presumption is substantially undermined by open access resources. They conclude that tariffs imposed by the resource importing country always benefit the resource exporter and may be Pareto-improving.

Hannesson 2000 modifies Brander-Taylor small, open economy model to allow for diminishing returns in the other goods sector. He shows that opening up for trade may result in steady-state gains from trade even under open access of the resource and when the country does not specialize fully in resource extraction. But he also argues that transition to optimal management might result in welfare loss.

Jinji 2006 also modifies Brander-Taylor model. He endogenizes the carrying capacity[2] of the resource. Unlike Brander and Taylor 1997, he also finds that trade liberalization might increase forest stock in the resource-abundant country and may decrease the forest stock in the resource-scarce country. He points out that policies that intend to protect forest in importing countries such as tariffs may actually have perverse effects on the stock of forest.

Property rights might also affect the gains from trade. Chichilniskly 1994 argues that differences in property rights create incentives for trade even if everything else is equal. She concludes that trade with a region with well defined property rights transmits and enlarges the problem of the commons. This is because the North (the region with well defined property rights) ends up consuming underpriced resource intensive products imported from the South (region with weak property rights). She argues that taxing the use of natural resources in the south might even lead to more over extraction. A more effective policy might be strengthening property rights in the south.

[2] Carrying capacity is the population size that the environment can sustain.

Ferreira 2004 develops a similar model with similar conclusions to the model developed by Chichilnisky 1994. Then she tests empirically the property right hypothesis. She looks at different ways in which trade can affect deforestation and finds that property rights are a key factor that determines the relationship between trade and deforestation. Ferreira finds that openness to trade increases deforestation mainly through its interaction with the quality of property rights.

Copeland and Taylor 2009 developed a model where the institutions or property right regimes are endogenously determined. Three forces determine success or failure in resource management: the regulator's enforcement power, the extent of harvesting capacity, and the ability of the resource to generate competitive returns without being extinguished. The model can explain heterogeneity across countries and resources in the effectiveness of resource management, and it predicts that changes in prices, population, and technology can cause transitions to better or worse management regimes.

They define three management regimes: Hardin economies, Ostrom economies and Clark economies. Hardin economies have limited enforcement power relative to their overcapacity. As a result, they always exhibit de facto open access (in steady state) and no rents are earned on the resource. Ostrom economies have sufficient enforcement power to generate some rents, but not enough to achieve the first best. At low prices they exhibit open access, but at high prices a degree of protection is afforded the resource, and it generates rents. Clark economies can obtain the first best at relatively high resource prices, but at low resource prices, even a Clark economy exhibits open access or limited management

They first examine the effects of trade liberalization in resource-exporting countries. They conclude that while trade liberalization leads to resource depletion and real income losses in Hardin economies, the trade induced increase in relative resource prices can lead to a transition to more effective management in Ostrom or Clark economies. If property rights are fully assigned and perfectly enforced, then the usual gains from trade results apply. On the other hand, if property rights are completely absent, then trade liberalization can be devastating.

Corruption might also play a key role shaping the way that trade affects natural resource extraction. It has been recognized that lobbying activities have played a significant role in land use decisions in many developing countries (Barbier et al 20005). This can lead to rent seeking activities by the government. Barbier et al 2005 argues that the impact of a rise in the terms of trade in reducing cumulative land conversion is dissipated if the country is more corrupt and amplified if there is less corruption.

4 Conservation Policies and Trade

In this section, we discussed the relationship between conservation policies, trade effects and deforestation. We first discuss what are the expected implications of the implementation of conservation policies on trade and in turn on deforestation elsewhere and then we discuss how trade policies have been used as an environmental regulation tool an if this strategy has been effective.

4.1 Land conservation policies and leakage effects through trade

When a country decides to protect forest, this can have consequences on economic variables and therefore on world prices and in turn deforestation in other countries. Robalino 2007 in a theoretical model argues that land conservation policies will lead to increases in agricultural prices and reductions in real wages in the agricultural sector, which in turn will create deforestation elsewhere. Lee et al. 2000 find that reducing agricultural exports in the US will in turn increase production in the rest of the world.

Sedjo 1994 discusses timber leakage effects across US regions. He finds that all the conservation efforts made in US west were offset by increases in timber extraction in the south of the US and in Eastern Canada. He also argues that as British Columbia reduces harvesting, the Nordic countires, eastern Canada and the south US will be joined by other regions such as Latin America and other parts of Asia and Ocenia in compensating these reductions.

Along the same lines, Gan and McCarl 2007 study this problem globally. They estimate that between 42% and 97% of the reductions of forest products in one country will be offset by the increase in production by other countries. Sohngen et al 1999 estimate that while the net effect of forest conservation policies will be globally positive, harvest will increase elsewhere and particularly in natural forests.

Meyfroidt and Lambin 2009 also find that the reduction in deforestation in Vietnam was possible because of the displacement of forest extraction to other countries. As observed by Pfaff and Walker 2009, many forest reversals involve trade between the transitioning region with lower deforestation rates or higher forest stock and a region that facilitates this transition by hosting substitute production. They conclude that, while transitions are easily seen locally, at the global scale it is more difficult due to the lack of such substitute locations.

All these results are under the assumption that trade is open between the regions or countries in which leakage takes effect. So, increases in trade will facilitate these types of interconnections and effects via international prices. Additionally, as Copeland et al. 1994 argues, lower income

countries chose lower environmental standards in the competition for capital. In this sense, international trade could worsen even further environmental outcomes in developing countries.

4.2 Creating conservation incentives through trade: sanctions, certification and labeling

In trade legislation, different measures have been applied in order to reinforce environmental protection and the conservation of species. The two most important types are trade sanctions, and certification/labeling. Each type of policy has strong supporters as well as critics.

4.2.1 Trade sanctions

Trade sanctions have been implemented in many forms. Taxes, quotas, exporting bans and embargos are examples of measures that intend to create incentives for the reduction of trade in specific products. These trade sanctions are mainly used to punish countries or people that engage in certain activities. It has been suggested that this type of measures could support conservation efforts.

In the literature there are two opposing positions related to the use of trade sanctions as measures for conservation of stocks of living resources. One position supports sanctions. To Schultz 1996 the central argument is that sanctions would reduce the harvest by making it less profitable, and thus the stocks are more protected. This approach has been the traditional basis for using trade policy as a measure for ecological conservation. The argument concentrates on the short-run partial effects on the harvesting from an international trade ban.

Goodland and Daly 1996 analyze the case of tropical log export bans. They argue that in some cases these could be beneficial to developing countries, especially when steps towards improving processing efficiency are taken. For them the goal of economic development seems to be better served by assisting developing countries to process more of their raw materials, rather than less. Encouraging the export of raw materials, rather than of value-added products, seems to them to be contrary to development. They discuss the case of Indonesia where a log exports ban was applied in 1985. This caused a significant decrease in log exports and a steady increase in processed wood export earnings. Processed exports eventually exceeded the value of unprocessed log exports. This capture of value added is identified as one of the benefits of the promotion of domestic processing in Indonesia. The impacts of this measure on deforestation are not discussed.

One of the most important examples of trade sanctions is the Lacey Act, which focuses on the prohibition of interstate and international trafficking in protected wildlife in the United States. It reinforces other national and foreign protection laws by requiring accurate labeling of wildlife

shipments and criminalizing most types of trafficking in fish, wildlife, and plants that have been taken, possessed, transported, or sold in violation of a state, federal, tribal, or (except in the case of plants) foreign law. Many criminal counts are filed every year in U.S. federal courts based on the Lacey Act. This law provides the most comprehensive coverage of all federal statutes related to wildlife trafficking, as well as the greatest potential for substantial penalties (Anderson 1995).

Another important trade sanction is the Ivory Trade Ban, which was included under the Convention for International Trade in Endangered Species (CITES) in 1978. The African elephant became part of CITES' list of imperiled plants and animals, banning trade in ivory and other elephant products among signatory nations. Since elephants have a high commercial value, in the absence of well-defined or enforceable property rights, constraints on harvesting are few. This led the world community to adopt measures such as CITES (Khanna and Harford 1996).

Barnes 1996 argues that the prohibition on trade in products of the African elephant, combined with other forms of demand suppression, has reduced poaching, ivory prices and illegal ivory trade in Africa, helping to slow the species decline. Nonetheless, the author states that the trade ban must be complemented with other policies to achieve its goal effectively in the future. For example, governments should give local communities rights, and apply funds, to assist them to control access to elephant, create a policy and investment environment to ensure that local communities derive use values from natural populations of elephant, and the international community should assist governments and local communities with funds and expertise to develop sustainable systems to invest in and use elephant.

Heltberg 2001 has a similar view. To the author this trade ban is likely to improve the protection of endangered species from poachers only if it has a large moral demand-reducing effect, facilitates interception of smuggled goods, there is little ivory from official production piling up, and it dos not negatively affect law enforcement efforts.

The other position in the literature opposes trade sanctions. According to Schultz 1996, this approach states that trade should be encouraged through international subsidies to make species profitable as investments and protect the stock. This is a mainstream conclusion in economic theory, where trade policy is neglected as a first best policy to manage international environmental problems. The analytical tool used to achieve these conclusions is the analysis of economic distortions.

Arguing against the ivory ban, Khanna and Harford 1996, affirm that the costliness and the imperfectness of enforcing constraints on the private taking of elephants for ivory have created further intergovernmental externalities. This is because of the potential for legal ivory to provide a cover for illegal ivory. According to them, Kenya has felt that the legal trade by some other countries has hampered their enforcement efforts, and that countries allowing legal ivory sales

have gained from ivory poached in non-trading states. They argue that without a genuine decline in demand trade ban has the effect of pushing trade underground and worsening the prospects for a successful conservation program.

Additionally, many countries opposed to the treaty that bans ivory trade (Zimbabwe, Botswana, Namibia, Malawi and South Africa are not members) argued that a ban would simply drive the price of ivory upwards and create more incentives for the poachers (Khanna and Harford 1996).

Others have also argued that trade sanctions might not be effective. Barbier and Rauscher 1994 develop a theoretical model to prove that trade interventions appear to be a second-best way of conserving forests. Their model studies the impact of policy interventions, market structure, and transfers on a timber exporting tropical forest country. The analysis focuses on how these impacts relate to the country's decisions to produce timber or processed goods that are based on timber extraction, and though the rate of tropical deforestation. In other words, the model indicates what would be the impacts of reductions in the terms of trade for tropical timber and forest products, either through import bans, tariffs or other controls, on deforestation decisions.

Their analysis suggests that the effects of a ban on tropical timber imports or the imposition of import taxes that discriminate against trade in tropical timber reduces the terms of trade. This reduction in the terms of trade may have different impacts of the long run equilibrium forest stock of the timber exporting country, depending on how responsive is the welfare of the importing countries to changes in imported consumption goods, i.e., how large is the elasticity of marginal utility. If this happens to be a large value, we would have a situation of "import dependency". Therefore trade interventions by importing countries do not always achieve the desired effect of encouraging timber-exporting nations to reduce exploitation of their tropical forest stock. This means that the results of a trade ban are ambiguous and under certain conditions counterproductive. According to the authors, international transfers, in contrast, are more effective in promoting conservation of the forest stock. These have an unambiguous positive effect on the long run equilibrium forest stock. In this case the results do not depend on "import dependency" conditions (Barbier and Rauscher 1994). Other studies present similar results (Barbier et. al 1993, Binkley and Vincent 1991 and Hyde et al 1991).

Damania 2000 makes reference to the political factors that may affect the effectiveness of environmental policies. The author develops a model to assess the interaction between political lobbying, trade and the incentives to extract renewable resources. In this approach it is assumed that a self-interested government cares not only about aggregate welfare, but also political contributions received from lobby groups. Moreover, the weight given to political donations in the government's functions may be interpreted as a measure of corruption. The results show trade sanctions may lead to lower stocks of the renewable resource in equilibrium. This reflects that fact that in a political equilibrium, the contributions of the lobby group mirror the profits

obtained from a given harvest. When sanctions are implemented, the profits from harvesting decline and political contributions fall. A government that values political donations sufficiently will adopt policies to avoid this decline in profits and contributions. Therefore harvest increases. Since the final result depends on the institutional arrangements, the effect of sanctions may be hard to predict. The author recommends a cautious use of trade interventions as a resource management instrument.

Schulz 1996 states that, first, trade bans may reduce the incentive to enforce local management, potentially leading to open access harvesting; and second, in the long-run harvesting influences the stock dynamics, and sanctions influence the economic evaluation of the stock as a natural asset. This means that the logic of sanctions' short run effects has important limitations. To Schulz 1996, trade sanctions seem to be too rough to cover the complexity of long run ecological effects. They make harvesting less profitable in the short-run, but in the long run specific management policies are necessary.

Environmental Regulations in Trade agreements

Concerns about the potential negative impacts of trade on deforestation and the environment have been reflected on the inclusion of chapters related to environmental protection in many regional trade agreements. Chile and China entered into a free trade agreement in 2005. Article 108 of that agreement refers to the intention of both parties to enter into an agreement on environmental cooperation. These two countries signed a Memorandum of Understanding (MoU) on environmental cooperation. The objective of this MoU is to promote cooperation in the field of environmental protection, on the basis of equality and mutual benefit (OECD 2008).

All the trade agreements concluded by the United States in 2007 (with Peru, Korea, Panama, Colombia and Oman) have environmental provisions in the body of the agreement. They include a reference to the environment in the Preamble, a detailed chapter on the environment, environmental considerations in provisions on government procurement, binding dispute settlement mechanisms with respect to environmental obligations, environmental exceptions to trade disciplines and a chapter on sanitary and phytosanitary measures. All the agreements are accompanied by an Environmental Co-operation Agreement (OECD 2008).

For example, Chapter 18 of the US-Colombia trade agreement states: "…the objectives of this chapter are to contribute to the parties efforts to ensure that trade and environmental policies are mutually supportive, to promote the optimal use of resources in accordance with the objective of sustainable development…". This section has detailed provisions on the Level of Protection, Environmental Agreements, Enforcement of Environmental Laws, Procedural Matters, and Mechanisms to Enhance Environmental Performance, among others.

The US-Peru trade agreement includes a groundbreaking Annex on Forest Sector Governance. Recognizing the environmental and economic consequences of trade associated with illegal logging, and illegal trade in wildlife, this section presents concrete steps that the Parties will take to improve forest sector governance and promote legal trade in timber products (OECD 2008).

Peru has committed to increase the number and effectiveness of personnel devoted to enforcing laws and regulations, impose criminal and civil penalties at levels sufficient to deter actions that impede sustainable management of forest resources (e.g. suspending the right to export products), and improve the administration and management of forest concessions. The United States will work to address capacity building (OECD 2008).

Other examples of regional trade agreements that include environmental provisions in the body of the agreement are the three recent free trade agreements by Canada (Canada-Peru, Canada-Columbia, Canada-Jordan), which are accompanied by an Agreement on the Environment, and the New Zealand-China agreement, which has been negotiated together with an Environment Cooperation Agreement (OECD 2009). Annex 2 presents an overview of recent trade agreements and their environmental provisions.

4.2.2 Certification and Labeling

Systems of ecological certification have also been proposed as instruments to reduce negative environmental impacts of forestry activities. Certification assures the consumer that a product has been produced with practices that meet fundamental ecological and social standards Kiker and Putz 1997 identify the following goals of certification programs: increase general consumer awareness of the relationship of the forest industry to the environment, increase consumer acceptance and confidence, modify consumer behavior, modify manufacturer behavior, improve the earth's environmental quality, increase market share, provide product differentiation, provide an objective audit of the management of the forest assets, promote sustainable forest management, and demonstrate that forest management provides sustainable economic, ecological and social benefits.

Ecological certification involves a wide variety of actors and processes. The decisions taken by forest management firms and certifying organizations are influenced by global market forces and institutions. Public perceptions of economic, social, and environmental conditions determine the demand for certified and uncertified wood products, as well as the viability of certifying organizations (Kiker and Putz 1997). Hence, the final impact of a certification scheme depends on complex relationships.

Given this context, the literature presents different perspectives on the effectiveness of certification systems. Swallow and Sedjo 2002 analyze the conditions where a price premium for

certified products may appear. To the authors, the existence of a price premium could be important in defraying the additional costs to forest management firms and could create additional incentives to produce more environmentally friendly eco-labeled goods. Their model suggests that there are reasonable circumstances in which some portion of consumers is willing to pay a price premium, but a premium or price differential will not arise in the market. For a voluntary system, if demand for certified wood is small relative to overall demand, if the costs of certification are insignificant to some producers, and if the amount of new demand created by certification is modest, then the market is less likely to generate a price premium for the certified product. In a mandatory system, the motivation of forest land owners to favor or oppose eco-labeling would depend on whether the net increase in costs due to certification are compensated by an increase in the equilibrium price for producers who retain land in forestry. If consumers are willing to pay a premium, there are more chances for producers to gain. However, according to the authors, there is no certainty in this issue.

Takeuchi et al 1993 argue that eco-labeling's main strength lies in its capacity to discriminate (through market signals) in favor of timber produced under sound environmental practices, in contrast to the impacts of bans. They affirm that eco-labeling programs in tropical timber should be consumer-driven, market based, and pursued at a multilateral level. Participation should be on a voluntary basis. To them the effectiveness of eco-labeling programs depends of the following factors: incentives for compliance by producing countries (e.g. better prices and improved markets from timber products from sustainable sources); credible (and manageable) systems to track timber from the source to the market; widely acceptable standards; effective land tenure systems on the producers side; public education campaigns by governments and NGOs.

Nunes and Riyanto 2001 present eco-labeling case studies for the Netherlands and Indonesia. According to their analysis, organic food labeling in the Netherlands has shown a weak development due to a lack in one of the most important aspects of certification, which is the use of clear and accurate information on the organic status of the product. This is a necessary element for the creation of markets. In Indonesia, due to the expansion of the forestry sector, the Indonesian Eco labeling Institute was established. This is an independent authority designed to allow producers to confront their management practices against standards and to demonstrate compliance. After a decade of certification, certified timber has only exerting pressure on specific products, the niche markets. Plywood for example, a product that represents 70% of all Indonesia's forestry exports has received very little eco-market pressure. Moreover, the demand for certified timber was strongest in eco-sensitive countries such as Germany and the Netherlands, and almost non-existent in countries like Japan and Korea (main commercial partners). Here the authors recognize a need to bring the national initiative closer together and encourage an international common ground for certification.

Nunes and Riyanto 2001 argue that the success of certification and eco-labeling as a policy instrument for creating markets for biodiversity depends on the ability of the proposed policy instrument to internalize in the market price the wide range of the non-market biodiversity benefits. Internalization depends on the public good nature of nonmarket biodiversity benefits, the application of appropriate economic valuation methodologies so as to assess the monetary magnitude of the nonmarket biodiversity benefits, and the characteristics of the market supply and demand mechanisms. The latter include the consumers' awareness with respect to environment sounding products and the producers' propensity to embrace certification schemes. Based on the case studies presented, their analysis also emphasizes the need to implement mixed policies strategies involving certification and direct government actions in the supply or demand forces for the successful creation of markets for biodiversity.

5 Conclusions

In this paper, we reviewed the literature that links trade liberalization and deforestation. We found that this research area is large and still growing. We found that agreements are reached in relation to how deforestation is affected by agricultural output prices and input prices. The relationship between agricultural output prices and deforestation is positive and very robust. However, the effects of agricultural input prices on deforestation are ambiguous. Transportation costs play a key role in deforestation but these effects are context specific. Changes on transport costs allow trade. As discussed previously, this will increase or decrease deforestation depending on how prices will be affected.

Also, it is agreed that opening for trade may not increase welfare. Trade can increase the depletion of the resource, which in the long run could lead to lower welfare. Also, institutions play an important role. If institutions are not functioning correctly it is likely that trade will reduce welfare. Property rights, corruption and resource management regimes are deeply studied within the role of trade. There are some empirical attempts to address the magnitudes of the effects in resource extraction but certainly more empirical research in this direction is needed.

The literature is also consistent when concluding that conservation policies might be, to some extent, offset through trade by deforestation in other regions or countries. Some divergence in the magnitudes is found but agreement exists on the direction. This is especially important for international agreements. Negotiations that only focus on countries with high deforestation rates, might not be effective as trade might generate deforestation in countries that are not part of the negotiations (low deforestation rate countries).

We found opposing positions in relation to the effects of timber extraction as a consequence of trade on deforestation. Researchers have found that for some countries, increase in prices of timber will lead to increases in deforestation. However, others have argued that the effect

depends on different conditions. Other drivers of deforestation should be jointly relevant. Additionally, some researchers argue that high prices of timber might actually lead to increases in forest plantations. Finally, accessibility of standing natural forest plays a key role when discussing the effects of higher timber prices.

Researchers are still discussing whether trade sanctions can be used for environmental purposes. Some argue that this can help global environmental efforts but other say that this can generate perverse incentives by reducing the value of the stock of the resource, which could lead to depletion. Certainly, the amount of environmental clauses has increased significantly in trade agreements. Cross-country empirical analysis of the effects of these types of restrictions might now be possible.

Systems of certification have also been proposed as instruments to reduce negative environmental impacts of forestry activities. The certification process is complex and has many stages. Price premiums are important, but it is still difficult to know if people are willing to pay more. Additionally, information of what certification means in the product labels needs to be clear and accurate.

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Annex 1

Net exporters/importers of agricultural products and high/low forest stock countries 2005

	Agricultural goods net exporters	**Agricultural goods net importers**
High forest stock	Austria, Belize, Bolivia, Brazil, Bulgaria, Cameroon, Canada, Cote d'Ivoire, Colombia, Costa Rica, Ecuador, Fiji, Gabon, Guatemala, Guyana, Honduras, Indonesia, Latvia, Lithuania, Malawi, Malaysia, New Zealand, Nicaragua, Norway, Panama, Paraguay, Peru, Seychelles, Swaziland, Viet Nam, Zambia	Angola, Bahamas, Belarus, Bosnia and Herzegovina, Cambodia, Central African Republic, Croatia, Czech Republic, Dominica, Estonia, Finland, Gambia, Georgia, Germany, Italy, Jamaica, Japan, Luxembourg, Mexico, Portugal, Russian Federation, Samoa, Senegal, Slovakia, Slovenia, Spain, Suriname, Sweden, Switzerland, Trinidad and Tobago, United States of America, Venezuela, Zimbabwe
Low Forest stock	Antigua and Barbuda, Australia, Belgium, Burundi, Chile, Denmark, Ethiopia, France, Ghana, Hungary, Iceland, India, Ireland, Kenya, Madagascar, Mauritius, Namibia, Netherlands, Poland, Rwanda, South Africa, Sri Lanka, Thailand, Togo, Turkey, Uganda, Ukraine, Uruguay	Albania, Algeria, Argentina, Armenia, Azerbaijan, Bangladesh, Barbados, Benin, Botswana, Cape Verde, China Cyprus, Dominican Republic, Egypt, El Salvador, Greece, Grenada, Haiti, Iran, Israel, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Libya, Maldives, Mongolia, Morocco Mozambique, Nepal, Niger, Nigeria, Pakistan, Philippines, Romania, Sao Tome and Principe, Saudi Arabia, Singapore, Sudan, Syria, Tunisia, United Arab Emirates United Kingdom, Yemen

Sources: WTO, WEO and FAO 2009.

Annex 2

Overview of recent trade agreements and their environmental provisions

Trade Agreements	Status (as of Oct. 2008)	Environmental considerations	Website (final text or information)
Agreements signed by Australia			
Australia-Chile Free Trade Agreement	Signed 30 July 2008; expected to enter into force 6 March 2009	Preamble, Chapter 10 (Investment), Chapter 15 (Government Procurement), Chapter 18 (Cooperation), Chapter 22 (General Provisions and Exceptions)	www.dfat.gov.au/GEO/chile /fta/Australia_Chile_FTA.pd f
Agreements signed by Canada			
Canada-European Free Trade Association (EFTA) Free Trade Agreement	Signed 26 January 2008	Preamble, Chapter 6 (Exceptions and Safeguards)	www.international.gc.ca/ de-agreements accordscommerciaux/ agr-acc/eftaaele. aspx?lang=en#2
Canada-Peru Free Trade Agreement, including an Agreement on the Environment	Signed 29 May 2008	Preamble, Chapter 1 (Initial Provisions and General Definitions), Chapter 5 (Sanitary and Phytosanitary Measures), Chapter 6 (Technical Barriers to Trade), Chapter 8 (Investment), Chapter 11 (Financial Services), Chapter 14 (Government Procurement), Chapter 17 (Environment), Chapter 20 (Administration of the Agreement), Chapter 21 (Dispute Settlement), Chapter 22 (Exceptions)	www.international.gc.ca/tra de-agreements accordscommerciaux/ agr-acc/peruperou/ peru-peroutable. aspx *Agreement on the Environment:* www.international.gc.ca/tra de-agreements accordscommerciaux/ assets/pdfs/ Canada-Peru_Environment-en.pdf
Canada-Colombia Free Trade Agreement, including an Agreement on the Environment	Concluded 7 June 2008, currently pending ratification	[Text of the agreement is not publicly available.] Trade-related environmental provisions contained in the FTA: o provide for specific Multilateral Environmental Agreements (MEA) (e.g., Montreal Protocol on Substances that Deplete the Ozone Layer) to prevail in the event of an inconsistency between	www.international.gc.ca/tra de-agreements-accordscommerciaux/ agracc/ andean andin/cancolombia-colombie.aspx *Agreement on the Environment (Fact Sheet):* www.international.gc.ca/tra de-agreements accordscommerciaux/ agracc/ colombiacolombie/ facts-fichesenv. aspx?lang=en

		an FTA obligation and the obligations in the MEA; o encourage the Parties not to weaken their domestic health, safety or environmental measures to attract investment; and • allow the Parties to take measures necessary to protect human, animal and plant life or health, that may be inconsistent with trade or investment obligations. The FTA includes a parallel Agreement on the Environment containing key environmental obligations and a framework to undertake environmental cooperation activities.	
Canada-Jordan Free Trade Agreement, including an Agreement on the Environment	Concluded 25 August 2008, currently pending ratification	[Text of the agreement is not publicly available.] The Free Trade Agreement sets out several provisions that strive to protect the environment by: • highlighting the importance of environmental conservation and protection and the promotion of sustainable development; • reaffirming the Parties' commitments to Multilateral Environmental Agreements (MEAs) and providing for specific MEAs (e.g. Montreal Protocol on Substances that Deplete the Ozone Layer) to prevail in the event of an inconsistency between an FTA obligation and the obligations in the MEAs; and	www.international.gc.ca/trade-agreementsaccordscommerciaux/agracc/ jordanjordanie/ index.aspx?lang=en *Agreement on the Environment (Fact Sheet):* www.international.gc.ca/trade-agreements accordscommerciaux/ agracc/ jordanjordanie/ index.aspx?lang=en

		• allowing the Parties to take measures necessary to protect human, animal and plant life or health, which may be inconsistent with trade or investment obligations. The Agreement on the Environment contains provisions relating to environmental protection, environment-related cooperation activities, enforcement of environmental standards, and complaints procedure/dispute resolution.	
Agreements signed by the European Union			
EU-CARIFORUM Economic Partnership Agreement	Initialled 16 December 2007; Signed 15 October 2008; currently pending ratification	Preamble, PART I (Trade Partnership for Sustainable Development); PART II (Trade and Trade-related Matters) / TITLE I (Trade in Goods): Chapter 5 (Agriculture and Fisheries), CHAPTER 6 (Technical Barriers to Trade); TITLE II (Investment, Trade in Services and Ecommerce): Chapter 2 (Commercial Presence); TITLE III (Trade-related Issues): Chapter 5 (Regulatory Framework) – Section 7 (Tourism Services); TITLE IV (Trade-related Issues): Chapter 2 (Innovation and Intellectual Property) – Section 1 (Innovation), Section 2 (Intellectual Property), Chapter 4 (Environment)	http://trade.ec.europa.eu/doclib/docs/2008/april/tradoc_138569.pdf
Agreements signed by Japan			
ASEAN3-Japan Comprehensive	Signed in April 2008; entered into force 1	Chapter 2 (Trade in Goods), Chapter 5	www.mofa.go.jp/policy/economy/fta/asean/agreement.

Economic Partnership Agreement	December 2008	(Standards, Technical Regulations and Conformity Assessment Procedure), Chapter 8 (Economic Cooperation)	pdf
Japan-Brunei Darussalam Economic Partnership Agreement	Signed in June 2007; entered into force 31 July 2008	Preamble, Chapter 5 (Investment), Chapter 7 (Energy), Chapter 9 (Cooperation)	www.mofa.go.jp/region/asiapaci/brunei/epa0706/agreement.pdf
Japan-Indonesia Economic Partnership Agreement	Signed in August 2007; entered into force 1 July 2008	Chapter 5 (Investment), Chapter 8 (Energy and Mineral Sources), Chapter 13 (Cooperation)	www.mofa.go.jp/region/asiapaci/indonesia/epa0708/agreement.pdf
Agreements signed by New Zealand			
New Zealand-China Free Trade Agreement, including an Environment Cooperation Agreement	Signed 7 April 2008; entered into force 1 October 2008	Preamble, Chapter 8 (Technical Barriers to Trade), Chapter 14 (Cooperation), Chapter 17 (Exceptions)	http://chinafta.govt.nz/1-The-agreement/2-Text-ofthe-agreement/0-downloads/NZChinaFTAAgreement-text.pdf *Environment Cooperation Agreement:* www.chinafta.govt.nz/1-The-agreement/1-Keyoutcomes/0-downloads/ECA-NZ.pdf
Agreements signed by Turkey			
Turkey-Albania Free Trade Agreement	Entered into force 1 May 2008	Article 31 (General Exceptions)	www.dtm.gov.tr/dtmadmin/upload/AB/SerbestTicaretDb/Arnavutluk/ARN_EN/01-MAIN_TEXT.doc
Agreements signed by the United States			
US-Oman Free Trade Agreement	Signed in September 2006; Entered into force 1 January 2009	Preamble, Chapter 6 (Sanitary and Phytosanitary Measures), Chapter 17 (Environment), Chapter 20 (Dispute Settlement), Chapter 21 (Exceptions)	www.ustr.gov/Trade_Agreements/Bilateral/Oman_FTA/Final_Text/Section_Index.html
US-Peru Trade Promotion Agreement, including Environment Cooperation Agreement	Entered into force 1 February 2009; parallel Environment Cooperation Agreement signed 26 July 2006	Preamble, Chapter 6 (Sanitary and Phytosanitary Measures), Chapter 9 (Government Procurement), Chapter 10 (Investment), Chapter 18 (Environment), Chapter 21 (Dispute Settlement), Chapter 22 (Exceptions) The parallel Peru Environment Cooperation Agreement, aiming at establishing a framework for enhancing bilateral	www.ustr.gov/Trade_Agreements/Bilateral/Peru_TPA/Final_Texts/Section_Index.html *Environment Cooperation Agreement:* http://www.state.gov/g/oes/env/trade/81638.htm

		and/or regional environmental cooperation between the Parties contains provisions related to, *inter alia*, cooperation mechanisms; participation in and operation of the Environmental Cooperation Commission; the work program and cooperation areas; necessary financial, human, technological and organisational resources; opportunities for public participation	
Agreements signed by non-OECD countries			
Pakistan-Malaysia Closer Economic Partnership Agreement	Signed 8 November 2007; entered into force 1 January 2008	Chapter 6 (Sanitary and Phytosanitary Measures)	www.commerce.gov.pk/PMFTA/PAk-Malaysia-FTA(TXT).pdf
Chile-Panama Free Trade Agreement	Entered into force 7 March 2008	Preamble: The FTA with Panama incorporates environmental provisions in a side agreement : Environmental Cooperation Agreement	www.direcon.cl/pdf/TLC_Chile_Panama.pdf
El Salvador- Honduras-Taiwan Free Trade Agreement	Signed 7 May 2007; entered into force 1 January 2008 for El Salvador and Taiwan, and 15 July 2008 for Honduras	Chapter 9 (Standardisation Measures, Metrology and Authorisation Procedures), Chapter 17 (Cooperation)	www.sice.oas.org/Trade/SLVHND_TWN_FTA_s/Index_s.asp
Peru-Singapore Free Trade Agreement	Signed 29 May 2008; expected to enter into force early 2009	Chapter 6 (Sanitary and Phytosanitary Measures), Chapter 7 (Technical Barriers to Trade), Chapter 7 (Investment), Chapter 18 (Exceptions)	www.sice.oas.org/TPD/PER_SGP/Final_Texts_PER_SGP_s/Index_s.asp [Spanish]

Source: OECD. 2009. Environment and Regional Trade AgreementS: Developments in 2008.