# Food Prices and the Multiplier Effect of Export Policy*

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**Abstract**

This paper studies the relationship between export policy and food prices. We show that, when individuals are loss averse, food exporters may use trade policy to shield the domestic economy from large price shocks. This creates a complementarity between the price of food in international markets and export policy. Specifically, unilateral actions by exporting countries give rise to a "multiplier effect": when a shock in the international food market drives up (down) its price, governments respond by imposing export restrictions (subsidies), thus exacerbating the initial shock and soliciting further export activism. We test this theory with a new dataset that comprises monthly information on trade measures across 125 countries and 29 food products for the period 2008-10, finding evidence of a multiplier effect. Global restrictions in a product (i.e. the share of international trade covered by export restrictions) are positively correlated with the probability of imposing a new export restriction on that product, especially for staple foods. Large exporters are found to be more reactive to restrictive measures, suggesting that the multiplier effect is mostly driven by this group. Finally, we estimate that changes in export restrictions had a positive and significant impact on increases of international food prices during 2008-10. These findings contribute to inform the broader debate on the proper regulation of export policy within the multilateral trading system.

*Keywords*: Loss aversion; Export policy; Multiplier effect; Food crisis; WTO

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# 1 Introduction

International food prices have been a key policy concern in recent times. Figure 1 illustrates the extent to which the 2006-2007 and the 2008-2010 periods differ from the preceding two decades, justifying the labeling of "food crises". While a large number of factors may have contributed to the sudden and rapid spikes in food prices (e.g. reduction in key food stocks, increasing demand in emerging economies, financial speculation, changes in monetary policy in leading economies), several observers have pointed out that trade policy may be part of the problem of escalating prices.[1] Export policy, in particular, has been on the spotlight. As Pascal Lamy, the Director General of the World Trade Organization (WTO), put it: "*export restrictions play a direct role in aggravating food crises*" (Lamy, 2011a). Figure 2 corroborates this view by showing a positive correlation between export restrictions and the global price of food in 2009 and 2010[2] and motivates our key research question: how does export policy interact with food prices? Any proposal of reform of the current rules presiding the multilateral trading system needs to depart from a better understanding of this issue.

INSERT FIGURES 1 AND 2 HERE

Our view can be very simply stated. When trade policy aims at shielding the domestic market from unfavorable developments in the world market, export measures have a "multiplier effect" on international prices. Specifically, high prices of food may trigger a series of export restrictions that exacerbate the rise of the world price that, in turn, feeds into even more restrictive policies. Similarly, low prices of food may lead exporting governments to set export promotion measures that lower the world price and induce further support to exports. This paper presents a micro-founded model of this interaction between export policy and food prices (both under the case of small and of large exporting economies) and tests its main prediction with trade policy data for the period 2008-10.

The theory is based on recent developments in the literature on behavioral economics and trade policy (Freund and Ozden, 2008, and Tovar, 2009). This literature modifies an otherwise standard trade model to account for the empirical fact that individuals value losses more than gains (loss aversion). In this setting, preventing losses looms large in government's objective functions, something that helps explain observed export policy in the food sector. When the world food market is hit by a negative price shock, food producers experience a welfare loss. A welfare maximizing government can (and will) offset this loss by offering an export subsidy. On the contrary, when the world food price is high, consumers face loss aversion and the government responds by imposing an export restriction. Finally, when global food prices are at intermediate levels, there is no rationale for government intervention to prevent losses and policy makers face the standard incentives in setting trade policy (hence, the unilaterally optimal policy is free trade for a small open economy and an export tax for a large exporter).[3]

[1] A partial list includes Anderson and Martin (2011), Chaffour (2008), Bouet and Laborde (2010), Hochman et al. (2010), Headey (2011).

[2] Appendix Table B1 provides a breakdown of the data for important food sectors, including wheat, maize and bovine meat.

[3] A model of trade under loss aversion is not the only framework that would support that export policy is a function of the international price of food: this, in fact, is formally shown in Appendix A1, which is based on a model where there

Small exporters take world prices as given and have, individually, no impact on global markets. However, as they all face the same international price of food and have similar incentives to insulate the domestic food market in presence of loss aversion, their simultaneous behavior will have aggregate consequences. Intuitively, the international price of food is determined by the equilibrium of global export supply and import demand. A simultaneous imposition of export subsidies in response to low food prices or export taxes to high prices has systemic implications as it shifts the global export supply outward or inward respectively. We show that these policy actions can give rise to a *multiplier effect*. Focus on export restrictions (but the same logic applies to export subsidies). When a shock to the world food market pushes up the global price of food, exporters set export restrictions to offset the world price shock and avoid consumer loss aversion. Because all exporting countries impose restrictions, however, the world price of food increases, which makes the initial policy response inadequate to compensate consumers. The higher food price induces further restrictions as governments strive to maintain a stable domestic price. Note that, differently from the initial response, further increases in restrictions are not driven by fundamentals, but are only a reaction to the restrictions imposed by the other exporters. This is precisely the idea behind the multiplier effect.[4]

The logic just discussed extends to the case where exporting countries' policy decisions have an impact on global markets. Contrary to small economies, large exporters do not take the international price of food as given and choose their trade measures strategically. In this context, export policies are strategic complements when loss aversion looms large in the governments' objective function (i.e. when the world price of food is hit by a positive or negative shock). Strategic complementarity in export policy can rationalize the observed pattern of trade measures in food markets. In the words of the WTO Director General: "*In response to the crises, some started looking further inwards, and we saw a whole host of export restrictions flourish. These export restrictions had a domino, market-closing, effect, with one restriction bringing about another*" (Lamy, 2011b).[5] Intuitively, if a large exporter raises its tax on exports, it increases the world price of food, which in turn leads other exporting governments to further restrict their exports to avoid consumers' losses. Similarly, by depressing the price of food in international markets, higher export subsidies by a large exporter induce others to take the same course of action in order to offset the welfare loss of domestic food producers. This strategic complementarity of large exporters' trade policy creates a multiplier effect that magnifies

is no loss aversion, but governments are averse to inequality across different groups in society. However, as argued in Anderson and Martin (2011), assuming that food trade policy responds to the risk of losses for certain social segments is consistent with the behavior of many governments (see also Ivanic, Martin and Mattoo, 2011). Moreover, anecdotal evidence discussed in Piermartini (2004) confirms that export policy in food sectors can be targeted at stabilizing domestic prices to avoid losses for specific groups. For instance, Papua Nuova Guinea set an export tax/subsidy rate for cocoa, coffee, copra, and palm oil equal to one-half the difference between a reference price (calculated as the average of the world price in the previous ten years) and the actual price of the year.

[4] The formal results are obtained under two main simplifying assumptions. First, the model abstracts from the political economy motivations of governments. Second, the analysis takes as given trade policy of importers. As we further elaborate in the paper, the existence of a multiplier effect in food export policy does not hinge on the specific structure employed. Removing these assumptions, however, does provide new insights. In particular, to the extent that trade policy of food importing countries is also characterized by loss aversion concerns, high food prices may lead to lower import tariffs which will magnify the initial price shock, thus summing up to the multiplier effect created by export policy.

[5] Note that we prefer to refer to this effect as a *multiplier*, rather than a *domino*, effect, as the latter generally denotes a linear sequence of events with no feedback (i.e. backward reaction), which is instead an implication of our model.

the consequences of exogenous shocks to the international price of food.

We then test empirically the predictions of the model for the years 2008-10. During this period, food prices have been almost 60 per cent higher than average prices between 1990 and 2006 and export policy has been dominated by restrictive measures. We investigate two issues. First, we study the determinants of export restrictions. Specifically, we employ a probability model to examine whether export policies implemented by governments are related with changes in international prices. We also investigate whether exporting countries use trade policy as a response to policies that have been implemented by other governments in order to protect their domestic market. Second, we estimate a simultaneous equation model to assess the overall impact of export restrictions on food prices. We use a new data set on trade policy measures from the WTO Monitoring exercise and complement it with additional information from the Global Trade Alert dataset. This novel dataset contains monthly information on export restrictions in the food sector across 125 countries at the 4-digit level for the 2008-2010 period.

The empirical results strongly support the existence of a multiplier effect in food export policy. First, exporting governments set restrictions in response to increases of international food prices, particularly for staple foods. Second, the aggregate level of export restrictions on a product has a positive and significant impact on the probability that a government imposes a new restriction to the exports of that food product. We show that this finding is mostly driven by large exporters and that it is robust to several specifications and to potential endogeneity problems. Finally, through the simultaneous equations estimation we find that changes in export restrictions have considerably increased world food prices in 2008-10. This effect on prices is not immediate: it materializes after three months on average and tends to increase in size and significance over time.

There is a wide body of related literature that deals with export policy in the agricultural sectors, and we do not attempt to summarize it here. Studies generally focus either on export restrictions or on export subsidization. In the first group, the closest to our paper are the afore-mentioned Anderson and Martin (2011) and Bouet and Laborde (2011). They share the view that trade policy in the food sector can aim at insulating the domestic market and that these policy actions may contribute to disrupt international food markets. The focus of these analyses is at the same time broader and more limited than ours. First, their argument is that raising food prices can be the result of a collective action problem between exporters on one side and importers of food on the other, while our model only focuses on exporting countries. Second, we provide a fully micro-founded model and analytically prove the existence of a multiplier effect in export policy. Finally, our empirical analysis uses actual information on export policy measures rather than indirect estimates based on agricultural distortions in selected food sectors (Anderson and Martin, 2011) or simulations (Bouet and Laborde, 2011).

Bagwell and Staiger (2001) provide a political economy model of export subsidies in agricultural products that shares some similarities with ours. In particular, they show that, when governments weigh sufficiently the interests of producers, exporting countries may end up in an inefficient equilibrium (a subsidy war) where export subsidies are high and world food prices low. While the two approaches are not mutually exclusive, two intriguing features of our framework appear to be consistent with observed export policy in the food sector. First, exporters respond to the level of the international price, so that whether the government chooses an export subsidy, tax or free trade depends on the conditions in the international food market. Second, the fact that prices of several commodities are characterized by long periods of stability interrupted by sudden and sharp disruptions that (we show) can be exasperated by export policy choices.

The paper is structured as follows. Section 2 presents the basic structure of the model of trade policy under loss aversion. The unilateral food export policy for a small exporting country is determined in Section 3, while the result of a multiplier effect in export policy is derived in Section 4. The case of large exporters is analyzed in Section 5. We discuss the assumptions of the model in Section 6 and study the empirical relevance of the main predictions of the model in Section 7. Policy implications for the design of multilateral trade rules are analyzed in the Conclusions. All the proofs are relegated to a technical appendix.

## 2 The model: Food prices and loss aversion

Consider a small open economy producing two goods, a numeraire and a commodity that we refer to as food. The economy imports the numeraire good at a unitary world price and exports food at the world price, $p^*$. The numeraire is produced with labor alone, using a constant returns to scale technology ($y_0 = l_0$). Assuming that labor supply is sufficiently large, the wage rate in the economy is fixed and equal to one. Food is produced using labor and a specific factor in fixed supply, land ($L$). Technology in the food sector also exhibits constant returns to scale and takes the form $y = f(l, L)$. Given the domestic price of food, $p$, the return to the owners of the specific factor is $\pi(p) = \max_l [pf(l, L) - l]$. Finally, the domestic output of food is $y(p) = \pi'(p)$.

The economy is composed of a *continuum* of individuals of measure one with identical preferences. We assume that agents derive utility from consumption of the two goods and from deviations from their reference-dependent utility. Specifically, the utility function has the following separable form:

$$U = c_0 + u(c) - I \cdot h(\overline{U} - c_0 - u(c)), \tag{1}$$

where $c_0$ is the consumption of the numeraire good and $c$ is food consumption. Function $u(\cdot)$ has the standard properties ($u'(\cdot) > 0$, $u''(\cdot) < 0$). Function $h(\cdot)$ captures the behavioral features of the model. In particular, $h(\cdot)$ is increasing in the difference between a reference level $\overline{U}$ and the actual utility from consumption (i.e. $h'(\cdot) > 0$), and it displays diminishing sensitiveness to losses (i.e. $h''(\cdot) < 0$). $I$ is an indicator variable that takes value one whenever the utility falls strictly below the reference level and zero otherwise. This utility structure supports the idea that individuals experience a welfare loss when they achieve a level of utility inferior to what they are accustomed to, but do not perceive any additional welfare gain when utility is higher than usual.[6] Since one of the two goods in this economy is food, it is tempting to associate the reference utility $\overline{U}$ to a *subsistence* level of consumption, which the policy maker considers unacceptably low and which might justify policy intervention.

Maximizing utility given by (1) subject to the budget constraint gives the individual demand function of food $d(p) = [u'(c)]^{-1}$, while remaining income is spent on the numeraire good, $c_0 =$

[6] Freund and Ozden (2008) and Tovar (2009) have introduced loss aversion in a model of trade policy and find that this behavioral extension explains several features of the observed pattern of trade protectionism. Classic works on reference-dependent utility include Kahneman and Tversky (1979), Tversky and Kahneman (1991), and Koszegi and Rabin (2006). Tversky and Kahneman (1981), Samuelson and Zeckhauser (1988), and Camerer (1995), among others, provide experimental evidence supporting this preference structure.

$E - pd(p)$, where $E$ is individual income level. The government can use trade policy to intervene in the food sector.[7] Specifically, the policy maker can impose an export tax or an export subsidy that create a wedge between the international and the domestic price of food. Formally, $p = p^* + s$, where positive values of $s$ correspond to an export subsidy and negative values to an export tax, defined as $t = -s$. Government revenue is, therefore, given by

$$GR(p) = t\,[y(p) - d(p)] \gtrless 0. \tag{2}$$

We assume that, whenever positive, the government redistributes revenue uniformly to all agents, while lump-sum taxes are used to finance a negative budget.[8]

We denote by $\alpha$ the fraction of the population that owns land (*land owners / producers*). Agents in the remaining share of the population $(1-\alpha)$ have one unit of labor each that they supply inelastically to the market. We refer to this latter group as *workers / consumers*. In this setting, interests in society are radically different, as a change in the price of food affects different social groups in opposite ways. Intuitively, owners of land see their income and welfare positively tied to the domestic price of food, while workers are hurt by a surge in food prices as this limits their consumption possibilities. A fall in the domestic price of food has the opposite effect on the utility of these two social groups. Formally, the indirect utility of a worker and of a land owner can be written respectively as

$$V^l_{\overline{p}}(p) = 1 + CS(p) + GR(p) - I^l \cdot h\left[V^l(\overline{p}) - 1 - CS(p) - GR(p)\right] \tag{3}$$

and

$$V^L_{\underline{p}}(p) = \frac{\pi(p)}{\alpha} + CS(p) + GR(p) - I^L \cdot h\left[V^L(\underline{p}) - \frac{\pi(p)}{\alpha} - CS(p) - GR(p)\right], \tag{4}$$

where $CS(p) = u\,[d(p)] - pd(p)$ is consumer surplus. The indicator variable $I^l$ is equal to 1 whenever $V^l(\overline{p}) > 1 + GR(p) + CS(p)$ and zero otherwise. The indicator variable $I^L$ is equal to 1 whenever $V^L(\underline{p}) > \pi(p)/\alpha + GR(p) + CS(p)$ and zero otherwise.

As labor income is constant, the extent of loss aversion for workers is determined by consumer surplus and government revenue. Since the sum of these terms is strictly decreasing in $p$, their reservation utility corresponds to a unique reference price denoted by $\overline{p}$. More precisely, according to condition (3), whenever domestic food prices are high ($p > \overline{p}$), expected utility falls below the reference point, and workers/consumers incur an additional welfare loss captured by the term $h(\cdot)$. When instead food prices are low ($p < \overline{p}$), they do not derive any additional utility.

On the other hand, assuming that land owners are a sufficiently small fraction $\alpha$ of the total population, they enjoy only a tiny share of the surplus generated by food consumption and perceive a negligible fraction of the tax revenue (or cost). For individuals in this group, an increase in the

[7] As confirmed by the evidence provided in this paper and in the studies discussed in the Introduction, governments do indeed actively use trade policy in food sectors. An important question, not addressed in this paper, is why governments use more distortive policies, such as trade policy, rather than more efficient tools, such as domestic measures. One reason may have to do with the availability of appropriate domestic policies, particularly in developing countries. Limao and Tovar (2009) provide an alternative explanation based on a political economy argument.

[8] The analysis of this paper focuses on export taxes that in our sample represent 20% of total export restrictions. As is well understood, this measure is equivalent to an export quota under the assumption that the quota rent is rebated lump-sum. In addition to taxes and quotas, other export restrictions used in the 2008-10 period include prohibitions, minimum export prices, technical barriers. See Table 3 for details.

domestic price of food strictly increases utility, as the positive effect on the rent from the specific factor dominates the loss in consumer surplus and government revenue. As a result, the reference utility for producers corresponds to the unique price $\underline{p}$. According to condition (4), whenever the domestic price of food falls below this threshold level ($p < \underline{p}$), they perceive a decline in their welfare, but no additional welfare gain is incurred when land owners face a price of food higher than their reservation price.[9]

# 3 Unilateral food export policy under loss aversion

This section explores the optimal export policy for a small open economy under loss aversion (Section 5 presents an extension to this basic framework where the economy is large in the international food market). Total welfare is defined as

$$G(p) = W(p) + H(p), \tag{5}$$

where standard social welfare (i.e., net of loss aversion) is the sum of labor income, revenue from the specific factor, consumer surplus and government revenue

$$W(p) = (1 - \alpha) + \pi(p) + CS(p) + GR(p),$$

while loss aversion for the entire economy is

$$H(p) = -(1-\alpha)\, I^l \cdot h\left[V^l(\overline{p}) - 1 - CS(p) - GR(p)\right] - \alpha I^L \cdot h\left[V^L(\underline{p}) - \frac{\pi(p)}{\alpha} - CS(p) - GR(p)\right].$$

The government sets trade policy to maximize social welfare given by condition (5). In this framework where loss aversion affects welfare, there are several different scenarios that need to be considered which depend on the level of the international price of food. In particular, there are three main regions. A first area corresponds to the situation where the international price of food has "intermediate" values, that is, when $p^* \in \left[\underline{p}, \overline{p}\right]$. In this case, the loss aversion term is null and the optimal trade policy is the one that corresponds to free trade.[10] When the international price is "low" (i.e. $p^* < \underline{p}$) and when it is "high" (i.e. $p^* > \overline{p}$), the derivation of the optimal policy for a small open economy is more complicated, as either land owners/producers or workers/consumers suffer an additional welfare loss (i.e. $H(\cdot) \neq 0$). The discussion of the optimal policy in presence of loss aversion is presented below.

[9] To be clear, this model introduces a slightly different feature relative to Freund and Ozden (2008) and Tovar (2009). These authors abstract from the effect that changes in prices have on consumer surplus and government revenue and focus instead on the direct effect that these price changes have on the income of factor owners. This is a reasonable assumption in their models where there are many consumption goods, none of which is supposed to represent a large share of total consumption. The structure presented here is instead better suited to capture the fact that the poor, particularly in developing countries, spend an important portion of their income on food. For example, the poorest decile of the population in Nigeria, Vietnam and Indonesia spend respectively 70, 75, and 50 per cent of their income on food (Ivanic, Martin and Mattoo, 2011).

[10] The proofs of this and the following statements, which form the basis of Proposition 1 below, are provided in footnote as they follow closely the work by Freund and Ozden (2008). When $H(\cdot) = 0$, total welfare reduces to the standard form: $G(p) = W(p) = (1 - \alpha) + \pi(p) + CS(p) + GR(p)$. The optimal domestic price is determined by the first order condition $\partial W/\partial p = (p^* - p)\,[y' - d'] = 0$, which is satisfied for $p = p^*$.

Consider first the case where the international price of food is below the lower-bound of the reservation price, $\underline{p}$ (this is the case considered in previous literature). It can be shown that there exists a region of *compensating protectionism*, where the government sets an export subsidy to fully compensate producers for the welfare loss caused by the fall in the international price of food. In fact, the first-oder condition (FOC) of social welfare (5) with respect to the domestic price, which takes into account that in this scenario land owners experience a loss ($I^L = 1$), may or may not be satisfied in the region $\left(p^*, \underline{p}\right)$. Specifically, there is a critical level of the international price (call it $\underline{p}^c < \underline{p}$) such that, for $p^* \in \left(\underline{p}^c, \underline{p}\right)$, the FOC is not satisfied in the relevant region, and we have a *corner* solution.[11] In this case, the government sets trade policy so that the domestic price equals $\underline{p}$, and the optimal export subsidy is

$$s = \underline{p} - p^*. \tag{6}$$

If $p^* \leq \underline{p}^c$, the maximum is an *interior* solution. The government still imposes an export subsidy, but in this case it does not fully compensate producers.[12]

Consider next the scenario in which the international price of food is high, that is, where the price is above the reservation price of workers/consumers, $\overline{p}$. Similarly to the previous scenario, it can be shown that there exists a second region of *compensating protectionism*, where the policy maker imposes an export tax to fully offset the welfare loss of consumers due to the increase in the world price of food. The FOC of social welfare with respect to the domestic price of food, which takes into account the additional welfare loss for workers ($I^l = 1$), may or may not be satisfied in the region $(\overline{p}, p^*)$, depending on whether the international price of food is below or above a threshold level, denoted by $\overline{p}^c > \overline{p}$. In particular, when $p^* \in (\overline{p}, \overline{p}^c)$, the FOC is not satisfied in the relevant region, and the government sets trade policy to maintain the domestic price of food at the reservation price

[11] The FOC can be expressed as

$$\frac{\partial G}{\partial p} = W' + H' = (p^* - p)x' + \left[(1-\alpha)\,y + \alpha(p^* - p)x'\right] \cdot h' = 0,$$

where $x(p) = y(p) - d(p)$ is net export supply of food. Consider the case in which the international price falls from $p^* = \underline{p}$ to $p^* = \underline{p} - \varepsilon$. For $\varepsilon$ small enough, $W'(\underline{p} - \varepsilon) = 0$, while $H'(\underline{p} - \varepsilon) > 0$, which implies $G'(\underline{p} - \varepsilon) > 0$. In this case, the optimal domestic price of food is a corner solution and is equal to the reservation price for land owners, $\underline{p}$. As $\varepsilon$ increases (and, hence, $p^*$ moves away from $\underline{p}$), the loss aversion effect weakens due to diminishing sensitivity to losses ($h'' < 0$), while $W'(\underline{p})$ becomes more negative. This implies that there is a critical level of the world price $p^* = \underline{p}^c < \underline{p}$, below which the optimal domestic price is an interior solution to the welfare maximizing problem.

[12] In particular, solving the FOC when $H(\cdot) \neq 0$ gives the following export subsidy:

$$\frac{s}{p^* + s} = \frac{(1-\alpha)\,h'}{1 + \alpha h'}\frac{z}{e},$$

where $z \equiv y/x$ is the ratio of domestic output to exports and $e \equiv (x'p)/x$ is the elasticity of export supply.

for workers $\overline{p}$ (corner solution).[13] The corresponding optimal export tax is

$$t = p^* - \overline{p}. \quad (7)$$

If instead $p^* \geq \overline{p}^c$, the optimal domestic price is an interior solution. The optimal trade policy is still given by an export tax, which in this case does not fully compensate consumers.[14]

The optimal export policy for a small open economy under loss aversion is characterized in the following

**Proposition 1** *For an international price of food $p^* \in \left[\underline{p}, \overline{p}\right]$, the optimal export policy for a small open economy is free trade. For $p^* < \underline{p}$, the optimal policy is an export subsidy; a region of full producer compensation (i.e. where $s = \underline{p} - p^*$) exists for $p^* \in \left(\underline{p}^c, \underline{p}\right)$. For $p^* > \overline{p}$, the optimal policy is an export tax; a region of full consumer compensation (i.e. where $t = p^* - \overline{p}$) exists for $p^* \in (\overline{p}, \overline{p}^c)$.*

Proposition 1 establishes that the optimal food export policy for a small open economy under loss aversion depends on the international price of food. This trade policy is depicted in Figure 3. The government does not intervene in the food sector when international prices are at intermediate levels. On the contrary, absent other tools to address loss aversion, a welfare maximizing government may use export policy in food markets when the international price of food is low (i.e. below the reservation price of land owners/producers, $\underline{p}$) or high (above the reservation price of workers/consumers, $\overline{p}$). In the first case, the government imposes an export subsidy to offset the welfare loss for land owners. In the second case, the policy maker sets an export tax aiming at decreasing the negative effect of high food prices on the utility of workers. In both cases, the rationale behind export policy is the one of offsetting (completely or in part) the effect that "extreme" conditions in international food markets have on the welfare of domestic constituencies.

INSERT FIGURE 3 HERE

The model also has insights on the structure of export promotion or restriction. When the international price of food moves slightly below the reservation price of producers ($\underline{p}$) or above the reservation

[13] In this case, the FOC is given by

$$\frac{\partial G}{\partial p} = W' + H' = (p^* - p)x' + (1 - \alpha)\left[-y + (p^* - p)x'\right] \cdot h' = 0.$$

The proof of this statement follows the same steps as in footnote 10. Specifically, for an international price of food $p^* = \overline{p} + \varepsilon$, with $\varepsilon$ small enough, $W'(\overline{p} + \varepsilon) = 0$, while $H'(\overline{p} + \varepsilon) > 0$, which implies $G'(\overline{p} + \varepsilon) > 0$. In this case, the optimal domestic price of food is a corner solution, which equals the reservation price for workers $\overline{p}$. As $\varepsilon$ increases, the loss aversion effect weakens, while $W'(\overline{p})$ becomes more negative. There is a critical level of the world price $p^* = \overline{p}^c > \overline{p}$, above which the optimal domestic price becomes an interior solution.

[14] In particular, the export tax can be shown to be

$$\frac{t}{p^* - t} = -\frac{(1-\alpha)\,h'}{1 + (1-\alpha)\,h'}\frac{z}{e}.$$

price of consumers ($\overline{p}$), the government intervenes to fully compensate the constituency that is incurring a welfare loss. In other words, there is a range of world prices such that the policy maker sets export policy to bring the domestic price at the reference level of the group that is experiencing loss aversion. These areas are represented in Figure 3 by the region $(\overline{p}, \overline{p}^c)$ for export taxes and $\left(\underline{p}^c, \underline{p}\right)$ for export subsidies. Export intervention increases as the price of food diverges, since the policy aims at fully compensating the losing constituency (i.e. taxes are augmented as food prices raise, subsidies are increased as prices plunge). As the world price of food continues to diverge from the reference prices of producers or consumers, the structure of export policy changes. Intuitively, the marginal cost of trade intervention on welfare net of loss aversion increases, and diminishing sensitivity to losses makes full compensation less attractive.[15] Export subsidies (and taxes) are still used to offset increasingly high (low) world food prices, but the optimal policy no longer aims at full compensation of the losing constituency.

# 4 Food export policy and the multiplier effect

The previous section established that, under loss aversion, the government of a small economy may have an incentive to use export taxes in response to high food prices in international markets and export subsidies to offset low prices. As discussed, the aim is essentially to insulate the domestic economy from large international price changes. Naturally, a trade measure by a small economy in itself has no effect on world markets. However, if all exporting economies face similar incentives to alter their trade policy in the same direction, an effect on the international price of food will materialize which may induce a further policy response. This section provides a formalization of how small exporters' collective action interacts with the international price of food.

Suppose that there exists a *continuum* of identical small countries, with the same features as in the previous section and indexed along the interval $[0, 1]$. Since we are looking for symmetric equilibria, pose $t_i = t \ \forall i \in [0, 1]$. The equilibrium condition in the international food market can be written as

$$x\left(p^* - t\right) = m\left(p^*\right) \tag{8}$$

where $m\left(p^*\right)$ is the global import demand of food,[16] and $x\left(p^* - t\right)$ is the world export supply defined as

$$x\left(p^* - t\right) = \int_0^1 x_i\left(p^* - t\right) di.$$

Expression (8) implicitly defines the world price as a function of the export policies of all exporting countries, $p^*(t)$. When $t = 0$, the international price corresponds to its free trade level (define $p^*(0) \equiv p^*_{ft}$). It is also immediate to prove that $p^*$ is an increasing function of $t$, and in particular

[15] More specifically, the expressions for subsidy and tax in footnotes 11 and 13 equate the marginal gain as a result of reducing the constituency's losses (land owners and workers respectively) to the marginal loss in standard social welfare induced by the export measure. As is usual, the optimal trade intervention is affected by the ratio of output to exports and the elasticity of export supply that influence the welfare cost of trade policy.

[16] This section abstracts from changes in import policy. Subsection 6.2 discusses how results change when this assumption is relaxed.

that $dp^*/dt \in (0,1)$.[17] Uniform trade policy responses by all exporters will alter the world price of food. In particular, a simultaneous imposition of export taxes will result in higher international prices, while export subsidies will depress the world price of food.

The above consideration and the findings of Proposition 1 highlight an important interaction between export policy and food prices. Governments respond to high (low) food prices by imposing export taxes (subsidies) that, if applied symmetrically, increase (decrease) the world price of food. This may induce further increases in export taxes (subsidies). We refer to this as the *multiplier effect* of export policy. Whether this multiplier effect will materialize or not depends on the conditions in global food markets. When the world price of food is at intermediate levels ($p^* \in \left[\underline{p}, \overline{p}\right]$), governments have no incentive to employ an active export policy and the multiplier effect is dormant. When, instead, a world price surge (fall) raises governments' protection of consumers (producers) -as in the regions of compensating protection-, a multiplier effect will characterize export policy.

For illustrative purposes, we focus on the price escalation effect of export taxes (export subsidies, which depress the world price of food, can be discussed in a similar way). Assume that an exogenous shock to the international market of food brings the international price under free trade to $p^*_{ft} > \overline{p}$. This situation induces each policy maker in exporting countries to impose an export tax to shield consumers by maintaining the level of the domestic food price at $\overline{p}$. But as all exporters face the same incentive and act similarly, the international price of food is pushed up by the fall in world supply. The consequence of this price surge is another round of export taxes that, in turn, lead to higher international prices and even higher export taxes. Note, however, that differently from the initial export tax, which is the response to a shock in the world food market, subsequent increases in export restrictions are the reaction to an escalation of the taxes set by all other exporters.

The key insights can be inferred by looking at Figure 4. The figure depicts (i) the optimal export policy for a small open economy as a function of the international price of food ($t(p^*)$) and (ii) the international price of food as a function of the (symmetric) tax imposed by exporters ($p^*(t)$) -the latter is depicted as a linear function for illustrative purposes only (see example 1). The solution to the system made up of these two functions, $(p^*_e, t_e)$, characterizes the equilibrium in the world market of food and is represented as point E in Figure 4.[18]

INSERT FIGURE 4 HERE

The equilibrium can be described as the result of a process of consecutive tax increases across exporting countries. For the international price $p^*_{ft} > \overline{p}$, the corresponding export tax for each individual country is optimally set at level $t_1$. However, if all exporters set a tax $t_1$, there is an excess demand in the global food market and the international price of food increases to $p^*_1$. At this price,

[17] Define $F(p^*, t) \equiv x(p^* - t) - m(p^*)$. By the implicit function theorem,

$$\frac{dp^*}{dt} = -\frac{\frac{dF}{dt}}{\frac{dF}{dp^*}} = \frac{\frac{dx}{dp}}{\frac{dx}{dp} - \frac{dm}{dp^*}},$$

which belongs to the interval $(0,1)$, as $dx/dp > 0$ and $dm/dp^* < 0$.

[18] The proof of the uniqueness of this equilibrium is a straightforward geometric implication of the two following general properties of the model: (i) $dp^*/dt \in (0,1)$, (ii) $dt/dp^* = 1$ along the regions of compensating protectionism.

the initial level of the export tax is inefficiently low, and each policy maker increases restrictions to $t_2$. This multiplicative process stops where the international price curve ($p^*(t)$) intersects the optimal export policy ($t(p^*)$): at that point, the uncoordinated behavior of exporters has caused the equilibrium international price of food to increase relative to its initial level under free trade.[19]

We formally characterize the relationship between export policy and food prices in Proposition 2, in which we show that the equilibrium reaction to an exogenous shock to supply or demand of food is greater than the partial response by each exporting country taking the policy of the others as given. Any shock to supply or demand can be captured by changes in $p^*_{ft}$, which univocally determines the position of function $p^*(t)$ in Figure 4.

**Proposition 2** *Along the regions of compensating protectionism, a multiplier effect characterizes export policy. In particular, it is*

$$\frac{dt}{dp^*_{ft}} = \theta \frac{\partial t}{\partial p^*_{ft}},$$

*where $\theta > 1$. There is no multiplier effect when the international price belongs to the interval $\left[\underline{p}, \overline{p}\right]$.*

Intuitively, following a shock to the price of food, a multiplier effect in export policy is present when the aggregate policy response to the shock exceeds the individual one. Specifically, the initial export tax (subsidy) imposed by an individual exporter in response to a high (low) price of food is smaller than the equilibrium measure set by that policy maker and by all other exporting governments.

**Example 1**. Let us provide a simple example of this multiplier effect for an economy with linear import demand and export supply. In particular, suppose $x_i(p^* - t) = \alpha + \beta(p^* - t)\ \forall i \in [0,1]$ and $m(p^*) = \gamma - \delta p^*$, with $\alpha, \beta, \gamma, \delta \in R_+$ and where $t$ is a specific export tax (or subsidy if lower than zero). Equilibrium in the world market of food implies

$$\int_0^1 [\alpha + \beta(p^* - t)]\, di = \gamma - \delta p^*,$$

from which we obtain the world price as

$$p^* = p^*_{ft} + \eta t,$$

where $\eta \equiv \beta / (\beta + \delta)$ and $p^*_{ft} \equiv (\gamma - \alpha) / (\beta + \delta)$ (the untaxed world price). Let us now analyze what happens when $p^*_{ft} > \bar{p}$ (the case in which $p^*_{ft} < \underline{p}$ is analogous and thus omitted). Along the region of compensating protection, each country $i$ poses $t_i = p^* - \bar{p}$. In a symmetric equilibrium it holds

$$\begin{cases} p^* = p^*_{ft} + \eta t \\ t = p^* - \bar{p}, \end{cases}$$

[19] While the focus of the above discussion is on export taxes, the logic of the result also applies to export subsidies to food products. Low prices induce governments to offer subsidies to compensate producers. However, as all exporters face similar incentives and enact the export promotion policy at the same time, the effect is to increase the export supply of food in world markets and further depress prices. The multiplier effect in export policy determines an equilibrium of high subsidies and low food prices relative to free trade.

from which it results

$$t^* = \frac{1}{1-\eta}\left(p^*_{ft} - \bar{p}\right) > 0.$$

Then it is

$$\frac{dt}{dp^*_{ft}} = \theta \frac{\partial t}{\partial p^*_{ft}},$$

where

$$\theta \equiv \frac{1}{1-\eta}$$

is the limit of a geometric series of ratio $\eta$, which in standard economic terminology is usually referred to as the multiplier. This multiplier is finite and strictly higher than 1 as $\eta \equiv \beta / (\beta + \delta) \in (0,1)$.

# 5 Food export policy with large exporters

Consider an economy composed of $n$ *large* identical exporters, each characterized by the same technology and preferences as the small economies described in Section 2. The only crucial difference is that large exporters do not take the world price of food as given: in deciding their trade policy, these countries take into account the effect of their measures on the world price.

As seen before, the equilibrium value of the world price of food is the one which equalizes import demand and export supply of food. Denote by $m(p^*)$ the global import demand and by $x_i(p^* - t_i)$ the export supply of food in country $i$. Since the $n$ countries share the same fundamentals, it is $x_i(\cdot) = x(\cdot)\ \forall i = 1, .., n$. Equilibrium in the world market implies

$$\sum_{i=1}^{n} x(p^* - t_i) = m(p^*) \tag{9}$$

The expression above implicitly defines the world price as a function of trade policy of all exporting countries, $p^*(\mathbf{t})$, where $\mathbf{t} \equiv \{t_1, .., t_i, .., t_n\}$. If $\mathbf{t} = \mathbf{0}$, then $p^*(\mathbf{0}) = p^*_{ft}$.

Now consider a generic country $i$. Its optimal unilateral policy is the one which maximizes

$$G_i(t_i, p^*(\mathbf{t})) = W_i(t_i, p^*(\mathbf{t})) + H_i(t_i, p^*(\mathbf{t})), \tag{10}$$

where, as before, standard social welfare (i.e. net of loss aversion) is the sum of labor income, revenue from the specific factor, consumer surplus and government revenue:

$$W_i(t_i, p^*(\mathbf{t})) = (1-\alpha) + \pi(t_i, p^*(\mathbf{t})) + CS(t_i, p^*(\mathbf{t})) + GR(t_i, p^*(\mathbf{t})), \tag{11}$$

while the loss aversion term is defined as

$$\begin{aligned} H_i(t_i, p^*(\mathbf{t})) \quad = \quad & -(1-\alpha) I^l \cdot h\left[V^l(\overline{p}) - 1 - CS(t_i, p^*(\mathbf{t})) - GR(t_i, p^*(\mathbf{t}))\right] \\ & -\alpha I^L \cdot h\left[V^L(\underline{p}) - \frac{\pi(t_i, p^*(\mathbf{t}))}{\alpha} - CS(t_i, p^*(\mathbf{t})) - GR(t_i, p^*(\mathbf{t}))\right]. \end{aligned}$$

Parameters $\underline{p}$ and $\overline{p}$ are to be interpreted as follows. When the *domestic* price lies inside interval $\left[\underline{p}, \overline{p}\right]$, the loss aversion term is null, and each government maximizes function (11). When instead $p > \overline{p}$ ($p < \underline{p}$), then $I^l = 1$ ($I^L = 1$), and each government maximizes function (10).

The optimal policy chosen by country $i$ directly depends on the policies chosen by all other exporting countries. The strategic interaction of these countries can be described as a simultaneous game with $n$ players, each deciding the trade policy which maximizes its own welfare. Given the symmetric structure of this game, we look for symmetric Nash equilibria. In analogy to the previous case of small exporting countries, different scenarios must be considered depending on whether or not loss aversion plays a role in the problem of welfare maximization.

If loss aversion does *not* play any role, the best response function of each country $i$ comes from the maximization of (11), and a candidate symmetric Nash equilibrium is given by the solution to the system made up of the $n$ best response functions (one for each country): call it $\hat{\mathbf{t}} \equiv \{\hat{t}, .., \hat{t}\}$.[20] Denote by $\hat{p} \equiv p^* (\hat{\mathbf{t}}) - \hat{t}$ the domestic price resulting from all large exporters implementing policy $\hat{t}$. If $\hat{p} \in [\underline{p}, \bar{p}]$, then the candidate solution $\hat{\mathbf{t}} \equiv \{\hat{t}, .., \hat{t}\}$ is indeed a Nash equilibrium of the game.

If instead $\hat{p} < \underline{p}$ or $\hat{p} > \bar{p}$, then $H_i(\cdot) > 0$ $\forall i$, loss aversion *does* play a role, and the $n$ best response functions are determined via the maximization of (10) for any country $i$. In this case, the equilibrium policy of the whole exporting region may be one of *compensating protectionism*, where the policy maker of each country chooses its export tax (subsidy) to maintain the domestic price at the reservation level of consumers (producers).

To gain an intuition of this statement, suppose that $\hat{p} > \bar{p}$, and denote by $\breve{\mathbf{t}} \equiv \{\breve{t}, .., \breve{t}\}$ the solution to the system made up of the $n$ best response functions obtained from the maximization of (10) with $I^L = 0$ and $I^l = 1$.[21] If the corresponding domestic price ($\breve{p} \equiv p^* (\breve{\mathbf{t}}) - \breve{t}$) is higher than $\bar{p}$, then tax $\breve{\mathbf{t}}$ is an equilibrium resulting from an *interior* solution. If instead $\breve{p}$ is lower than $\bar{p}$, the equilibrium tax results from a *corner* solution in which $\mathbf{t}$ is the tax that keeps the domestic price constant at level $\bar{p}$. An analogous reasoning holds when $\hat{p} < \bar{p}$. In the next proposition we formally prove this statement and, in particular, we show that, in analogy to the small country case, two intervals of values for the -exogenously given- free trade world price of food ($p^*_{ft}$) exist, for which the equilibrium policy of the exporting region is one of compensating protectionism.

**Proposition 3** *(i) For any* $p^*_{ft} \in (\overline{p}_{ft}, \overline{p}^c_{ft})$*, the equilibrium policy for large exporters is a tax* $\mathbf{t} \equiv (t, ..., t)$ *such that* $p^* \left(\mathbf{t}, p^*_{ft}\right) - t = \bar{p}$ *(i.e. full consumer compensation). (ii) For any* $p^*_{ft} \in \left(\underline{p}^c_{ft}, \underline{p}_{ft}\right)$*, the equilibrium policy for large exporters is a subsidy* $\mathbf{s} \equiv (s, ..., s)$ *(or a tax if* $\mathbf{s} < \mathbf{0}$*) such that* $p^* \left(\mathbf{s}, p^*_{ft}\right) + s = \underline{p}$ *(i.e. full producer compensation).*

[20] As is well-known from the theory and supported by recent evidence (in particular, Broda et al. 2008), countries that have power in international markets have an incentive to set trade policy in order to obtain a terms-of-trade gain (the optimal tariff argument). It can be easily shown that the equilibrium policy in the absence of loss aversion is an export tax. Specifically, welfare maximizing governments set

$$\hat{t} = \frac{1}{[n\zeta + (n-1)e]},$$

where $1/n$ is the share of each country's exports on total exports, and $\zeta$ is the foreign import demand elasticity. The equilibrium tax goes to zero as $n \to \infty$ (as in Section 3), and it reaches the standard optimal export tax level for $n = 1$. Whenever $n \geqslant 2$, welfare of exporting countries would increase if they could coordinate on a higher export tax (see, Limao and Saggi, 2011, for a formal discussion of this point in the case of multiple symmetric importers).

[21] The fact that $\breve{\mathbf{t}} > \hat{\mathbf{t}}$ is formally proven in the proof of Proposition 3. It is, however, rather intuitive that the optimal tax policy when consumers' loss aversion matters is strictly higher than the optimal tax when it does not matter.

As in the small country case, along the two regions of compensating protectionism, the loss aversion effect is so strong that all governments set export policy to maintain their domestic price at the reservation level of land owners/producers or workers/consumers. In what follows we show that, when this is the case, export policy is still characterized by a multiplier effect. We can now enunciate the following

**Proposition 4** *Along the regions of compensating protectionism identified in Proposition 3: (i) countries' export policies are strategic complements, that is* $dt_i/dt_{-i} \in (0,1)$ *for* $i = 1, ..., n$*; (ii) a multiplier effect characterizes export policy, that is*

$$\frac{dt_i}{dp^*_{ft}} = \Phi \frac{\partial t_i}{\partial p^*_{ft}} \ \forall i = 1, .., n,$$

*where* $\Phi > 1$*.*

The intuition for these results is straightforward. If country $-i$ raises its export tax, it contributes to increase the world price of food, which in turn leads country $i$ to raise its own export tax to keep its domestic price constant (result (i)). This strategic complementarity is the source of the *multiplier effect* that, as discussed in the Introduction, several practitioners have observed in food markets during the recent crises. It magnifies the effects of an exogenous (common) shock to export supply or import demand of food (as embodied in a change of the untaxed world price of food) (result (ii)). A graphical representation of the domino and the multiplier effects is provided in Figure 5 in the simplest case of two exporting countries and linear import demand and export supply (a formal analysis of this case is developed in Example 2 below). The upward sloping reaction functions of the two food exporters capture the strategic complementarity of export policy in the region of full consumer compensation.[22] Any increase in export restrictions by exporter $i$ will lead exporter $-i$ to move its policy in the same direction. If the world market of food is hit by a shock which drives up the (untaxed) international price, the two reaction function shift outward. Each exporter has an incentive to restrict its policy stance to offset consumers' losses, which causes a multiplier effect. In the new equilibrium ($E'$ in Figure 5), the total policy response (from the initial tax $t_e$ to $t'_e$) is strictly larger than the initial response to the shock (from $t_e$ to $t'$).

INSERT FIGURE 5

**Example 2.** We provide an example of a world economy characterized by linear import demand and export supply. Assume that two identical exporting countries exist, which are characterized by export supply $x_i(p^* - t_i) = a/2 + b/2 \cdot (p^* - t_i) \ \forall i = 1, 2$, with $a, b \in R_+$ and where $t_i$ is the country $i$'s specific export tax (or subsidy if lower than zero). The import demand of the importing region is instead given by $m(p^*) = c - dp^*$, with $c, d \in R_+$. The world market of food is in equilibrium when

$$a/2 + b/2 \cdot (p^* - t_1) + a/2 + b/2 \cdot (p^* - t_2) = c - dp^*,$$

[22] Despite the strategic complementarity, the unuiqueness of equilibrium in this policy game is ensured by the fact that, in general, it holds $dt_i/dt_{-i} \in (0,1) \ \forall \ i = 1, ..., n$.

from which we obtain the world price as

$$p^* = p^*_{ft} + v\,(t_1 + t_2)\,, \tag{12}$$

where $v \equiv b/\left[2\,(b+d)\right]$ and $p^*_{ft} \equiv (c-a)\,/\,(b+d)$ (as it is the world price obtained by posing $t_1 = t_2 = 0$).

Each country implements the export policy which maximizes its own welfare. Loss aversion does not matter whenever the domestic price is "intermediate" ($p \in \left[\underline{p}, \overline{p}\right]$), while it matters when the price is "too high" ($p > \overline{p}$) or "too low" ($p < \underline{p}$).

First suppose that the domestic price is intermediate. In this case, the loss aversion term is null ($H_i = 0$), and each government maximizes expression (11). Under the linear assumptions of this example, solving the FOC gives rise (after some elementary algebra) to the following tax as a function of the international price:

$$t_i = \left(\frac{a}{b} + p^*\right) v.$$

The reaction function of country $i$ can then be simply found by substituting for (12) into this last equation, thus obtaining

$$t_i = \frac{v}{1-v^2}\left(\frac{a}{b} + p^*_{ft} + v t_{-i}\right).$$

Posing $t_i = t_{-i} = \hat{t}$, the symmetric equilibrium tax policy is

$$\hat{t} = \frac{v}{1-2v^2}\left(\frac{a}{b} + p^*_{ft}\right).$$

To characterize the upper region of compensating protection, we need to find the values of $\overline{p}_{ft}$ and $\overline{p}^c_{ft}$. The value of $\overline{p}_{ft}$ is, by definition, the one such that the domestic price resulting from policy $\hat{t}$ be equal to $\overline{p}$, that is to say,

$$p^*\left(\hat{t}, \overline{p}_{ft}\right) - \hat{t} = \overline{p}.$$

Exploiting our linear price function in (12) and substituting for the value of $\hat{t}$ found above, we can solve for $\overline{p}_{ft}$ to obtain

$$\overline{p}_{ft} = \frac{(1-2v)\,\frac{a}{b} + \overline{p}\left(1-2v^2\right)}{1-v}$$

If the world economy fundamentals are such that $p^*_{ft} < \overline{p}_{ft}$, then the equilibrium tax is $\hat{t}$.

If $p^*_{ft} > \overline{p}_{ft}$ instead, loss aversion matters, and each government maximizes expression (10). The steps necessary to characterize $\overline{p}^c_{ft}$ are analogous to those just taken to characterize $\overline{p}_{ft}$.[23] Since they do not add any additional insight, we omit them and study the strategic interaction along this upper region of compensating protection.

We know that, when $p^*_{ft} \in \left(\overline{p}_{ft}, \overline{p}^c_{ft}\right)$, each country $i$ wants to keep its domestic price constant at $p_i = \overline{p}$. Thus it poses $t_i = p^* - \overline{p}$. The reaction function of country $i$ can then be simply found by substituting for (12) into this last equation, thus obtaining

$$t_i = \frac{p^*_{ft} - \overline{p}}{1-v} + \frac{v}{1-v} t_{-i}.$$

[23] The maximization of (10) gives rise to an export tax $\check{t}$, which is strictly higher than $\hat{t}$. This allows us to find the value of the free trade world price such that the domestic price resulting from the equilibrium policy be equal to $\overline{p}$, that is to say, that value of $\overline{p}^c_{ft}$ such that $p^*\left(\check{t}, \overline{p}^c_{ft}\right) - \check{t} = \overline{p}$. To find the explicit value for $\overline{p}^c_{ft}$ as a function of all the parameters of the model however, we would further need to specify a functional form for both $h(\cdot)$ and for the utility function $u(\cdot)$.

Given that $v \in (0, 1/2)$, it is immediate to prove that export taxes are strategic complements, that is

$$\frac{dt_i}{dt_{-i}} = \frac{v}{1-v} > 0.$$

In a symmetric equilibrium it holds

$$\begin{cases} t_i = \frac{p_{ft}^* - \bar{p}}{1-v} + \frac{v}{1-v} t_{-i} \\ t_i = t_{-i} \end{cases}$$

from which we obtain the equilibrium tax as

$$t^* = \frac{1}{1-2v}\left(p_{ft}^* - \bar{p}\right) > 0.$$

Then it is

$$\frac{dt^*}{dp_{ft}^*} = \Phi \frac{\partial t^*}{\partial p_{ft}^*},$$

where the multiplier is given by

$$\Phi \equiv \frac{1}{1-2v} > 1 \text{ as } v < \frac{1}{2}.$$

Of course, an analogous reasoning can be carried out to identify the lower region of compensating protectionism, and to show the strategic complementarity of export policies and the existence of a multiplier effect.

# 6 Discussion

The previous sections have shown that loss aversion may be the root cause of trade policy intervention in food markets. Specifically, there are two price regions where governments set export policy to maintain a constant level of the domestic price of food. However, as the world price responds to country measures, the end result of these policy actions is a multiplier effect: in equilibrium, export measures magnify the effect of the shock to the world price of food.

The analysis so far is based on two main simplifying assumptions. First, governments maximize national welfare. Second, importers do not alter their trade policy. This section discusses how we expect our central result of a multiplier effect in food trade policy to be affected as we remove each of these assumptions. The goal here is to guide the empirical analysis of the next section rather than providing a complete analytical discussion.

## 6.1 Political economy

A large body of trade literature assumes that owners of specific factors are politically organized to lobby the government, as they are generally more easily coalised into an interest group. In a political economy context, it can be shown that governments weigh more heavily organized interests that, as a result, receive favorable policies in the form of tariff protection or export subsidies (Grossman and Helpman, 1994). The recent works by Freund and Ozden (2008) and Tovar (2009) show that this result carries over to a situation where producers face loss aversion. Similarly, within the context of our model, it is immediate to realize that, when the domestic price is "intermediate" ($p \in [\underline{p}, \bar{p}]$), a politically motivated government would set an export *subsidy* rather than free trade in response to lobbying pressures by land owners. In addition, it can be shown that there is a first region of full producer compensation when the price is low (below $\underline{p}$), where the government sets an export subsidy given by condition (6).[24]

When the domestic price is high ($p > \overline{p}$), a politically motivated government faces a trade off between political economy considerations and the loss aversion caused by high food prices. However, it is easy to prove that there is a region of full consumer compensation where the loss aversion effect is strong, and the government wants to keep the domestic price constant at $\overline{p}$.[25] Hence, while political economy considerations bias trade policy towards the granting of export subsidies, a multiplier effect of export policy would still result when the food price falls within the regions of full compensation.

## 6.2 Import policy

The model presented in this paper focuses on food exporters. However, importing countries are likely to respond to changes in international prices, which is likely to exacerbate situations of stress in international food markets. First, a multiplier effect may arise in import as well as in export policy. Assuming that preferences in importing countries are defined as in condition (1) and that there is a continuum of identical small importers, it is possible to show that, similarly to the exporters in our model, importing governments face incentives to use trade policy to insulate their domestic food market. Specifically, for a given export policy, there are regions of full compensation where the objective of trade policy is to preserve the level of the domestic price of food. When prices are high, importers provide food import subsidies or lower trade barriers; while the response to a low price is the imposition of tariffs on food products or lower subsidies to imports. As all importers face exactly the same incentives and act simultaneously, their trade policy affects the international price of food, creating a multiplier effect similar to the one discussed earlier for exporters.

Second, and more importantly, as discussed in Anderson and Martin (2011) and Bouet and Laborde (2011), the interaction between exporters on the one hand and importers on the other may further exasperate situations of stress in world food markets. Specifically, if world food prices are high, both exporters and importers set trade policy to shield the domestic market from developments in the international market. However, the joint imposition of higher export taxes and lower import tariffs (or higher import subsidies) contracts world supply and expands world demand, thus resulting in even

[24] The proofs of these statements are omitted as they follow directly from Freund and Ozden (2008).

[25] We only sketch the argument here, while a detailed proof is available from the authors upon request. Define the political welfare of government as $J = \Omega + H$, where $H$ is defined as in Section 3, while $\Omega = b\pi + CS + GR$, with $b > 1$ representing the political bias. This can be interpreted as the reduced-form of a two stage lobbying game, as in Grossman and Helpman (1994). Denote by $s(p^*)$ the politically optimal subsidy when the domestic price is intermediate, that is, when $p = p^* + s(p^*) \in \left[\underline{p}, \overline{p}\right]$. This domestic price is the one for which $G' = \Omega' = 0$. When -as a result of an increase in the world price $p^*$- the domestic price grows slightly above the upper threshold, say when $p = \overline{p} + \epsilon$, we have that $G' = \Omega' + H' > 0$, as $\Omega' = 0$ but $H' > 0$. For a range of $\epsilon$ small enough, the solution to this maximization problem is a *corner* solution in which the government utilizes export policy to keep the domestic price constant at $p = \overline{p}$. This policy consists of gradually reducing the subsidy $s(p^*)$ as $p^*$ grows large. When $p^*$ grows higher than $\overline{p}$, the optimal policy becomes an export tax.

higher international food prices.[26,27]

# 7 Export policy and the 2008-10 food crisis

In this section, we test empirically the validity of the model. Specifically, we examine whether the pattern of export policies that countries implement during periods in which prices move away from their reference point is consistent with our theoretical predictions. As a first step, we test whether export measures are related with changes in international food prices. We then examine whether exporting countries use trade intervention as a response to policies implemented by other governments. As seen in Sections 4 and 5, this behavior gives rise to the export policy multiplier effect and thus determines an equilibrium where world food prices are pushed further away from their free trade level. We then tackle the issue of endogeneity of our two key variables (export policies and prices) to verify the robustness of our empirical findings. In the final part of this section, we evaluate the impact of overall export policy changes on international prices. Given the mutual interaction between export policies and world prices, we do this by estimating a system of simultaneous equations.

The focus of our analysis is the time period 2008-2010, which is characterized by high food and other commodity prices.[28] During this period, food prices were almost 60 per cent higher than average prices during the period 1990-2006. This surge in prices has been particularly strong in some sectors, namely staple foods such as cereals, where the increase in average prices was higher than 90 per cent. Also price volatility has been significantly high during the last three years compared with 1990-2006 (see Table 1). These figures allow us to assume that during 2008-2010, prices were above their reference level $\overline{p}$ for the set of food products considered in the study. This is a convenient simplification, since it allows us to undertake the analysis without having to identify the precise reference price for different products, which is not always an easy task. Finally, we focus on the universe of export restrictions rather than export subsidies.[29] This is because, consistently with the theory, during periods of high international food prices countries tend to use export restrictions to insulate the domestic market.

INSERT TABLE 1

## 7.1 Data

Data on export and import policy implementation comes from two different sources: the WTO Trade Monitoring Reports (TMR) and from the Global Trade Alert (GTA) database. The main objective of

[26] Clearly, increases on the international price of food are a terms-of-trade gain for exporting countries and a terms-of-trade loss for importing countries. This simple observation supports the view that in a food crisis net importers have more to lose compared to net exporters of food.

[27] In terms of Figure 4, changes in import policy can be captured by shifts to the right of the international price line $p^*(t)$.

[28] Detailed data on export policy, our main variable of interest, are only available for these three years (see further below).

[29] A similar exercise could, in principle, be done with export subsidies for periods where international food prices were historically low and presented a downward trend, such as the second half of the 1980s.

the WTO monitoring reports is to increase the transparency and understanding of the trade policies and practices of member countries affecting the multilateral trading system. Specifically, the monitoring reports of October 2009 and November 2010 provide information on the type and the status of trade-related measures that have been implemented by governments after the 2008 global financial crisis. These measures have been notified by WTO members and observer governments to the secretariat of the WTO. Our second source, the Global Trade Alert, is an independent monitoring exercise of policies that affect global trade. The GTA database not only includes information on discriminatory measures provided by governments, but it also contains information collected from exporters, the media and trade analysts. An evaluation group composed by expert analysts is responsible for assessing this information and deciding whether to publish it on the website.

A total of 85 export restrictions have been recorded in food products during the time period 2008-2010.[30] The share of trade that is covered by these restrictions significantly varies across products. For commodities such as palm oil and cocoa, the amount of trade covered by export restrictive policies is equal to 50 and 47 per cent respectively. In the case of staple products such as cereals, which constitute a dominant part of consumers' diet especially in low income countries, the share of trade covered by export restrictions is also significant, ranging from 14 per cent in the case of wheat and meslin to almost 35 per cent in the case of rice. Details are provided in Table 2.

INSERT TABLE 2

With respect to the type of export measures implemented by countries, almost half of the restrictions are export prohibitions, 24 percent are either an imposition or an increase in an existent export tax and 10 per cent are export quotas and licensing. The remainder is represented by other measures such as price references or technical requirements (see Table 3). The pattern in the type of export measures implemented by countries for staple foods is very similar to those used in the food sector as a whole.

INSERT TABLE 3

The rest of the data are from standard sources. International nominal prices come from the FAO and IMF databases. Data on production shares are also taken from FAO. The share of agricultural value added is collected for 2009 and comes from the World Development Indicators. Data on total exports come from UN Comtrade and from the Global Trade Atlas database.

## 7.2 Determinants of export policy

To analyze the impact of international prices and overall export policies on the probability of imposing an export restriction, we regress the following specification using monthly data for a set of 77 exporting countries and 29 commodity products:

[30] This figure is likely to underestimate the effective number of export measures that have been implemented. The reason is that export restrictions recorded in each month often include more than a single measure. Our data sets, however, do not allow us to precisely discern this information.

$$Prob(ER_{ikt} = 1) = \beta_o + \beta_1 \ln p^*_{k(t-1)} + \beta_2 \ln Global\ Exp\ Restrictions_{k(t-1)} + \\ + \beta_3 \ln Global\ Tariff\ Reductions_{k(t-1)} + \beta_4 Share\ Agric.VA_i + \\ + \beta_5 \ln Exports_{iky} + \lambda_t + \gamma_k + \varepsilon_{ikt}. \quad (13)$$

$ER_{ikt}$ represents a dichotomous variable that takes the value of one whenever country $i$ implements or increases an already existent export restriction on the exports of product $k$ at time $t$ and zero otherwise. $\ln p^*_{k(t-1)}$ is the log of the international price, deflated by the United States GDP price deflator, of product $k$ in period $t-1$. From the model, we expect the coefficient $\beta_1$ to be positive: the higher the world price, the more likely is any given exporter to implement an export restriction in order to shield its domestic market. $Global\ Exp\ Restrictions_{k(t-1)}$ is the main variable of interest, representing the share of trade that is covered by export restrictions in a given product. This is calculated as the weighted sum, in terms of export shares[31], of countries implementing an export restriction at time $t-1$ in product $k$ ($\sum_i \left( \frac{Exp_{ik}}{World\ Exp_k} Restriction_{ik(t-1)} \right)$). According to the theory developed in sections 4 and 5, we expect that the more restrictive the global policy stance, the higher the probability that country $i$ will also implement an export restriction.

A set of country specific control variables that could potentially have an impact on the probability of imposing an export tax is also included in the specification. $Share\ Agric.VA_i$ is the share of agricultural value added over gross value added of country $i$ and captures the importance of the primary sector in an economy. $Exports_{iky}$ represents the total exports of product $k$ in country $i$ at time $y$.[32] $Global\ Tariff\ Reductions_{k(t-1)}$ is the sum of countries that have implemented tariff cuts, weighted by their imports shares in product $k$. This variable captures the fact that exporter $i$ could also be reacting to the import policies of its trading partners, as discussed in section 6.

### 7.2.1 Baseline regression results

The outcomes from regression (13) are reported in Table 4. The estimations are performed using both a logit model (columns (1) and (4)) and a linear probability model (LPM) (columns (2), (3), (5) and (6)). We undertake the analysis for all food products in our dataset (columns (1) to (6)) and for a sub-set of staple food products (columns (7) to (9)).[33] In the regressions we also include 4-digit product and time (month) fixed effects in order to control for product and time specific characteristics, and we cluster standard errors at country level to take into account the fact that the observations in the variables of our main interest (international prices and policies) are not independent across countries. The estimations of the linear probability model are also performed including country fixed effects (columns (3) and (6)).[34]

[31] Export shares are calculated as the average export share between 2009-2010.

[32] This variable is recorded quarterly instead of monthly.

[33] Specifically, we consider the following products: grain, weath and meslin, maize, barley and rice. For simplicity, only the logit regressions results are included in the Table -results using a LPM are very similar and available upon request.

[34] In the logit model country fixed effects are excluded from the estimation. This in order to be able to include in the regression a control group of countries that have never imposed an export restriction.

INSERT TABLE 4

From columns (1)-(3) we can observe that increases in international prices have a positive and significant impact on the probability of implementing an export tax. In the regressions that include all the 29 food products in our sample, the size of the coefficient is however rather small. A 100 per cent surge in international prices in $t-1$ increases the probability of imposing an export restriction in $t$ by 0.1 per cent. The story is different for staple food products. From column (7) it is possible to see that the impact of international prices is forty times higher for staple foods compared to the whole food sector. Specifically, a 100 per cent surge in international prices in $t-1$ increases the probability of imposing an export tax in $t$ by 4 per cent. This is not surprising given that staple products represent an important component of total food consumption, therefore governments (in line with the spirit of our model) tend to use export policy for products where consumers' losses are more significant.

In columns (4)-(6), we look at the impact of export and import policies on the probability of imposing an export restriction. A positive and significant coefficient of the variable capturing the global level of export restrictions confirms that governments impose these measures in reaction to the restrictive policy imposed by other exporters. Specifically, in the logit model, a 100 per cent increase in the share of trade covered by export restrictions in a market raises the probability of imposing a new trade restricting policy on that product by 2 per cent on average and by 4 per cent for staple food products (see column (4) and (8) respectively). The coefficient is still positive and significant when a linear probability model is estimated (see columns (5) and (6)). Interestingly, once global restrictions are introduced in the regression, the coefficient on the price becomes smaller and, in some specifications, loses significance. This is compatible with the prediction of the theoretical model that new restrictive measures are mostly driven by other export restrictions. Finally, the coefficient capturing the global level of import restrictions is never significant. This result is in contrast with studies such as Anderson and Martin (2011) and Bouet and Laborde (2011) which show that the interaction between exporting and importing countries should lead to further increases in international prices and even more stringent export policies. One possible explanation is that in our dataset, the share of trade represented by import reducing barriers is not very significant (less than 2 per cent).

The coefficients of the country specific control variables all have the expected sign. $\beta_5$ is positive and significant, implying that countries with higher levels of exports of a product are more inclined to impose an export restriction. We come back to this point below. Also $\beta_4$ is positive and significant suggesting that the higher the share of agriculture on gross value added of a country, the higher the probability of imposing an export restriction. Economies that have a higher dependency on the production of primary products are typically low income countries. During periods of high food prices, there are two reasons why these countries may be more inclined to impose export restrictions. First, people in low income economies spend a higher shares of their income on food. Second, these countries generally have a limited number of domestic policy instruments available to protect consumers from an increase in domestic food prices.

### 7.2.2 Are large exporters different?

Next we investigate whether larger exporters are more likely to impose an export restriction when international prices are increasing or as a reaction to other countries' export restrictions. In order to do this, we introduce two interaction terms in the regression for all 29 food products: the first between large exporters and the level of international prices; the second between large exporters and the global level of export restrictions. The term representing large exporters is captured by a dichotomous variable equal to one if the share of country $i$'s exports over world exports of a certain product $k$ is greater than 10 percent.[35]

The results are presented in Table 5. Columns (1) and (2) show the impact of being a large exporter on the probability of imposing an export restriction. The first regression includes as a control variable the quarterly level of exports. The coefficient on the large exporter dummy is positive in both cases and significant only in the latter case, due to high correlation between this variable and the quarterly level of exports. As predicted by the theory, countries with contractual power in export markets are more likely to impose an export restriction to exploit terms of trade effects. In columns (3) and (4) the interaction term between large exporter and international prices is included. A positive and significant coefficient for this term confirms that larger exporters are more likely to react to increases in international prices than smaller exporters. When the global level of export restrictions is introduced in the regression, the effect of international prices for small exporters becomes insignificant, whilst the interaction between international prices and large exporters is still significant (see columns (5) and (6)).

INSERT TABLE 5

The interaction term between large exporters and the global level of export restrictions is introduced in the last two columns of Table 5. The effect of the global level of export restrictions in a market on the probability of imposing a new restrictive measure is magnified for large exporters of food. Once this interaction term is introduced in the regression, the coefficient on the variable measuring global restrictions in a product loses significance. This suggests that the multiplier effect of export policy is driven by actions of large exporters, whose policies are strategic complements along the region of consumer compensation. The prominence of large exporters may also contribute to explain why the coefficients in the baseline regressions (while significant and with the expected sign) are relatively small. In our sample, large exporters of a certain food product tend to be also large consumers of that good. Therefore, most of the effects described in our model are likely to be present for large exporters/consumers. Many small exporting countries are inactive simply because they also consume very little of the food product they export. For this reason, these countries generally have a small incentive to intervene to offset consumer losses (the main exception being for staple foods where, in facts, coefficients were larger).

### 7.2.3 Endogeneity

A possible concern with the previous estimations is that the level of international prices and the global level of export policy restrictions are likely to be endogenous due to the presence of simultaneity bias. It is especially important to address endogeneity of our two key variables, as the international price

[35] Regressions are also performed considering as large exporters those countries whose share of world exports is higher than 5 percent. The results presented below still hold.

of food and the global export restrictions are both endogenous in the theoretical model. To deal with this problem we use two different strategies: a lagged explanatory variables and an instrumental variables (IV) approach.

First we perform our regressions increasing the number of lags in the independent variables of our interest. Specifically, estimations are performed calculating international prices and the global level of export policy restrictions in $t-2$ and $t-3$ respectively for both the broader sample of all food products and the sub-set of staple foods. The results, presented in Appendix Table B2, show that the magnitudes of the impact of international prices and of the global level of export restrictions on the probability of imposing a new restrictive measure are very similar to the ones in our baseline regressions (Table 4). In addition, we interact the dichotomous variable capturing large exporters with the lagged international prices and the lagged global export restrictions. The results in Appendix Table B3 are once more very similar to the findings in Table 5.[36]

As a second strategy to address the endogeneity bias, we follow an instrumental variables approach to estimate specification (13). For the international price variable we generate two different instruments based on climatic conditions, which have a direct impact on the total production of food products and, therefore, affect their prices in international markets through the supply channel. The first instrument $\textit{Rainfall top5}_{kt}$ is given by the total level of rainfalls taking place in the top 5 producer countries of a certain product $k$ at time $t$.[37] The second instrument, $\textit{Rainfall var top5}_{kt}$, captures the total variability of rainfalls in the top 5 producer countries of a certain product $k$ at time $t$.[38] The results from the first stage regression of the IV specification, presented in columns (1) and (2) of Appendix Table B4, suggest that rainfall is a good predictor for the international prices variable. High levels of rainfall are negatively correlated with crops production. In addition, the higher the number of top producers experiencing levels of rainfall that highly deviate from their historical mean, the higher the negative impact on total production.

For the overall level of export restrictions existent in a product $k$ we use two instruments. The first instrument, $\textit{Elections top}5_{kt}$, is a variable that indicates whether there will be elections taking place in the next three months in the top 5 producer countries. As discussed in Section 6, lobby groups representing producers' interests will generally oppose the imposition of an export restriction. In the proximity of elections, governments may be more willing to cede to requests from these special interests and, hence, are less likely to impose a restrictive export measure. As a second instrument, we use the total number of restrictions that have been applied in the two-digit industry to which the product belongs ($ER_{-kt} = \sum_i \sum_{j \neq k} \textit{Exp restriction}_{ijt}$). During periods of increasing food prices, countries might react to the fact that international markets are getting more restrictive by imposing an export restriction themselves. This may be the result of a sort of "simulation effect" or may occur because countries expect increasing prices in product $k$ deriving from shifts in international demand caused by restrictions in other products. The first stage results for the IV specification confirm a negative correlation between the global level of export restrictions in a product and the variable

[36] Note that the variable log of quarterly exports has been excluded from the regression since it is sometimes collinear with the variable big exporter.

[37] Alternative instruments have been created considering the top 3 and the top 10 producers of a product. Results do not change significantly.

[38] This instrument is computed as the total count of top producers for which the amount of rain in a certain month has been either above the 85th percentile or below the 25th percentile compared to the historical mean of that month.

capturing elections in large producing countries (the first instrument) and a positive correlation with the number of export restrictions in the corresponding industry (the second instrument). In addition, the F-statistic of the regression indicates that none of the instruments are weak (see columns (2) and (3) of Appendix Table B4).

Second stage regression results are presented in Table 6 below. The first two columns are introduced for comparison and simply report the coefficients of the two main variables of interest (international prices and global export restrictions) for the baseline regressions on the entire sample and for the subset of large exporters. Columns (3) to (8) report results of the IV regressions. Columns (3) and (4) use the two different instruments for the international price. A positive and significant coefficient confirms that countries react to increases in prices by imposing export restrictions. Columns (5) and (6) use the two instruments for the global level of restrictions. The overall level of export restrictions is still found to have a positive and significant impact on the probability of imposing a new restrictive policy. In the last two columns of Table 6, regressions are computed for large exporters only. Results confirm that the multiplier effect is especially strong for big food exporters. Note also that it is still true that the coefficient on international prices loses significance once global export restrictions are introduced as an explanatory variable, compatibly with the theoretical prediction that restrictive export policy is driven by the choices of other exporters. Finally, in all IV regressions, the magnitude of the coefficients capturing the variables of our interest is in line with the ones of the baseline regressions reported in columns (1) and (2).

INSERT TABLE 6

### 7.3 Impact of export restrictions on food prices

The empirical analysis so far has shown that exporters set trade policy in response to developments in international food markets, as captured by the world price of food, and -more importantly- that they react to the trade policy chosen by other exporters. As we discussed, this evidence is compatible with the existence of a multiplier effect in food export policy. A compelling, but rather difficult, issue is to assess the magnitude and impact that changes in export policy had on international food prices in the time of our observation. The difficulty, as shown in the theoretical models of Sections 4 and 5, lies in the fact that changes in export policy may be induced by increases in international food prices, which in turn are affected by trade policy changes. To capture this interaction, we use a two-stage least squares (2SLS) approach in order to estimate the following system of simultaneous equations:

$$\begin{cases} \Delta \ln p^*_{kt} = \alpha_0 + \alpha_1 \Delta ER_{kt} + \alpha_2 \Delta \mathit{Rainfalltop5}_{kt} + \alpha_3 \Delta \mathit{Rainfallvartop5}_{kt} + \alpha_4 \Delta \mathit{Energy}_t + \gamma_k + \varepsilon_{kt} \\ \Delta ER_{kt} = \beta_0 + \beta_1 \Delta \ln p^*_{kt} + \beta_2 \Delta \mathit{Elections\ top5}_{kt} + \beta_3 \Delta ER_{-kt} + \lambda_t + \gamma_k + u_{kt} \end{cases}$$

The first equation of the system is the one of our interest and represents the variation in the level of the world price of product $k$ between time $t$ and time $t-x$, where $x$ can take values between 1 and 6. We expect that changes in overall export restrictions imposed on product $k$ between $t-x$ and $t$ will have a positive impact on the variation of its international price in that interval of time.

In the specification, we introduce a vector of time-varying control variables that could potentially affect the international price. These variables include variations in the total level and the variability of rainfalls in the top producer countries (as defined above) and in the level of energy prices. Finally, $\gamma_k$ represents a set of product fixed effects in order to control for product specific characteristics.

The second equation of the system represents the variations in the total number of countries imposing export restrictions on product $k$. This variable depends on the variation in the level of the international price, because increases in the price of product $k$ are expected to induce exporting governments to use export policy to address consumers' losses. As additional explanatory variables in the regression, we include the two instruments defined above -i.e. the variable indicating the proximity of elections in top producing countries and the overall level of export restrictions being imposed on similar products (e.g. products that belong to the same industry), also in variation terms.

The second stage results are presented in Table 7 and provide further evidence of the existence of a multiplier effect of export policy in the food sector. The regressions are performed using the entire sample of 29 food products. A positive variation in the total level of export restrictions in a certain product $k$ has a positive and significant impact on the increase in international prices of that product. This effect, however, is not immediate, but it materializes after three months and increases over time, reaching a peak at six months. Intuitively, this confirms that, as exporters react to each others' restrictions, the impact of these measures on the international price of food becomes more important, as captured by the increasing size and significance of the coefficients. Note also that these are likely to be "conservative" estimates of the impact that variations in export restrictions had on food prices during 2008-10. The reason is that these coefficients average out products such as staple foods, where policy makers were shown to be more prone to impose restrictions in response to other countries' export restraints, and products where the multiplier effect was found to be less relevant. While the presumption is that these coefficients would be substantially higher if we were to perform the regression only for the sub-set of staple food products, the data are too limited to obtain statistically meaningful results using this methodology.

INSERT TABLE 7

# 8 Conclusions and policy implications

In his essay "Of the Balance of Trade", David Hume wrote:

> "It is very usual, in nations ignorant of the nature of commerce, to prohibit the exportation of commodities, and to preserve among themselves whatever they think valuable and useful. They do not consider, that, in this prohibition, they act directly contrary to their intention ... To this day, in France, the exportation of corn is almost always prohibited; in order, as they say, to prevent famines; though it is evident, that nothing contributes more to the frequent famines, which so much distress that fertile country." (Hume, 1742).

As this quote reminds us, economists have for long time believed that a link exists between restrictive export policy and food crises. This paper fits in this tradition by presenting a model of food export policy when agents are averse to losses. The theory predicts a pattern of trade policy that is broadly consistent with observed behavior. Specifically, exporting governments offer export subsidies when food prices are low and set export restrictions when prices are high. Moreover, the theory formalizes a significant channel through which export policy can exacerbate a situation of stress in global food markets. This results from a multiplier effect, similar to the concept familiar in macroeconomic theory, where world food price changes feed into increasingly export policy activism.

We test empirically this theory by looking at the period of high food prices of 2008-10. Specifically, we study two theoretical predictions of the model. First, exporting countries set export restrictions in response to restrictions imposed by other food exporters. Second, this multiplier effect of export policy impacts on the world prices of food. In the empirical analysis we employ a novel dataset that contains detailed information on trade policy choices taken by exporting governments by food sector. Our results confirm that changes in export policy are set in response to restrictions imposed by other exporters, particularly for large exporters and in important products such as staple foods, and that the overall impact of these measures has been to significantly increase food prices in 2008-10.

This multiplier mechanism in food markets affects on global welfare. An increase (fall) in the world price of food is a terms of trade gain (loss) for exporting countries and a terms of trade loss (gain) for importers. While these effects cancel each other out, export policy activism creates the traditional distortions and deadweight loss that lower global welfare. The interests of exporters and importers are, however, not aligned: the negative welfare effect of an escalation of export restrictions (subsidies) will fall on food importing (exporting) countries. This fact makes any policy reform difficult. In addition to these welfare consequences, the multiplier effect may also have an adverse impact on welfare through its effect on short-run volatility in food prices. A formal analysis of this aspect is beyond the scope of the present study, but it represents an interesting avenue for future research.

Several academic studies and a report by a number of international organizations have recently addressed the efficiency of multilateral trade rules in the wake of the recent food crises and discussed avenues for improvements.[39] We see the present work as a contribution to this broader debate. WTO rules on export policy are characterized by two asymmetries. Differently from industrial products, export subsidies for agricultural goods are not prohibited under WTO rules. However, in the Uruguay Round Agreement on Agriculture signed in 1995, member governments from developed countries agreed to introduce in the multilateral trading system commitments to bind agricultural export subsidies. In the context of the on-going Doha negotiations, member countries are discussing further restraints on their food subsidy policy. While the adequacy (i.e. the depth and width) of existing commitments can be debated, the logic of the agreement appears to be consistent with the need to address an export subsidy multiplier effect.[40] The model also explains why the value of this reform is

[39] See FAO et al. (2011). The report proposes to eliminate export subsidies, limit the applicability of food bans and improve the notification requirement for food export restrictions. The report also includes a number of proposals to improve policy tools directly targeting losses arising from changes in food prices.

[40] In the Chapter dedicated to export subsidies, Bagwell and Staiger (2002, ch. 10) note that rules that facilitate a reduction in trade volume warrant special scrutiny. Their argument being that, differently from export restrictions, export subsidies have a positive effect on welfare of importing countries via a terms-of-trade change. While this argument is clearly correct, it is softened by the theory presented here. The reason is that, as the model and recent experience

likely to be more relevant than what is perceived at times, as the current one, when high food prices have greatly reduced the use of export subsidies. This is precisely because, if world prices were to fall again in the future, the incentive to apply export support measures in this sector would certainly re-emerge, along with the associated multiplier mechanism.

A second asymmetry in WTO rules is that the regulation of export restrictions is weaker than the disciplines on export promotion. Under WTO rules, members are prohibited from instituting or maintaining quantitative restrictions, but exceptions (subject to specific requirements) are allowed in food sectors. In addition, export taxes are loosely regulated and are, in general, not covered by binding commitments. This implies that there are no export duties ceiling rates and no limitations regarding the timeframe for applying or increasing an export duty. Overall, this legal framework generally gives WTO members a significant discretionary scope in applying export restrictions. The results presented in this paper, however, suggest that this flexibility may adversely affect global welfare, as unilateral export restrictions in times of high food prices create a multiplier effect that pushes prices further up. The introduction of commitments in export policy, for instance in the form of negotiated export tax bindings, would smooth this impact, both directly and by inducing countries to develop more targeted policy instruments to protect consumer losses, rather than relying on second-best trade policy intervention.

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show, exporting governments recur to subsidies when the world price of food is low while imposing restrictions when the price is high. Therefore the positive terms-of-trade effect of subsidies hits when it is, so to say, less needed by importers.

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# A Appendix

## A.1 The optimal export policy under *inequality* aversion

Consider a small open economy with an identical structure as the one described in Section 2, except for two features. The first feature is that consumers are standard rational agents, that is, they are *not* loss averse. Hence, $I^l = I^L = 0$, and the sum of land-owners' indirect utility can be expressed as

$$V_L(p) = \pi(p) + \alpha\left[CS(p) + GR(p)\right],$$

while the sum of workers' indirect utility is given by

$$V_l(p) = (1-\alpha)\left[1 + CS(p) + GR(p)\right].$$

The second feature is that the government is assumed to be averse to inequality. The simplest way to capture government's inequality aversion is by defining social welfare as

$$G(p) = h(V_L(p)) + h(V_l(p))$$

where function $h(\cdot)$ is twice continuously differentiable with $h'(\cdot) > 0, h''(\cdot) < 0$. Function $h(\cdot)$ is meant to capture the idea that, *coeteris paribus*, a more equitable distribution of resources across workers and land-owners is welfare enhancing.

Government's objective is the one of finding price $p$, and hence tax/subsidy $t = -s = p^* - p$, which maximizes social welfare. From the FOC we obtain

$$\frac{dG}{dp} = (p^* - p)\, x'(p)\left[h'_l(1-\alpha) + h'_L\alpha\right] - (1-\alpha)\, y(p)\left(h'_l - h'_L\right) = 0,$$

where

$$h'_l \equiv \frac{dh}{dV_l}, h'_L \equiv \frac{dh}{dV_L}.$$

After a few algebraic steps we can finally express the optimal tax/subsidy as

$$\sigma = \frac{t}{p^* - t} = \frac{(1-\alpha)\left(h'_l - h'_L\right)}{(1-\alpha)\, h'_l + \alpha h'_L}\frac{z(p)}{e(p)}, \tag{14}$$

where $z(p) \equiv y(p)/x(p)$, $e(p) \equiv x'(p)p/x(p)$.

The optimal policy is the one which optimally trades off the usual marginal loss caused by the deviation from free trade with the marginal gain associated with a more equitable society. In particular, the optimal policy is a *tax* if and only if $h'_l > h'_L$, that is, if the marginal contribution of workers' utility to social welfare is strictly higher than the one of land-owners, while it is a subsidy in the opposite case. Only when $h'_L = h'_l$ (which happens when workers and land-owners reach the same level of welfare), the optimal policy is free trade.

Moreover, and crucially for our purpose, it is possible to prove that the optimal export tax (subsidy), given by expression (14), is an increasing (decreasing) function of international food price $p^*$.[41] The intuition for this result is straightforward: an increase in $p^*$ is beneficial to land-owners and harmful to workers. A government which is inequality averse raises the export tax (or lowers the export subsidy) to attenuate the welfare loss of workers.

On the other hand, and as shown in Section 3, a simultaneous imposition of export taxes across a *continuum* of identical exporting countries raises the international price of food (while export subsidies lower it). Once it is proven that a complementarity exists between export taxes and food prices -as the former respond positively to the latter and viceversa-, a *multiplier effect* necessarily follows (a formal proof of this statement is isomorphic to that of Proposition 6 in Cooper and John, 1988). As a result, the theoretical findings of this paper continue to hold and to deliver the same hypotheses which have been tested in the empirical analysis.

## A.2 Proofs

**Proof of Proposition 1**. The proof of Proposition 1 follows, *mutatis mutandis*, from Freund and Ozden (2008) and is thus omitted.

**Proof of Proposition 2**. For $p^* \in (\overline{p}, \overline{p}^c)$, the policy rule of each country is captured by expression $t = p^* - \bar{p}$. However, while each country takes $p^*$ as given (being too small to affect it), its value is affected by the tax policy implemented by the whole set of exporters. World price $p^*$ is implicitly defined by (8), while the untaxed world price $p^*_{ft}$ is implicitly defined by the *laissez faire* equilibrium in the world market, $m\left(p^*_{ft}\right) = x\left(p^*_{ft}\right)$. We can then define the world price as an increasing function of the export tax and of the free trade world price, $p^*\left(t, p^*_{ft}\right)$, where $p^*_{ft}$ parameterizes the world price function and captures any shock that affects functions $m(\cdot)$ or $x(\cdot)$ other than changes in $t$.

The equilibrium tax is then implicitly defined by

$$t = p^*\left(t, p^*_{ft}\right) - \bar{p}.$$

We now want to show that the total derivative of $t$ with respect to $p^*_{ft}$ is greater than its partial

[41] Define the "non-standard" part of the formula for the optimal export policy in (14) as

$$H \equiv \frac{(1-\alpha)\left(h'_l - h'_L\right)}{(1-\alpha)h'_l + \alpha h'_L},$$

It is possible to prove that $dH/dp^* < 0$ to the extent that $h''_l, h''_L < 0$ (that is, to the extent that the government is inequality averse). The rest of the proof follows from the previous literature on trade policy (Grossman and Helpman, 1994, Freund and Ozden, 2008).

derivative. It is

$$\frac{\partial t}{\partial p^*_{ft}} = \frac{\partial p^*}{\partial p^*_{ft}}, \tag{15}$$

while

$$\frac{dt}{dp^*_{ft}} = \frac{\partial p^*}{\partial p^*_{ft}} + \frac{dp^*}{dt}\frac{dt}{dp^*_{ft}},$$

from which we obtain

$$\frac{dt}{dp^*_{ft}} = \frac{1}{1-\frac{dp^*}{dt}}\frac{\partial p^*}{\partial p^*_{ft}}.$$

Using expression (15) and the fact that $dp^*/dt \in (0,1)$ (which is proven in footnote 17), it follows immediately

$$\frac{dt}{dp^*_{ft}} = \theta \frac{\partial t}{\partial p^*_{ft}},$$

where the multiplier is given by

$$\theta \equiv \frac{1}{1-\frac{dp^*}{dt}} > 1.$$

The proof for the multiplier effect of subsidies when $p^* \in \left(\underline{p}^c, \underline{p}\right)$ follows immediately once it is realized that $t = -s$. For $p^* \in \left[\underline{p}, \overline{p}\right]$, $t\left(p^*\right) = 0$ implying that $p^*\left(0, p^*_{ft}\right) = p^*_{ft}$. The pair $(p_{ft}, t) = \left(p^*_{ft}, 0\right)$ describes the equilibrium in the world food market and no multiplier effect exists: $dp^*/dp^*_{ft} = 1$.

**Proof of Proposition 3.** (i) World price $p^*$ is defined implicitly by (9), while the untaxed world price $p^*_{ft}$ is implicitly defined by the *laissez faire* equilibrium in the world market, $m\left(p^*_{ft}\right) = \sum_{i=1}^{n} x\left(p^*_{ft}\right)$. As in the small country case, it is useful to define the world price as a function of both export taxes and of the untaxed world price, $p^*\left(\mathbf{t}, p^*_{ft}\right)$, where $\mathbf{t} \equiv \{t_1, .., t_i, .., t_n\}$, and $p^*_{ft}$ parameterizes the world price function, thus capturing all exogenous forces affecting import demand and export supply other than export taxes.

Define (a) $\overline{p}_{ft}$ as the value of the free trade world price such that the domestic price resulting from the maximization of (11) by all countries is equal to $\bar{p}$:

$$\overline{p}_{ft} : p^*\left(\hat{\mathbf{t}}, \overline{p}_{ft}\right) - \hat{t} = \bar{p}; \tag{16}$$

(b) $\overline{p}^c_{ft}$ as the value of the free trade world price such that the domestic price resulting from the maximization of (10) by all countries is equal to $\bar{p}$:[42]

$$\overline{p}^c_{ft} : p^*\left(\check{\mathbf{t}}, \overline{p}^c_{ft}\right) - \check{t} = \bar{p}. \tag{17}$$

It can be shown that $\overline{p}_{ft} < \overline{p}^c_{ft}$. This results from exploiting the following three facts in expressions (16) and (17): (1) $\check{\mathbf{t}}$ is strictly higher than $\hat{\mathbf{t}}$; (2) the domestic price in country $i$ is a decreasing function of $t_i$; (3) the equilibrium world price $p^*$ is increasing in $p^*_{ft}$.[43] Facts (1) and (2) imply a lower domestic

[42] To simplify the notation we only write $\hat{\mathbf{t}}$ and $\check{\mathbf{t}}$ instead of $\hat{\mathbf{t}}\left(p^*_{ft}\right)$ and $\check{\mathbf{t}}\left(p^*_{ft}\right)$. Both, however, depend on the exogenous $p^*_{ft}$.

[43] Fact (1) can be proven as follows. Tax $\hat{\mathbf{t}}$ is the one for which $W_i'\left(\hat{\mathbf{t}}\right) = 0$. Moreover, for any $\mathbf{t} > \hat{\mathbf{t}}$ ($\mathbf{t} < \hat{\mathbf{t}}$), it is $W_i'\left(\hat{\mathbf{t}}\right) < 0$ ($W_i'\left(\hat{\mathbf{t}}\right) > 0$). Tax $\check{\mathbf{t}}$ is instead the one such that $W_i'\left(\check{\mathbf{t}}\right) + H_i'\left(\check{\mathbf{t}}\right) = 0$. Given that, where it is defined, $H_i'(\cdot) > 0$, it must be $W_i'\left(\check{\mathbf{t}}\right) < 0$, which only occurs for tax values strictly higher than $\hat{\mathbf{t}}$. To prove Fact (2), first notice

price associated to tax $\check{\mathbf{t}}$. Hence, in order for both domestic prices to be exactly equal to $\overline{p}$ as in (16) and (17), fact (3) implies $\overline{p}_{ft} < \overline{p}^c_{ft}$.

We can now distinguish among three regions. **Region 1**: If the fundamentals of the world economy are such that $p^*_{ft} \leqslant \overline{p}_{ft}$ (and higher than $\underline{p}_{ft}$), loss aversion does not matter, the equilibrium policy is the interior solution ($\hat{\mathbf{t}}$) resulting from the maximization of (11) (see footnote 20), and hence fact (3) applied to (16) implies that the domestic price is strictly lower than threshold $\overline{p}$. **Region 2**: If instead $p^*_{ft} \geqslant \overline{p}^c_{ft}$, the domestic price is above the upper threshold and loss aversion matters. In this case, the equilibrium policy is the *interior* solution ($\check{\mathbf{t}}$) resulting from the maximization of (10). The reason is that, for any $p^*_{ft} \geqslant \overline{p}^c_{ft}$, fact (3) applied to (17) implies $p^*\left(\check{\mathbf{t}}, p^*_{ft}\right) - \check{t} > \overline{p}$. **Region 3**: When $p^*_{ft} \in \left(\overline{p}_{ft}, \overline{p}^c_{ft}\right)$, loss aversion matters but the interior solution ($\check{t}$) is such that the domestic price would be lower than $\bar{p}$ (again, this is an implication of fact (3) applied to (17)). The solution to the maximization of (10) is then a *corner* solution such that the domestic price is exactly equal to $\bar{p}$:

$$t_i = t : p^*\left(t, ..., t, p^*_{ft}\right) - t = \bar{p} \quad \forall i = 1, ..., n \text{ and } \forall\ p^*_{ft} \in \left(\overline{p}_{ft}, \overline{p}^c_{ft}\right).$$

(ii) The proof of this second statement proceeds through the same logical steps as above. First, values $\underline{p}^c_{ft}, \underline{p}_{ft}$ are defined as the values of the free trade world price such that the domestic price is equal to $\underline{p}$ when loss aversion (of *producers*) matters and does not matter, respectively. Then it is shown that $\underline{p}^c_{ft} < \underline{p}_{ft}$, and that, along the interval $\left(\underline{p}^c_{ft}, \underline{p}_{ft}\right)$, the export policy is one of compensating protectionism. The only difference is that this policy is not necessarily a subsidy but may also be a tax. The reason for this is the following: since the equilibrium export policy when loss aversion does *not* matter is a strictly positive tax ($\hat{\mathbf{t}} > \mathbf{0}$), when $p^*_{ft}$ is "slightly" below $\underline{p}_{ft}$, the equilibrium policy (which is the one that keeps the domestic price constant at $p = \underline{p}$) is still a tax and so it remains until $p^*_{ft}$ becomes sufficiently low. In particular, when the free trade world price is lower than $\underline{p}$, the only way to keep the domestic price at level $\underline{p}$ is to reverse the policy to an export subsidy. Formally, we can distinguish among the following three possibilities when $p^*_{ft} \in \left(\underline{p}^c_{ft}, \underline{p}_{ft}\right)$. If $p^*_{ft}$ is above $\underline{p}$, a strictly negative subsidy $\mathbf{s} = -\mathbf{t} < \mathbf{0}$ is needed in order to make $p^*\left(\mathbf{t}, p^*_{ft}\right) - t = \underline{p}$. If $p^*_{ft} = \underline{p}$, $\mathbf{s} = \mathbf{0}$ is needed in order to make $p^*\left(\mathbf{0}, p^*_{ft}\right) - 0 \equiv p^*_{ft} = \underline{p}$. Finally, if $p^*_{ft} < \underline{p}$, a strictly positive subsidy $\mathbf{s} > \mathbf{0}$ is needed in order to make $p^*\left(\mathbf{s}, p^*_{ft}\right) + s = \underline{p}$.

**Proof of Proposition 4.** (i) The reaction function of country $i$, $t_i\left(\mathbf{t}_{-i}\right)$, is implicitly given by

$$t_i = p^*\left(t_i, \mathbf{t}_{-i}, p^*_{ft}\right) - \bar{p}. \tag{18}$$

where $\mathbf{t}_{-i} \equiv \{t_1, .., t_{i-1}, t_{i+1}, ..t_n\}$. Define

$$J\left(t_i, \mathbf{t}_{-i}\right) \equiv p^*\left(t_i, \mathbf{t}_{-i}, p^*_{ft}\right) - \bar{p} - t_i.$$

that $dp_i/dt_i = dp^*/dt_i - 1$. Then, it suffices to prove that $dp^*/dt_i$ belongs to $(0,1)$ $\forall i = 1, ..., n$. Define

$$\Psi\left(p^*, \mathbf{t}\right) \equiv \sum_{i=1}^{n} x\left(p^* - t_i\right) - m\left(p^*\right)$$

as the implicit function of the world price w.r.t. the export taxes. Using the implicit function theorem, we obtain

$$\frac{dp^*}{dt_i} = -\frac{\frac{d\Psi}{dt_i}}{\frac{d\Psi}{dp^*}} = \frac{\frac{dx}{dp}}{n\frac{dx}{dp} - \frac{dm}{dp^*}} \quad \forall i = 1, ..., n.$$

which belongs to $(0, 1/n)$ as $dm/dp^* < 0$. Hence, it is $dp_i/dt_i < 0$. Fact (3) is true by definition of $p^*$ and $p^*_{ft}$.

Using the implicit function theorem, for any element $t_{-i} \in \mathbf{t}_{-i}$ we obtain

$$\frac{dt_i}{dt_{-i}} = -\frac{\frac{dJ}{dt_{-i}}}{\frac{dJ}{dt_i}} = \frac{\frac{dp^*}{dt_{-i}}}{1 - \frac{dp^*}{dt_i}}.$$

Notice that -as proven in footnote 23- it is $dp^*/dt_i = dp^*/dt_{-i} \in (0, 1/n)$, where $n \geqslant 2$. It then follows that $dt_i/dt_{-i} \in (0, 1)$.

(ii) From the reaction function of country $i$ (expression 18) we now want to show that the total derivative of $t_i$ with respect to $p^*_{ft}$ is greater than its partial derivative. It is

$$\frac{\partial t_i}{\partial p^*_{ft}} = \frac{\partial p^*}{\partial p^*_{ft}},$$

while

$$\frac{dt_i}{dp^*_{ft}} = \frac{\partial p^*}{\partial p^*_{ft}} + \frac{dp^*}{dt_i}\frac{dt_i}{dp^*_{ft}} + \sum_{j \neq i} \frac{dp^*}{dt_j}\frac{dt_j}{dp^*_{ft}}.$$

As countries share symmetric fundamentals, it is $dt_i/dp^*_{ft} = dt_j/dp^*_{ft}$ and $dp^*/dt_i = dp^*/dt_j$. Hence, from the last two equations we obtain

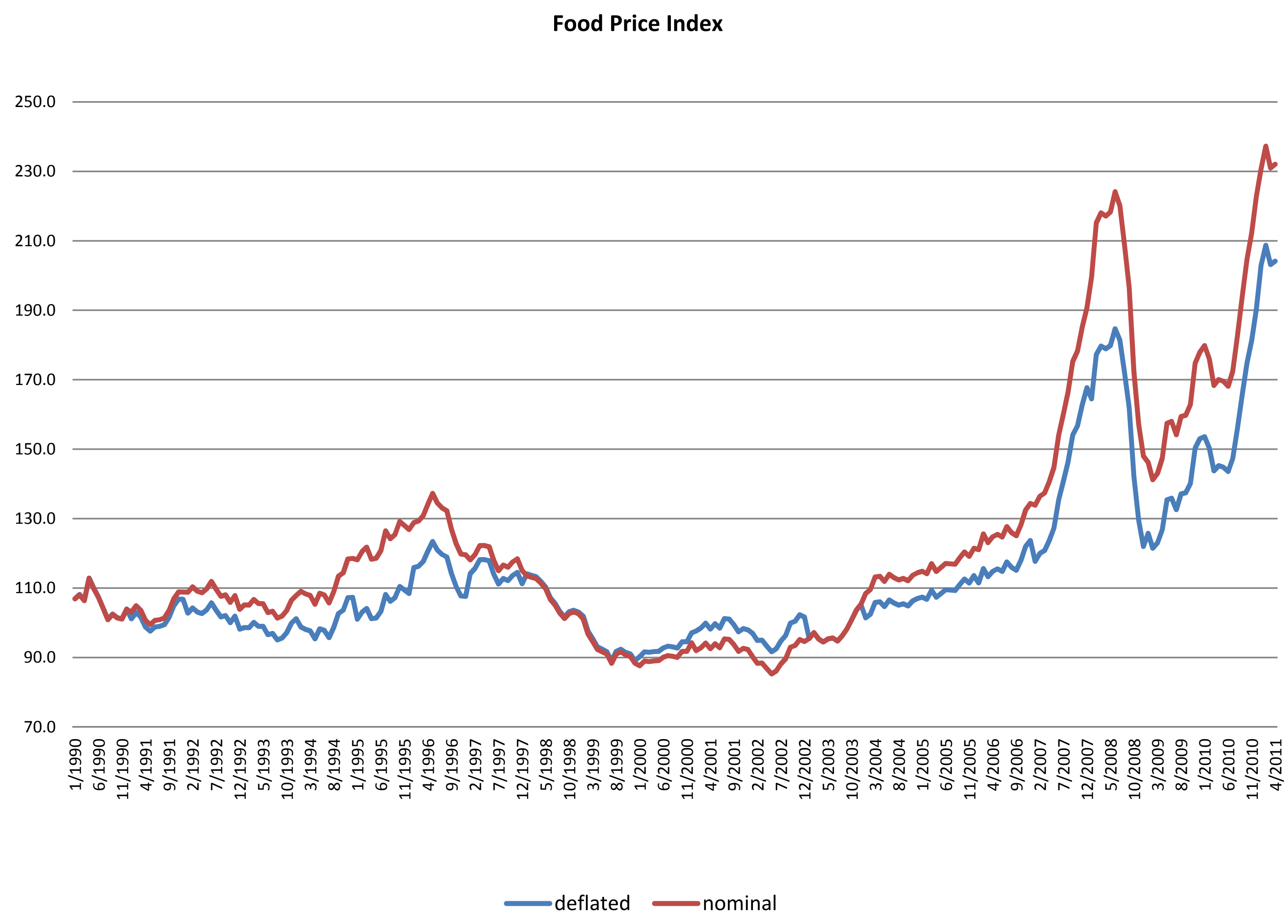
$$\frac{dt_i}{dp^*_{ft}} = \Phi \frac{\partial t_i}{\partial p^*_{ft}} \;\; \forall i = 1, .., n.$$

where

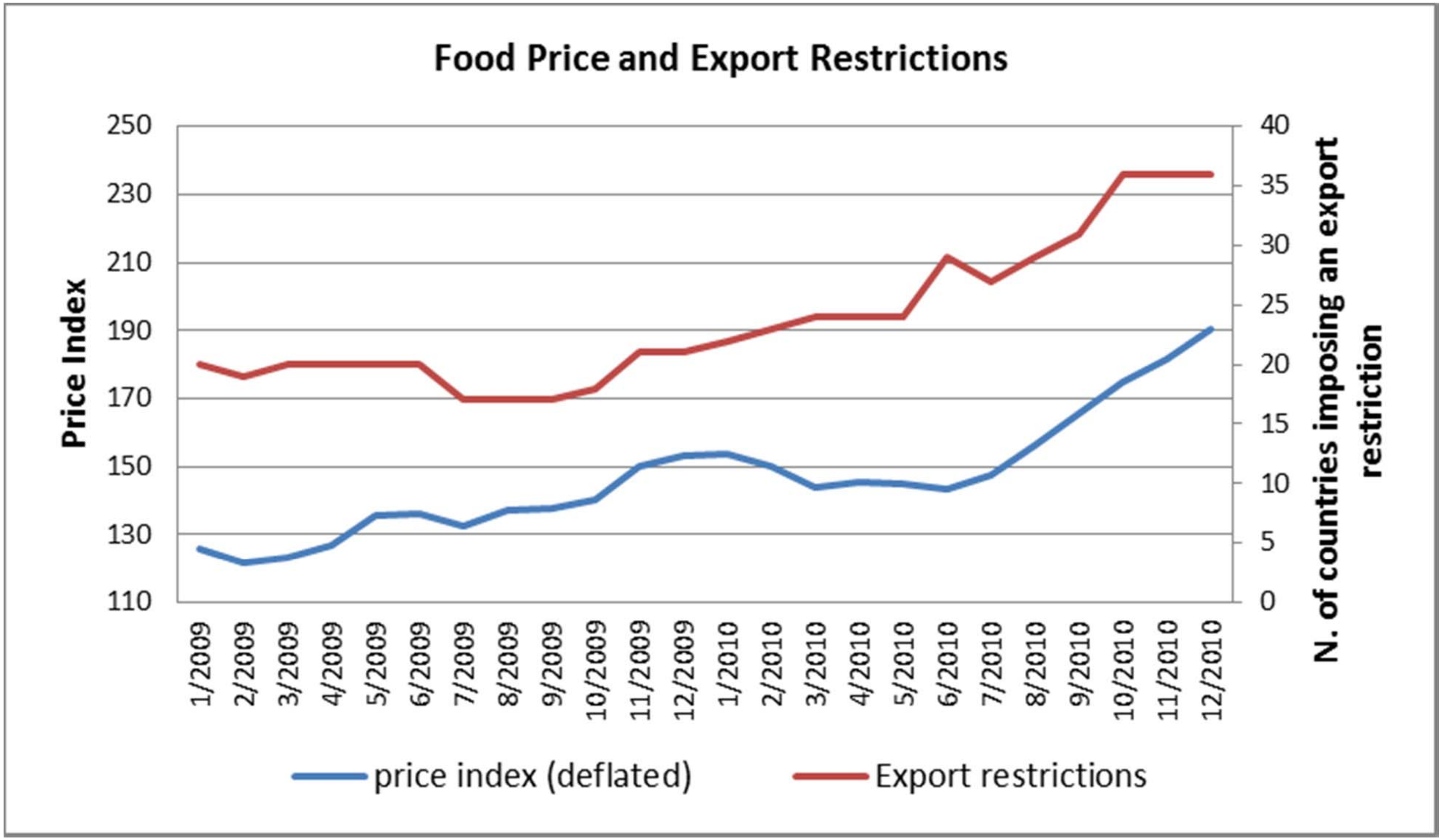
$$\Phi \equiv \frac{1}{1 - n\frac{dp^*}{dt_i}} > 1,$$

as $dp^*/dt_i \in (0, 1/n)$.

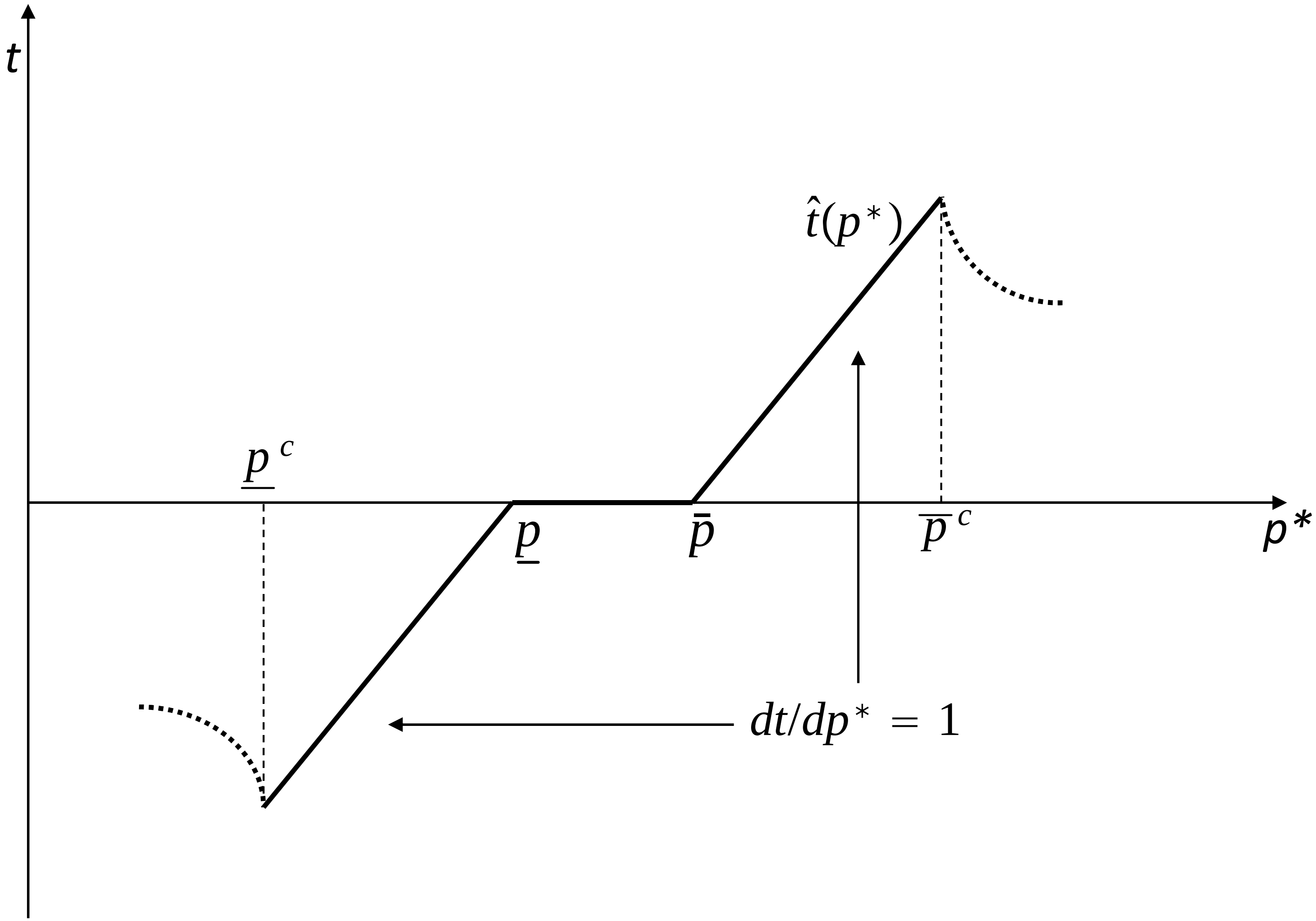
# FIGURE 1: Food prices 1990-2010



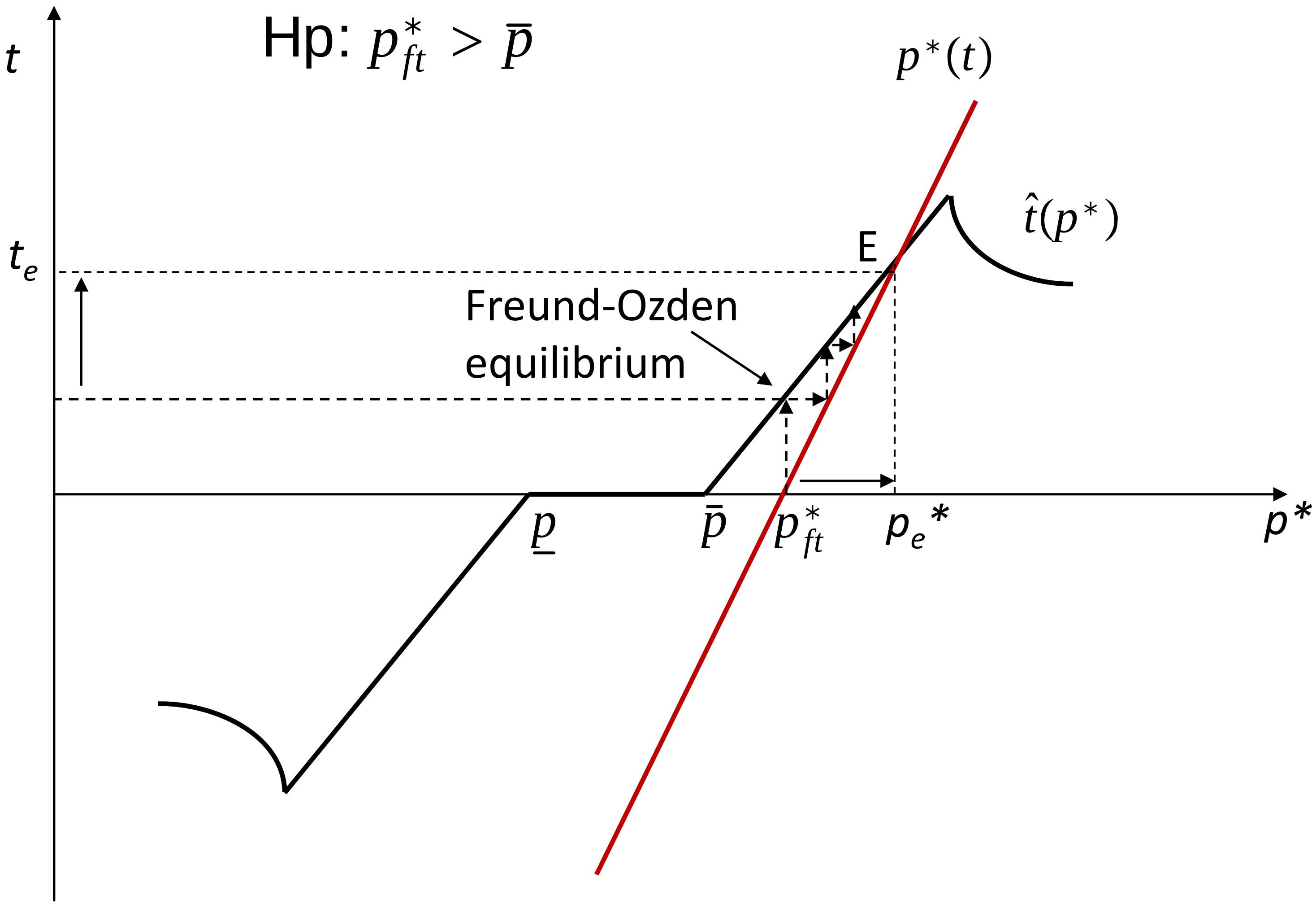
# FIGURE 2: Food prices and export restrictions



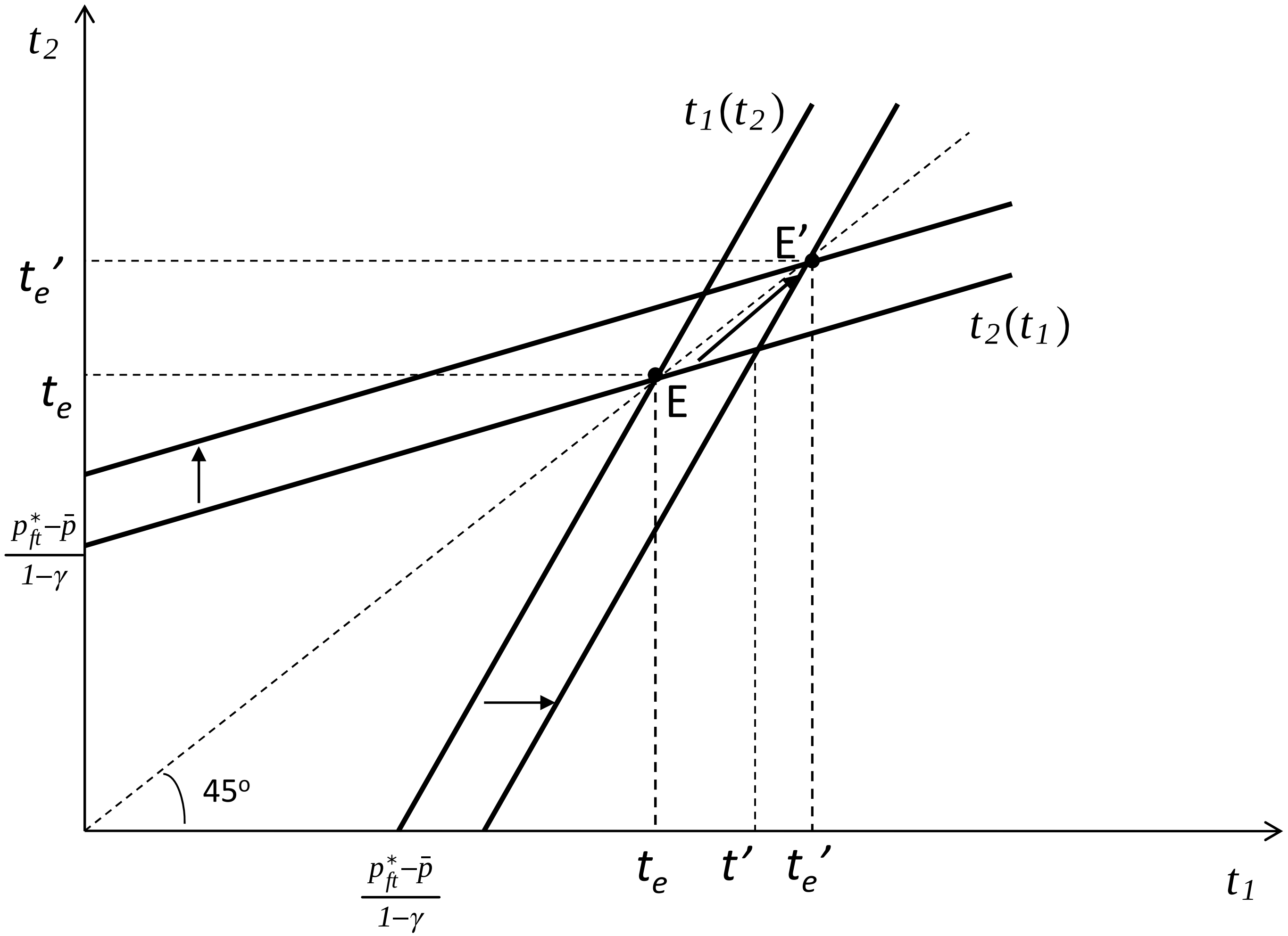
# FIGURE 3: Export policy (small economy)



# FIGURE 4: Multiplier effect (small economies)



# FIGURE 5: Multiplier effect (large economies)



# Table 1: Food prices before and after 2006

| | Food | | Meat | | Dairy | | Cereals | | Oils | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | s.d. | Mean | s.d. | Mean | s.d. | Mean | s.d. | Mean | s.d. |
| 1990-2006 | 107.6 | 12.6 | 112.3 | 13.0 | 99.5 | 18.0 | 103.5 | 15.7 | 97.5 | 20.2 |
| World Food crisis 2007- mid-2008 | 177.5 | 32.4 | 132.7 | 13.6 | 223.8 | 41.4 | 199.5 | 52.4 | 202.0 | 54.2 |
| World Food crisis 2009-2010 | 170.9 | 21.0 | 142.5 | 11.8 | 171.0 | 38.9 | 178.2 | 23.0 | 171.5 | 32.8 |

# Table 2: Export restrictions by sector

| hscode | Product Name | N Exp. Restrictions | % of trade covered by exp restrictions |
|---|---|---|---|
| 0203 | *Meat of swine, fresh, chilled or frozen* | 1 | 0.001 |
| 1509 | *Olive oil and its fractions, whether or not refined* | 2 | 0.001 |
| 1507 | *Soya-bean oil and its fractions* | 4 | 0.023 |
| 1207 | *Other oil seeds and oleaginous fruits* | 1 | 0.0 |
| 1508 | *Ground-nut oil and its fractions* | 2 | 0.0 |
| 1514 | *Rape, colza or mustard oil and fractions* | 5 | 0.1 |
| 1201 | *Soya beans, whether or not broken* | 2 | 0.5 |
| 1512 | *Sunflower-seed, safflower or cotton-seed oil and fats* | 5 | 0.6 |
| 0204 | *Meat of sheep or goats, fresh, chilled or frozen* | 1 | 0.6 |
| 1504 | *Fats and oils and their fractions* | 2 | 0.8 |
| 0405 | *Butter and other fats and oils derived from milk* | 6 | 0.9 |
| 1007 | *Grain sorghum* | 2 | 1.0 |
| 1701 | *Cane or beet sugar and chemically pure sucrose* | 4 | 1.2 |
| 0207 | *Meat and edible offal, of the poultry of heading 0* | 1 | 1.6 |
| 1208 | *Flours and meals of oil seeds or oleaginous fruits* | 1 | 2.3 |
| 0201 | *Meat of bovine animals, fresh or chilled* | 7 | 3.8 |
| 0901 | *Coffee, whether or not roasted or decaffeinated* | 1 | 4.0 |
| 0703 | *Onions, shallots, garlic, leeks and others* | 1 | 9.3 |
| 1001 | *Wheat and meslin* | 9 | 14.1 |
| 1005 | *Maize (corn)* | 6 | 16.0 |
| 1003 | *Barley* | 3 | 22.4 |
| 1006 | *Rice* | 13 | 34.6 |
| 1511 | *Palm oil and its fractions, whether or not refined* | 4 | 46.7 |
| 1801 | *Cocoa beans, whole or broken, raw or roasted* | 2 | 50.1 |
| | | | |
| | Total | 85 | |

# Table 3: Export restrictions by type of measure

| Type of export restricion | Food (all sectors) | Staple Food |
|---|---|---|
| | | |
| *Export tax* | 20 | 24 |
| *Export prohobition* | 42 | 48 |
| *Quotas or licensing* | 10 | 10 |
| *Other* | 28 | 24 |

# Table 4: Determinants of export restrictions

| | All food products | All food products | All food products | All food products | All food products | All food products | Staple products | Staple products | Staple products |
|---|---|---|---|---|---|---|---|---|---|
| | Logit | LPM | LPM | Logit | LPM | LPM | Logit | Logit | Logit |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| log Int. Prices $_{t-1}$ | 0.001* | 0.001* | 0.001* | 0.0004* | 0.001* | 0.001* | 0.038* | 0.011 | 0.034** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.020] | [0.009] | [0.017] |
| log quarterly Exp | 0.001** | 0.002** | 0.001 | 0.001** | 0.002** | 0.001 | 0.001** | 0.001** | 0.001** |
| | [0.000] | [0.001] | [0.001] | [0.000] | [0.001] | [0.001] | [0.001] | [0.000] | [0.001] |
| Share Agr. Va | 0.056* | 0.147 | | 0.055* | 0.147 | | 0.077** | 0.067** | 0.073** |
| | [0.033] | [0.091] | | [0.033] | [0.091] | | [0.037] | [0.034] | [0.036] |
| Global Restrictions $_{t-1}$ (weighted) | | | | 0.019** | 0.084** | 0.084** | | 0.041** | |
| | | | | [0.009] | [0.039] | [0.039] | | [0.019] | |
| Global tariff reductions t-1 (weighted) | | | | 0.002 | 0.004 | 0.004 | | -0.005* | -0.003 |
| | | | | [0.001] | [0.003] | [0.003] | | [0.003] | [0.002] |
| Time (monthly) FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Product FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | | | Yes | | | Yes | | | |
| Observations | 43186 | 63548 | 63548 | 43186 | 63548 | 63548 | 7716 | 7716 | 7716 |
| R-squared | | 0.022 | 0.14 | | 0.024 | 0.142 | | | |

Standard errors clustered at country level. *** p<0.01, ** p<0.05, * p<0.1.

# Table 5: Determinants of export restrictions (large exporters)

| VARIABLES | LPM | LPM | LPM | LPM | LPM | LPM | LPM | LPM |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| log Int. Prices $_{t-1}$ | 0.001** | 0.001** | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0004 | 0.001 |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| log quarterly Exp | 0.001** | | 0.001** | | 0.001** | | 0.001** | |
| | [0.000] | | [0.000] | | [0.000] | | [0.000] | |
| big exporter | 0.033 | 0.039* | 0.027* | 0.033* | 0.027* | 0.033* | -0.011** | -0.007 |
| | [0.020] | [0.022] | [0.016] | [0.017] | [0.016] | [0.017] | [0.005] | [0.005] |
| log Int. Prices t-1 x Big Exporter | | | 0.016* | 0.016* | 0.016* | 0.016* | 0.003* | 0.003* |
| | | | [0.009] | [0.009] | [0.009] | [0.009] | [0.001] | [0.001] |
| Global Restrictions $_{t-1}$ (weighted) | | | | | 0.082** | 0.082** | 0.014 | 0.014 |
| | | | | | [0.039] | [0.039] | [0.012] | [0.011] |
| Global Exp. Restr. (weighted) x Big Exporter | | | | | | | 1.717*** | 1.721*** |
| | | | | | | | [0.529] | [0.530] |
| Observations | 63280 | 63280 | 63280 | 63280 | 63280 | 63280 | 63280 | 63280 |
| R-squared | 0.026 | 0.025 | 0.031 | 0.03 | 0.034 | 0.033 | 0.116 | 0.115 |

Standard errors clustered at country level. *** p<0.01, ** p<0.05, * p<0.1.

Other control variables included in the regression are the share of agricultural value added and product and time FE.

# Table 6: Determinants of export restrictions (IV regression)

| | All exporters | Big exporters | All exporters | All exporters | All exporters | All exporters | Big exporters | Big exporters |
|---|---|---|---|---|---|---|---|---|
| | LPM | LPM | IV | IV | IV | IV | IV | IV |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| log Int. Prices $_{t-1}$ | 0.001* | -0.0008 | 0.161** | 0.161** | -0.0007 | 0.001 | 0.136 | 0.051 |
| | [0.000] | [0.001] | [0.077] | [0.078] | [0.011] | [0.010] | [0.201] | [0.211] |
| Global Restrictions $_{t-1}$ (weighted) | 0.082** | 1.685*** | | | 0.110* | 0.110* | 1.647*** | 1.655*** |
| | [0.039] | [0.480] | | | [0.066] | [0.066] | [0.593] | [0.601] |
| Time (monthly) FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Product FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | | Yes | | Yes | | Yes |
| Observations | 63548 | 2236 | 39434 | 39434 | 39434 | 39434 | 1435 | 1435 |
| Hansen J statistic | | | 1.286 | 1.222 | 3.563 | 3.406 | 0.902 | 0.786 |
| p-value of Hansen J statistic | | | 0.257 | 0.269 | 0.168 | 0.182 | 0.637 | 0.675 |

Standard errors clustered at country level. *** p<0.01, ** p<0.05, * p<0.1.

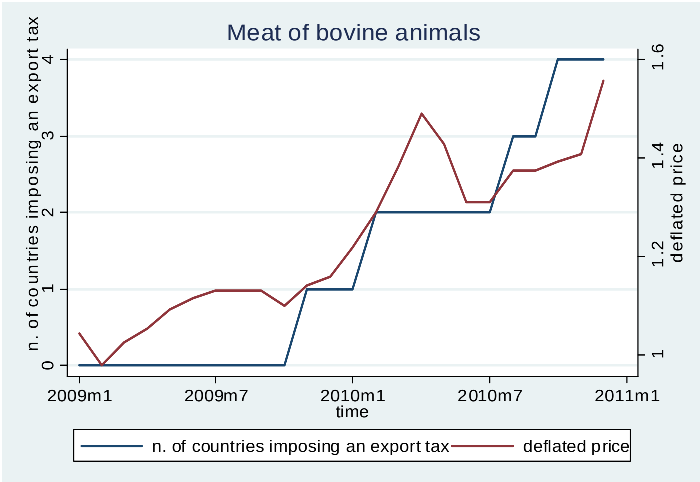
Other control variables are the share of agricultural value added and the log of quarterly exports.

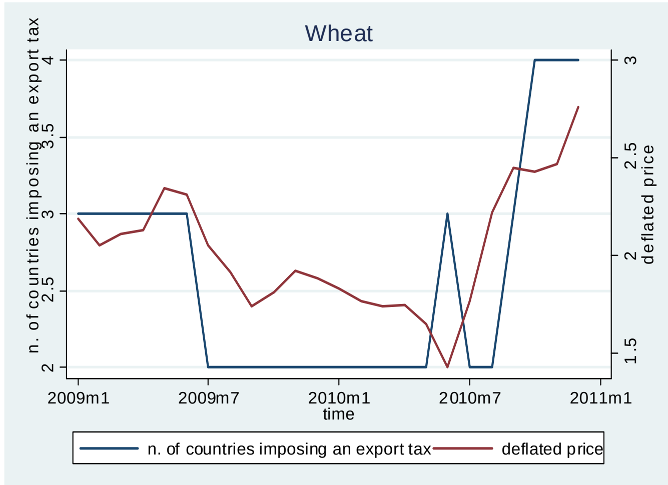
# Table 7: Impact of export restrictions on food prices

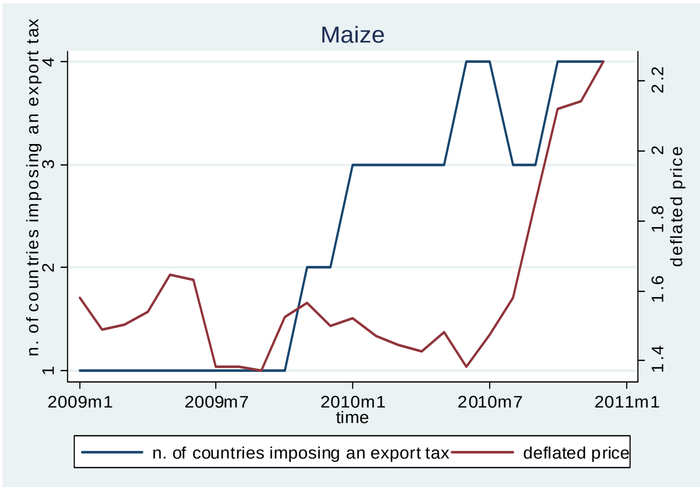
| Second stage results | | | | | | |
|---|---|---|---|---|---|---|
| Dep var: $\Delta_{t-(t-x)}$ log prices | x=1 month | x=2 months | x=3 months | x=4 months | x=5 months | x=6 months |
| $\Delta_{t-(t-x)}$ N. export restrictions | -0.0114 | 0.0281 | 0.0435 | 0.0558* | 0.0752* | 0.1069** |
| | [0.031] | [0.027] | [0.030] | [0.033] | [0.041] | [0.054] |
| $\Delta_{t-(t-x)}$ log rainfall | 0.0209 | 0.0168 | 0.0138 | 0.0125 | 0.0118 | 0.0116 |
| | [0.017] | [0.016] | [0.015] | [0.015] | [0.015] | [0.016] |
| $\Delta_{t-(t-x)}$ rainfall deviation | -0.001 | 0.0003 | 0.0009 | 0.0006 | 0.0003 | 0.0002 |
| | [0.004] | [0.003] | [0.003] | [0.003] | [0.003] | [0.003] |
| $\Delta_{t-(t-x)}$ log energy prices | 1.2319 | 1.021 | 0.415 | 0.1926 | 0.0945 | -0.0817 |
| | [1.019] | [0.691] | [0.482] | [0.421] | [0.427] | [0.504] |
| Observations | 630 | 612 | 594 | 576 | 558 | 540 |
| F-statistic from first stage regression | 37.3 | 38.27 | 22.02 | 14.39 | 29.57 | 8.86 |
| P-value F statistic | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

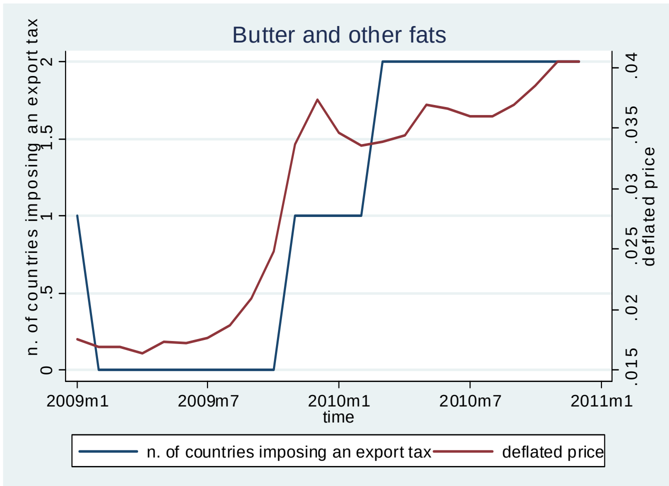
Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Regressions include time FE.

# Appendix Table B1: Food prices and export restrictions by sector



# Appendix Table B2: Determinants of export restrictions (lagged explanatory variables)

| | All food products | All food products | All food products | All food products | Staple products | Staple products | Staple products | Staple products |
|---|---|---|---|---|---|---|---|---|
| | Logit | Logit | Logit | Logit | Logit | Logit | Logit | Logit |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| log Int. Prices $_{t-2}$ | 0.0005* | | 0.0004* | | 0.0344* | | 0.0198 | |
| | [0.000] | | [0.000] | | [0.018] | | [0.014] | |
| log Int. Prices $_{t-3}$ | | 0.0004* | | 0.0004 | | 0.0310* | | 0.0171 |
| | | [0.000] | | [0.000] | | [0.017] | | [0.014] |
| log quarterly Exp | 0.0008** | 0.0008** | 0.0008** | 0.0008** | 0.0013** | 0.0013** | 0.0013** | 0.0013** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.001] | [0.001] | [0.001] | [0.001] |
| Share Agr. Va | 0.0559* | 0.0560* | 0.0555* | 0.0558* | 0.0789** | 0.0810** | 0.0777** | 0.0803** |
| | [0.033] | [0.033] | [0.033] | [0.033] | [0.038] | [0.040] | [0.038] | [0.039] |
| Global Restrictions $_{t-2}$ (weighted) | | | 0.0151** | | | | 0.0368** | |
| | | | [0.007] | | | | [0.016] | |
| Global Restrictions $_{t-3}$ (weighted) | | | | 0.0127** | | | | 0.0389** |
| | | | | [0.006] | | | | [0.016] |
| Observations | 43186 | 43186 | 43186 | 43186 | 7716 | 7716 | 7716 | 7716 |

Standard errors clustered at country level. *** p<0.01, ** p<0.05, * p<0.1. All regressions include product and time FE.

# Appendix Table B3: Determinants of export restrictions (lagged explanatory variables, large exporters)

| VARIABLES | LPM | LPM | LPM | LPM |
|---|---|---|---|---|
| | (2) | (2) | (3) | (4) |
| log Int. Prices $_{t-2}$ | -0.0001 | | 0.0004 | |
| | [0.000] | | [0.000] | |
| log Int. Prices $_{t-3}$ | | -0.0001 | | 0.0003 |
| | | [0.001] | | [0.000] |
| big exporter | 0.0336* | 0.0346* | -0.0045 | -0.0017 |
| | [0.018] | [0.018] | [0.005] | [0.005] |
| log Int. Prices t-2 x Big Exporter | 0.0168* | | 0.0035* | |
| | [0.009] | | [0.002] | |
| log Int. Prices t-3 x Big Exporter | | 0.0172* | | 0.0012 |
| | | [0.010] | | [0.012] |
| Global Restrictions $_{t-2}$ (weighted) | 0.0734** | | 0.0067 | |
| | [0.036] | | [0.012] | |
| Global Restrictions $_{t-3}$ (weighted) | | 0.0668* | | 0.0043* |
| | | [0.034] | | [0.002] |
| Global Exp. Restr. t-2 (weighted) x Big Exporter | | | 1.7119*** | |
| | | | [0.530] | |
| Global Exp. Restr. t-3 (weighted) x Big Exporter | | | | 1.6972*** |
| | | | | [0.532] |
| Observations | 61492 | 61492 | 59704 | 59704 |
| R-squared | 0.033 | 0.111 | 0.033 | 0.106 |

Standard errors clustered at country level. *** p<0.01, ** p<0.05, * p<0.1.

# Appendix Table B4: First stage IV regression

| | All exporters | All exporters | Big exporters |
|---|---|---|---|
| | (1) | (2) | (3) |
| | log Int. Prices $_{t-1}$ | | |
| log Rainfall top5 $_{t-1}$ | -0.0235*** | -0.0591*** | -0.0842** |
| | [0.002] | [0.002] | [0.040] |
| log Rainfall var top5 $_{t-1}$ | 0.0133*** | 0.0087*** | 0.0056 |
| | [0.000] | [0.000] | [0.004] |
| $ER_{-k, t-1}$ | | -0.0323*** | -0.0364*** |
| | | [0.000] | [0.005] |
| Elections top5 | | 0.0192*** | 0.0034 |
| | | [0.001] | [0.022] |
| R squared | 0.988 | 0.989 | 0.99 |
| | Global Restrictions t-1 (weighted) | | |
| log Rainfall top5 $_{t-1}$ | | -0.0301*** | -0.0357 |
| | | [0.002] | [0.024] |
| log Rainfall var top5 $_{t-1}$ | | 0.0109*** | 0.0129*** |
| | | [0.000] | [0.004] |
| $ER_{-k}$ | | 0.0016*** | -0.0006 |
| | | [0.000] | [0.005] |
| Elections top5 | | -0.0191*** | -0.0252* |
| | | [0.001] | [0.013] |
| R squared | | 0.618 | 0.617 |
| Observations | | 39434 | 1435 |
| F statistic | | | |

Standard errors clustered at country level. *** p<0.01, ** p<0.05, * p<0.1.