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An Assessment of Carousel Value-Added Tax Fraud in The European Carbon Market

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Abstract: The literature on the European Union Emission Trading System (EU ETS) is by now very rich. Much is known about the efficiency, the effectiveness, and the environmental and distributional impacts of the EU ETS. Less, however, is known about the carousel value-added-tax (VAT) fraud phenomena in the European carbon market. This article evaluates the welfare effects of carousel VAT fraud in the EU ETS using a computable general equilibrium (CGE) analysis. According to our findings, if VAT fraud occurs in the EU ETS, the effects on welfare for the EU Member States are negative, with welfare loss significantly higher than the VAT fraud value. This article also discusses the reverse charge mechanism that EU Member States could adopt to reduce the VAT fraud phenomena in the European carbon market.

Keywords: computable general equilibrium modeling, emission trading, reverse charge, value-added tax fraud, welfare
JEL Classification: C68, H26, K34, Q58

1 Introduction

By signing the Kyoto Protocol in 1997, a number of industrialized countries, the so-called *Annex 1* countries, committed themselves to reducing their greenhouse gas emissions relative to their 1990 levels (UN, 1998). Therefore, in 2000 the European Union (EU) Commission launched the European Climate Change Programme (ECCP), a continuous multi-stakeholder consultative process, which serves to identify cost-effective ways for the EU to meet its Kyoto commitments, to set priorities for action, and to implement concrete measures. One of the main elements of this program was the establishment of the European Union Emissions Trading Scheme (EU ETS), regulated by Directive 2003/87/EC of the European Parliament and Council of 13 October 2003 (EC, 2003) and recently

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amended by Directive 2009/29/CE of the European Parliament and Council of 23 April 2009 (EC, 2009).

The EU ETS is a cap-and-trade system for transactions of European Union Allowances (EUAs) and is implemented as a downstream system; i. e. the users (rather than the producers and importers of fossil fuels) will be obliged to hold emission allowances. Under the EU ETS, trading is to occur between individual emitters, which comprise more than 11,000 installations in 30 different countries (the 27 EU Member States and Iceland, Lichtenstein and Norway), worth EUR 103 billion in 2009. In this regime, the EU Member States have three important tasks. First, they have to decide the quantity of emissions that should be allocated to the installations participating in the ETS. Second, they have to draw up a list of all installations that are subject to emissions trading. Third, they have to decide how to allocate the total quantity among individual installations. The EU ETS started on 1 January 2005 and is being implemented in three main phases. The first trading phase – nicknamed the "warming-up phase" or 'learning phase' – covered the years 2005–2007. The scheme covered only CO_2 emissions from high-emitting installations in the power and heat generation industry and in selected energy-intensive industrial sectors. It established free trade in emission allowances across the EU and the necessary infrastructure for monitoring, reporting and verifying actual emissions from the businesses covered. The Directive 2003/87/EC sets some general rules according to which the allocation has to be made, but there is substantial scope for national priorities. In fact, the decisions have to be set down in a national allocation plan (NAP). The second phase covered the years 2008–2012, the five-year period during which the EU and its Member States must comply with their emission targets under the Kyoto Protocol. In this phase, new industrial sectors, such as glass and petrochemical production, have been introduced. Emissions of nitrous oxide from the production of nitric acid have also been included in this phase. Furthermore, the Commission has cut the volume of emissions allowances permitted in phase 2 to 6.5 % below the 2005 level. The third phase covers the period from 2013 to 2020. It requires an increased proportion of installations to buy their emissions allowances via auction rather than receiving free allocations. It includes the abolition of the NAPs and adoption instead of a centralized emissions cap. It also includes CO_2 emissions from civil aviation. The main aim of this phase is to encourage long-term investment in emissions reductions.

The literature on EU ETS is by now very rich (i. e. Endres and Ohl, 2005; Betz and Sato, 2006; Kemfert et al., 2006; Silva and Zhu, 2008; Woerdman et al., 2008; Eichner and Pethig, 2009; Wettestad, 2009; Heindl and Voigt, 2012; Jones et al., 2013; Skjærseth, 2013) and different aspects have been addressed: efficiency, effectiveness, and environmental and distributional consequences.

Branger et al. (2013) report a detailed survey of the major issues related to EU ETS. Criticisms include insufficient carbon emissions reduction, competitiveness losses and unfair distributional effects. Furthermore, during the first trading phase over the period 2005–2007, value-added-tax (VAT) carousel fraud emerged as a major threat to the EU ETS market (Estrada and Marquez, 2010; Kogels, 2010; Nield and Pereira, 2011; Wolf, 2011; Branger et al., 2013). The carousel VAT fraud in EUAs is a form of "missing trader fraud", well known in the trade of goods. Fraudulent traders, making use of stolen VAT identification numbers, buy carbon credits tax-free in one EU Member State, then sell them in another Member State at a mark-up by including VAT. After one or more transactions, they disappear without having paid the VAT to the government. It is estimated that up to 90 % of the volume of the market for tradable emission rights was the result of fraudulent activities, leading to a loss of tax revenues of approximately 5 billion euros (Europol, 2009).

Despite the relevance of the VAT carousel fraud in the EU carbon market, this phenomena has not been systematically addressed in the literature. The present article stands as a novel research that aims at evaluating the welfare effects of the VAT carousel fraud in the EU ETS.

We use a computable general equilibrium (CGE) model for the quantitative impact assessment. A CGE model describes an economy in equilibrium with endogenously determined relative prices and quantities. An assessment of the usefulness of CGE models for policy analysis can be found in Shoven and Whalley (1992) and Hertel (1997). More specifically, we use the GTAP-E model, developed by Burniaux and Truong (2002), and the GTAP database (Dimaranan and McDougall, 2006). This model and database have been widely used for the analysis of emissions trading (i. e. Nijkamp et al., 2005; Dagoumas et al., 2006; Kemfert et al., 2006).

In our policy analysis, we first simulate the EU ETS in the first phase (2005–2007); then we investigate the question of what the welfare effects would be if VAT fraud occurs in the European carbon market. Our findings show that there is an increasing relationship between VAT fraud and welfare loss, but we also identify a diminishing marginal effect of VAT fraud on welfare loss. The negative welfare change is significantly higher than the VAT fraud value. The article concludes with a discussion on a reverse charge mechanism that the EU Member States could adopt to reduce the phenomena.

The paper is organized as follows: the second section explains the VAT carousel fraud phenomena; the third section reports the modeling framework, database and calibration; the fourth section explains the policy scenarios; the fifth section reports the simulation results; the sixth section discusses the reverse charge mechanism aimed at eliminating the risk of VAT fraud and, in the last section, we draw concluding remarks.

2 The VAT fraud

Carousel fraud is nothing more than stealing VAT from the tax authorities. It all boils down to charging VAT on sales and collecting this VAT from customers. These amounts are then embezzled instead of being paid to the tax authorities.

Carousel fraud takes advantage of the workings of the VAT scheme to hit the system itself. At the heart of each carousel fraud is the so-called "missing trader": this is a company controlled by the "ringmaster" (the mastermind behind the fraud). Carousel fraud is not limited to trade in tangible goods (mobile phones, computer equipment, perfumes, and other high value, low volume goods, often used due to their ease of transportation and the high VAT revenues that can be generated from them); intangibles can also be used to set up a VAT carousel (Wolf, 2011).

Carousel fraud is a serious problem imposing a threat to government income of the EU countries. Following Efstratios (2012), a typical example, reported in Figure 1, would be one in which a company (X, or missing trader), registered for

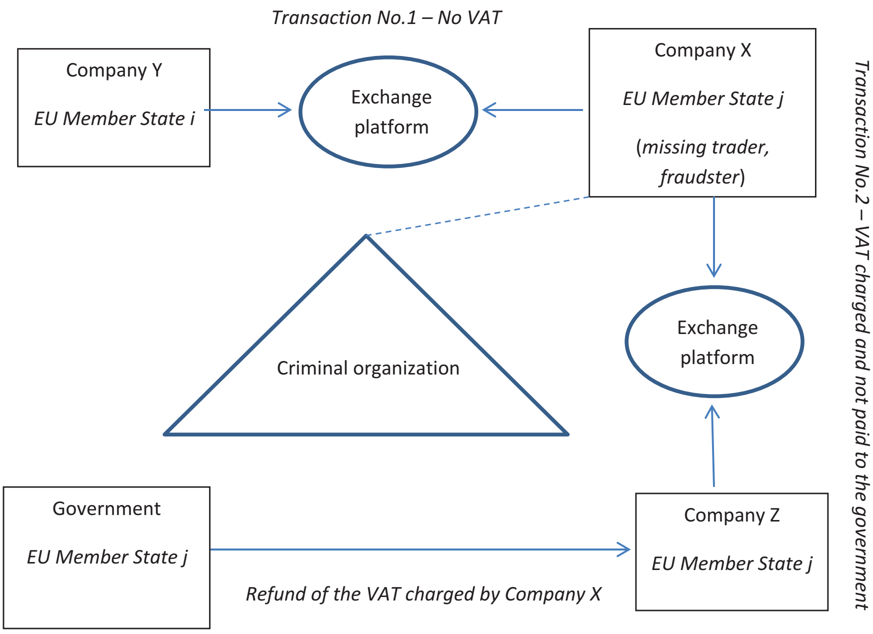


Figure 1: The VAT carousel fraud.

VAT in any EU Member State, buys goods from another company (Y) of another EU Member State and then sells those goods to a company (Z) located in the same EU Member State as the missing trader (company X). Company X is controlled by a criminal organization that may be located in any EU Member State. As the first operation between company X and Y constitutes an intra-Community transaction, it is exempt from VAT, and the purchaser (X) does not incur any VAT from the seller (Y). However, the subsequent transaction between the buyer (Z) and the seller (X), residing in the same EU Member State, constitutes a supply of goods liable and non-exempt, and the selling company (X) charges the VAT to the purchaser (Z). Thus, having charged VAT on the internal transaction, the selling company (X) quickly disappears or declares itself insolvent without paying its dues to the Treasury, fraudulently obtaining the amount of VAT due. For its part, the purchaser (Z) subsequently applies to deduct the VAT, with the consequent loss to the corresponding Treasury. In fact, as a result, the government does not collect the VAT charged by the seller company (X) to buyer company (Z), while at the same time refunding this amount to the buyer. In this representation, we consider only one transaction of VAT fraud, but the crime often includes a complex web of transactions and the existence of many fraudsters, as the crime is quick to execute and leaves little documentary evidence. Thus, VAT fraud is difficult to detect and prosecute (Nield and Pereira, 2011).

Although large individual fraud cases are discovered now and then, it is not clear exactly how much the EU countries lose on carousel fraud each year. In 2009, the European Commission published a study on the VAT gap in the EU countries during the period 2000–2006. This VAT gap was calculated as the difference between the theoretical VAT liability for the economy as a whole and the accrued VAT receipts in a given year. In the report produced by Reckon LLP, following a study commissioned by the European Commission, Directorate-General for Taxation and Customs Union, the yearly EU-wide VAT gap is estimated to range around 100 billion euros. This figure does not represent the actual level of fraud, as it also includes losses as a result of tax avoidance structures and regular insolvencies. However, it does seem to provide an upper limit for the losses as a result of VAT fraud, including carousel fraud.

The nature of emissions rights makes the carbon market a perfect tool for the execution of fraud. In fact, emissions allowances are not real physical goods, but represent intangible, tradable environmental property rights or regulatory property rights, as defined by Cole (2002). In particular, the potential for large trading volumes together with their intangible nature enables quick operations with very large quantities and, hence, allows the theft of huge sums of money. Through (electronic) exchanges, carbon credits can be traded instantly, avoiding the cost and delay involved in physical delivery (Wolf, 2011). The carousel fraud in emissions trading is a relatively simple form of "missing trader fraud": fraudulent traders, making use of stolen VAT identification numbers, buy carbon credits tax-free in one EU Member State, then sell them in another Member State at a markup by including VAT and then (after one or more transactions, including those with bona fide traders) disappear without having paid the VAT to the Treasury of the country in which the sale was made (Kogels, 2010). By trading emissions allowances via a series of "carousels", the amount of VAT that can be fraudulently acquired is increased each time the allowances are circulated among this carousel of conspirator companies.

In this scheme, sometimes transactions were apparently concluded at a loss. It does not matter, as the real profit is the embezzled VAT. With tax percentages ranging from 15 % to 25 %, the VAT offers a comfortable profit margin. The missing trader's only interest is to make as much trade as possible. As a result, it creates a situation where you have a party that is willing to buy at relatively high prices and sell at relatively low prices. In an electronic marketplace, such a party can generate huge trading volumes in the blink of an eye (Nield and Pereira, 2011; Wolf, 2011).

VAT fraud on the EU ETS was first suspected due to an unprecedented rise in EUA spot trading volumes towards the end of 2008. This peaked on June 2^{nd} 2009, when a record of 19.8 million metric tons of CO_2 was traded on the Bluenext spot exchange (the largest carbon spot exchange in Europe). It appeared that allowances for immediate delivery were purchased by a company with little business activity and few assets, and VAT charged to other companies without its subsequent declaration. Rumors that these volumes were being driven by VAT carousel fraud prompted Bluenext to close its spot exchange. Before allowing the exchange to open again, the French authorities imposed a zero-rated VAT status on domestic trades of emission allowances. It estimated that up to 90 % of the volume of the market for tradable emissions rights was the result of fraudulent activities, leading to a loss of tax revenues of approximately 5 billion euros for a number of EU Member States (Europol, 2009; Nield and Pereira, 2011; Wolf, 2011).

3 Modelling framework and data calibration

In this study we use the GTAP-E model, developed by Burniaux and Truong (2002). The GTAP-E model is a comparative static, multi-commodity, multi-region CGE model with the assumptions of perfect competition, market equilibrium and open economy. The GTAP-E is a refinement of the standard GTAP model (Hertel, 1997), where "E" jointly stands for energy and environment. In fact, it incorporates energy substitution, carbon emissions from the combustion of fossil fuels, as well as a full accounting of carbon tax revenues and a more specific treatment of carbon emissions trading into the standard GTAP model. As we use a general equilibrium multi-sectorial and multi-regional trade model, we can take account of the important interactions between changes in fuel prices, fuel, and factor substitutions, and therefore we can evaluate the welfare effects of any policy change taking into account not only the direct effects derived by using partial equilibrium analysis, but also the indirect effects derived using a CGE modelling framework. The GTAP-E model has been widely used to discuss energy and climate policy (i. e. Nijkamp et al., 2005; Dagoumas et al., 2006; Kemfert et al., 2006).

On the consumption side, there is a representative household in region *r*, whose Cobb-Douglas utility function allocates expenditures between private consumption (C), government consumption (G), and savings expenditure (S) as follows:

$$U_r = C_r^{\alpha_{C,r}} G_r^{\alpha_{G,r}} S_r^{\alpha_{S,r}} \tag{1}$$

with $\alpha_{C,r}$, $\alpha_{G,r}$ and $\alpha_{S,r}$ income shares and $\alpha_{C,r} + \alpha_{G,r} + \alpha_{S,r} = 1$

The constrained optimizing behavior of the household in region *r* for private consumption is represented by a non-homothetic Constant Difference of Elasticity (CDE) expenditure function for the set of goods and services. The CDE, introduced by Hanoch (1975), is based on the assumption of implicit additivity and allows for a richer representation of income effects on the demand system. A Cobb-Douglas sub-utility function is employed for government spending. In this case the expenditure shares are constant across all commodities. Furthermore, we use the so-called Armington assumption, which treats goods and services produced in different regions as qualitatively different, that is, heterogeneous rather than homogeneous, across countries (Armington, 1969).

Savings are exhausted on investment and capital markets are assumed to be in equilibrium only at the global level. In fact, a hypothetical world bank collects savings from all regions and allocates investments so as to achieve equality of changes in expected future rates of return:

$$\Delta\eta_r = \Delta\eta \tag{2}$$

where $\Delta\eta_r$ and $\Delta\eta$ are the percentage changes, respectively, in region's rate of return and global rate of return.

On the production side, producers receive payments for selling consumption goods to private households and the government, intermediate inputs to other producers, and investment goods to the savings sector. Under the zero profit assumption employed, these revenues must be precisely exhausted on expenditures for intermediate inputs and primary factors of production. The nested production technology exhibits constant returns to scale and every sector produces a single output. The technology is simplified by employing the Constant Elasticity of Substitution (CES) functional form:

$$y_{i,r} = \left(\sum_{j=1}^{n} \theta_j x_{j,r}^{1-\frac{1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad (3)$$

where, in region r, $y_{i,r}$ is the production of the good i, $x_{j,r}$ is the input j, θ_j is a non-negative parameter, with $\sum_{j=1}^{n} \theta_j = 1$, and σ is the elasticity of substitution. CES functions are usually used to allow substitution between primary factors and intermediate inputs.

Next, the energy composite is combined with capital to produce an energy-capital composite, which is in turn combined with other primary factors in a value-added-energy nest through a CES structure. The energy commodities are first separated into 'electricity' and 'non-electricity' groups. Some degree of substitution is allowed within the non-electricity group, as well as between the electricity and the non-electricity groups. Both intermediate and final products from different regions are considered to be imperfectly substitutable with each other (Armington, 1969).

All factor inputs (land, labor, capital and natural resources) are assumed to be fully employed and immobile across regions. Capital and labor are perfectly mobile across sectors and, hence, they earn the same market return regardless of where they are employed; land and natural resources are sluggish to adjust and their returns may differ across sectors.

Every economy includes government interventions. Private households and the government not only spend their available income on consumption goods, but also pay taxes to the regional household. In the case of the government, taxes consist of consumption taxes on commodities. In the case of private households, taxes consist of consumption taxes and income tax net of subsidies. The firms have to pay taxes to the regional household. These value flows represent taxes on intermediate inputs and production taxes net of subsidies. Also trade-generated tax revenues and subsidy expenditures are included in the GTAP model. All taxes levied in the economy always accrue to the regional household.

In GTAP-E, CO_2 emissions are derived from energy volume data through fixed coefficients. Coefficients are fuel specific, but not region or sector specific. In calculating the emissions of CO_2 it is assumed that every use of fossil energy goods leads to CO_2 emissions, except for the use of crude oil by refineries to produce petroleum products. Only when these petroleum products are used (combusted), is CO_2 emitted in the atmosphere. For the rest, no account is taken of energy goods used as non-energy feedstocks. Changes in regional CO_2 emissions are calculated as CO_2-weighted changes in domestic production of fuels plus changes in CO_2-weighted imports minus changes in CO_2-weighted exports of fuels. CO_2 reduction policies can be implemented in GTAP-E through taxes and (tradable) quotas. In the model, taxes and quotas are completely equivalent, i. e., given a certain reduction target, CO_2 taxes are identical to CO_2 permit prices. Because both tax revenues and the revenues of the sale of permits are directly transferred to the regional household, there are also no differences in wealth effects between the two policy instruments. GTAP-E offers the possibility for regions to engage in emissions trading.

The regional income, Y_r, is equal to the sum of the endowment income (net of depreciation), $Y_{e,r}$, the indirect tax revenues, $T_{ind,r}$, the emission trading revenues, E_r, and the carbon tax revenues, $C_{tax,r}$:

$$Y_r = Y_{e,r} + T_{ind,r} + E_r + C_{tax,r} \tag{4}$$

Finally, the GTAP-E model respects Walras' law, which is a principle in general equilibrium theory asserting that budget constraints imply that the values of excess market demands (or, conversely, excess market supplies) must sum to zero. The macroeconomic accounting identity that must be respected by the model is that the national savings (S_r) minus investment (I_r) is identically equal to the net exports (NX_r), that is:

$$S_r - I_r = NX_r \tag{5}$$

As global exports (X) need to be equal to global imports (M) such that

$$\sum_r X_r = \sum_r M_r \tag{6}$$

global investment will be equal to global savings by Walras' law:

$$\sum_r S_r = \sum_r I_r \tag{7}$$

The GTAP-E model is calibrated using version 6 of the GTAP database (available at https://www.gtap.agecon.purdue.edu/databases/v6/default.asp), which consists of 57 commodities/sectors and 87 regions, including the 27 European Member states (Dimaranan and McDougall, 2006). The GTAP database is a cross-country data set of international trade flows and national input-output tables. All of the information in the database is reported in values converted to

US dollars adjusted to year 2001 values. The regional and sectoral aggregation used for this study is shown in the Appendix. The GTAP database has been integrated with CO_2 emissions data provided by Ludena (2007).

4 Policy design

Our policy analysis has been specifically designed for a welfare assessment of VAT fraud in the European carbon market.

Following Kemfert et al. (2006), we first apply the "*business-as-usual*" (BAU) emissions for the period leading up to 2007 for each of the sectors. Then we simulate the first phase of EU ETS (2005–2007) by allowing all designated sectors of each region to trade in emissions with each other. Emissions trading is also allowed across national borders of the EU Member States. If the permit price is higher (lower) than the domestic abatement cost, the difference between allocated CO_2 allowances (emission targets) and CO_2 emissions level is positive (negative) and the country is a net seller (buyer) with positive (negative) emissions trading revenues.

The emissions trading revenues (E_r) are calculated as follows:

$$E_r = (1 + t_r)P_r Q_r \tag{8}$$

where t_r is the *ad-valorem* tax (VAT) rate, P_r and Q_r are, respectively, the market price and the total amount of emissions permits exchanged (equal to the difference between allocated CO_2 allowances and CO_2 emissions level).

If no VAT fraud occurs, the change in income from emissions trading for the regional household in country r, ΔY_r, will be equal to the sum of the change in income due to the emissions trading revenues, $E_r = (1 + t_r)P_r Q_r$, and the change in income for the government (equal to the difference between the VAT charged and then paid by the seller to the government, $t_r P_r Q_r$, and the refund to the buyer, $t_r P_r Q_r$), that is:

$$\Delta Y_r = E_r + t_r P_r Q_r - t_r P_r Q_r = E_r \tag{9}$$

If VAT fraud occurs, the regional household receives emissions trading revenues (E_r), but the VAT charged is not paid by the seller to the government that refunds the buyer. Thus, the change in income for the regional household in country r, ΔY_r, will be equal to the sum of the change in income due to emissions trading revenues, $E_r = (1 + t_r)P_r Q_r$, and the change in income for the government (equal to the refund to the buyer, $t_r P_r Q_r$), that is

$$\Delta Y_r = E_r - t_r P_r Q_r \tag{10}$$

The difference between eqs (9) and (10) gives us the amount of the VAT fraud due to emissions trading in country r, V_r, that is:

$$V_r = t_r P_r Q_r \tag{11}$$

Given E_r and t_r, and using eq. (8), it follows that $P_r Q_r = \frac{E_r}{1+t_r}$ and the VAT fraud can thus be rewritten as follows:

$$V_r = \frac{t_r E_r}{1+t_r} \tag{12}$$

Furthermore, as the transaction between the seller (missing trader) and the buyer occurs in the same country and, hence, the VAT fraud is related to the country's transaction and occurs if the country is a net seller or a net buyer. Thus, the VAT fraud is calculated on the absolute value of the emissions trading revenues as follows:

$$V_r = \frac{t_r |E_r|}{1+t_r} \tag{13}$$

which is simulated by decreasing the indirect tax revenues to government.

5 Simulation results

Table 1 reports the results in terms of allocated CO_2 allowances and the emissions trading revenues, valued at market price, of the simulation related to the first phase of EU ETS. We find that Spain is the main seller of emissions permits, with a share of the total positive emissions trading revenues of almost 52 %, followed by Estonia, with a share of 28 %. Amongst the main buyers, there is the United Kingdom with a share of the total negative emissions trading revenues of about 76 %, followed by Bulgaria and Latvia, with a share of 10 %. The revenues from EU ETS are, generally, higher for the countries with the highest number of allocated CO_2 allowances. However, some countries with a high number of allocated CO_2 allowances become the main buyers of emission permits, such as the United Kingdom. This is because in the United Kingdom the permit price is lower than the domestic abatement cost, so in this country it is more efficient to buy CO_2 allowances than to reduce CO_2 emissions levels.

In terms of welfare, we compute the equivalent variation as a money metric measure of welfare and we find that positive (negative) emissions trading revenues mainly yield welfare gains (loss). For Portugal, we find welfare loss associated with positive emissions trading revenues, but we can consider Portugal as an

Table 1: First phase of the EU ETS (2005–2007).

Country		Allocated CO_2 allowances (million tonnes per year)	Emissions trading revenues ($ millions)	Equivalent variation ($ millions, change w.r.t. *BAU* scenario)	Type
1 aut	Austria	33	37.5	48.0	Net Seller
2 bel	Belgium	62.1	58.3	82.6	Net Seller
3 dnk	Denmark	33.5	−43.4	−57.4	Net Buyer
4 fin	Finland	45.5	6.1	13.8	Net Seller
5 fra	France	156.5	1132.1	1449.6	Net Seller
6 deu	Germany	499	187.9	247.2	Net Seller
7 gbr	United Kingdom	245.3	−1446.4	−1733.6	Net Buyer
8 grc	Greece	74.4	317.7	391.2	Net Seller
9 irl	Ireland	22.3	8.2	20.9	Net Seller
10 ita	Italy	223.1	34.8	32.4	Net Seller
11 lux	Luxembourg	3.4	0	0.0	Net Seller
12 nld	Netherlands	95.3	17.4	42.6	Net Seller
13 prt	Portugal	38.9	0.7	−29.0	Net Seller
14 esp	Spain	174.4	4951.5	5597.4	Net Seller
15 swe	Sweden	22.9	63.9	87.9	Net Seller
16 bgr	Bulgaria	42.3	−224.6	−35.5	Net Buyer
17 cyp	Cyprus	5.7	0	−0.3	Net Seller
18 cze	Czech Republic	97.6	5.9	25.1	Net Seller
19 hun	Hungary	31.3	0.2	1.3	Net Seller
20 mlt	Malta	2.9	0	−0.3	Net Buyer
21 pol	Poland	239.1	0.3	4.3	Net Seller
22 rom	Romania	74.8	35.1	41.0	Net Seller
23 svk	Slovakia	30.5	−2.7	−0.5	Net Buyer
24 svn	Slovenia	8.8	0.8	−0.4	Net Seller
25 est	Estonia	19	2698.0	173.2	Net Seller
26 lva	Latvia	4.6	−174.2	−25.8	Net Buyer
27 ltu	Lithuania	12.3	44.4	36.6	Net Seller

outlier due to the small value of the emissions trading revenues, that is, on the one hand, they have a positive income effect on welfare (direct effect); on the other hand, they have negative effects on welfare due to terms of trade and allocative efficiency (indirect effects) that offset the income effect. Also for Slovenia, which is a net seller, a negative equivalent variation occurs; but in this case the sum of direct and indirect effects does not yield significant welfare loss.

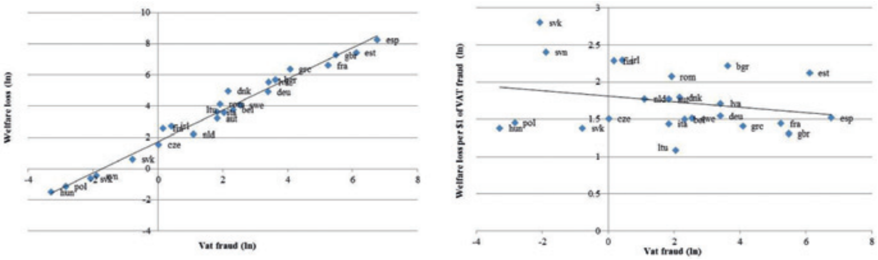
Further, we investigate the question of what the welfare effects would be if the VAT fraud were to occur in the European carbon market (Table 2). We have excluded from this policy scenario three small countries (Luxembourg, Cyprus

Table 2: EU ETS VAT fraud.

Country		Standard tax rate (%)	VAT fraud ($millions)	Equivalent variation ($ millions, change w.r.t. 1st Phase)	Welfare loss per $1 of VAT fraud ($)
aut	Austria	20	6.2	−24.8	4.0
bel	Belgium	21	10.1	−43.3	4.3
dnk	Denmark	25	8.7	−143.2	16.5
fin	Finland	24	1.2	−13.1	11.1
fra	France	20	188.7	−749.5	4.0
deu	Germany	19	30.0	−135.6	4.5
gbr	United Kingdom	20	241.1	−1420.9	5.9
grc	Greece	23	59.4	−583.9	9.8
irl	Ireland	23	1.5	−15.2	9.9
ita	Italy	22	6.3	−36.9	5.9
nld	Netherlands	21	3.0	−9.0	3.0
prt	Portugal	23	0.1	−0.5	4.2
esp	Spain	21	859.4	−3845.1	4.5
swe	Sweden	25	12.8	−57.9	4.5
bgr	Bulgaria	20	37.4	−298.3	8.0
cze	Czech Republic	21	1.0	−4.8	4.7
hun	Hungary	27	0.0	−0.2	6.0
pol	Poland	23	0.1	−0.3	5.6
rom	Romania	24	6.8	−62.4	9.2
svk	Slovakia	20	0.5	−1.9	4.1
svn	Slovenia	22	0.2	−0.6	4.2
est	Estonia	20	449.7	−1670.2	3.7
lva	Latvia	21	30.2	−252.9	8.4
ltu	Lithuania	21	7.7	−35.2	4.6

and Malta), because they have zero emissions trading revenues. The VAT fraud has been obtained by applying the standard tax rates as defined in the EU Member States. Although the GTAP model applies the effective tax rate, we have applied the standard tax rate, because the effective tax rates (equal to 5 %, on average) are much lower than the standard tax rates and, hence, a downward bias may occur if we apply the effective tax rates.

Our findings in Table 2 show that the VAT fraud yields welfare loss with respect to the first phase of the EU ETS. There is an increasing relationship between the VAT fraud and the welfare loss (Figure 2(a)). The highest welfare loss occurs in Spain among the seller countries and in the United Kingdom among the buyer countries. The welfare loss is expected to be approximately equal to $6 (on average) per $1 of VAT fraud in the EU countries, which implies



(a) (b)

Figure 2: Welfare loss vs. VAT fraud.

a welfare decrease of almost 20 % (on average) with respect to the first phase of the EU ETS. The relationship between the VAT fraud and the welfare loss per $1 of VAT fraud is decreasing (Figure 2(b)). This means that there is a diminishing marginal effect of the VAT fraud on welfare loss.

Table 3 reports the welfare decomposition. Following Hanslow (2000) and Huff and Hertel (2000), we decompose the welfare change in a series of components. In particular, we identify three contributions to welfare change: terms of trade, allocative efficiency and income change. The contribution to welfare change in terms of trade is due to changes in the prices received from an economy's exports relative to the prices paid for its imports. The contribution to welfare change in terms of allocative efficiency is due to the change in the allocation of productive resources. The contribution to welfare change in terms of income is due to the change in the income of the regional household. The sum of the welfare contributions (in percentage) must be equal to 100 %. The analysis of the results on welfare decomposition shows common results for the EU countries. The terms of trade effects, equal to 64 % on average, substantially prevail over the others. The lowest contribution is due to income change (3.5 % on average). In the case of Bulgaria we find that the contributions to welfare change in terms of allocative efficiency and income are negative, because the welfare change due to VAT fraud in this country is due to the sum of two opposite effects: (i) increase of net exports that yields welfare loss and negative income change; (ii) allocation of productive resources so as to increase efficiency that yields welfare gains and positive income change. The total effect on welfare is negative, obtained by the contribution of terms of trade that prevail over the other two contributions (allocative efficiency and income). This means that the welfare loss in terms of trade effects is slightly reduced by the welfare gains due to the contributions in terms of allocative efficiency and income rather than reinforced as occurs in the other countries.

Table 3: Welfare decomposition, contribution in % to the equivalent variation (EU ETS VAT fraud).

Country		Terms of trade	Allocative efficiency	Income
aut	Austria	54.1	42.8	3.2
bel	Belgium	83.7	12.3	4.1
dnk	Denmark	48.1	48.7	3.3
fin	Finland	44.4	52.5	3.1
fra	France	45.8	51.2	3.0
deu	Germany	56.2	40.6	3.2
gbr	United Kingdom	78.8	16.1	5.1
grc	Greece	65.6	30.4	4.0
irl	Ireland	49.2	44.4	6.4
ita	Italy	58.4	38.5	3.2
nld	Netherlands	73.0	22.9	4.1
prt	Portugal	47.3	49.6	3.1
esp	Spain	73.8	21.9	4.4
swe	Sweden	49.3	47.2	3.4
bgr	Bulgaria	114.8	−5.5	−9.3
cze	Czech Republic	63.3	32.5	4.2
hun	Hungary	55.8	40.8	3.3
pol	Poland	52.2	44.8	3.0
rom	Romania	81.8	14.6	3.6
svk	Slovakia	21.9	73.4	4.7
svn	Slovenia	78.8	16.0	5.2
est	Estonia	58.0	36.6	5.4
lva	Latvia	94.3	1.4	4.3
ltu	Lithuania	91.1	4.6	4.3

6 The reverse charge mechanism

On March 2010 the European Commission adopted Directive 2010/23/EC, allowing EU countries to apply a reverse charge mechanism on carbon emissions allowances.

xThe reverse charge mechanism means that no VAT is charged by the supplier to taxable customers who, in turn, become liable for the payment of the VAT; the buyer only, not the seller, is responsible for surrendering VAT on domestically traded emissions allowances. Thus, a reverse charge system obligates the buyer to pay the VAT on purchased allowances directly to the authorities, rather than including the VAT in the purchase price and leaving the seller responsible for the payment of this amount to the authorities. In practice, taxable persons with a full rights of deduction input VAT purchase would be able to declare and deduct VAT at the same time without any actual payment to the treasury. These revisions have enabled Member States to apply a reverse charge system mechanism to the VAT treatment of emissions allowances, a measure that, if implemented consistently across the EU, would prevent the possibility of VAT fraud on the EU ETS. However, this Directive only created the option for Member States to temporarily adopt this regime. Since it entered into force on April 5, 2010 many Member States have failed to implement this reverse charge system. A reverse charge will stop carousel fraud with these specific carbon credits, but it is only effective if all EU countries apply this measure. Otherwise, fraudsters continue to move to countries where the reverse charge measure does not apply.

7 Conclusions

The EU ETS is an important policy instrument to achieve climate policy objectives, such as the Kyoto commitments. But the past years have seen VAT carousel fraud emerge as a major threat in the European carbon market. Thus, this article has investigated the welfare effects due to the existence of VAT fraud in the EU ETS applying a CGE model. Our findings show that there will be welfare gains from the elimination of VAT fraud in the European carbon market, but the welfare change is not equal amongst the EU Member States. In fact, some countries may gain more than others from the elimination of VAT fraud. This result must be related to the heterogeneity of the EU Member States. However, from this analysis we can draw three common results, which are striking. Firstly, there is an increasing relationship between the VAT fraud and the welfare loss. Secondly, there is a diminishing marginal effect of the VAT fraud on the welfare loss. Thirdly, the welfare loss is higher than the VAT fraud; in fact, we find that the welfare loss is six times (on average) higher than the value of the VAT fraud.

Different legislative measures may be applied to reduce the welfare loss due to VAT fraud in the EU carbon market. For example, the French authorities have imposed a zero-rated VAT status on domestic trades of emission allowances after the Bluenext spot exchange case. The European Commission has adopted Directive 2010/23/EC, allowing EU countries to apply a reverse charge mechanism on carbon emissions allowances. However, to be successful, the reverse charge mechanism and any other legislative measure requires law harmonization amongst the European countries. To this aim, the EU Commission has developed the Monitoring and Reporting Regulation (MRR), by Commission

Regulation (EU) No.601/2012 of 21 June 2012, and the Accreditation and Verification Regulation (AVR), by Commission Regulation (EU) No.600/2012 of 21 June 2012, recognizing that robust, transparent, consistent and accurate monitoring and reporting with accreditation and verification of greenhouse gas emissions are essential for the effective operation of the EU Emissions Trading System (EU ETS) and thus the EU's key mechanism for cost-effective reduction of greenhouse gas emissions. Finally, Commission Regulation (EU) No 389/2013 of 2 May 2013 has established a Union Registry, which provides a harmonized basis to transfer allowances across the EU Member States.

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Appendix

Table 4: Categorization of regions and sectors.

Regions	Description	Sectors	Description
aut	Austria	coa	Coal
bel	Belgium	oil	Oil
dnk	Denmark	gas	Gas
fin	Finland	omn	Minerals nec
fra	France	tex	Textiles
deu	Germany	wap	Wearing apparel
gbr	United Kingdom	ppp	Paper products, publishing
grc	Greece	p_c	Petroleum, coal products
irl	Ireland	crp	Chemical, rubber, plastic prod
ita	Italy	nmm	Mineral products nec
lux	Luxembourg	i_s	Ferrous metals
nld	Netherlands	nfm	Metals nec
prt	Portugal	fmp	Metals products
esp	Spain	mvh	Motor vehicles and parts
swe	Sweden	ele	Electronic equipment
bgr	Bulgaria	ome	Machinery and equipment nec
cyp	Cyprus	omf	Manufactures nec
cze	Czech Republic	ely	Electricity
hun	Hungary	wtr	Water
mlt	Malta	cns	Construction
pol	Poland	roe	Rest of the economy
rom	Romania		
svk	Slovakia		
svn	Slovenia		
est	Estonia		
lva	Latvia		
ltu	Lithuania		
row	Rest of World		