Food and Agriculture Organization
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Border and related measures in the context of adaptation and mitigation to climate change

Background paper for
The State of Agricultural Commodity Markets (SOCO) 2018

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Acronyms

AFOLU	Agriculture, forestry and other land uses
BTAs	Border tax adjustments
CETA	European Union – Canada Comprehensive Economic and Trade Agreement
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
ETS	European Union Emissions Trading System
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse gas
INDCs	Intended National Determined Contributions
ISO	International Organization for Standardization
LCA	Life Cycle Analysis
LULUCF	Land use, land-use change and forestry
NAFTA	North American Free Trade Agreement
OIE	International Office of Epizootics
RFID	Radio-frequency identification
RTAs	Regional trade agreements
SCM	Subsidies and countervailing measures
SDT	Special and differential treatment
SPS	Agreement on Sanitary and Phytosanitary Measures
TBTs	Agreement on Technical Barriers to Trade
TPP	Trans – Pacific Partnership
TRQs	Tariff Rate Quotas
WTO	World Trade Organization

Executive summary

Although international trade is not specifically mentioned in the Paris Climate Agreement, trade can play a facilitating role in achieving the mitigation and adaptation objectives of signatories to the Agreement. Trade policies can also undermine those objectives. The focus of this paper is on examining how the facilitating role of trade can be achieved.

One of the challenges created by the 'bottom-up' approach of self-declared national mitigation targets adopted in the Agreement is that if the economic costs of greenhouse gas (GHG) emissions are internalized in production and consumption, the implicit price of carbon will differ across countries. This creates the potential for trade distortions. Domestic mitigation policies in importers will almost inevitably result in some carbon leakage, i.e. offsets to reductions in domestic emissions through additional emissions generated in supplying imports. But an important distinction needs to be made between carbon reallocation and carbon misallocation resulting from changes in trade volumes. In the reallocation case, trade leads to a shift in production to lower-emitting producers thereby contributing to global mitigation. In the misallocation case, the opposite occurs.

This paper analyses how various border measures, including border tax adjustments (BTAs) might be used to reduce potential carbon misallocation. The conclusion is that technical and legal constraints on the effective application of border measures for food and agricultural products to prevent carbon misallocation are extremely challenging and their use could open the door to protectionism.

The use of carbon standards and labelling offers an alternative approach to reducing misallocation and promoting reallocation. It poses fewer technical difficulties and reduces the potential for legal challenges. An added advantage of labelling is that it can help to promote changes in consumption that will be needed to reduce the carbon footprint of food and agriculture. The use of the approach could be facilitated through the adoption of international standards for carbon measurement and labelling, such as those being developed through the International Organization for Standardization (ISO).

Labelling is not a panacea and may have limited effectiveness when consumers base their consumption decisions primarily on the basis of price. For this reason, the use of domestic policy measures that increase carbon efficiency in agriculture (reduce emissions per unit of output) and limit changes in land use that contribute to emissions will also be important for achieving mitigation aims under the Paris Agreement.

An increasing number of regional trade agreements (RTAs) have incorporated environmental provisions, with the most common types of provisions focusing on environmental cooperation. Recent agreements recognise the importance of mutually supportive trade and environmental policies, and national commitments to multinational environmental agreements. RTAs could play a supporting role to the Paris Climate Agreement, by fostering international cooperation on climate mitigation measures in the context of freer trade.

Climate change is likely to result in greater variability in the production of many crops and this could imply greater international price variability. International trade can exert a stabilising effect on the prices of agricultural commodities in domestic markets in the presence of weather-induced fluctuations in production. However, both domestic agricultural policies and border measures can increase the transmission of instability from domestic to international markets, and insulate domestic markets from changes in international prices. Both of these effects contribute to the likelihood of greater international price instability for basic foodstuffs with climate change. World Trade Organization (WTO) disciplines on the use of potentially destabilising policies vary in their effectiveness. Proposed changes in commitments, for example under the Agreement on Agriculture, have differing implications for future international price stability. The lack of effective disciplines for measures that restrict exports during periods of shortages increases potential price instability in global markets. The reform of domestic agricultural policies, reductions in trade barriers, and greater transparency in the use of domestic and border measures would exert a stabilising effect on international markets in the face of climate-induced production instability.

It is generally accepted that the agricultural sector in many developing countries will face major challenges in mitigation and in adapting to climate change, although given that developing countries account for over 90 percent of global emissions from agriculture and land-use change it is imperative that they make significant progress in limiting GHG emissions if the rise in global average temperature is to be constrained (Blandford and Hassapoyannes, 2018). The Climate Agreement recognises differentiated responsibilities and capacities, and the role of financial and technical assistance in helping developing countries meet mitigation and adaption objectives. WTO agreements recognise the role of special and differential treatment (SDT). In the context of climate policy, SDT implies that developing countries, particularly least developed countries, could be accorded special treatment in terms of the stringency of obligations and periods of adjustment, for example in meeting product standards relating to carbon footprint. Priority could also be placed on capacity building and the provision of technical assistance for developing countries in effecting a transition to a lower-carbon food and agricultural system. Potential priority areas relating to trade are capacity building for implementing technical standards and assistance with carbon certification. Labelling could be used as a mechanism to promote the sale of sustainable, low-carbon food products from developing countries.

Developing countries, particularly least developed countries, may face challenges in adapting to increased price instability for basic agricultural commodities in international markets. Expanded provisions for food aid to meet short-term production shortfalls will be needed, targeted specifically to the poorest and most vulnerable countries.

An important conclusion of this paper is that policies that seem to make sense from a national perspective for pursuing mitigation and adaptation aims may not be efficient from a global perspective. In general, global mitigation and adaptation is facilitated by international trade, but countries must be willing to pursue national policies that are consistent with this role.

Introduction

Agriculture, forestry and other land uses (AFOLU) is a major contributor to greenhouse gas (GHG) emissions, particularly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Agriculture contributes to climate change directly by emitting CH_4 and N_2O through crop and livestock production, and indirectly by affecting net CO_2 emissions through its impact on soil, forests and other land uses, particularly through the deforestation of land for conversion to agriculture.[1] Agriculture's direct and indirect emissions make the sector and forestry and other land uses (AFOLU) the second largest contributor to total anthropogenic global emissions (IPCC 2014: 47, Figure 1.7). Agriculture also contributes CO_2 emissions through the use of fossil-fuel energy (e.g. to power machinery and to pump irrigation water, and for heating and cooling) and by consuming inputs that are produced in an energy-intensive manner (e.g. fertilizers and pesticides). In contrast, soil and the biomass of growing trees and plants can act as natural CO_2 sinks, thereby reducing the anthropogenic effect of GHG emissions. Despite agriculture's capacity to sequester carbon, net total (direct and indirect) GHG emissions from AFOLU are positive (Smith *et al*., 2014).

AFOLU will have to play a part in GHG mitigation in order to achieve the objective of limiting the rise in global average temperature this century below 2^0C from pre-industrial levels under the UN Climate Agreement of 2015. At the same time, global warming will affect the levels and variability of crop yields as well as the productivity of livestock. This will mean that the agricultural sector will need to adapt to the effects of climate change.

As countries pursue their goals for mitigation and adaptation under the Agreement, the role of international trade in the transition to a lower carbon global economy comes to the fore. Measures taken at the border can either facilitate or impede mitigation and adaptation. The purpose of this paper is to examine technical issues in the use of border and related measures for food and agriculture in the context of climate change.

The use of measures affecting international trade inevitably involves agreements under the World Trade Organisation (WTO). Reference is made to the implications of some key provisions in the General Agreement on Tariffs and Trade (GATT) and in other WTO agreements, but this paper does not attempt to provide an exhaustive treatment of the legal implications of the technical options discussed.

The following areas are covered in the paper:

1. Border measures in support of GHG mitigation policies
2. The use of standards and carbon labelling for food and agricultural products
3. Climate measures in regional and bilateral trade agreements

[1] Land-uses in AFOLU comprise forest land, cropland, grassland, wetlands (peatlands and flooded land), settlements, and other land (IPCC, 2006). Overall, agricultural activities account for at least 90 percent of emissions due to land-use change (Bennetzen, Smith and Porter, 2016: 764).

4. Border measures in the context of adaptation to the effects of climate change
5. Special and differential treatment.

Reductions of AFOLU emissions in the context of the Paris Climate Agreement

FAO (2016) analyses the contents of 140 Intended National Determined Contributions (INDCs) submitted prior to the United Nations Climate Change Conference (UNFCCC) that resulted in the Paris Agreement (COP21), and 22 Nationally Determined Contributions that form part of the ratification of the Agreement (i.e. the information available on proposed or confirmed country commitments as of the end of July 2016).[2]

The analysis reveals that land use, land-use change and forestry (LULUCF) and agriculture feature prominently in countries' mitigation goals; 89 percent of the countries include agriculture and/or LULUCF.[3] All Annex 1 countries and 72 percent of Non-Annex 1 countries that submitted an INDC (106 out of 147 countries) included agriculture in mitigation targets and/or actions and these countries account for 92 percent of global GHG emissions from agriculture (FAO, 2016: 12).[4] However, the majority of the countries (54 percent) do not elaborate on the measures they propose to employ to achieve mitigation in agriculture (FAO, 2016: 13).

With respect to LULUCF, 83 percent of countries include this in mitigation targets and/or actions. Most of the countries that mention policies or measures focus on forests (e.g. afforestation, reforestation and forest management, as well as deforestation), although some countries include other forms of land use, such as cropland, grassland and rangelands, and wetlands (FAO, 2016: 17).

The approach adopted in the Paris Agreement is widely characterized as being primarily 'bottom up', in the sense that individual countries identify mitigation aims through their NDCs and are left to determine the policy measures to be taken to pursue these aims (FAO, 2016: vii). This is in contrast to a 'top-down' approach in which legally binding mitigation commitments are imposed, as under the Kyoto Protocol.

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[2] One of the INDCs covered the 28 members of the European Union, which is also a separate party to the Convention, hence the information analysed covered 189 countries (190 parties). The remaining seven parties to the Convention (there are 197 parties in total) did not submit INDCs.

[3] In the terminology used by the Intergovernmental Panel on Climate Change (IPCC) 'agriculture' includes emissions from enteric fermentation, manure management, rice cultivation, prescribed burning of savanna and grassland, and from soils (predominantly CH_4 and N_2O). Emissions relating to forestry and other land uses are included under LULUCF, i.e. the FOLU part of AFOLU.

[4] Annex 1 and non-Annex 1 countries refer to groups defined under the UN Framework Convention on Climate Change (UNFCC). Annex 1 parties are the members of the Organisation for Economic Co-operation and Development as of 1992, plus economies in transition (including the Russian Federation, the Baltic States and several Central and Eastern European States); non-Annex 1 countries are mostly developing countries (unfccc.int/parties and observers/items/2704.php).

Mitigation policies can be directed to all stages of the food system, as well as to non-agricultural activities such as forestry in AFOLU (Blandford and Hassapoyannes, 2018). Approaches identified below are conceptually possible, although their feasibility may vary across sub-sectors and regions:

1. Carbon pricing. This can be achieved explicitly through carbon taxes, implicitly through regulation or through a mixed approach, such as emissions trading (cap and trade). The implementation of carbon pricing in the food system can include the following:

   - Pre-production stage (supply of inputs): carbon pricing, applied indirectly on energy used in the production of agricultural inputs or directly on the inputs themselves (e.g. fertilizer taxes and taxes on fossil-fuel energy)

   - Production stage: direct or indirect taxes, applied to agricultural outputs (crops and livestock) according to emissions intensity or to AFOLU practices (e.g. deforestation)

   - Post-production stage: direct or indirect taxes on energy use (processing, storage, packaging and transportation, refrigeration, retail activities); direct regulation of energy use (e.g. energy efficiency requirements in the cold chain); taxes on waste; consumer taxes on emissions-intensive foods.

2. Inducement policies. These involve the creation of economic incentives for the use of low-emission inputs or the adoption of low-emission AFOLU practices; the promotion of production or consumption of low-emission products; or the promotion of production and use of biomass as an alternative to fossil energy. This category of policies includes:

   - Pre-production stage: subsidisation of the development and use of emissions-reducing inputs (e.g. nitrogen-inhibiting fertilizers; and inputs, such as natural pesticides, the production of which does not rely on fossil fuels)

   - Production stage: use of environmental programmes (subsidies and regulations) to promote the adoption of emissions-reducing AFOLU practices (e.g. minimum tillage, restoration of degraded soils, retirement of carbon-rich soils from agricultural production, sustainable forest management)

   - Post-production stage: subsidisation of the development and use of emissions-reducing technologies and practices (e.g. energy-efficient equipment in food processing, storage and distribution).

3. Behavioural change policies. These involve the use of information, education and knowledge transfer to effect emissions-reducing behaviour by producers,

consumers and land managers in AFOLU. Implementation could include the following:

- Pre-production stage: diffusion of information on the implications of production practices for emissions
- Production stage: increasing managerial efficiency and enhancing the understanding of the implications of production practices and decisions for emissions
- Post-production stage: promotion of voluntary schemes for energy conservation and waste reduction in post-production activities (e.g. reduction of packaging, changes in date labelling of food); promotion of emissions-reducing food choices and reduction of waste at the consumer level (e.g. through labelling of carbon footprint on food, consumer education on the emissions implications of food choices).

Economic incentives and disincentives (i.e. inducement policies and explicit or implicit carbon pricing) can affect both the level of agricultural output and its composition, and the cost of production. The latter is also affected by the reallocation of land to different uses (e.g. from agriculture to forestry).

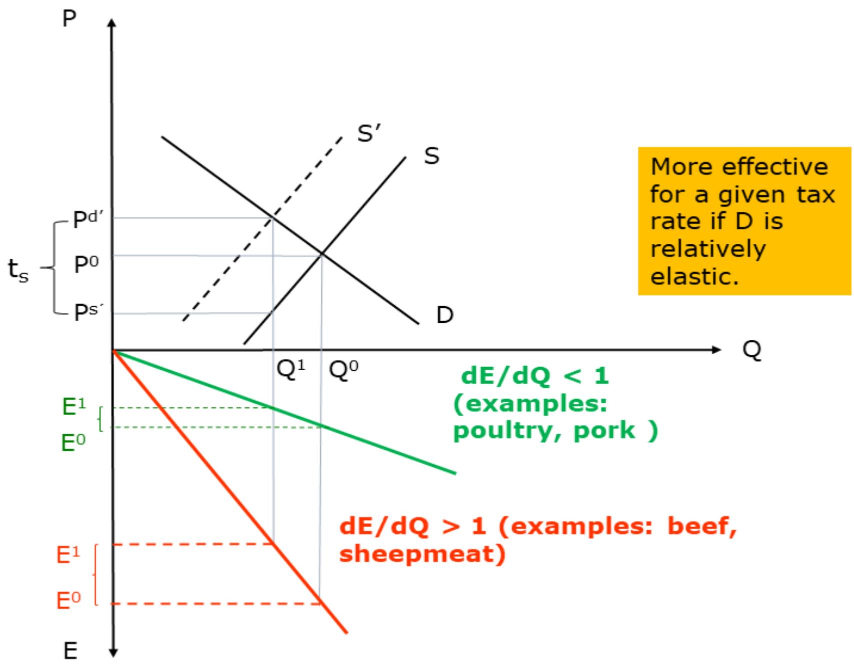
The impact of emissions reductions – domestic and international dimensions

As indicated above, various policy approaches can be used to pursue mitigation objectives in AFOLU. In this section we focus primarily on explicit or implicit taxes on the production or consumption of agricultural products. Such taxes are likely to have the most direct impact on domestic and international markets for these products.

Economists argue that an effective way to deal with an externality such as GHG emissions is to internalise the economic costs of the externality into production and/or consumption. In this way, producers and/or consumers take into account the full cost of a product, including environmental costs, in making production and consumption decisions. The environmental costs of an externality can be imposed through an explicit tax or through regulation. We first consider the impact of internalisation when international trade is not a factor, i.e. there are no exports or imports of the product. In this case we have a closed economy.

Figure 1 provides a simple diagrammatic representation of the implications of internalising the environmental cost of emissions through an explicit or implicit tax on production in a closed economy. The imposition of the tax t_s shown in the top part of the diagram leads to a leftward shift in the supply curve from S to S'. The supply curve captures the marginal costs of supplying the commodity and the emissions tax translates into an increase in those costs. With the demand curve for the product represented by D, the volume of the product produced and consumed declines from Q^0 to Q^1 as a result of the tax.

Figure 1. Cost-increasing mitigation in a closed economy



Source: author's own analysis

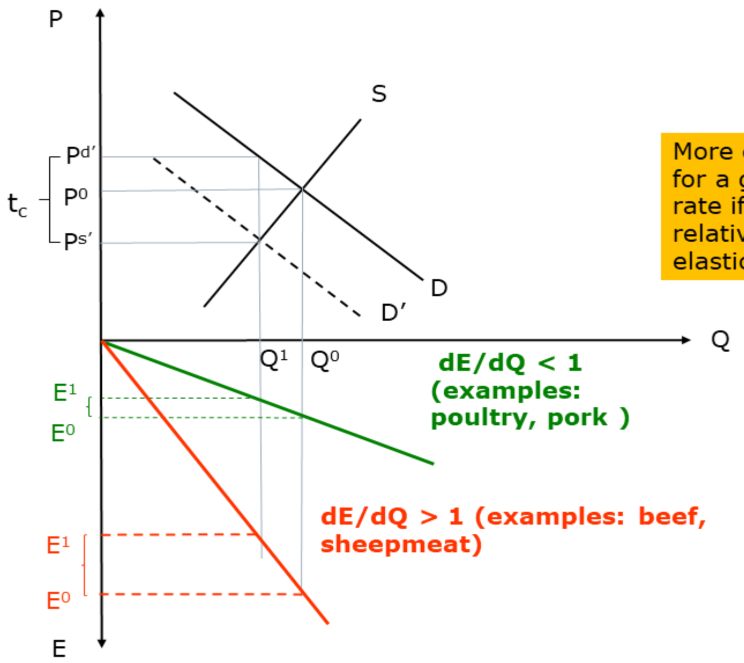
The impact of the reduction in production and consumption on GHG emissions depends on the emissions intensity of output, i.e. the volume of emissions generated by each unit of production. In the lower part of the diagram we have included two examples of emissions functions. The upper function (in green) is one in which a unit change in output associated with the tax results in a less than proportional change in emissions, i.e. the emissions intensity ratio is less than unity. The lower function (in red) represents the case in which a unit change in output leads to a more than proportional change in emissions, i.e. the emissions intensity ratio is greater than unity.[5] These examples are

[5] To simplify the diagrammatic analysis we have used linear curves originating from the origin to reflect the relationship between output and emissions. These functions imply that the elasticity of emissions with respect to output is unity. Whether or not this will apply in any given case is an empirical question. The emissions elasticity may vary with output. If there are emissions economies of scale (marginal reductions in emissions as output increases) the elasticity will decline. The opposite will apply if there are diseconomies of scale. Differences in emissions/output ratios and elasticities across products or production systems within and among countries are important issues. They will influence the change in total emissions in a country as a result of its mitigation policies. They are also important in the context of

relevant to the discussion of the relationship between emissions and food production since, for example, it is generally observed that non-ruminant products such as poultry meat, eggs and pork tend to be less emissions intensive than ruminant products such as beef and sheep meat (see Gerber *et al.*, 2013: 16).

As demonstrated by Figure 1, internalising the cost of emissions through a tax on the supply side (t_s) has an impact on consumers, since the market price for the commodity increases from P^0 to $P^{d'}$ as a result of the reduction in supply in a closed economy. An alternative approach to mitigation would be to focus on taxing consumption, rather than production (Figure 2). In this case an explicit or implicit tax of t_c per unit of product is imposed on consumers. Consumers pay the tax inclusive price of $P^{d'}$ and producers receive a price of $P^{s'}$ due to the reduction in demand from Q^0 to Q^1.

Figure 2. Mitigation through consumption-reducing measures in a closed economy



Source: author's own analysis

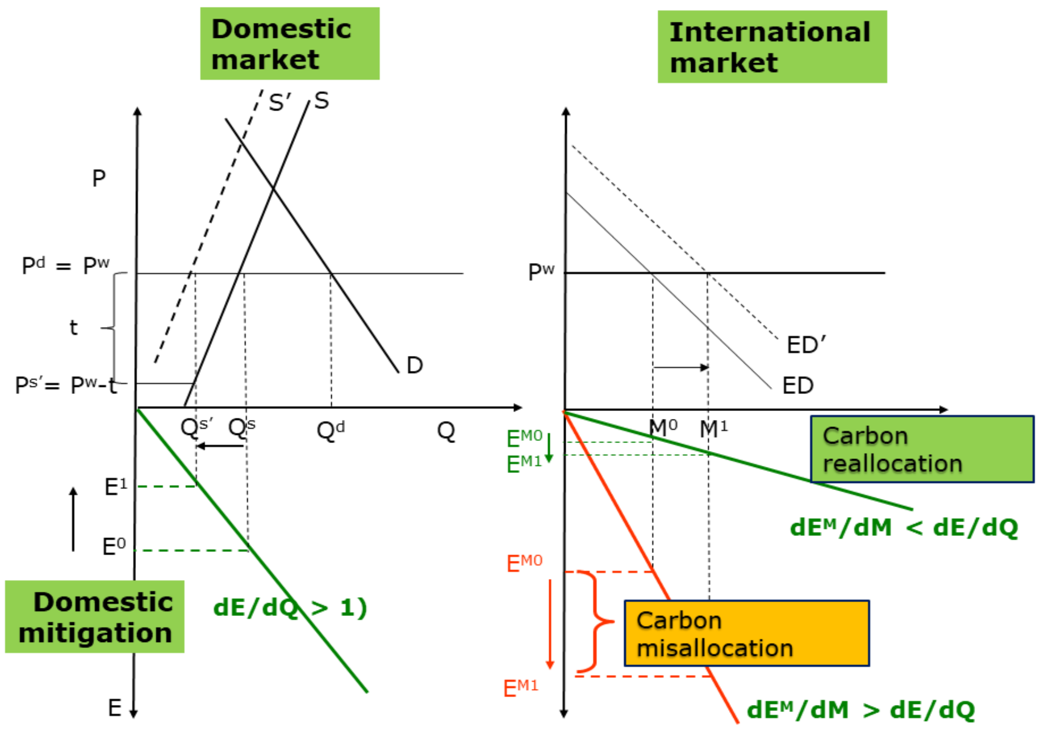
We should note that the shift in the demand curve could also be achieved by changing consumer preferences (the behavioural change option identified above) since this is relevant to the discussion of carbon labelling later in this paper. Alternatively, if the focus is on achieving mitigation by operating on the supply side without internalising the cost of emissions through taxation, the focus would need to be on changing the emissions functions (i.e. reducing emissions per unit of output, for example, by employing new

carbon leakage and carbon reallocation associated with international trade. The latter issues are discussed in more detail below.

technology or management practices that result in flatter emissions functions). This approach could also have implications for production costs.

The introduction of international trade into the picture (the open economy case) can affect the outcome of the policies illustrated by figures 1 and 2 with respect to changes in emissions domestically and in other countries.[6] Figure 3 depicts the case when a country is a 'small' importer of the commodity concerned, in other words changes in its imports have a negligible effect on prices in world markets, but not necessarily on global emissions generated through the production of the commodity. In this case the country faces a constant import price of P^w. The two left panels in the diagram are similar to those already used in figures 1 and 2. They capture the impact of the policy on domestic supply and demand and the potential implications for domestic emissions. However in the diagram, we depict a situation in which the domestic product has an emissions ratio in excess of unity with respect to a change in output.

Figure 3. Cost-increasing mitigation for a small importing country



Source: author's own analysis

The top right panel reflects the impact on international trade associated with the change in domestic supply resulting from mitigation policy. The shift in the domestic supply curve caused by internalising the cost of emissions results in a rightward shift in the

[6] A reduction in emissions in a closed economy will reduce global emissions, even though emissions in other countries are unaffected. In an open economy, global emissions can vary both as the result of changes in emissions in the mitigating country and in other countries as a result of that country's mitigation policies.

excess demand curve from ED to ED'; imports increase from M^0 to M^1. Viewed from a mitigating country's perspective, when there is an increase in imports associated with mitigation policy, this is generally characterised as *carbon leakage*. Emissions generated in the supply of additional imports offset to some extent the reduction in emissions in the mitigating country and as such there is a 'leakage' due to increased production overseas.[7] But while it is clear that emissions associated with imports will change, this does not mean that emissions will increase globally; that depends on the relative emissions intensity of domestic production and imports.

Two different emissions functions for imports are included in the lower right panel of Figure 3. The upper green line depicts a situation in which the emissions generated in supplying imports are relatively low (i.e. the emissions ratio is less than unity for the given change in imports). The lower red line captures the case when the emissions ratio is greater than unity. If the emissions relationship corresponds to the upper green line, the increase in emissions associated with the increase in imports (the difference between the green E^{M1}- E^{M0} in the lower right panel) is smaller than the corresponding reduction in domestic emissions (the green E^0-E^1 in the lower left panel). On the other hand, if the import emissions function corresponds to the red line in the lower right panel (emissions intensity of imports is higher than in domestic production), global emissions will increase (E^{M1}- E^{M0} from the lower function in the lower right panel is larger than the E^0-E^1 in the lower left panel).

Both of these cases constitute carbon leakage and can be viewed to be problematic if the focus is solely on the net emissions balance in the mitigating country. But when leakage results in a net reduction in global emissions, it is more accurately characterised as *carbon reallocation*. International trade in that case results in the replacement of relatively high-emitting domestic production by lower-emitting imports. This is clearly positive for global mitigation. Conversely, if there is a net increase in emissions through the replacement of lower-emitting domestic production by higher-emitting imports, this is more accurately characterised as *carbon misallocation* from a global perspective.[8]

The distinction between carbon reallocation and misallocation in the context of international trade is important given that there is a fundamental need to produce food, and that food production will inevitably result in some GHG emissions.[9] In order to limit

[7] Carbon leakage has often been discussed with respect to the re-location of domestic industries overseas in response to environmental regulations or taxes, e.g. the international relocation of manufacturing. Such re-location can certainly occur in food and agriculture (particularly in food processing), but given that one of the principal inputs in agriculture (land) is immovable, complete re-location in response to taxation or regulation may be less likely; the effect is likely to be manifested through a reduction in the returns to land and in land values in the mitigating country.

[8] When international trade is not involved (as in figures 1 and 2) the situation is one of *carbon autarky*. Other things being equal, a given tax on carbon will have a greater impact on net emissions (those associated with both production and consumption) in a closed economy than in an open economy that is subject to carbon leakage.

[9] While it is technically feasible to envisage a future in which there will be zero net emissions in certain sectors of the economy (e.g. energy), it is far more challenging to achieve this in AFOLU. Changes in production methods can reduce direct emissions of GHGs (CH_4 and N_2O) in crop and livestock production and can also increase carbon sequestration in soils. However, in order to offset agriculture's direct

these emissions and to reduce global warming, production should be concentrated in areas that are able to produce food with the lowest emissions intensity, i.e. the lowest ratio of emissions per unit of output, and lower-emitting producers should supply a larger share of global consumption. This is implied by carbon reallocation in Figure 3. The transfer of production to countries able to employ lower-emission technologies can help to achieve an overall increase in global carbon efficiency. Climate change is likely to alter comparative advantage in many countries. Given the demands that will be placed on global agricultural resources by an expanding world population, it is important that increased global production of food is associated with a relative reduction in its environmental footprint. Focusing on reductions in emissions in each country individually may not be the most effective way to achieve a reduction in global emissions, since global emissions efficiency is likely to require the relocation of production to more environmentally efficient regions (Nelson *et al*., 2009).[10]

Despite the important distinction between carbon reallocation and misallocation, countries may seek to avoid an increase in imports associated with domestic mitigation policies, i.e. to prevent carbon leakage and to attempt to mirror the closed economy situation depicted in figures 1 and 2. Domestic producers are likely to argue that the taxation of domestic supply puts them in an unfavourable competitive position with respect to imports, particularly if the suppliers of those imports are not subject to an emissions tax. The imposition of a charge on imports or the use of other measures that restrict imports to M^0 in Figure 3 will create a situation similar that in Figure 1 (i.e. *carbon autarky*). From a global perspective, where the internalisation of carbon costs is limited or incomplete, the rationale for placing limitations on imports by an individual country is stronger if imports have high emissions intensity relative to domestic production.

Before we leave Figure 3 we should note that it would also be possible to achieve a domestic mitigation objective in a small importer through the use of a consumption tax rather than an output tax (as analysed in the autarky case in Figure 2). In this case the tax would apply to both the domestically-sourced product and to imports. If a country wants to limit carbon leakage, the application of such a tax can pose significant technical challenges and may raise issues under international trade law. These issues are analysed further below.

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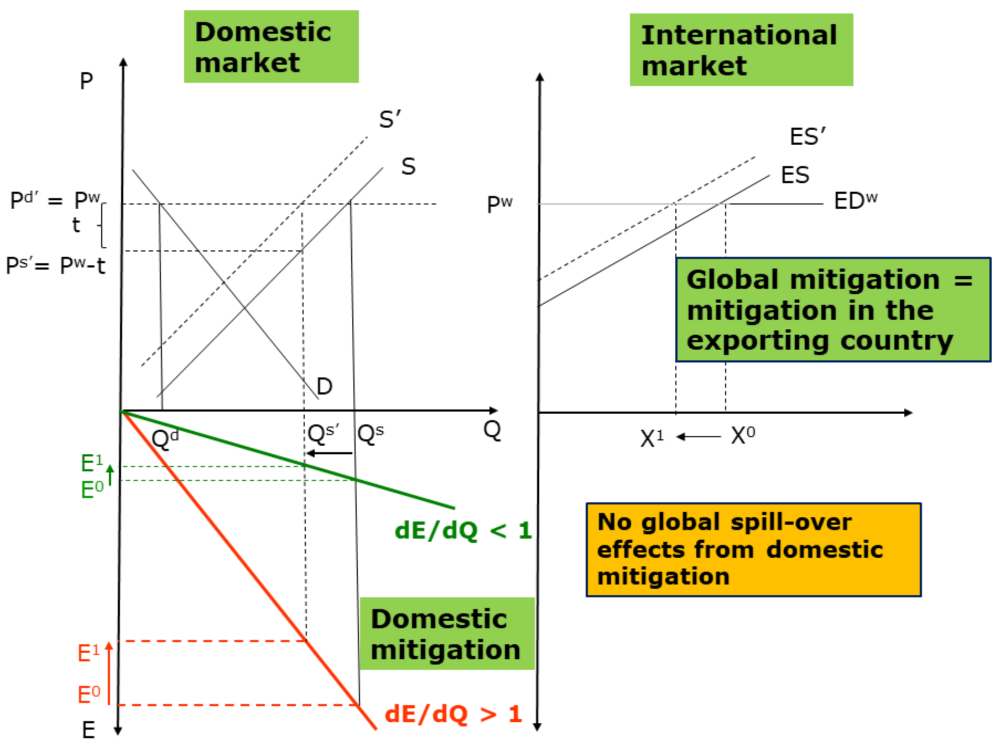
emissions, particularly in the face of increasing demand for food and agricultural raw materials, sustained changes in land use that result in enhanced carbon sequestration would be required. Unless there are technological innovations that permit the extraction of carbon from the atmosphere or other structural changes, such as a shift to low-carbon diets, achieving a 'steady state' in which there are zero net global emissions of GHGs in AFOLU, while not impossible, would be extremely challenging given the limited supply of land.

[10] Note that global carbon efficiency would require efficiency in the aggregate production and consumption of all goods and services, not just food. In order to achieve this, countries should produce the bundle of goods and services in which they have a comparative advantage in terms of carbon efficiency. This could mean that a country having an absolute carbon advantage in the production of a given commodity but a comparative disadvantage in that commodity, should import it from countries that have a comparative carbon advantage in the commodity.

We now turn to the impact of mitigation policy for a small exporter. Figure 4 shows the impact of internalising the cost of emissions in domestic production for the exporter. The leftward shift in the domestic supply curve in this case results in a leftward shift in the excess supply curve from ES to ES'. As we can see, the reduction in domestic supply does not affect domestic consumers; it simply reduces the country's exports. The impact of this change on emissions in other countries is negligible, since with the small country assumption there is no significant change in production or consumption in those countries. Again it is possible to consider using a consumption tax to achieve the reduction in emissions (as in Figure 2), but in that case the tax would also have to be applied to exports in order to prevent a rightward shift in the excess supply curve with the reduction in domestic demand, without a corresponding effect on domestic supply. As in the import case, the use of border measures to support a consumption tax could pose technical challenges, in addition to political challenges.

Figure 4. Cost-increasing mitigation for a small exporting country



Source: author's own analysis

The graphical analysis demonstrates that domestic mitigation policies can be influenced by what happens to international trade.[11] This naturally raises the issue of the use of border measures in the context of domestic mitigation policies.

The use of border measures in the context of domestic mitigation policies

As has already been demonstrated from the discussion of the import case in Figure 3, the effectiveness of domestic mitigation policies that focus on internalising the costs of emissions can be strengthened or weakened by international trade. Trade can serve as a mechanism for reallocating production to areas with production systems that generate fewer emissions per unit of output, i.e. to achieve greater global emissions efficiency. This effect is likely to be most pronounced when the costs of emissions are internalised in all countries, e.g. when there is a uniform global tax per unit of emissions. From the perspective of economic efficiency, a tax that internalises an environmental externality should be equal to the value of the damage caused by that externality. In many cases it is difficult to determine the amount of damage and to place a value on it. Hence, it is challenging to calculate the required tax per unit of carbon. Applying a carbon tax at either the production or consumption level is not straightforward technically and may generate political opposition.[12]

Taxes on emissions can be levied at source if emissions can be monitored. This generally applies, for example, to emissions from power plants. But it is extremely challenging to monitor emissions at source in agriculture (from cropland or livestock for example). Thus the tax would have to be applied on agricultural products when these are marketed.[13] In order to levy the tax it is necessary to determine how much carbon is emitted per unit of agricultural production. Emissions can vary with the type of production system employed as well as with technical and managerial efficiency. Some of the issues involved in making calculations of emissions on a product basis are examined later in this paper under the section on carbon standards. For the moment, we shall assume that it is possible to quantify emissions per unit of output and consequently that it is possible to apply carbon taxes on a product basis.

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[11] Figures 3 and 4 (and the discussion of the use of a consumption tax) are based on the small-country case, i.e. where changes in domestic supply and/or demand do not have an impact on prices in international markets. If a country accounts for a large share of global exports or imports of a commodity, international prices will change as a result of domestic mitigation policy. Changes in international prices can exert offsetting or reinforcing effects on domestic and global GHG mitigation. Outcomes are influenced by the relative magnitudes of elasticities of supply and demand in the domestic and international markets. Some analysis of large country export and import cases is contained in Blandford *et al.* (2015).

[12] Since a carbon tax is likely to reduce domestic production (at least in the short run) and can lead to higher food prices and reduced consumption, there may be opposition to taxation on the basis of food security considerations.

[13] This would not internalize the cost of emissions if food is produced for self-consumption.

Despite the challenges involved in internalising the costs of agricultural emissions, some countries may choose to apply explicit carbon taxes or to generate implicit carbon prices through cap-and-trade schemes in order to pursue mitigation aims under the Paris Agreement.[14] Other countries may choose not to employ such measures. The implication of the bottom-up approach to mitigation adopted in the Climate Agreement is that explicit or implicit prices for carbon could vary substantially among countries. To the extent that carbon prices are reflected in product prices, the pattern of international trade is also likely to be affected. As has already been indicated, changes in imports resulting from internalising the cost of carbon can be particularly challenging for policymakers, especially if imports come from suppliers that have not attempted to internalise or taken other measures to reduce emissions intensity in production.[15]

Addressing differences in emissions intensity through trade measures is likely to confront provisions in agreements under the World Trade Organisation (WTO). Among the relevant provisions are those that provide for most-favoured-nation (MFN) treatment, regulate the use of tariffs on imports and provide for equality of national treatment. Table 1 provides a summary of relevant GATT articles and other WTO agreements relating to the use of internal taxes and regulations of relevance to the use of carbon-related border adjustments (Holzer, 2010).

[14] One of the advantages of cap-and-trade schemes is that the trading of emissions permits generates a carbon price through permit values. Whether this price accurately reflects the damage caused by emissions depends on the level of the emissions cap and on whether all the firms and industries that generate emissions are included in the scheme. Caps are often set such that the implicit price of carbon is low and agriculture is generally excluded.

[15] As noted above, the application of a carbon tax is not the only way to induce a reduction in emissions intensity. For example, policy measures that induce the adoption of new technology or changes in production practices that are emissions-reducing can also play an important role. Some of these measures may actually be cost reducing rather than cost increasing (see, for example, MacLeod *et al*., 2015) and hence result in a rightward shift in the domestic supply curve. Whether the adoption of such measures results in a net reduction in global emissions will depend on the relative emissions intensity of domestic and traded products (potential imports or competing exports). The important point to note is that unilateral adoption of cost-reducing mitigation measures may actually result in an increase in global emissions if these measures result in the displacement of lower-emission traded products.

Table 1. WTO provisions relevant to carbon-related border adjustments

Border adjustment	An internal tax	An internal regulation
Imports	GATT Ad Articles III and Article II:2 (a) plus Article III:2 (NT for fiscal measures) and Article I:1 (MFN) If non-compliant – prohibited under Article II:1 (b) as in excess of binding tariff ceiling	GATT Ad Article III and III:4 (NT for non-fiscal measures) plus the TBT Agreement and GATT Article I:1 (MFN). If non-compliant – prohibited under GATT Article XI:1 as a quantitative restriction
Exports	GATT Article VI:4 and Ad Article XVI plus the SCM Agreement (including Annex I) and GATT Article I:1 (MFN on exportation). If non-compliant – prohibited under Article 3.1 of the SCM Agreement as an export subsidy	N/A

Source: Holzer (2010).
Explanatory notes:
GATT Ad refers to notes and supplementary provisions to the General Agreement on Tariffs and Trade (GATT) as amended
NT = national treatment
MFN = most-favoured nation
TBT = technical barriers to trade
SCM = subsidies and countervailing measures
See www.wto.org for details and texts of agreements

Tariff adjustments

Countries have limited ability to adjust tariffs to address carbon leakage under existing WTO agreements. If applied rates are less than bound rates, tariffs could be increased to discourage additional imports but not in a manner that would be judged to be discriminatory. This means that increases in tariffs cannot be applied selectively to imports of a given product from different WTO member countries on the basis of emissions per unit of output. Hence, while a general tariff increase could reduce imports from high carbon emitters with relatively low production costs (including those that have not internalised the cost of emissions in production), it will disproportionately affect low-carbon emitters with relatively high production costs (including those that have internalised the cost of emissions in production). Reductions in tariffs under the WTO process, preferentially under regional trade agreements or for developing countries through special and differential treatment, could be used to promote trade in low-emitting products or technologies that contribute to low-emissions production, but such reductions could not be implemented in a way that could be viewed to be discriminatory if they are to avoid potential challenges under the WTO's dispute settlement mechanism.

Tariff rate quota adjustments

Food and agricultural trade is subject to special provisions in the WTO Agreement on Agriculture that could provide limited flexibility in adjusting imports on the basis of emissions content. Tariff Rate Quotas (TRQs) covering 1 370 individual tariff lines were included in the tariff schedules of 36 countries as a result of the Uruguay Round (FAO, 2000). A TRQ places a limit on the total volume of imports subject to a zero or low tariff, but does not limit the volume of imports subject to a higher over-quota tariff if these become profitable. Imports that are either below the quota (at low or zero tariffs) or in excess of the quota raise the same issues for a small importer as those discussed above with respect to Figure 3. But when the quota is binding there is an additional dimension.

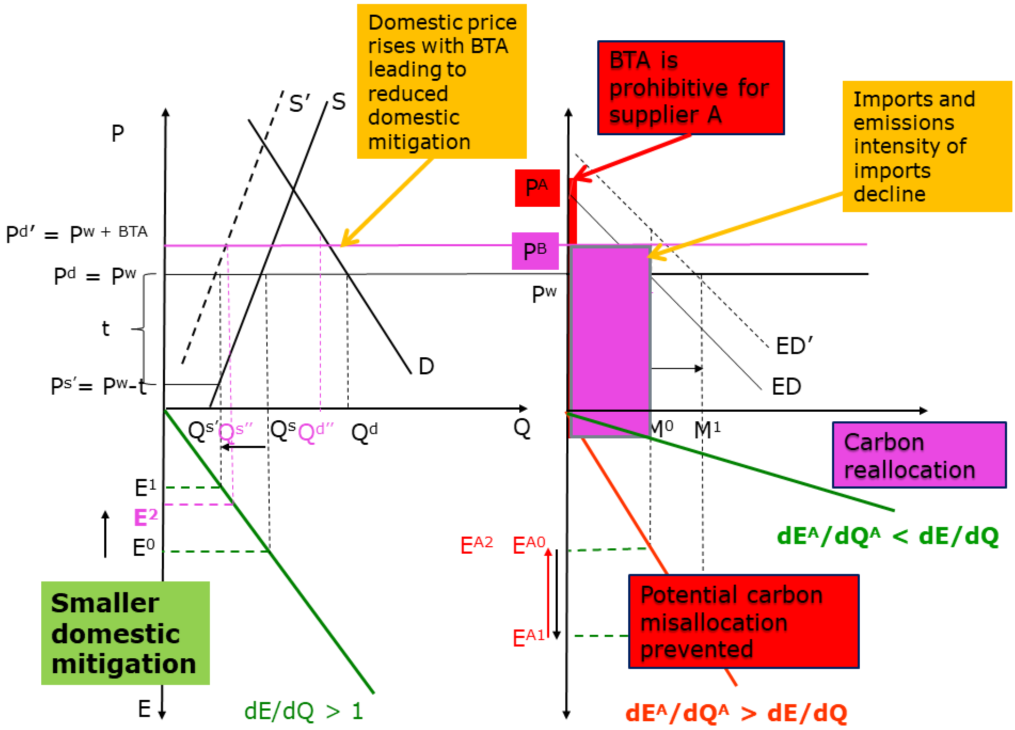
Countries use various methods to administer the quota under a TRQ, including licensing suppliers. Since WTO rules do not specify how quotas should be allocated, in principal there could be some flexibility to provide preferential access to low-carbon suppliers under the quota.[16] Whether it would be feasible for countries to vary quota allocations to reduce carbon leakage is an open question, since countries that view themselves to be disadvantaged could lodge a complaint under the WTO's dispute settlement procedure. In any event, to the extent that the lack of internalisation of emissions costs provides a cost-advantage to certain suppliers, the issues discussed earlier in relation to Figure 3 remain relevant if the demand for imports is above or below the quota. That is, carbon misallocation can still occur in those cases.

Tax adjustments

A carbon tax is a broad-based tax and raises issues similar to the use of sales taxes or value-added taxes. If industries are taxed at the point of production (the origin principle) then a country's exports will be disadvantaged and imports encouraged, unless imports face the same tax and corresponding domestic products are taxed in the country of destination. For this reason there has been considerable debate about the potential use of border tax adjustments (BTAs) to correct for carbon leakage. The potential application of a BTA on imports is illustrated in Figure 5.

[16] Roughly 47 percent of the product groups covered by TRQs shortly after their introduction were handled through licensing or on the basis of historical allocation. Licensing seems to offer the potential for inter-country adjustments in quota allocation (de Gorter and Sheldon, 2000).

Figure 5. Use of border tax adjustments for a small importing country



Source: author's own analysis

The left-side panels in Figure 5 represent domestic market relationships similar to those in Figure 3 for a small importer. The right-side panels differentiate between two sources of imports: supplier A with carbon-intensity of production higher than the importer's and supplier B with lower-carbon production. The importer imposes a border tax on imports from both suppliers based on the carbon content of imports. The magnitude of the tax is prohibitive for supplier A because of high carbon intensity. All imports are sourced from supplier B and the domestic price rises from P^w to $P^w + {}^{BTA}$. The tax adjustment reduces the amount of mitigation in the importing country due to an expansion of supply in response to the higher domestic price. Despite this, while the tax eliminates potential carbon misallocation by excluding imports from A, it allows for carbon reallocation by allowing imports from B.

Note that the diagram assumes that suppliers of imports do not impose internalisation costs on their producers. If, for example, B has already fully internalised the costs of emissions, no BTA should be applied to imports from that source. The price of imports from B will determine the domestic price for the product (equivalent to $P^{d'}$ in the diagram). Imports from A will not occur with full internalisation of emissions costs since the price from that source will exceed the supply price from B. The imposition of a BTA on imports from B in this case will create carbon misallocation by reducing lower-carbon imports from B and increasing higher-emitting domestic production.

With respect to exports, rebates have often been applied in the context of value-added taxes. The logic is that the payment of these taxes on products that are subsequently exported would put domestic exporters at a competitive disadvantage. But it is difficult to apply the same logic to carbon taxes, since the purpose of the tax is to internalise external costs of production that would otherwise not be incurred by producers. In this sense, rebates of carbon taxes for products that are exported would be deleterious from the perspective of global GHG mitigation. They would create a situation that could be characterised as *carbon dumping*, since failure to internalise emissions costs in exports could be viewed as providing a subsidy to exports. Exporters that internalise these costs in their exports would presumably view carbon tax rebates for exports as an export subsidy (Table 1).

There is a large volume of literature on the legality of the use of BTAs in the context of carbon taxes and related measures for internalising the costs of emissions, such as emissions trading (e.g. Astoria, 2015; Holzer, 2010; Howse, 2015; Ismer and Neuhoff, 2007; Kauffman and Weber, 2011; McLure, 2011; Pauwelyn, 2012; Tamiotti, 2011; Trachtman, 2017). The consensus of opinion seems to be that border tax adjustments (BTAs) linked to the internalisation of carbon costs might be judged to be consistent with WTO rules. But their implementation could be technically complicated and they run the risk of being challenged by suppliers of imports, particularly on the basis of a violation of the non-discrimination principle of the GATT.[17]

A major technical challenge in determining and applying a BTA is to determine the carbon emissions content of an import and to apply a tax that is commensurate with that content in order to 'level-the-playing-field' with domestic products that are subject to a carbon tax. Where an explicit carbon tax is applied domestically, it would seem to be relatively straightforward to apply a corresponding tax on imports, providing that the carbon content of imports can be determined.[18] In principle, the same could be done at the point of consumption, rather than importation, although this presents greater logistical challenges. It would require that imports be traced to the point at which consumption occurs (this is similar to the traceability challenge in tracking products for food safety purposes). The point of consumption might vary, since many imported agricultural products do not go straight to final consumers, but are used as intermediate inputs. Consequently, the tax adjustment for intermediate inputs would have to be applied at the point of first use. With information technology and the use of tracking mechanisms such as radio-frequency identification (RFID) and barcoding it is possible to trace agricultural

[17] Article III of the GATT specifies that BTAs should not be applied so as to afford protection to domestic production. In the absence of the application of an explicit tax on carbon domestically, the level set for a BTA could be contentious. Also a domestic regulation relating to emissions is not a tax, so a levy on imports designed to match compliance costs (e.g. additional costs imposed by cap and trade) is not strictly a BTA.

[18] The carbon generated in the production of a commodity is not 'contained' in the import, so strictly speaking the correct terminology is 'emissions generated in supplying the import to the importing country'. For the sake of brevity we use shorthand expressions such as 'carbon content' and 'embodied emissions'. Accurate measurement of emissions should take into account those generated in production and the transportation of the product to the point of importation. Embodied emissions for imports can vary depending on the mode of transportation from a given supplying country.

products (in principle) through the food system, although this can be challenging in complex supply chains.[19]

The use of BTAs is more complicated when measures other than a carbon tax are used domestically and implicit or explicit carbon taxes are applied in exporting countries. In the former case, it would be necessary to determine the per unit carbon-tax equivalent of domestic measures with respect to the domestic product. This is not necessarily straightforward. For example, if cap and trade is in use, the implied carbon tax would depend on the allocation of sectoral emissions allowances (the more constraining these are, the higher the implicit tax imposed on a sector), and on how sectoral allowances affect the final price of a product, taking into account the impact of the cap on direct and indirect (input) costs. Since agriculture is typically not included in cap-and-trade schemes, the prices of primary agricultural commodities would not be directly affected by these schemes, but input costs and the cost of processed products would be affected.[20] Thus the prices of foods, whose production and processing is energy intensive, would reflect carbon taxes on energy, even if emissions from production agriculture were not capped.[21]

The second case, in which carbon taxes are applied in exporting countries, presents additional challenges. In that case, the imposition of a BTA by the importer might constitute double taxation. If the exporter has fully internalised the cost of carbon in its products, the imposition of a tax on imports could clearly be viewed as protectionism. If the imported product had an embodied carbon tax less than that imposed domestically, the appropriate BTA should reflect the difference between the domestic carbon tax and that applied by the exporter. In both cases it would be necessary to determine the level of taxation on the product in import suppliers. This could be a major undertaking if imports are obtained from a variety of suppliers with different production systems, carbon intensities and carbon tax levels.

[19] The complexity can be illustrated with reference to beef in the United States of America. Beef is produced domestically from animals that are raised domestically and from feeder cattle that are imported (e.g. from the United Mexican States) and fed to slaughter weight. If a carbon tax were imposed at the point of consumption, this might need to reflect the potential difference in carbon content of beef raised wholly from domestic animals and from imported animals. Beef that is imported in frozen or chilled form (e.g. from Australia) would need to incur a tax based on product-equivalent emissions. Determining how much tax to apply to various categories of imports (e.g. carcasses, cuts with bone in, boneless etc.), while not impossible, is not straightforward.

[20] While agriculture is typically excluded from cap-and-trade schemes (except in so far that carbon credits can sometimes be purchased through such schemes as a result of the implementation of agricultural practices that reduce GHG emissions or sequester carbon), it has often been subject to production or marketing quotas. Such quantitative restrictions could be used in lieu of cap and trade to limit the production of carbon-intensive products, thereby mimicking the effect of a carbon tax. Agriculture is supported through output-enhancing subsidies in some countries. Blandford *et al.* (2018) show how a reduction in domestic support in the Kingdom of Norway could generate output and emissions reductions that parallel those with a carbon tax. Whether these sorts of policy approaches would qualify as domestic 'taxes' for the purposes of applying BTAs is an open question.

[21] The situation is even more complicated if instead of a tax, a reduction in domestic output designed to reduce emissions is achieved through the use of an output-reducing subsidy. In that case, the tax adjustment on imports would have to reflect the tax-equivalent impact of the subsidy on domestic output.

If the carbon tax applied in an exporting country exceeded that applied by an importer there is a case for a tax rebate on imports since this would promote the substitution of a more climate-friendly source of product for the domestic product (i.e. carbon reallocation). Despite the economic case for such an approach, it would be unlikely to be viewed favourably by domestic producers.

This brief review indicates that there are major technical challenges in determining the level of carbon tax adjustments. Tax adjustment at the border is less problematic technically than tax adjustment at the point of consumption, although the latter approach might (in principle at least) face a lower risk of challenge from trading partners on the basis of conformity with GATT provisions, particularly non-discrimination. Any approach to tax adjustment faces the challenge of determining carbon content (implied emissions) for domestic and imported products. This issue is addressed below in the context of product standards.

Import bans

Rather than attempting to deal with increases in imports due to differential internalisation of carbon costs through the use of tariffs and taxes, another approach might be to ban imports that are identified as high carbon or deleterious to national objectives for achieving a reduction in the carbon intensity of domestic production or consumption. Article XX of the GATT provides some exceptions for the use of border measures that are inconsistent with GATT principles. Exception (b) covers measures "necessary to protect human, animal or plant life or health" and exception (g) covers measures "relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption."[22] The use of measures relating to these exceptions has generated a limited number of dispute settlement cases (e.g. the Shrimp-Turtle case involving the United States of America, DS58). The ruling in that case (that a prohibition on imports of products that were caught in ways that could cause injury or death to sea turtles as a result of shrimp fishing was permissible in principle, but only if applied in a non-discriminatory way) seems to open the possibility that non-discriminatory import restrictions could be imposed under exception (g). However, following the line of reasoning above in connection with the use of tariffs and border taxes, the requirement for non-discriminatory application of restrictions would seem to limit severely the

[22] It should also be noted that an exemption is also provided under Article XI.2 for the use of quantitative restrictions on imports when quantitative restrictions are also applied to the production or marketing of a *like* product. See the discussion of *like* products below in the context of standards and carbon footprint.

practical usefulness of the exception.[23] This issue also has relevance for the use of product standards and labelling, as discussed below.

In conclusion, while the bottom-up approach to mitigation adopted in the Paris Agreement facilitated acceptance of the Agreement by signatories, the lack of a mechanism for the implementation of a global carbon price creates difficulties for the international trading system. Trade can lead to reallocation to lower-emitting sources of products, but it can also result in misallocation when the costs of emissions are not embodied in prices. While the use of border measures (taxes and import restrictions) might seem to offer a mechanism to correct for potential trade distortions due to differential carbon pricing, it is extremely challenging technically and opens up the possibility for protectionism. For these reasons, it seems preferable to search for alternative approaches to facilitate the transition to a lower-carbon food and agricultural system in the context of international trade.

The use of product standards and carbon labelling

The application of environmental standards to food products and the use of environmental labelling are becoming popular in many countries. To the extent that low-emission products can be differentiated from high-emissions products, a market could be created for low-emission food and agricultural products. This could help consumers to express their preferences for low-emitting products. Product standards and labelling could help to achieve differentiation in the same way as they have helped to create a market for food produced using 'organic' methods or under 'fair-trade' principles in some countries.[24]

Various categorisations can be used for climate-related standards, but the most popular is labelling based on carbon footprint. This typically corresponds to an estimate of the amount of carbon-equivalent emissions generated in the production, processing and transportation of a product. A number of carbon labelling initiatives have been launched since 2007. The majority of these use private voluntary standards (PVS) initiated and implemented by retailers. Retailers use PVS to address the perceived concerns of consumers about the environmental implications of their purchasing decisions. Labelling the carbon footprint of products informs buyers who are concerned about the potential

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[23] As a result, some authors have suggested that a specific acknowledgement by WTO members of the legitimacy of using climate policy measures under Article XX is needed in order to facilitate the implementation of the Paris Agreement, providing that requirements under article 3.5 of the UNFCCC are satisfied (e.g. Bacchus, 2016). That provision states that "measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade." As the discussion of the use of BTAs demonstrates, satisfying the article 3.5 requirement could be challenging.

[24] The promotion of the sourcing of wood and paper products that are produced through sustainable forest management is an example of the existing use of standards to influence purchasing decisions affecting AFOLU (see http://sustainableforestproducts.org/).

environmental impact of their purchasing decisions and keeps them as customers. Retailers may also be able to collect a price premium from consumers willing to pay for low-carbon goods. Early adoption of carbon monitoring systems may provide a first-mover advantage over competitors in the longer-term (MacGregor, 2010).

There are many challenges involved in measuring the carbon footprint of food and agricultural products. Ideally, one would wish to use Life Cycle Analysis (LCA) – i.e. the total amount of carbon-equivalent emissions associated with the full industrial process of producing and distributing a good. However, estimating LCA carbon content can be extremely difficult, particularly in the context of food and agriculture.[25] The LCA would need to take into account direct and indirect emissions in AFOLU associated with the production of the product and the additional emissions associated with the processing and transportation of products to the point of consumption.[26]

PVS are likely to impose additional costs on suppliers through their implications for process requirements and the need for monitoring and verification. They are likely to put small-scale producers at a particular disadvantage and can be challenging for producers in developing countries. However, it is difficult to argue that many PVS are an explicit discriminatory device against traded products, since they are also generally imposed on local suppliers. Local small-scale suppliers of food and agricultural products are often vocal in complaining about the difficulties that PVS can create for them. The difficulty arises if PVS are transformed into legislated standards (LS) and if these are structured in such a way as to discriminate against imports.

Standards and WTO agreements

The treatment of product standards is covered by the Agreement on Technical Barriers to Trade (TBTs). Several other WTO agreements, e.g. the Agreement on Sanitary and Phytosanitary Measures (SPS), may also be relevant. All the agreements indicate that no country should be prevented from taking measures necessary to ensure the protection of human, animal or plant life or health. The TBT Agreement extends this principle to the protection of the environment. All indicate that such measures should not be

[25] Consider the example of palm oil, much of which is produced in Asia. Palm plantations have been established in some areas by clearing forests and/or using carbon-rich soils. Both of these generate high emissions. In contrast, the production of a perennial crop can contribute to carbon sequestration. Given the inter-temporal implications of land clearing and cultivation for emissions, it is challenging to allocate net emissions to the current production of palm oil.

[26] Labelling based on simple concepts such as *Food Miles* – the distance that a product travels from the place of production to the point of sale to consumers – can be extremely misleading because of differences in emissions in production. Because of its exclusive focus on transportation, labelling based on Food Miles is likely to benefit local products and disadvantage internationally traded products, even if those products have a low-carbon footprint and their prices reflect the internalisation of carbon costs.

discriminatory across countries or constitute a disguised restriction on international trade.

The TBT Agreement focuses on ensuring equality of treatment in technical regulations for imported products and *like* products of national origin (Article 2:1). An important issue is whether the environmental provision would permit countries to impose technical regulations associated with the environmental characteristics of products, such as their carbon footprint. Would products that involve differing carbon footprints be considered to be like products? GHGs emitted in the course of production and delivery of a product to the point of importation or to consumers are not actually embodied in the product, so products that are imported and/or domestically produced with different carbon footprints cannot be considered to be unlike physically and hence potentially eligible for different regulatory treatment.

Suppose a country decided to require its farmers to use production practices that reduced GHG emissions. Could it then require that imports be produced using the same or comparable practices? A priori, the answer would seem to be no. The TBT does not allow countries to impose their production regulations or standards on other countries nor does it allow prohibitions on imports produced using a lower standard.[27] On the other hand, the ruling in the Shrimp-Turtle case seems to suggest that an exemption to this requirement might be possible under Article XX.

Suppose instead, a country required all domestic products to be labelled on the basis of their carbon footprint. Could it require the same for imported products? The answer is unclear. To the extent that labelling is required for both domestic and imported products, this would seem to be permitted under the TBT Agreement. But, since carbon footprint is not directly incorporated into products (but is a consequence of the method of production) the implications of the TBT Agreement requirement for the equal treatment for imports of *like* products is unclear. It certainly does not appear to be permissible that imports alone could be required to be labelled or that the requirements for labelling would likely result in discrimination.[28] The difficulties posed in accurately determining carbon footprint might lead to trade disputes, unless a mechanism for assessing this could be agreed between trading countries (this issue is examined below).

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[27] The European Union uses environmental standards (net reduction in carbon emissions) to discriminate among different biofuels and these standards may discriminate against certain types of imported products (Swinbank, 2009). Restrictions on trade (whether through import regulations or other measures) resulting from biofuels policies may be subject to challenge under existing international trade law (Lendle and Schaus, 2010).

[28] This was the essence of the ruling that the United States of America requirement for country of origin labelling (COOL) for beef and pork was inconsistent with Article II of the GATT (DS384). A key part of the ruling by the WTO Appellate Body was that the recordkeeping and verification requirements for imported livestock imposed a disproportionate burden on upstream producers and processors compared to the origin information conveyed to consumers. If the use of carbon labelling and verification were generally accepted as being legitimate (tacitly if not formally) by WTO members to meet their commitments under the Paris Agreement this might not be an issue, particularly if a fair and mutually acceptable system for labelling was applied to both domestic and imported products.

The issue of the consistency of climate-change policies with GATT rules surfaced directly through the expansion of the European Union Emissions Trading System (ETS) to cover aviation on January 1, 2012. This required all airlines to acquire and surrender allowances for carbon emissions generated by their flights. Originally it was proposed to apply the requirement to both European and non-European airlines and to flights between the European Union and non-European Union airports. The scheme proved to be controversial and is currently applied only to flights within the European Economic Area. While the original scheme may contravene some articles of the GATT, it might be justified under Article XX primarily since the measure is designed to protect an exhaustible natural resource (the atmosphere) and is implemented in conjunction with similar domestic measures (Bartels, 2012). If that were so, other environmental measures that meet the requirements of Article XX could also be judged to be permissible. The key requirement is that any measures shall not be applied "in a manner which would constitute a means of arbitrary of unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade."

In the context of carbon standards, a minimum requirement would seem to be that an objective approach to the quantification of carbon footprint and for the use of carbon labelling be developed and accepted internationally. As noted earlier, in many countries where product standards and labelling are used, this is often led by private companies. The SCM Agreement makes reference to the activities of 'private bodies' in the provision of subsidies, so that such activities are not entirely excluded from the ambit of WTO agreements. However, it remains to be seen to what extent specific activities undertaken by private entities that may provide a competitive advantage to domestic producers or disadvantage foreign suppliers could be subject to challenge under WTO agreements. The SCM specifies that this may be the case if "a government makes payments to a funding mechanism, or entrusts or directs a private body to carry out functions (for which a subsidy shall be deemed to exist) which would normally be vested in the government and the practice in no real sense differs from practices normally followed by governments." (Article 1.1 (iv)). The potential for the lack of transparency and harmonisation in the development and application of private standards in the context of carbon labelling poses problems for the international trading system, implying that a harmonised international approach would be needed.

Development and use of international standards

WTO agreements relating to standards place particular emphasis on the development of international standards. The SPS Agreement, for example, links the work of bodies such as FAO's Codex Alimentarius Commission and the International Office of Epizootics (OIE) explicitly to the Agreement. The role of international standardisation is also central to the TBT Agreement. This seems to suggest that an international approach to identifying the environmental characteristics of goods, such as their carbon footprint, would reduce the likelihood of challenge through the WTO to the use of standards or labelling requirements, and could also help to limit the tendency for the proliferation of private standards which could be costly and potentially trade distorting (Earley, 2009; Roberts and Josling, 2011).

The International Organization for Standardization (ISO), a non-governmental international organisation with a membership of 162 national standards bodies, has developed a series of standards for environmental labelling (the ISO 14020 series). ISO 14021 covers the evaluation and verification of claims relating to GHG emissions. It requires the use of verifiable LCA measurement for labels relating to carbon footprint with disclosure of the information on which the labelling is based to any interested party. ISO 14024 covers environmental labelling (ecolabels). It requires that 'procedures and requirements for environmental labelling programmes cannot be prepared, adopted or applied with a view to, or with the effect of, creating unnecessary obstacles to international trade' (ISO, 2012:18). It also requires that the criteria used for the label be based on sound scientific and engineering principles and appropriate data. ISO 14025 establishes the principles and procedures for the use of quantified environmental information based on LCA data (e.g. labels that disclose the carbon footprint of a product). Standards in the ISO 14064-14067 series further refine specifications for the quantification and reporting of GHG emissions. ISO 14067, currently under development, covers requirements and guidelines for the quantification and communication of the carbon footprint of products. The aim is to finalise this standard for publication in 2018 (Baumann, n.d.).

Unlike CODEX and the OIE, the ISO is not an inter-governmental organisation, although the technical committees that develop ISO standards often include a wide range of experts from industry as well as consumer associations, academia, NGOs and government. If countries could agree on the adoption of objective methods for determining implied emissions, such as those developed by the ISO, and these methods were seen to be applied fairly to domestic and imported products, countries might decide that it would be in their interests to pursue a collective approach to the use of carbon labelling (i.e. to refrain from challenging the use of labels based on accepted, objective and verifiable measurement methods through the dispute settlement procedure of the WTO).[29]

It might be noted that carbon labelling does not require that any information be provided on whether countries have taken steps through the use of carbon taxes or any other means to reduce the emissions intensity of products. Some countries might be low-carbon producers due to natural advantages (e.g. resource endowment or production methods).[30] Some countries might use a variety of policy measures to reduce carbon footprint, including non-tax measures. The internalisation of carbon costs does not

[29] One might consider that the use of objective methods to measure carbon content might also make it easier to use border tax adjustments. However, it is less likely that countries would agree to cooperate in developing such standards if these were to be used as the basis for taxing or restricting imports rather than for labelling.

[30] As noted earlier, with a uniform price for carbon, prices of goods and services will reflect comparative advantage in carbon efficiency among countries rather than absolute advantage.

guarantee that consumption will result in a carbon-minimising outcome, since prices reflect not only carbon costs, but also other costs.[31] To the extent that increased carbon efficiency is reflected in a reduced carbon footprint, labelling provides a way to capture the carbon-competitive standing of food and agricultural products and to guide consumption in the direction of low-carbon choices. It will also support carbon reallocation through international trade by providing a non-price competitive advantage to international suppliers of low-carbon products. Naturally, for labelling to be effective, consumers should be adequately informed about the implications of the choices they make.

As with organic or animal-welfare-friendly versus conventional products, consumers can always choose to ignore climate-friendly product characteristics and make their purchasing decisions largely on the basis of price. They must be willing to pay a possible price premium for low-carbon products. The only way to ensure that price and carbon labelling work in a mutually supportive way (i.e. to promote emissions minimisation in global food and agriculture) is for the prices of labelled products to reflect fully and credibly the internalised cost of carbon involved in their production and delivery to consumers, and for consumers to take carbon footprint into consideration in making their purchases. Some analysts have argued that it will be difficult to achieve the reduction in emissions intensity in the food system necessary to constrain the increase in global average temperature to less than 2^0C during the current century without changes in food consumption (e.g. Wollenberg *et al*., 2016). A major advantage of carbon labelling is that it can help to promote such a shift in consumption.

Despite this, labelling is not a panacea. Low-income consumers may be unable to exercise choice for low-carbon, high price products even if they would like to do so due to their lack of income. And there is still a need to focus on policies for reducing the carbon footprint of agricultural production by promoting lower carbon intensity (e.g. through the adoption of technological advances and increases in technical and managerial efficiency in production). But the use of a cooperative approach in the use of carbon labelling could play a part in the transition to a low-carbon economy.

[31] Given the prevalence of domestic support policies in agriculture, prices may also be distorted by subsidies unrelated to climate-change objectives.

Climate measures in bilateral and regional trade agreements

An increasing number of regional trade agreements (RTAs) have incorporated environmental provisions, with the most common types of provisions focusing on environmental cooperation (George, 2014). The WTO notes that the number and reach of RTAs have increased over the years and that all WTO members are parties to at least one such agreement. Over 400 RTAs covering trade in goods and services have been notified to the WTO since 1994 (WTO, Regional Trade Agreements).

Ever since the conclusion of the North American Free Trade Agreement (NAFTA) in 1994, the United States of America has included environmental provisions in its RTAs. While the NAFTA environmental provisions were in the form of a side agreement (the North American Agreement on Environmental Cooperation), environmental provisions have been incorporated directly into agreements from the FTA with the Hashemite Kingdom of Jordan in 2001 onwards and have been progressively strengthened in terms of their scope and enforcement. Lattanzio and Fergusson (2015) observe that the United States of America Free Trade Agreements (FTAs) have increasingly incorporated cooperation and dispute settlement (DS) provisions relating to the environment.

The European Union – Republic of South Africa Trade, Development and Cooperation Agreement of 1999 was the first European Union trade agreement to include a separate article on the environment. From the European Union – Republic of Korea Free Trade Agreement (2010) onwards environmental provisions in European Union FTAs have become broader in scope and more specific in their stipulations. Postnikov (2015: 3) observes that the European Union's approach to the use of environmental standards in trade agreements has focused on "soft enforcement… as the European Union continues to eschew sanctions as a way to ensure compliance, and emphasises consultation and dialogue." However, CETA (the European Union –Canada Comprehensive Economic and Trade Agreement) includes commitments for cooperation between Canada and the European Union on trade-related environmental issues. The European Union has placed particular stress on the involvement of stakeholders, including NGOs, in the implementation of environmental provisions in recent RTAs (e.g. the creation of the CETA Civil Society Forum).

A comprehensive set of provisions relating to the environment is contained in the Trans – Pacific Partnership (TPP) Agreement that was signed on 4 February 2016. The TPP originally included twelve countries (Australia, Brunei Darussalam, Canada, the Republic of Chile, Japan, Malaysia, the United Mexican States, New Zealand, the Republic of Peru, the Republic of Singapore, the Socialist Republic of Viet Nam and the United States of America). On his first day in office, President Trump signed an executive order removing the United States of America from the TPP by 2019. At the time, the Agreement had not been ratified by the United States of America Congress. The remaining signatories resumed negotiations on and the Agreement came into force in March 2018.

Article 20 of the TPP includes a suite of environmental provisions and commitments that aim to provide a similar level of environmental protection across the signatories to the Agreement. The objectives of the provisions "are to promote mutually supportive trade and environmental policies; promote high levels of environmental protection and effective enforcement of environmental laws; and enhance the capacities of the Parties to address trade-related environmental issues, including through cooperation (20.2)." Countries are free to establish their own laws for environmental protection and agree not to waive or derogate from them in order to promote trade or investment between the parties. The TPP confirms national commitments to multinational environmental agreements and specifically provides for the use of a dispute resolution procedure for non-compliance with commitments under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The TPP predates the Paris Agreement and does not contain any specific references to GHG emissions or to climate change. However, the provision with respect to observing commitments under multinational environmental agreements could apply to the Paris Agreement. Article 20.11 in the TPP Agreement recognises the role that "flexible and voluntary mechanisms" can play in protecting the environment and natural resources; encourages the development of criteria for evaluating environmental performance under voluntary mechanisms, particularly those based on international standards, recommendations or guidelines and best practices, but that do not treat a product less favourably on the basis of origin (20.11.3). These provisions could support initiatives such as those described earlier for the development of environmental standards through the International Organization for Standardization (ISO). Cooperation is encouraged among the parties on environmental protection and sustainable development, particularly in the context of transition to a low-emissions economy; deforestation and forest degradation is listed as an area for potential transnational cooperation (20.15.2). Combating illegal logging and associated illegal trade and the protection of natural areas, including wetlands, are specifically included under provisions relating to conservation and trade.

In conclusion, regional trade agreements could play a supporting role to the Paris Climate Agreement, by fostering cooperation on climate-mitigation measures in the context of freer trade.

Border measures in the context of adaptation to the effects of climate change

Climate change is likely to result in greater variability in the production of many crops (IPCC, 2014) and this could imply greater international price variability.[32] Pronounced upward fluctuations in international market prices in 2006–08 and 2010–11, generated significant food security concerns, particularly in developing countries.[33] One the challenges posed by climate change is how to adapt to greater price instability. This needs to be viewed in the context of the range of domestic and border measures that can influence such instability.

International trade can exert an inter-temporal stabilising effect on the prices of agricultural commodities in domestic markets. In a closed economy, weather-induced (exogenous) fluctuations in domestic production have to be absorbed through adjustments in domestic consumption and (for storable commodities) through adjustments in stocks. Prices will fluctuate in line with the balance between production plus stocks, and demand. Other things being equal, the lower the responsiveness of demand to changes in prices and the smaller the volume of stocks relative to variations in domestic production, the larger the amplitude of potential fluctuations in prices. The broadening of the market created by an open economy provides a buffer against exogenous fluctuations in domestic supply and exerts a stabilising effect on domestic prices. However, for a country that is not subject to significant weather-induced fluctuations in domestic production, trade openness can introduce greater variability in its domestic prices. The price stabilising effect of trade globally does not necessarily mean that prices in an individual country will be stabilised as the result of trade.

Blandford (1983), in focusing on variations in international grain prices, identified two ways in which variability in domestic and international agricultural markets are linked. The first is through the *transmission* of short-run variability in domestic production to international markets through variations in imports or exports. The transmission effect is influenced by the extent to which exogenous variations in domestic production (e.g. due to weather) are absorbed by changes in domestic stocks and consumption. The greater the response of domestic stocks and consumption to fluctuations in domestic production, the smaller the transmission of those fluctuations to international markets through changes in the volume of trade.

[32] Other factors can contribute to variations in international commodity prices (e.g. changes in demand), but these often tend to have longer-run systemic impacts on prices than short-term fluctuations in production induced by changes in weather conditions. Longer-term upward pressures on food prices created by climate-induced changes in yields require different policy responses than border measures (e.g. policies relating to productivity).

[33] While much of the focus has been on price spikes for agricultural commodities as a result of their implications for consumers in developing countries, excessive falls in international prices can create problems for producers in open economies.

The second linkage is through the *absorption* of international price variability in domestic markets. This is reflected by the extent to which short-term variations in international prices (e.g. from season to season) are absorbed in the domestic market through variations in the volume of trade, with consequent adjustments in domestic consumption and stocks.

From the perspective of international prices, other things being equal, the lower the transmission elasticity and the higher the absorption elasticity, the greater the potential contribution of a country to international price stability. Conversely, other things being equal, the higher the transmission elasticity and the lower the absorption elasticity, the greater a country's potential contribution to the short-term variability of international prices.[34]

Both domestic agricultural policies and trade policies play a key role in transmission and absorption effects. The use of trade to manage short-term domestic fluctuations in supply, for example, by increasing subsidised exports to dispose of surpluses created by short-term increases in production, and by decreasing subsidised exports in response to short-term reductions in domestic production will contribute to increased international market variability. Similarly, the operation of counter-cyclical import policies – reducing imports in response to above average harvests and increasing imports in response to below average harvests will add to variability in international markets.[35] The key issue is not whether exports or imports vary as a result of domestic production, but whether the resulting variation in trade is unrelated to international prices. The more open an economy to international markets, the more exports or imports respond to fluctuations in international prices rather than to fluctuations in domestic production, the more that economy will contribute to international price stability.

The Agreement on Agriculture (AoA) under the WTO places some restrictions on the use of domestic and trade measures that influence the degree of openness of domestic agricultural markets and the linkage between domestic and international prices.

There are limitations on the value of export subsidies and the volume of subsidised exports. These limitations prevent unlimited subsidisation of exports, which could add to the transmission effect in international markets, although they do not prevent the counter-cyclical use of subsidies within the agreed limits on subsidisation.[36]

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[34] The magnitude of the effects naturally depends on country size. Countries that have significant volumes of exports or imports compared to the volume of world trade will, other things being equal, have a larger potential impact on international price stability. However, high transmission and low absorption can have a cumulative effect across small countries. Weather-induced fluctuations in production can often be positively correlated across countries in a given geographical region, thereby potentially enhancing the transmission effect regionally.

[35] Imports can be managed in a counter-cyclical manner in various ways, e.g. through purchases by a government agency, import licensing or through counter-cyclical import subsidies.

[36] There are no limits on the use of import subsidies. If these are used to reduce the impact of increases in world prices on domestic consumer prices, they will also reduce absorption and contribute to upward pressure on world prices.

There are agreed limits on maximum tariffs that can be applied on imports through the AoA. Imports subject to bound tariffs can vary in response to international prices, which will facilitate the absorption effect and exert a dampening effect on international price variability. However, where maximum bound tariffs are high, countries can vary applied tariffs in a counter-cyclical manner up to the bound rate in order to stabilize the price of imports. Since this partially insulates the domestic market from changes in international prices (reduces the absorption effect), it can contribute to greater variability in international prices. The partial insulation provided by TRQs (i.e. unresponsiveness of imports to international prices when the quota is binding) will reduce absorption and contribute to international price variability, particularly when the over-quota tariff is high (i.e. there is a large margin between the price of imports below and above the quota).[37]

Limits are imposed on the total value of the most trade-distorting forms of agricultural support under the amber box category through the AoA. While these limitations may constrain the ability to provide counter-cyclical payments (i.e. increased price and income support when prices fall) the implications for transmission and absorption in domestic markets and hence for international price variability are unclear. If the way in which support is provided reduces the responsiveness of domestic supply or demand to exogenous shifts in production, this is likely to add to transmission and reduce absorption.

Finally, public stockholding for food security purposes is covered under Annex 2 of the AoA. If stocks are managed as specified under Annex 2, this should reduce the transmission of domestic production variability to world markets, since it implies that the accumulation and release of stocks will be inversely related to market prices.[38] However, government stockholding policies typically focus on stabilising domestic prices in conjunction with the use of border measures that regulate imports and exports. To the extent that the combined effect of these measures is to insulate the domestic market from prices in international markets, they will contribute to international price instability.

Some types of policies that can also contribute to international price variability are not covered by WTO agreements. The most prominent example is the use of export taxes, as distinct from export subsidies. Ad valorem export taxes will reduce the impact of short-

[37] The use of counter-cyclical tariffs and the partial insulation provided by a TRQ can both mimic the effects of a variable import levy, i.e. insulate domestic prices from variations in international prices, at least over a range of prices.

[38] The provisions are as follows: "The volume and accumulation of such stocks shall correspond to predetermined targets related solely to food security. The process of stock accumulation and disposal shall be financially transparent. Food purchases by the government shall be made at current market prices and sales from food security stocks shall be made at no less than the current domestic market price for the product and quality in question." These provisions imply that in an open economy public management of stocks could contribute to international price stability by virtue of the linkage between domestic and international prices.

run fluctuations of international prices on domestic prices since the level of the tax increases with international prices and vice versa. This will weaken absorption.[39]

The use of quantitative restrictions on exports can also contribute to international price instability, particularly if restrictions are imposed when world prices are rising. Such restrictions are covered by Article XI of the GATT, but Article 2a provides for an exemption for "export prohibitions or restrictions temporarily applied to prevent or relieve critical shortages of foodstuffs or other products essential to the exporting contracting party." As Howse and Josling (2012: 11) observe: "it has been relatively easy, therefore, for countries to justify export restrictions as a means of relieving critical food shortages." Most RTAs prohibit the use of export restrictions between RTA members but also allow for exceptions under Article XI of the GATT, with a few making specific reference to foodstuffs (OECD, 2015).

It is difficult to determine the overall effect of domestic and trade policies for agriculture on international price variability. Martin and Anderson (2011) provide some empirical analysis of the contribution of border measures to the sharp increases in international prices during the periods 1973-74 and 2006-08. They conclude that border measures that insulated domestic markets from changes in international prices (i.e. reduced absorption) accounted for 45 percent of the increase in international rice prices in 2006-08 and 30 percent of the increase in the international price of wheat in 2005-08. If the likelihood of price spikes for basic agricultural commodities increases as a result of climate change, the use domestic and trade policies that amplify the impact of such spikes is clearly cause for concern. As noted earlier, access to international markets can be a key factor in helping to stabilise domestic markets when short-term fluctuations in production occur. In this sense, trade can play an important role in adaptation to the effects of climate change. But if policies accentuate fluctuations in international prices, this will undermine the role of trade in adaptation by amplifying the effect of climate-induced fluctuations in production on international prices and by destabilising markets that are open to trade.

Some of the modifications to WTO disciplines that have been discussed in the context of the Doha Round of negotiations could enhance the role of international trade in adaptation to the effects of climate change.[40] For example, elimination of export subsidies, reductions in bound tariffs and reductions in amber box support could strengthen the linkage between domestic and international prices, thereby helping to stabilise international prices in the face of fluctuations in global production. In contrast, the introduction of a special safeguards mechanism that would allow developing countries to impose additional tariffs when the total volume of imports of an agricultural product exceeds a specified level, or when import prices from a particular supplier fall

[39] Note that ad valorem import tariffs have the opposite effect, i.e. accentuating the impact of short-term fluctuations in international prices on domestic prices. Specific import tariffs (fixed tariffs per unit of imports) or fixed export taxes have no impact on the short-term transmission of fluctuations in international prices to domestic markets.

[40] To the extent that reductions in subsidies and trade barriers facilitate carbon reallocation (as discussed earlier), this can also play a role in global mitigation.

below a specified price could increase insulation from short-term declines in international prices and this could intensify downside movements in prices. Changes in stockholding policies that result in greater insulation of domestic prices from international prices could also contribute to increased global price instability.

Proposed Doha Round modifications would not cover the use of export taxes or impose greater discipline on the use of export bans. Howse and Josling (2012: 25) observe: "Given the resort to export restrictions in periods of high prices and their tendency to further exacerbate price hikes, any attempt to streamline the international institutions devoted to food security must grapple with how best to establish a procedure that ensures that countries cannot undertake such measures without due consideration to their impact on other countries." The experience of the period 2007-09 when there were substantial increases in the international prices of basic foodstuffs, such as rice, and widespread use of export prohibitions and restrictions has led to calls for greater discipline in the use of such measures. While it may be difficult to obtain agreement on strengthening disciplines in the context of WTO agreements, greater transparency in the use of export measures would help to foster international price stability, particularly during periods when prices are tending to increase. Transparency could be enhanced by strengthening notification processes on the use of export restrictions through the WTO and by taking into account the impact of the use of such measures on other countries (particularly the least-developed countries and net food-importing developing countries). The impact of export restriction measures could also be reduced if there is agreement that they should only be used as a last resort and then only for a limited period of time.

As was observed in the discussion of national policies and their relationship to global mitigation in agriculture, the impact of domestic and border measures on the functioning of international agricultural markets and on food prices in the presence of climate change is complex. Policies used to address the impact of climate change that seem to make sense from a national perspective may not be efficient from a global perspective. In general, global mitigation and adaptation is facilitated by trade and the efficient operation of international markets, but countries must be willing to pursue national policies that are consistent with this role.

Special and differential treatment

It is generally accepted that the agricultural sector in many developing countries will face major challenges in mitigating and adapting to climate change. Countries located in tropical and sub-tropical zones are likely to experience significant increases in average temperatures and increased climatic instability. Some areas will face major reductions in precipitation and critical water problems, whereas others could face increases in precipitation and higher flood risk. Estimates suggest that over 10 percent of the arable land in developing countries could be affected by climate change (Keane *et al*., 2009). Much of the projected growth in the world's population is in developing countries and this will place additional pressures on land and natural resources. There will be an urgent need for mitigation and adaptation in developing countries, while at the same time increasing productivity in the agricultural sector. While it may be extremely difficult to achieve a reduction in the total emissions of GHGs from agriculture in developing countries (and globally for that matter), it will be vital to reduce the intensity of emissions – emissions per unit of agricultural production – at the same time as increasing efficiency in the use of scarce natural resources, particularly water.

Meeting requirements to reduce the carbon footprint of traded agricultural products could prove challenging for developing countries, particularly for least-developed countries. The Paris Agreement includes provisions for financial and technical assistance for developing countries in meeting their obligations under the Agreement and stresses the role of international cooperation. However, it is important to note that developing countries (especially in Asia and Africa) are the largest and the fastest growing source of AFOLU emissions, accounting for an estimated 92 percent of global AFOLU emissions in 2012-2014 (Blandford and Hassapoyannes, 2018). Consequently, it will be vital for developing countries to play their part in mitigation in AFOLU if the aim of the Paris Agreement to limit the increase in global average temperature to less than 2^{0}C during this century is to be achieved.

The Climate Agreement recognises differentiated responsibilities and capacities and the role of financial and technical assistance in helping developing countries meet mitigation and adaption objectives. WTO agreements recognise the role of special and differential treatment (SDT) for developing countries. In recent years, emphasis has been placed on helping developing countries to take advantage of opportunities to expand exports in order to contribute to economic development. Aid for Trade can be strengthened to both enhance climate change resilience in the agricultural sectors of developing countries and enable them to cope with the challenges and opportunities that will be created for the international trading system by climate change (Keane *et al*., 2009). In the context of climate policy, SDT implies that developing countries, particularly least-developed countries, could be accorded special treatment in terms of the stringency of obligations and periods of adjustment, for example in meeting product standards relating to carbon footprint. Priority could also be placed on capacity building and the provision of technical assistance in effecting a transition to a lower-carbon food and agricultural system.

Potential priority areas relating to trade are capacity building for implementing technical standards and assistance with carbon accounting for certification. At the same time, labelling could be used as a mechanism to promote the sale of sustainable, low-carbon food products from developing countries in importing countries.[41]

International trade can stimulate the production of high-emitting agricultural products. A notable case is palm oil, the production of which in Asia has been associated with deforestation and the use of high-emitting peatland.[42] In contrast, trade can play an important supporting role in helping developing countries make the transition to lower emissions intensity in food and agriculture. But in the longer run, this transition has less to do with trade and more to do with the transfer and adoption of improved technology and the use of appropriate domestic policies that are land-sparing and stimulate improvements in agricultural productivity in developing countries, so that emissions per unit of output are reduced (Blandford and Hassapoyannes, 2018).

Developing countries, particularly the least-developed countries, may face challenges in adapting to increased instability in international markets for basic agricultural commodities. International agreements, such as the International Wheat Agreements from 1949-62 and the International Grains Agreement of 1967 embodied multilateral supply and purchase commitments between exporting and importing countries and provisions to stabilise prices, but the approach was unsuccessful in the face of recurrent surpluses of wheat in international markets. Since the first food aid convention of 1967, the focus has been on the provision of food aid to developing countries to meet emergency needs or to further longer-term development objectives. Developing countries, particularly the least-developed countries, will naturally be concerned about the availability of sufficient aid to meet weather-induced emergencies in supply. Adaptation will need to focus on domestic measures to increase the resilience of agriculture and the economy more generally. But expanded provisions for food aid to meet short-term production shortfalls will also be needed, targeted specifically to the poorest and most vulnerable countries.

[41] Labelling on the basis of *food miles* is likely to have the opposite effect due to distance from markets; the promotion of *local foods* may also have negative implications for products supplied by developing countries.
[42] This is a case in which effective domestic policies, in particular policies governing land use, are required to deal with an environmental externality.

References

Astoria, R. (2015). 'Design of an international trade law compliant carbon border tax adjustment', *Arizona Journal of Law and Environmental Policy* 6: 491-534.

Baumann, T. (undated). *Primer: ISO climate-related standards, updates and choosing the right committee*. GHG Management Institute. Washington, D.C.

Bacchus, J. (2016). *Global rules for mutually supportive and reinforcing trade and climate regimes.* E15 Expert Group on Measures to Address Climate Change and the Trade System – Policy Options Paper. E15 Initiative. International Centre for Trade and Sustainable Development (ICTSD) and World Economic Forum, Geneva.

Bartels, L. (2012). *The inclusion of aviation in the EU ETS: WTO law considerations*. Trade and Sustainable Energy Series, Issue Paper No. 6, International Centre for Trade and Sustainable Development, Geneva.

Bennetzen, E.H., Smith, P. and Porter J.R. (2016), 'Decoupling of greenhouse gas emissions from global agricultural production: 1970-2050', *Global Change Biology* 22: 763-781, Wiley Online, http://dx.doi.org/10.1111/gcb.13120.

Blandford, D., Gaasland, I. and Vårdal, E. (2018). 'Greenhouse gas emissions, land use and food supply under the Paris Climate Agreement – policy choices in Norway', *Applied Economic Perspectives and Policy,* ppy011, https://doi.org/10.1093/aepp/ppy011.

Blandford, D. and Hassapoyannes, K. (2018). *Agriculture's role in global GHG mitigation towards the below 2^{0}C warming objective: potential, means and economic implications.* OECD Food, Agriculture and Fisheries Papers, No. 112, OECD Publishing, Paris. http://dx.doi.org/10.1787/da017ae2-en

Blandford, D., Gaasland, I., Hassapoyannes, K. and Vårdal, E. (2015). *The implications of international trade for GHG mitigation policies in agriculture.* Contributed Paper presented at the 89th Annual Conference of the Agricultural Economics Society, University of Warwick, England. Available at: https://www.researchgate.net/publication/275409918

Blandford, D. (1983). 'Instability in world grain markets', *Journal of Agricultural Economics* 34(3): 379-395.

de Gorter, H. and Sheldon, I. (2000). 'Issues in the administration of tariff-rate quotas in the Agreement on Agriculture in the WTO: An introduction', *Agricultural and Resource Economics Review* 29: 54-57.

Earley, J. (2009). *US trade policies on biofuels and sustainable development*. ICTSD Programme on Agricultural Trade and Sustainable Development, Issue Paper No.18, International Centre for Trade and Sustainable Development, Geneva.

FAO. (2016). *The agriculture sectors in the Intended Nationally Determined Contributions: Analysis*, by Stohmaier, R., Rioux, J., Seggel, A., Meybeck, A., Bernoux, M., Salvatore, M., Miranda, J. and Agostini, A. Environment and Natural Resources Management Working Paper No. 62, Rome.

FAO. (2000). *Multilateral trade negotiations on agriculture; A resource manual*. Rome. http://www.fao.org/docrep/003/X7351e/X7351e00.HTM

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. and Tempio, G. (2013). *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities.* Food and Agriculture Organization of the United Nations (FAO), Rome.

George, C. (2014). 'Environment and regional trade agreements: emerging trends and policy drivers', *OECD Trade and Environment Working Papers* 2014/02, OECD Publishing, Paris.

Holzer, K. (2010). 'Proposals on carbon-related border adjustments: prospects for WTO compliance', *Carbon and Climate Law Review* 1: 51-64.

Howse, R. (2015). 'Non-tariff barriers and climate policy: Border-adjusted taxes and regulatory measures as WTO-compliant climate mitigation strategies' in C. Herrmann *et al*. (eds.), *European Yearbook of International Economic Law* 6: 3-18.

Howse, R. and Josling, T. (2012). *Agricultural export restriction and international trade law: a way forward*. International Food & Agricultural Trade Council, Washington, D.C.

IPCC. (2014). *Climate Change 2014: Synthesis Report*, *Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], Geneva.

IPCC. (2006). 'Volume 4: Agriculture, Forestry and Other Land Use', in *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Intergovernmental Panel on Climate Change, Geneva.

Ismer, R. and Neuhoff, K. (2007). 'Border tax adjustment: a feasible way to support stringent emission trading', *European Journal of Law and Economics* 24: 137-164.

ISO. (2012). *Environmental labels and declarations: How ISO standards help*. Geneva.

Kauffman, C. and Weber, R.H. (2011). 'Carbon-related border tax adjustment: mitigating climate change or restricting international trade?', *World Trade Review* 10(4): 497-525.

Keane, J., Page, A., Kergba, A. and Kennan, J. (2009). *Climate change mitigation and developing country agriculture: An overview of expected impacts, adaptation and mitigation challenges and funding requirements*. ICTSD-IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No. 2, International Centre for Trade and Sustainable Development, Geneva, and International Food & Agricultural Trade Policy Council, Washington D.C.

Lattanzio, R.K and Fergusson, I.F. (2015). *Environmental provisions in Free Trade Agreements (FTAs)*. IF10166. May 28. Congressional Research Service, Washington D.C.

Lendle, A. and. Schaus, M. (2010). *Sustainability criteria in the EU renewable energy directive: Consistent with WTO rules?* ICTSD Project on WTO Jurisprudence and Sustainable Development. Information Note No.2, International Centre for Trade and Sustainable Development, Geneva..

MacGregor, J. (2010). *Carbon concerns: How standards and labelling initiatives must not limit agricultural trade from developing countries*. ICTSD-IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No. 3, International Centre for Trade and Sustainable Development, Geneva, and International Food & Agricultural Trade Policy Council, Washington D.C.

MacLeod, M., Eory, V., Gruère, G. and Lankoski, J. (2015). 'Cost-effectiveness of greenhouse gas mitigation measures for agriculture: a literature review.' *OECD Food, Agriculture and Fisheries Papers*, No. 89, OECD Publishing, Paris.

Martin, W. and Anderson, K. (2011). 'Export restrictions and price insulation during commodity price booms', *American Journal of Agricultural Economics* 94(2): 422-427.

McLure Jr., C.E. (2011). 'The GATT-legality of border adjustments for carbon taxes and the cost of emissions permits: a riddle, wrapped in a mystery, inside an enigma', *Florida Tax Review* 11(4): 221-294.

Nelson, G., Palazzo A., Ringler C., Sulser T. and Batka M. (2009). *The role of international trade in climate change adaptation*. ICTSD-IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No. 4, International Centre for Trade and Sustainable Development, Geneva, and International Food & Agricultural Trade Policy Council, Washington D.C.

OECD. (2015). 'Regional trade agreements and agriculture'. *OECD Food, Agriculture and Fisheries Papers*, No 79, OECD Publishing, Paris.

Pauwelyn, J. (2012). 'Carbon leakage measures and border tax adjustments under WTO law', in D. Prevost and G. Van Calster (eds.), *Research Handbook on Environment, Health and the WTO,* Edward Elgar, Cheltenham, UK.

Postnikov, E. (2015). 'Can environmental standards in trade agreements be an effective instrument of EU external environmental governance?' *Erasmus+ Policy Brief* 05/2015. European Commission, Brussels.

Roberts, D. and Josling, T. (2011). *Tracking the implementation of internationally agreed standards in food and agricultural production*. Policy Brief. International Food & Agricultural Trade Policy Council, Washington D.C.

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E.A., Haberl, H., Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N.H., Rice, C.W., Abad, C. R., Romanovskaya, A., Sperling, F. and Tubiello, F. (2014).

Agriculture, Forestry and Other Land Use (AFOLU) in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, New York.

Swinbank, A. (2009). *EU Support for Biofuels and Bioenergy, Environmental Sustainability Criteria, and Trade Policy*. ICTSD Programme on Agricultural Trade and Sustainable Development, Issue Paper No.17, International Centre for Trade and Sustainable Development, Geneva.

Tamiotti, L. (2011). 'The legal interface between carbon border measures and trade rules', *Climate Policy* 11: 1202-1211.

Trachtman, J.P. (2017). 'WTO law constraints on border tax adjustment and tax credit mechanisms to reduce the competitive effects of carbon taxes', *National Tax Journal* 70(2): 469-493.

Wollenberg, E., Richards, M., Smith, P., Havlík, P., Obersteiner, M., Tubiello, F.N., Herold, M., Gerber, P., Carter, S., Reisinger, A., van Vuuren, D.P., Dickie, A., Neufeldt, H., Sander, B.O., Wassman, R., Sommer, R., Amonette, J.E., Falcucci, A., Herrero, M., Opio, C., Roman-Cuesta, R.M., Stehfest, E., Westhoek, H., Ortiz-Monasterio, I., Sapkota, T., Rufino, M. C., Thornton, P.K., Verchot, L., West, P.C., Soussana, J-F., Baedeker, T., Sadler, M., Vermeulen, S. and Campbell, B.M. (2016). 'Reducing emissions from agriculture to meet the 2^0C target', *Global Change Biology* 22: 3859-3864.

World Trade Organisation. Regional Trade Agreements. https://www.wto.org/english/tratop_e/region_e/region_e.htm. Accessed December 7, 2017.

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