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# **Agricultural support and vulnerability of food security to trade in developing countries**

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## **Introduction**

Food security is a major concern, especially for developing countries, where a large share of the population lives in rural areas and the agricultural sector represents a substantial weight in the economy. The food security issue has come to the fore in recent years with the 2007-2008 food crisis and agricultural price volatility. In previous decades, the focus was more on producers with lower incomes due to lower agricultural price trends. The 2007-2008 price hike redirected attention to poor consumers as food riots erupted in many developing countries. Low-income countries are particularly vulnerable to agricultural price surges because most of them are net food-importing countries. Gilbert (2012) affirms that a country's level of development is important and that global food security policy should be oriented towards the poorest countries. For instance, Dávila (2010) finds that higher prices for maize affected Mexican household living standards and food security in both urban and rural areas during the period 2006-2008. The World Trade Organization (WTO) Ministerial Conference on 7 December 2013 in Bali decided to raise a negotiation on an agreement for the issue of public stockholding for food security and, in the interim, authorized developing countries to provide support for traditional staple food crops for food security reasons and under certain conditions (WTO 2013). Indeed, Dawe et al. (2015) analyse the behaviour of cereal prices because cereals are the most important expenditure item for the poor and food insecure. According to them, price volatility is substantially higher in poor countries in particular in Africa.

First coined in the mid-1970s, food security is a multi-dimensional concept, as shown by the many attempts to define it (Maxwell 1996; Smith 1998). Food security has been analysed at many levels (individual, household, regional, national and global) over time, but food security at one level does not guarantee food security at another level. According to the FAO, "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit 1996). This definition includes four components: physical availability, economic access, stability and adequate utilization. Van Duij and Meijerink (2014) review major global food security studies from 2000 to 2013. They show that most scenarios address only two of the four dimensions of food security—food availability and food accessibility—while food utilization and stability are largely ignored.

Additionally, a number of hunger estimates are proposed in the literature without any consensus (see, for instance, Clay 2002; Butler 2015). However, this paper does not set out to redefine and re-explain the food security concept (which is discussed, for instance, in Regmi and Meade (2013) and Grote (2014)).

In this paper, we are in line with Diaz-Bonilla et al. (2000), who take the World Food Summit's definition of food security and propose a conceptual framework that is adapted from Smith (1998) and displays the multiple links and interactions between trade and food security at each level (from individual to global). Diaz-Bonilla and Ron (2010) demonstrate the key role played in national food availability by i) agriculture, a major sector in most developing countries where food security is at risk; ii) domestic agricultural and food policies prompting agricultural price deviations that have opposite effects on net buyer *versus* net seller households; and iii) trade policies in developed and developing countries that affect the domestic and foreign agricultural markets because WTO regulations have little influence on the use of trade policy tools. They also suggest considering the positive effects on employment and poverty alleviation of suitable macroeconomic policies in other areas, such as agricultural, financial, human and institutional concerns.

The world agricultural price surge in 2007-2008 showed that developing countries, particularly those in Africa, are constantly at risk of chronic food crisis. Food riots, rocketing prices and concerns about the future effects of climate change have led some to claim that food security is improved by agricultural trade liberalization because trade can offset local market shortcomings and provide consumers with commodities at low prices. Timmer (2010) suggests that the best way to prevent food crises in the long run is to invest in "agricultural productivity and policies on behalf of stable food production and prices" rather than "trying to cope afterwards with the food crisis impact on the poor."<sup>1</sup> To be more specific, agricultural and food imports play a key role in food security in low-income countries. Indeed, dependence on imports for food may increase food insecurity in the case of sudden price hikes in the national food bill. The national state of food availability in the form of food imports and domestic food production is therefore crucial information. Analysing the stability of food availability through the agricultural domestic and trade policies of importing countries is the core of this paper.

Following Diaz-Bonilla et al. (2000), this contribution aims to shed light on the vulnerability of food security to trade at the national level and on the way some political tools may be used to reduce the vulnerability and instability of food availability. The originality of this paper is that it takes into account most policy-distortion measures that introduce a gap between world and domestic prices of importable food products. Section 1 analyses the economic links between the national vulnerability of

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<sup>1</sup> A third view defended by the food sovereignty movement is that long-term food security cannot depend on food imports but must be built on the development of domestic production with enough barrier protection to shelter it from world price fluctuations and unfair trading (Laroche-Dupraz and Postolle 2013).

food security and different forms of policy interventions in agriculture. Those relationships are formalized using an indicator of vulnerability of food security to trade called the Bonilla Index. Then, in section 2, we test this theoretical framework with empirical data to understand the weight of national policy responses to the 2008 price surge. Section 3 statistically tests the extent to which our hypotheses and relationships are actually confirmed by the data covering the period 2005-2010, before concluding.

## **1. Agricultural assistance and food security**

### ***1.1. Effects of border and domestic measures on agricultural distortions***

National trade policies cover border import and export taxes (tariffs) or subsidies and quantity restrictions (export bans or import quotas). The effects of such trade policies on domestic supply, imports and the economic welfare of producers and consumers are well known (Krugman et al. 2012): these tools impact the relative competitiveness of domestic production compared with the world market. A protective policy (high agricultural tariffs) has positive effects on domestic supply but negative impacts on domestic consumers. Given that agricultural commodities are a staple foodstuff, such a policy applied to the agricultural sector is conducive to self-sufficiency but may not promote food security where domestic supply is insufficient or unsuitable for the domestic population's food needs. At the same time, applied tariffs (resp. subsidies) represent resources (resp. costs) for national budgets. This impact on government revenues may contribute to (resp. threaten) the funding of domestic policies that directly or indirectly promote an increase in household incomes (and therefore individual food security) or that invest in health and education. An open market (low or zero tariffs) is positive for urban consumers but could discourage domestic producers from developing their production supply if they cannot compete with international competition. Therefore, an open market has a positive effect on food security in that it facilitates domestic access to international agricultural supply, but it can also have a negative impact on domestic supply and increase food dependence on imports, which becomes a serious problem in the case of high world food prices and price surges.

Agricultural domestic support measures also include taxes (if negative) or subsidies (if positive) applied to outputs or inputs. A positive domestic support coupled to production, such as price support or production payments, introduces a gap between a higher domestic price and a lower world price. This is not the case with decoupled domestic support, which is not expected to have such a distortive effect on agricultural prices. As a result, positive domestic support, if coupled, has similar effects to border tariff protection, i.e., a positive impact on domestic supply and a negative effect on domestic demand. However, the impact on government revenue is not the same: price support is directly financed by domestic consumers, while subsidies are charged to the national budget.

Positive domestic support and tariff protection to encourage domestic supply both may have a negative distortive impact on the world price. This is why the use of border measures and domestic support

measures has been regulated by the WTO in the agricultural sector since the Uruguay Round Agricultural Agreement (1994) to limit the negative impact of agricultural support on world agricultural prices. However, although WTO rules are binding in major developed countries, which have had to reform their agricultural policies to comply, most developing countries are not similarly bound, for two reasons. First, most developing countries have experienced very low agricultural support levels, often even negative ones in the 1970s or 1980s. Second, WTO reduction commitments are much lower for developing countries than for developed countries, and the recent WTO Ministerial Decision confirms this differential treatment at the middle term for food security purposes (WTO 2013). Note that WTO regulations are designed only to counter negative agricultural world price distortions. There are no rules to restrict support measures that have positive effects on world prices, such as export restraints or import subsidies.

In this article, we use the nominal rate of assistance (NRA) as a consistent indicator of the global agricultural support level. Calculated by the World Bank for a large panel of countries of all geographic regions, the NRA assesses the “agricultural incentive distortions” by taking into account not only subsidies or taxes in the agricultural sector but also indirect effects due to other sectoral policies or exchange rate distortions (Anderson 2009, 2010). More precisely, we use the last updated data (Anderson and Nelgen 2012). Note that in this updated database, the only exchange rate-induced indirect effect covered is the case where a government imposes a different exchange rate for importers and exporters that implicitly taxes them. Such a distortion is taken into account in the NRA database by using the appropriate official exchanges rates to correct downwards and upwards the prices respectively of exportable and importable products - except if the authors consider that the black market of foreign currency is enough developed to cancel the distortive effect of the official multitier foreign exchange regime. However, the “straightforward” overvaluation is disregarded because Anderson (2009) considers that “a change in the real exchange rate alters equally the prices of exportable and importable [products] relative to the price of non-tradable goods and services (...). The real exchange rate appreciation reduces the incentive to produce importable and exportable [products] to the same degree and (...) does not generate any change in the price of exportables relative to importables”. In this respect, Anderson (2009) considers that such an overvaluation does not really constitute a trade distortion. This point of view is questionable<sup>2</sup>. This methodological choice is understandable because one main aim of Anderson (2009) is to assess and compare distortions to agricultural incentives for the production of importable and of exportable agricultural products at national level. But one can note that previous World Bank’ works had conversely considered overvaluation as a distortive policy to be taken into account in their calculations of NRA. Hence Krueger et al. (1988), for example, attribute a largely negative rate of assistance in the case of Côte

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<sup>2</sup> In his book review, Mahé (2010) regrets this exclusion of the effects of overvalued currency and notes that “ The reasons behind are not further made explicitly, save for saying it is not a welfare reducing distortion, which implies that no real effect can result from lasting currency misalignment.”

d'Ivoire in the late 1970s, not only due to the direct taxation of the agricultural sector following the end of guaranteed producer prices, but also because of the overvaluation of the exchange rate in that period, that had negative impact on the competitiveness of agricultural sector mainly based on exported products. Moreover, recent case studies show how an overvaluation has negative effects not only on agricultural exports competitiveness, but also may affect negatively consumers of agricultural products in developing countries, particularly in the case where imports are actually sold domestically at a parallel exchange rate, rather than the official rate, cancelling the effect of low food import prices expected from an overvalued local currency (see for example Pauw et al. , 2013 about Malawi's exchange rate policy). In other words, omitting the likely effects of overvaluations on the import food bill for domestic consumers according to whether consumers actually have access to official rate or not, constitutes a shortcoming of the present contribution and would be the core of further researches. The following section analyses the links between domestic policy and national food security indicators to understand how the determinants of food security interact, particularly by differentiating market contexts (falling *versus* rising agricultural prices).

### **1.2. The Bonilla Index and its determinants**

Diaz-Bonilla et al. (2000) put forward that the ratio of national food import expenditure to the value of total exports is a useful indicator of national access to the world food supply. We call this ratio the Bonilla Index. Assessed at the domestic level, we can write

$$BI = \frac{V_{mf}}{V_x} = \frac{Q_{mf} \cdot P_{mf}^d}{Q_x \cdot P_x^d} \quad (1)$$

where  $V_{mf}$  : value of food imports in local currency;  $V_x$  : value of total exports in local currency;

$Q_{mf}$  : quantity of food imports;  $Q_x$  : quantity of total exports;

$P_{mf}^d$ ,  $P_x^d$  : domestic aggregated prices in local currency for food imports and for total exports.

The Bonilla Index is a consistent indicator of the national capacity to finance food imports from exports. In this regard, it is an interesting indicator of the vulnerability of food security to trade in developing countries, especially net food-importing countries. This index is sensitive to variations in:

- The volume of food imports and total exports because food imports reflect national food needs not covered by domestic production, and total exports are indicative of the country's trade performance and competitiveness;
- The value of food imports and total exports; these values depend on world price trends and their effects on the local currency *via* the exchange rate.

The Bonilla Index assessment finds that food security is less vulnerable to trade when the BI decreases and more vulnerable when the BI increases. Contrary to the food trade position (food net

importer/exporter), the BI considers the relative food import bill to total export earnings, thus demonstrating the role of international trade and its effects on national food security.

In the following analysis, we focus on the agricultural food sector, assuming the relative stability, *ceteris paribus*, of the total export sector, at least in the short term.

A large body of the literature simply uses world price data to compute the Bonilla Index as follows:

$$BI = \frac{V_{mf}}{V_x} = \frac{Q_{mf} \cdot P_{mf}^w}{Q_x \cdot P_x^w} \quad (2)$$

where  $P_{mf}^w$  : world price in foreign currency for food imports;  $P_x^w$  : export price in foreign currency for total exports.

Taking into account agricultural world prices in this ratio leads to disregarding any distortion mechanisms that introduce a gap between world and domestic food prices. Thus, to highlight the pass-through from domestic prices (in local currency) to world prices (in foreign currency), equation (3) introduces not only the exchange rate but also any border measures (export and import taxes and subsidies) and domestic support that actually introduce a gap between the world and domestic food prices. This is a major contribution of this paper. The Nominal Rate of Assistance (NRA) index on importable food products, as calculated by the World Bank (Anderson 2009; Anderson and Nelger 2012), provides information on the distortion effects of such agricultural policy domestic support and border measures. The NRA is defined as the percentage by which government policies have raised revenues to producers above what they would be without the government's intervention (agricultural policy domestic support and border measures).

$$BI^* = \frac{Q_{mf} \cdot P_{mf}^w \cdot (1 + NRA_m) \cdot E}{Q_x \cdot P_x^w \cdot E} \quad (3)$$

where  $E$ : nominal exchange rate, i.e., the number of national currency units against one unit of foreign currency;  $NRA_m$ : nominal rate of assistance assessed for importable food products (in %).

Thus, in the following developments, we focus on the Bonilla Index, taking into account support and border measure distortion effects expressed in local currency after custom clearing  $BI^*$ . For comparison reasons, we also use the ratio without any distortion measure, BI.

Equation (3) highlights the role of the several determinants of the vulnerability of food security to trade: the world price  $P_{mf}^w$  (and its potential volatility), the level of national or trade policies applied to the food import sector ( $NRA_m$ ), and the exchange rate policy with nominal exchange rate  $E$ , which may modify the value of the food import bill.

### ***1.3. Impact of $NRA_m$ and $E$ deviations on $BI^*$***

In the very short term, in an environment of relative agricultural price stability, we observe the following:

- In the event of the depreciation (resp. appreciation) of the local currency to the foreign currency,  $E$  rises (resp. falls); then, the cost of food imports expressed in the local currency rises (resp. decreases).<sup>3</sup> However, the  $BI^*$  may not move because expressed in local currency, food imports and total exports increase in the same proportion if  $Q_x$  remains at the same level.
- If  $NRA_m$  increases (resp. decreases) due, for example, to higher (resp. lower) food import tariffs or domestic food production subsidies, the  $BI^*$  automatically increases (resp. decreases) due to the price distortion for imported food, increasing (resp. decreasing) the vulnerability of food security to trade.

In the longer term, the estimated effects of  $E$  and  $NRA_m$  on food security vulnerability to trade are not so clear because a local currency depreciation (resp. appreciation) or an increase (resp. decrease) in agricultural support may improve (resp. undermine) domestic agricultural competitiveness and stimulate (resp. cut back) domestic food production and total exports. This may have a negative (resp. positive) impact on food import demand  $Q_{mf}$ , have a positive impact on exports  $Q_x$  and drive down (resp. drive up) the  $BI^*$  by reducing (resp. increasing) food dependence on imports.

### ***1.4. Impact of price volatility on food security***

In 2000, the downward trend in world agricultural prices started to shift. Global demand rose more sharply than supply, slowing the downward trend in agricultural prices from 2000 to 2007. Suddenly, agricultural prices spiralled in 2007-2008, triggering hunger riots in a number of developing countries in 2008.

The price volatility debate was reopened following the 2007-2008 price surge as farmers' earnings and consumer purchasing power suddenly looked uncertain, putting food security at risk. Recent years have seen two peaks in world prices for cereals and other major food commodities: once in 2007-2008 and again in 2010-2011. Prices have generally remained at a higher level than they were from the 1980s to the early 2000s. There may be a number of reasons for this trend, such as a growing imbalance between food demand and supply, the rise in oil prices, exchange rate movements and trade restrictions.

Price hikes can have mixed effects in terms of food security. High food prices could be viewed as an opportunity for producers. They could drive an increase in food production, improving the physical availability and access to food and raising producers' incomes. Simultaneously, however, the cost of consumption increases such that under the hypothesis of stable food aid, economic access to food is

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<sup>3</sup> Except in the case where a large part of imports is sold domestically at a parallel exchange rate, rather than the official rate, cancelling the effect of low food import prices expected from an overvalued local currency.

reduced (Diaz-Bonilla and Ron 2010). This phenomenon is more of a concern in developing countries, where a large proportion of household income goes to food. Households in these countries therefore face a drop in real income, and greater uncertainty may suddenly shoot up agricultural prices. Moreover, many producers are net food buyers (being mostly small farmers, livestock producers and artisanal fishers in the developing countries). The main impacts of price variability on producers and consumers are in the uncertainty surrounding income, investment decisions and access to food. Price transmission from international prices to domestic prices can be limited for a number of reasons, including previously analysed policies, such as trade, exchange rate, and other domestic policies, and factors such as infrastructure and transportation costs (Baffes and Gardner 2003; Meyer and von Cramon-Taubadel 2004; Greb et al. 2012; Dawe et al. 2015). Developing countries suffer from a lack of agricultural productivity and weak infrastructures. They may face obstacles such as poor access to credit.

Developing countries responded in different ways to the 2007-2008 price surge. At least as a short-term emergency measure in response to rocketing domestic food prices and to the threat to their cities' food supply, many chose to raise imports by lifting tariffs (and even subsidizing imports) and to restrict their exports with export taxes and bans (FAO, 2009). It has been shown that export taxes generally made food crises worse and contagious, which is why they are widely criticized in a general way by both developed and developing countries and international agencies (Lui and Bilal 2009). However, following the experience of the 2008 price surge, developing countries individually refused any prohibition of export restrictions because they considered them an efficient tool to reduce domestic prices at the national level, especially when food security was at stake (Bouet and Laborde-Debusquet 2010). Looking into WTO members' responses to structural food crises, Crump (2010) concludes that export restrictions would most certainly be used on a massive scale in response to cases such as climate change.

The theoretical framework presented in this section clearly demonstrates the potential impact when a national government implements corrective policies. Changes in the exchange rate and/or the level of domestic support theoretically offset the effects of an agricultural price deviation on the food import bill (numerator of  $BI^*$ ). Equation (3) also shows that by raising (resp. reducing)  $NRA_m$ , it is theoretically possible to offset a fall (resp. rise) in  $P_{mf}^w$  and keep  $BI^*$  stable. The abovementioned policies adopted by importing countries in 2008 can be understood in this way: lifting import tariffs and reducing  $NRA_m$  may offset the food price surge and limit the  $BI^*$  deviation so as not to damage food security vulnerability to trade. The following section analyses the 2008 food crisis in a panel of developing countries for which data are available precisely to assess the scale of using such corrective policies on importable agricultural commodities.

## 2. Evolution of the food security vulnerability to trade of developing countries from 2005 to 2010

### 2.1. Available Data

BI is first computed from the BACI database using equation (1), *i.e.*, at the import border, before the application of any distortive measure.

The annual food import value (numerator) and total export value (denominator) are used to calculate the BI for each country. The BACI-92 database provides consistent trade data in US dollars (import and export values) at HS2, HS4 and HS6. The HS4 level is used to differentiate food commodities from other products so that we can calculate food import values<sup>4</sup>. To be consistent with the statistical regressions of section 3, highly transformed products are excluded because  $NRA_m$  data are given only for agricultural products. We consider chapters 1 to 12 of the HS4 classification (excluding chapters 5 and 6 and Code 1209<sup>5</sup>) as agricultural food commodities. We call the agricultural food imports “food imports”. We are aware that this database restricted to agricultural products may be viewed as a limitation of this paper. However, an analysis of data reveals that the share of our agricultural products imports in total agricultural and processed food imports is larger than 50% in most countries (three-fifths of our sample) (see table A1 in Appendix). The World Bank’s latest updated NRA data (Anderson and Nelgen 2012) present the nominal rate of assistance (NRA) for 81 countries worldwide from 1955 to 2009 or 2010. The data do not cover the entire period for all developing countries, but the years 1995 (or 1996) to 2009 (or 2010) are well covered. A number of NRA aggregates are calculated (as weighted averages), such as NRA applied to tradable products, importable and exportable products, total NRA and its components, *i.e.*, NRA due to domestic measures *vs.* NRA due to border measures. Addressing the food import bill in this section, this study focuses in particular on total NRA applied to importable agricultural commodities ( $NRA_m$ ).

Due to the available data, our sample is composed of 39 developing countries. The characteristics of those countries are presented in Appendix, table A1. Our analysis essentially focuses on the period 2005-2010.

### 2.2. BI evolution paths of developing countries from 2005 to 2010

Figure 1 presents the 2005-2010 average BI of the sample countries. Each country is represented by a point placed on a plan by including the value of food imports on the x-axis and the value of total exports on the y-axis. Axis values are plotted using a decimal logarithmic scale to allow the representation of the vast differences in national situations in our sample. The value of BI grows when moving northwest to southeast on the graph. To see the countries more clearly according to the value

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<sup>4</sup> The World Bank NRA database also computes the nominal exchange rate needed to convert USD trade data into local currency units, when necessary.

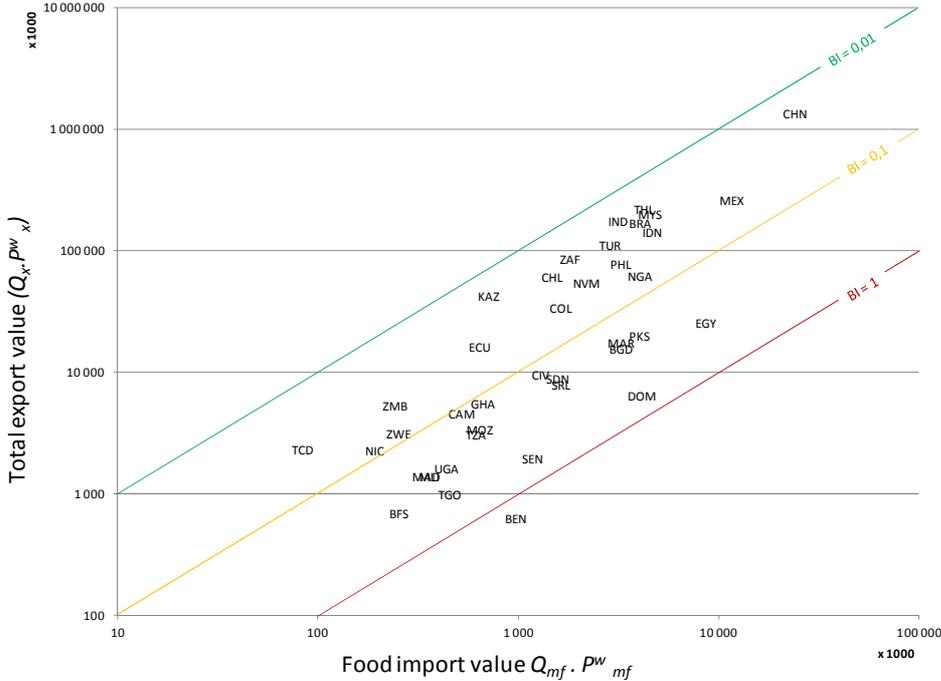
<sup>5</sup> Chapter 5 covers feathers and other animal products for non-food use, Chapter 6 covers ornamental plants, and Code 1209 corresponds to seed for sowing.

of their BI, 3 lines iso-BI are shown, taking BI values of 1% (BI = 0,01), 10% (BI=0,1) and 100% (BI=1), respectively

This graph enables distinguishing:

- Countries at a low or moderate BI (1-10%) and countries with a high BI (10-100%) or a BI greater than 100% (i.e., the case of Benin). Again, a BI higher than 100% indicates that the total export value is insufficient to finance food imports.
- Large countries (China, Mexico, Asian countries, Egypt), which are located in the northeast of the graph, and small countries (Chad, Burkina Faso, Nicaragua, Benin, Mali, Togo, Madagascar), located in the southwest quarter. Indeed, the value of total exports on the one hand and food imports on the other hand are correlated, respectively, to the economic size and the number of inhabitants of the country.

**Figure 1: 2005-2010 average BI of our panel of 39 developing countries**



We can observe on this graph that countries that present very close BI averages are not necessarily in the same situation. For example, Egypt, with a BI level of 34%, is a large country whose exports are important resources, while Burkina Faso, with BI level of 37%, is a much smaller country whose food import needs and export resources are lower than Egypt's.

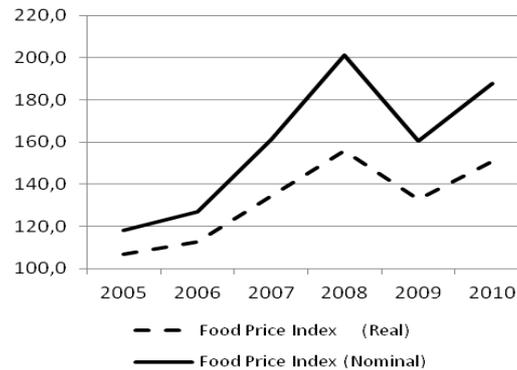
During the period 2005-2010, food prices are characterized by an upward trend with a high level of variability, even in real terms (fig 2b), compared to the previous decade (fig 2a). Without corrective adjustments, one can expect observed variations of food prices to lead to similar fluctuations of food import value that would have an impact on their BI, particularly for countries that are net food-importing countries and have limited export resources.

**Figure 2: FAO Food Price Index from 1990 to 2010; 2002-2004 = 100.**

(2a) Nominal Food Price Index evolution from 1990 to 2010



(2b) Nominal and Real Food Price Index



Source: authors from FAO data, website <http://www.fao.org/worldfoodsituation/foodpricesindex/en/>

“Food Price Index consists of the average of 5 commodity group prices indices [meat, Dairy, Cereals, Vegetable Oils, Sugar]) weighted by the average export shares of each of the group for the base period 2002-2004: in total 73 price quotations considered by FAO commodity specialists as representing the international prices of the food commodities are included in the overall index”.

Figure 3 shows the temporal path of BI and BI\* from 2005 to 2010 in countries in different geographic areas. Black lines correspond to BI calculated with the food import value before import border measures, while grey lines refer to BI\* calculated including  $NRA_m$ , *i.e.*, after import border measures. Corresponding dashed lines indicate the respective averages.

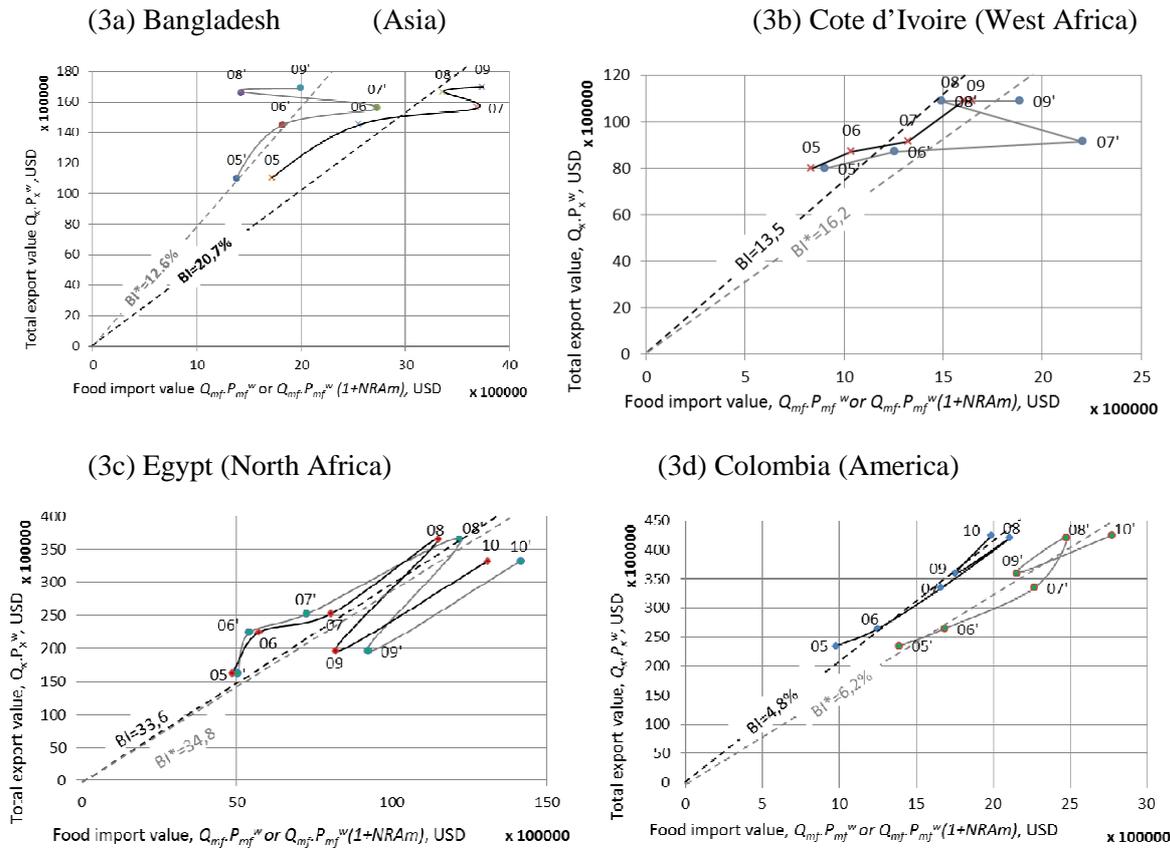
Over the whole period 2005-2010, the average BI calculated before application of trade measures at the import border (without  $NRA_m$ ) may be higher (as in Bangladesh), lower (as in Cote d'Ivoire or Colombia) or very similar (as in Egypt) to the average BI\* calculated after applying  $NRA_m$ . This corresponds to the fact that during this period, agricultural products are subject to a greater or lower import protection by country: negative in Bangladesh, absent or low in Egypt and generally positive in Colombia and Cote d'Ivoire.

An examination of the black curves shows that for the four countries, there is a jump in the value of food imports between 2005-2006 and 2007-2008; this results in a strong eastward shift of the BI points on the graph. We also observe a concomitant increase in the value of total exports. Graphically, BI points are located in 2005 and 2006 in the northwest of the average BI line and move southeast of this line in 2007, 2008 and 2009, except for Egypt.

The examination of the grey shows that the evolution of the BI\* does not substantially follow the same trend as the BI (black curves). A correction appears between 2007 and 2008: BI\* points return northwest of the average BI\*. This suggests that countries seek to adjust their level of  $NRA_m$  to stabilize the BI\* after crossing the border, at least when the variations in the value of food imports are not offset by the change in the value of total exports.

Indeed, as mentioned in section 1, many authors have shown that during the food price peak of 2008, many countries reduced their food exports and reduced their protection against imported food.

**Figure 3: BI and BI\* paths from 2005 to 2010**



### 2.3. Was agricultural support an adjustment variable during 2008 food price surge?

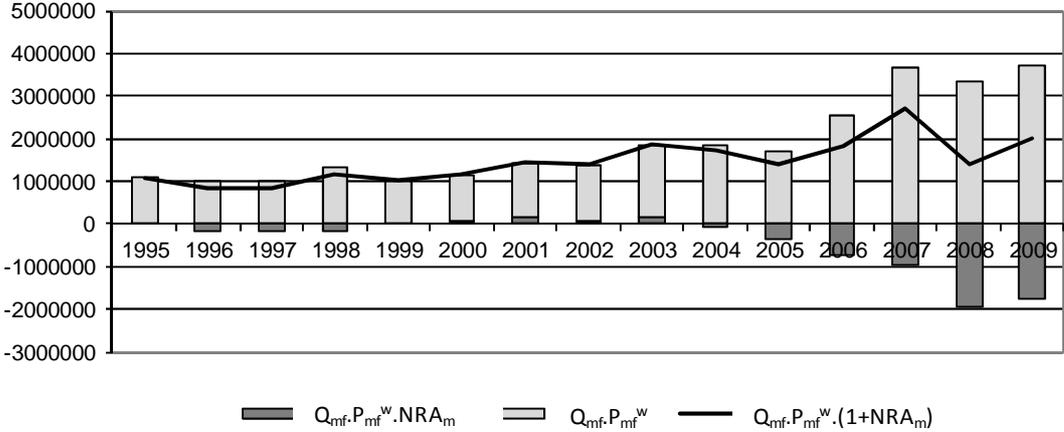
The numerator of BI\* corresponds to the value of food imports, i.e., the food import bill. At this stage, using equation (3) expressed in US dollars, we need to break down this food import bill into two main components:

$$\text{food imports bill} = [Q_{mf} \cdot P_{mf}^w \cdot (1 + NRA_m)] = [Q_{mf} \cdot P_{mf}^w] + [Q_{mf} \cdot P_{mf}^w \cdot NRA_m] \quad (4)$$

In this section, to highlight the particularities of the 2005-2010 period in the longer term, figures of the following graphs and table are reported since 1995.

Figure 4 shows the composition of the food import bill in the case of Bangladesh.

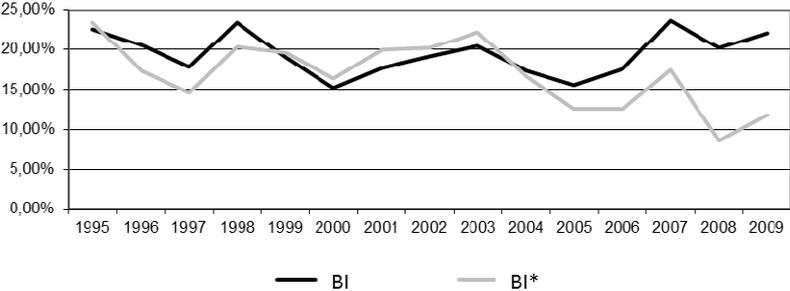
**Figure 4: Impact of  $NRA_m$  on food import bill 1995-2009 in USD thousands in Bangladesh**



Source: authors' calculations using World Bank and BACI data

The line shows Bangladesh's actual food import bill value. The grey bars indicate the value of food imports in undistorted domestic prices, and the black bars represent the additional import cost if  $NRA_m > 0$  or a reduction in the import bill if  $NRA_m < 0$ . In the case of Bangladesh, it can be observed that  $NRA_m$  is close to zero from 1995 to 2004. It is negative from 1996 to 1998 and slightly positive from 2000 to 2003 before becoming significantly negative from 2005 to 2009, especially in 2008. In this particular year, a negative  $NRA_m$  reduced the food import bill by more than half, from USD 3.736 billion to USD 1.996 billion<sup>6</sup>.

**Figure 5: Bonilla Index growth 1995-2009**



Source: authors' calculations using World Bank and BACI data

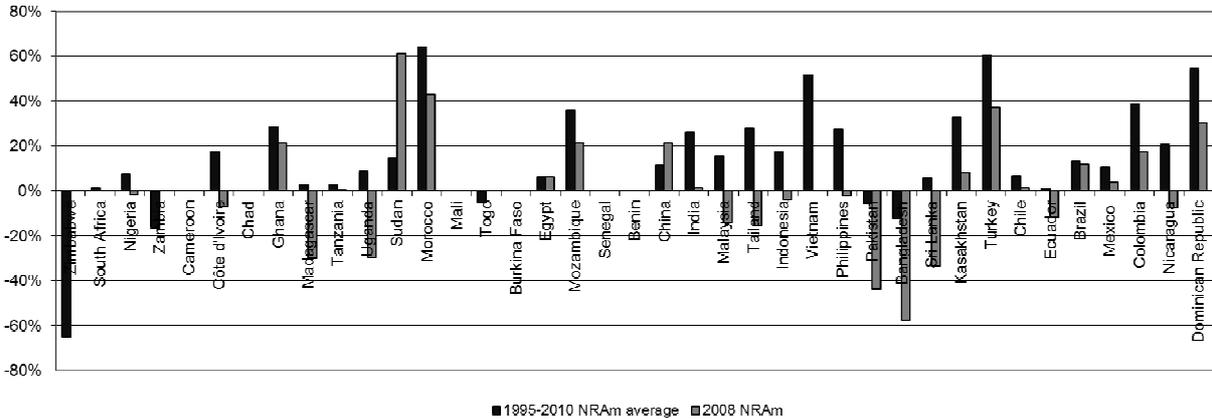
<sup>6</sup> Note that this result does not indicate that if Bangladesh had not provided such a negative  $NRA_m$  in 2008, its food import bill would have been 3.736 billion USD. Actually, it would have been significantly lower, for two reasons. First, Bangladesh is a large country, and its negative  $NRA_m$  in 2008 has a certainly positive distortive effect on  $P_{mf}^w$ . Second, without a negative  $NRA_m$  (i.e., without import subvention), Bangladesh would have imported less. However, the reduction of the food import bill remains effective in the context of negative  $NRA_m$  provided by Bangladesh in 2008, compared to the food import bill calculated without  $NRA_m$ .

Beyond the food bill, i.e., the numerator, we notice in figure 5 that the downward adjustment of  $NRA_m$  observed from 2005 to 2009 led to a negative trend of BI\* over this period, contrary to the BI corresponding to a situation without NRA.

The use of  $NRA_m$  to offset price volatility and especially price surges seems to be effective for many developing countries. Table 1 sums up the impact of  $NRA_m$  on the Bonilla Index for each of the 39 developing countries across the 1995-2010 period and for 2008. The case of Bangladesh is particularly striking.

As shown by Figure 6, all countries—except Sudan and China—present a 2008  $NRA_m$  below the 1995-2010 average  $NRA_m$ .

**Figure 6: 2008  $NRA_m$  compared to 1995-2010  $NRA_m$  average**



Source: authors' calculations, from World Bank and BACI data

**Table 1: Summary statement of  $NRA_m$  impact on  $BI^*$ , 1995-2010 and 2008** (Source: authors' calculations, from Word Bank and BACI data)

Country	1995-2010 $NRA_m$ minimum	1995-2010 $NRA_m$ maximum	1995-2010 $NRA_m$ average	2008 $NRA_m$	Deviation (%) $NRA_m$ 2008 compared to 1995-2010 $NRA_m$ average	1995-2010 $BI^*$ minimum $NRA$ included	1995-2010 $BI^*$ maximum	1995-2010 $BI^*$ average	2008 $BI^*$	Deviation (%) 2008 $BI^*$ compared to 1995-2010 $BI^*$ average	2008 $BI$ without $NRA_m$	Overcost versus reduction cost on 2008 food import bill due to $NRA_m$ (USD)
Zimbabwe	-0.915	-0.339	-0.654	na	na	0.003	0.028	0.015	na	na	0.117	na
South Africa	-0.145	0.122	0.013	0.000	-100.00%	0.012	0.035	0.022	0.020	-8.03%	0.020	0
Nigeria	-0.277	0.456	0.076	-0.017	-122.17%	0.027	0.109	0.057	0.037	-35.13%	0.038	-56 733
Zambia	-0.490	0.046	-0.164	na	na	0.042	0.158	0.079	0.000	-100.00%	0.047	na
Cameroon	0.000	0.000	0.000	0.000	/	0.011	0.192	0.088	0.120	36.76%	0.120	0
<b>Cote d'Ivoire</b>	<b>-0.069</b>	0.668	0.175	<b>-0.069</b>	-139.60%	0.113	0.241	0.149	0.137	-8.46%	0.147	<b>-110 999</b>
Chad	0.000	0.000	0.000	0.000	/	0.026	0.427	0.174	0.037	-78.67%	0.037	0
Ghana	0.046	1.108	0.285	0.212	-25.68%	0.078	0.319	0.176	0.176	-0.32%	0.145	183 354
<b>Madagascar</b>	<b>-0.300</b>	0.448	0.028	<b>-0.300</b>	-1186.34%	0.127	0.344	0.181	0.190	4.66%	0.271	<b>-133 571</b>
Tanzania	-0.521	0.308	0.026	0.002	-90.99%	0.158	0.396	0.259	0.198	-23.60%	0.198	1 614
<b>Uganda</b>	<b>-0.299</b>	0.223	0.085	<b>-0.299</b>	-452.74%	0.174	0.511	0.280	0.188	-32.99%	0.268	<b>-162 695</b>
Sudan	-0.937	0.624	0.146	0.611	317.90%	0.010	0.621	0.284	0.242	-14.57%	0.150	1 186 809
Morocco	0.429	1.010	0.640	0.429	-33.06%	0.234	0.446	0.292	0.275	-6.04%	0.192	1 952 514
Mali	0.000	0.000	0.000	0.000	/	0.181	1.972	0.356	0.210	-41.13%	0.210	0
Togo	-0.492	0.000	-0.053	0.000	-100.00%	0.206	0.650	0.373	0.320	-14.17%	0.320	0
Burkina Faso	0.000	0.000	0.000	0.000	/	0.232	0.641	0.453	0.558	23.22%	0.558	0
Egypt	-0.161	0.292	0.060	0.060	-0.96%	0.242	0.922	0.520	0.334	-35.85%	0.315	684 856
Mozambique	-0.052	0.694	0.357	0.215	-39.63%	0.185	1.333	0.614	0.203	-66.88%	0.167	159 258
Senegal	0.021	0.201	na	na	na	0.548	0.804	0.624	0.000	-100.00%	0.672	na
Benin	0.000	0.000	0.000	0.000	/	0.645	3.747	1.170	2.301	96.71%	2.301	0
China	0.011	0.233	0.117	0.212	81.92%	0.010	0.027	0.018	0.018	-3.77%	0.017	1 205 968
India	-0.113	0.553	0.258	0.013	-94.76%	0.016	0.033	0.024	0.016	-33.49%	0.016	45 563
<b>Malaysia</b>	<b>-0.140</b>	0.445	0.152	<b>-0.140</b>	-192.17%	0.020	0.034	0.026	0.021	-21.06%	0.024	<b>-744 317</b>
<b>Thailand</b>	<b>-0.154</b>	0.732	0.275	<b>-0.154</b>	-155.89%	0.020	0.042	0.031	0.021	-32.31%	0.025	<b>-741 946</b>
Indonesia	-0.210	0.731	0.173	-0.039	-122.24%	0.028	0.067	0.039	0.032	-17.72%	0.033	<b>-212 955</b>
Vietnam	0.000	1.188	0.514	0.000	-100.00%	0.032	0.058	0.048	0.039	-19.22%	0.039	0
Philippines	-0.146	0.596	0.274	-0.021	-107.48%	0.029	0.132	0.059	0.066	12.51%	0.067	-95 578
<b>Pakistan</b>	<b>-0.436</b>	0.232	-0.056	<b>-0.436</b>	683.16%	0.117	0.209	0.164	0.133	-18.84%	0.236	<b>-2 395 621</b>
<b>Bangladesh</b>	<b>-0.578</b>	0.121	-0.125	<b>-0.578</b>	362.34%	0.086	0.234	0.169	0.086	-49.41%	0.203	<b>-1 941 644</b>
<b>Sri Lanka</b>	<b>-0.334</b>	0.466	0.054	<b>-0.334</b>	-713.91%	0.142	0.288	0.187	0.145	-22.42%	0.217	<b>-663 786</b>
Kazakhstan	0.059	1.159	0.327	0.082	-75.00%	0.015	0.041	0.021	0.016	-24.57%	0.015	75 335
Turkey	0.167	1.285	0.605	0.371	-38.67%	0.018	0.087	0.047	0.040	-15.26%	0.029	1 571 356
Chile	0.009	0.149	0.066	0.015	-77.79%	0.020	0.049	0.032	0.029	-9.94%	0.029	28 408
Ecuador	-0.387	0.405	0.011	-0.117	-1166.39%	0.016	0.095	0.039	0.039	-0.66%	0.044	<b>-108 760</b>
Brazil	0.037	0.303	0.134	0.118	-12.30%	0.020	0.091	0.046	0.028	-38.65%	0.025	618 917
Mexico	-0.065	0.312	0.106	0.035	-66.54%	0.043	0.058	0.050	0.053	6.92%	0.051	513 285
<b>Colombia</b>	<b>0.172</b>	0.666	0.389	<b>0.172</b>	-55.75%	0.038	0.139	0.083	0.059	-28.90%	0.050	363 483
<b>Nicaragua</b>	<b>-0.075</b>	0.522	0.206	<b>-0.075</b>	-136.33%	0.080	0.294	0.134	0.086	-35.50%	0.093	-18 579
Dominican Republic	0.040	0.943	0.542	0.304	-43.84%	0.169	0.534	0.321	0.377	17.55%	0.289	657 513

Table 1 and Figure 6 suggest that almost all developing countries for which data are available<sup>7</sup> took measures to cut their food bill by reducing the agricultural rate of assistance on importable agricultural products and even by introducing a negative  $NRA_m$ , i.e., import border subsidies on agricultural commodities. (Nigeria, Cote d'Ivoire, Madagascar, Uganda, Malaysia, Thailand, Indonesia, Philippines, Pakistan, Bangladesh, Sri Lanka, Ecuador and Nicaragua represent this case.) For ten countries (Cote d'Ivoire, Madagascar, Uganda, Malaysia, Thailand, Pakistan, Bangladesh, Sri Lanka, Colombia and Nicaragua), the 2008  $NRA_m$  is the lowest  $NRA_m$  of the 1995-2010 period and is even negative, with the exception of Colombia.

Our sample includes several densely populated Southeast Asian countries with a sharply reduced 2008 food import bill due to  $NRA_m$ : USD 1.941 billion for Bangladesh, USD 2.396 billion for Pakistan, USD 0.664 billion for Sri Lanka, USD 0.744 billion for Malaysia and USD 0.741 billion for Thailand (Table 1). Note that this finding also implies large costs for national revenue: the World Bank  $NRA$  data analysis actually confirms that a negative  $NRA_m$  is due to border measures. In other words, in practice, a negative  $NRA_m$  actually consists of subsidizing agricultural food imports to reduce agricultural import prices, so it costs the government money to maintain household purchasing power. A number of these countries (particularly Bangladesh, Pakistan and Sri Lanka) saw violent food riots in 2008, which may explain the high level of government intervention in response to political and social unrest.

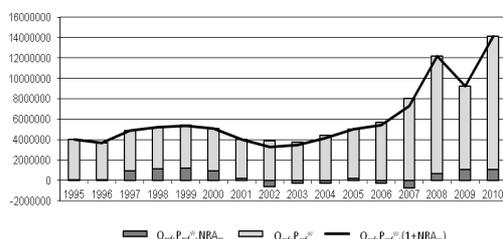
From this point of view, Egypt, where particularly violent food riots erupted in 2008, is surprising in that  $NRA_m$  remained positive in 2008 and near-average for the period 1995-2010. Figure 7 sheds light on other factors that might explain such a paradox. The food bill rose steadily from 2000 onwards, but the Bonilla Index fell in the whole period because the total export revenue increased proportionally more than the food import bill. Consequently, the BI\* did not leap upward in 2008 compared with previous years. In the case of Egypt, the macroeconomic food security situation as reported on by the Bonilla Index was not significantly worse in 2008 than in previous years, but the food import bill was actually significantly higher than at any point previously. Therefore, if export revenues were not well redistributed to the population, this could explain the violence of the food riots in Egypt.

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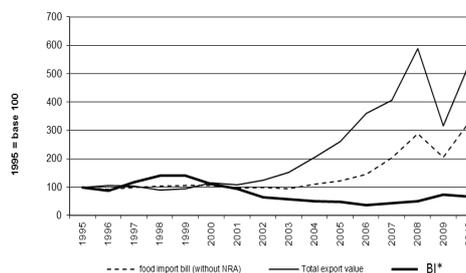
<sup>7</sup> Data on 2008  $NRA_m$  are not available for Zimbabwe, Zambia or Senegal.

**Figure 7:** Food Security in Egypt, 1995-2010 – focus on several determinants

**Impact of  $NRA_m$  on food import bill (USD)**



**Food import bill, export value and BI\*<sup>8</sup>**



Source: authors' calculations using World Bank and BACI data

### 3. Is domestic support level an adjustment variable for the short-run stability of food security?

Section 2 has shown that most developing countries have used their possibility to play with the nominal rate of the assistance level to compensate for the effects of the 2008 food price surge. Was 2008 an isolated year, or does it fit in a BI\* stabilization strategy in the longer term, with global food prices varying upward or downward? Does the exchange rate play a role in stabilizing food availability at the national level?

Based on equation (3), this section assesses to what extent variations in  $NRA_m$  and  $E$  are adjusted to external variations of food import prices or export prices in the recent period 2005-2010, for our sample of 39 developing countries. Our assumption is that countries that have to bear an external shock in food market price  $P_{mf}^w$  or export price  $P_x^w$  give priority to stabilizing their own perception of vulnerability of food security to trade, i.e., by stabilizing BI\* through  $NRA_m$  or only the food bill (numerator of BI\*) through  $E$  adjustments.

Because our sample is partially composed of countries belonging either to monetary or custom unions, countries are linked together through common agricultural, trade and/or monetary policies that affect their  $NRA$  and  $E$  levels. To take that into account, we distinguish these groups of countries in a second stage.

#### 3.1 Materials and method

The trade and NRA data used are presented in section 2.1. We use the nominal exchange rate collected from the World Bank<sup>8</sup> (Anderson and Nelgen 2012): it is expressed as the unit of local currency against one US dollar.

We estimate the following two equations using random effects:

<sup>8</sup> We use the exchange rate defined by Anderson and Nelgen (2012): estimated equilibrium economy-wide accounting for distortions in currency markets (in local currency per dollar). We compare this exchange rate with the nominal bilateral exchange rate provided by the IMF (in local currency per USD), and both datasets exhibit similar patterns.

$$d \ln(1 + NRA_m)_{i,t} = \alpha + \beta_1 d \ln(Q_{mf} \cdot P_{mf}^w)_{i,t} + \beta_2 d \ln(Q_x \cdot P_x^w)_{i,t} + \beta_3 dum_{i,t} + \beta_4 dum_{i,t} * d \ln(Q_{mf} \cdot P_{mf}^w) + u_i + w_{i,t} \quad (5)$$

$$d \ln E_{i,t} = \alpha' + \beta_1' d \ln(Q_{mf} \cdot P_{mf}^w)_{i,t} + \beta_2' d \ln(Q_x \cdot P_x^w)_{i,t} + \beta_3' dum_{i,t} + \beta_4' dum_{i,t} * d \ln(Q_{mf} \cdot P_{mf}^w) + u_i + w_{i,t} \quad (5')$$

where  $i$  is the number of observations over time;  $t$  denotes time,  $\alpha$  ( $\alpha'$ ) is the average NRA (exchange rate) according to the equation,  $u_i$  is the individual-specific random effect, and  $w_{i,t}$  is the error term.

$Q_{mf} \cdot P_{mf}^w$  and  $Q_x \cdot P_x^w$  are expressed in USD, and  $(1 + NRA_m)$  is computed with  $NRA_m$  in percentage; this term is always positive.  $E$  is the exchange rate in local currency per USD. The variables are introduced in growth rates.

Dum is a dummy variable equal to 1 for the year 2008.

As we are interested in the role of the value of food imports regarding the impact of the price shock of 2008, we add interaction term  $dum_{i,t} * d \ln(Q_{mf} \cdot P_{mf}^w)$  to test for a nonlinear effect of the value of food imports due to the price shock.

### 3.2 Results and discussion

We estimate two panel data models that provide information on two dimensions, i.e., across individuals (countries) and over time (years). Of the various types of panel data models, fixed and random effects models are the most commonly analysed. The question remains regarding which model to choose. Several arguments are found in the literature to justify the use of each of these models, but they are often contradictory or inclusive (Clark and Linzer 2015).

The fixed effects model is also known as the within estimator. Its main assumption is that the error term is correlated with the individual specific term because the model can exclude time-invariant variables. In the random effects model, the specific term is assumed to be independent of the errors and also mutually independent (Greene 2005). It is generally considered that random effects models are more appropriate when the observations constitute a sub-sample of the whole population (Nerlove 2003).

Finally, the Hausman test (Hausman 1978) is frequently used to check the validity of the random effects assumptions, i.e., the conditional independence between group-specific intercepts and covariates. If the associated probability of the test (p-value) is over 0.05 (at the 5% significance level), then we can conclude that the random effects model is most likely appropriate.

To better identify the role of a custom union or a monetary union, we split the sample in two sub-samples according to membership in a custom union (we add dummy variable  $cu$  as equal to 1 in equation (5)) or in a monetary union (we add dummy variable  $mu$  as equal to 1 in equation (5')).

In our sample of 39 countries, 8 countries belong to a monetary union, and 19 countries belong to a custom union.

**Table 2:** Results of estimated random models, 2005-2010

	NRA <sub>m</sub> Equation (5)			Exchange Rate Equation (5')		
	All countries	Countries belonging to a Custom Union	Countries not in a custom union	All countries	Countries belonging to a monetary union	Countries not in a monetary union
intercept	0.06 (0.04)	0.54 (0.05)	0.08*** (0.03)	-0.01 (0.16)	0.01 (0.01)	0.02 (0.20)
$\text{dln } Q_{mf} P_{mf}^w$	-0.35* (0.18)	-0.45 (0.37)	-0.24* (0.14)	0.36 (0.76)	-0.13** (0.06)	1.24 (0.98)
$\text{dln } Q_x P_x^w$	0.03 (0.09)	0.04 (0.12)	-0.01 (0.13)	-0.54 (0.40)	0.01 (0.02)	-2.20** (0.87)
dum	-0.29** (0.12)	-0.24 (0.19)	-0.34*** (0.11)	0.54 (0.51)	-0.07** (0.04)	0.93 (0.63)
$\text{dln } Q_{mf} P_{mf}^w * \text{dum}$	0.70* (0.39)	0.86 (0.65)	0.53 (0.37)	-2.10 (1.69)	0.13 (0.11)	-3.51* (2.15)
Observations	174	91	83	181	35	146
Hausman test	Random effects	Random effects	Random effects	Random effects	Random effects	Random effects

Note: standard errors in brackets

\*\*\*, \*\*, \*: statistically significant at 1%, 5% or 10% levels, respectively.

The Hausman test suggests that the random effects model better fits our data for all cases.<sup>9</sup> Random-effects models are estimated using the generalized least squares (GLS) estimator.

The key coefficient of interest is the one associated with the value of importable food products, whatever the estimated equation. With regard to the evolution of prices over the period, we interpret the changes in the value of imports as those from the food prices. We thus suppose that the volume remains broadly stable.

Our results suggest that  $NRA_m$  adjusts well to variations in food prices  $P_{mf}^w$  to reduce the food import bill when we consider either the whole sample or the sub-sample of countries not belonging to a custom union; the estimated direct impacts are, respectively, -0.35 and -0.24. This may suggest that the countries aim at stabilizing the Bonilla Index from one year to the next using their agricultural and trade policies to compensate for the effects of the changes in the prices of imported food products. On the contrary,  $NRA_m$  does not adjust to variations in export prices  $P_x^w$ .

The year dummy variable set at 2008 emerges significantly. It therefore appears clear that the downward adjustment of  $NRA_m$  is particularly marked in 2008, a year with a global spike in food prices. To control for this price shock in 2008, we add an interaction term with  $Q_{mf} \cdot P_{mf}^w$  deviation, which appears to be significant when considering the whole sample.<sup>10</sup> The estimated impact of the

<sup>9</sup> Additionally, when comparing both estimates of the models, we notice that there is no significant difference between fixed effects models and random effects models. Fixed effects models are available upon request.

<sup>10</sup> We also test an interaction term with  $Q_x P_x^w$  deviation, but it remains insignificant for all cases.

food import bill once controlling for this shock price is -0.21. This confirms that countries actually adjusted their  $NRA_m$  downward to compensate for the rising cost of food bills related to the 2008 peak prices, but this adjustment seems to be lower. The  $NRA_m$  adjustment for the change in the BI\* (compared to the previous year and compared to the average for the period) is also tested but never emerges significantly. It seems to exclude a strategy of countries to use border instruments as a stabilization tool of their BI\* over the long term.

However, those results are not found for countries belonging to a custom union. This may be explained by the fact that most of these countries are not flexible enough to use any trade policies (by cutting tariffs, for instance) at the national level without a broader agreement at the custom union level. They depend on the trade policy of the area to which they belong.

According to the results of the exchange rate estimated equation, it appears that the exchange rate adjusts downward (appreciation of the local currency) in the event of rising food prices in countries belonging to a monetary union. Most of these concerned countries use the CFA franc as the currency, which is anchored to the euro. Additionally, the studied period is characterized, beyond the upward trend of agricultural and crude oil prices, by an appreciation of the euro and consequently the CFA franc, relative to the dollar. These countries probably have benefited from such an appreciation of the local currency that actually reduces the food bill expressed in local currency since the prices of imported food products are expressed in foreign currency. It thus contributes to improving the purchasing power of domestic households in the food-importing country.

However, this argument deserves to be deepened because the appreciation of the local currency presents the risk of reducing the competitiveness of exported products over the long term. The capacity to finance food imports by exports revenue could then be prejudicially affected.

Note that the exchange rate growth adjusts to the variation of total exports value only when countries are not members of a monetary union. In this case, the estimated impact is negative, indicating that the exchange rate decreases (appreciation of the local currency) when the value of total exports increases. This is consistent with international macroeconomics expectations.

## **Conclusion**

The main contribution of this paper is shedding light on the theoretical and empirical economic links between agricultural assistance, measured using the nominal rate of assistance (NRA) and the vulnerability of food security to trade at national level, measured using the Bonilla Index. The novelty of this paper is the use of NRA to assess the impact of domestic support on food security vulnerability to trade. We first draw an overall picture of government border intervention in the agricultural sector for 39 developing countries over the period 1995-2010, especially during the 2005-2010 period.

BI\* calculated taking into account  $NRA_m$  seems not to follow the same pattern as BI calculated before custom clearing, as if the effects of changes in food prices were offset by direct intervention of states

seeking to stabilize their ability to source food products on the world market, especially in case of the food price surge observed in 2008. The assumption that in a context of highly volatile food prices, developing countries aim to stabilize their vulnerability to trade by compensating food price deviations using trade policy is then partially checked over the period 2005-2010. A few conclusions emerge. First, this adjustment is mainly observed through the  $NRA_m$  channel. Second, the  $NRA_m$  adjustment seems to be correlated to food import value deviations for most countries but not to total export value deviations. This suggests that countries are more sensitive to the numerator of the  $BI^*$ , i.e., the food import bill, than to the global  $BI^*$ . Finally, the estimated adjustment appears to be more pronounced in case of a food price surge, such as the one in 2008, than outside of this context.

Import subsidies actually have a highly significant effect on the level of food security by sharply reducing the food import bill for households in the case of price surge. However, this type of intervention weighs heavily on the national government's budget, possibly at the expense of other intervention policies (such as agricultural policy). This cost probably prevents very poor countries from adopting a negative  $NRA_m$ . Poor countries may eventually reduce their  $NRA_m$  provided that the  $NRA_m$  is positive, but developing countries' NRAs are generally very low compared with developed countries. Moreover, a negative  $NRA_m$  drives up world agricultural prices, having a worse effect on the level of food security in poor net food-importing countries.

Further research could be investigated to answer to some limitations of this paper. First, our analysis considers only the support applied to importable agricultural products ( $NRA_m$ ). However, agricultural products account for a large proportion of total exports for most developing countries. Hence, positive or negative assistance for exportable agricultural commodities ( $NRA_x$ ) can have an effect on total export value if this share is significant. For example, during the 2008 food crisis, a number of countries introduced export bans or taxes on food commodities. These decisions will normally result in a negative  $NRA_x$  being applied to exported agricultural products with a positive effect on the Bonilla Index (and hence a negative effect on food security). Available World Bank (NRA) and BACI (trade) data could be used to complete this study by extending it to the  $BI^*$  denominator. Such a global analysis could provide clearer explanations of paradoxical situations (such as in Egypt) observed at this stage. Second, this study focuses on the more recent period, 2005-2010, characterized by great instability and volatility of food prices and an upward trend. It would be interesting to complete the analysis regarding developing countries' behaviour in a different context, when world food prices were falling during the nineties'. Third, using NRA, despite the originality of our work, may lead to some shortcomings. Given the lack of NRA data on processed food products, it could be interesting to extend this analysis with other agricultural support indicators to be able to determine in a broader way the implications in terms of food security. Besides, the NRA only gives incomplete information about distortive effects of overvaluation of the local currency. This point deserves further researches to lead specific analysis of the effects of the variation of the exchange rate on the food import bill for

domestic consumers, according to national change regimes they have to endure, and the competitiveness of exported products at short or longer terms. The respective role of the national monetary policy and of international market volatility on the vulnerability of food security would be the core of further researches.

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### **Conflict of Interest**

The authors declare that they have no conflict of interest.

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**Appendix: Table A1. Characteristics of the 39 developing countries in our sample**

Area	Country	CODE	Average BI	Monetary Union	Custom Union	Share of agricultural imports in total agricultural and processed food imports (%)
Africa	Benin	BEN	153.83%	1	1	55%
	Burkina Faso	BFS	36.82%	1	1	48%
	Cameroon	CAM	11.17%	1	1	71%
	Chad	TCD	3.66%	1	1	36%
	Cote d'Ivoire	CIV	13.52%	1	1	34%
	Egypt	EGY	33.58%	0	0	76%
	Ghana	GHA	11.98%	0	1	49%
	Madagascar	MAD	24.85%	0	0	47%
	Mali	MLI	25.46%	1	1	75%
	Morocco	MAR	18.46%	0	0	67%
	Mozambique	MOZ	18.73%	0	0	53%
	Nigeria	NGA	4.78%	0	1	64%
	Senegal	SEN	60.15%	1	1	66%
	South African Republic	ZAF	2.10%	0	1	46%
	Sudan	SDN	17.47%	0	1	61%
	Tanzania	TZA	19.80%	0	1	19%
	Togo	TGO	46.48%	1	1	28%
	Uganda	UGA	26.98%	0	1	30%
	Zambia	ZMB	4.52%	0	1	27%
Zimbabwe	ZWE	8.03%	0	1	57%	
America	Brazil	BRA	2.40%	0	1	58%
	Chile	CHL	2.41%	0	0	53%
	Colombia	COL	4.78%	0	1	59%
	Dominican Republic	DOM	25.80%	0	0	57%
	Ecuador	ECU	3.93%	0	1	57%
	Mexico	MEX	4.46%	0	0	68%
	Nicaragua	NIC	8.40%	0	1	36%
Asia	Bangladesh	BGD	20.66%	0	1	61%
	China	CHN	1.76%	0	0	72%
	India	IND	1.79%	0	0	31%
	Indonesia	IDN	3.28%	0	0	72%
	Kazakhstan	KAZ	1.66%	0	1	45%
	Malaysia	MYS	2.27%	0	0	49%
	Pakistan	PKS	20.05%	0	0	39%
	Philippines	PHL	4.21%	0	0	68%
	Sri Lanka	SRL	20.70%	0	0	62%
	Thailand	THL	2.30%	0	0	71%
	Turkey	TUR	2.58%	0	0	65%
Vietnam	NVM	3.99%	0	0	65%	