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Agricultural Trade Policy Distortions and Food Security: Is there a Causal Relationship?

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Abstract

The aim of this paper is to assess the causal impact of trade policy distortions on food security. This is an hot issue since restrictions to agricultural trade have been generally applied by national governments, especially in developing countries, as a tool to insulate domestic markets from international prices turmoil. The added value of this work is twofold: i) the use of a non parametric matching technique with continuous treatment, namely the Generalised Propensity Score (GPS) to address the self selection bias; ii) the analysis of heterogeneity in treatment (by commodities) as well as in outcome (i.e., different dimensions of food security). The outcomes of our estimates show clearly that trade policy distortions are, overall, significantly correlated with the various dimensions of food security under analysis. Specifically, countries supporting the primary sector tend to be better off in all the dimensions of food security (food availability, access, utilisation and stability). However, the maximum level of food security is associated with moderate protection policies.

Keywords: Food security, International trade, Trade measures, Impact evaluation, GPS

JEL classification: C21, F14, Q17, Q18

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1. Introduction

The empirical evidence on agricultural protection/taxation has been summarized by three patterns (Swinen, 2010): the “development pattern” referring to the positive correlation between agricultural protection and average country incomes; the “anti-trade pattern” referring to the bias in favor of the import-competing products; the “relative income pattern” referring to the observation that protection increases when farm incomes fall relative to the rest of the economy. While there is some consensus about the explanation of these patterns in the specialized literature, the debate about the impact of these measures is still hot and timely. Most of the literature is currently focusing on the impact on price level and volatility (Anderson and Nelgen, 2012a,b; Anderson *et al.*, 2013), but less attention has been devoted to the impact of these trade restrictions on food security.

This paper contributes to the literature on the relationship between trade policy and food security in two ways. First, we apply a non-parametric matching technique, namely the Generalised Propensity Score (GPS) (Hirano and Imbens, 2004), to control for the likely presence of self-selection bias (i.e., unobserved heterogeneity in treatment propensity that may be related to the variables of outcomes). Second, we control for treatment heterogeneity (by product) as well as for outcome heterogeneity (dimension of food security) in order to assess the presence of different causal relationships across products and food security dimensions.

The GPS method has been recently applied to various impact evaluation problems lacking experimental conditions: e.g., the impact of labour market programmes (Kluve, 2010; Kluve *et al.*, 2012), regional transfer schemes (Becker *et al.*, 2012), foreign direct investments (Du and Girma, 2009), the EU preferential margins (Magrini *et al.*, 2014), and also the relationship between migration and trade (Egger *et al.*, 2012). To the best of our knowledge this is the first GPS application to the assessment of the causal relationship between trade policy distortions and food security.

The outcomes of our estimates show the likely presence of a self-selection bias in the causal relationship between agricultural trade distortions and food security, cross-country and by product. Moreover, we report the empirical evidence of a significant impact of agricultural trade distortions on the various dimensions of food security under analysis. However, this impact is not consistent with the usual claims by free trade supporters arguing that any policies would do more harm than good. As a matter of fact, countries supporting the primary sector tend to be better off in all the dimensions of food security (food availability, access, utilisation and stability).

The work is organised as follows: Section 2 briefly summarises, theoretically and empirically, the links between trade and food security; Section 3 presents the GPS estimator; Section 4 describes variables and

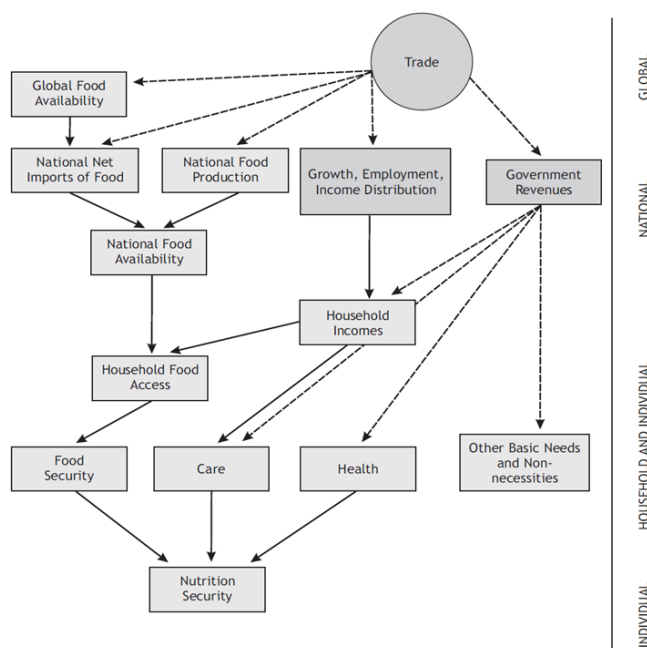
data; Section 5 shows the empirical results; Section 6 concludes.

2. Trade, trade policies and food security: what are the links?

2.1. The conceptual framework

Trade and food security are closely interconnected. International trade affects food security, directly through the impact on food availability, and indirectly through the effects on food accessibility and stability. Smith (1998) and Diaz-Bonilla *et al.* (2002) were among the first to analyse the full set of interactions among these issues and to emphasise the variety of impacts that international trade can have on the determinants of food security. More recently, Huchet Bourdon and Laroche Dupraz (2014) proposed an extended version of the same conceptual framework. Fig. 1 displays the multiple links and interactions between trade and food security from individual to global level.

Figure 1: Conceptual framework for food security and linkages with trade



Source: Diaz-Bonilla *et al.* (2002), adapted from Smith (1998).

The first channel by which trade influences food security is both via its impact on global - in the case of the major importer and exporter countries - and national - in the case of the smaller countries - food availability. The second channel is through the impact both on the level and the stability of the rate of growth, as well as on the employment, income distribution, and poverty. A third channel is *via* trade policy

through government revenues, directly (as collection of trade taxes) and indirectly (through their impact on the rate and variability of growth)([Diaz-Bonilla and Ron, 2010](#)) .

While these multiple channels have heterogeneous impacts on the various components of the standard definition of food security, it is undeniable that trade and trade policies influence profits of food producers and food costs to consumers, mainly because of their effect (both on levels and volatility) on world and domestic food prices. High food prices can impact positively on food availability, improving food production and its access by increasing producers' incomes. At the same time, they can reduce economic access to food because it becomes more costly on the consumption side ([Diaz-Bonilla and Ron, 2010](#)). Also price volatility can affect food security via its impact on household welfare both on the production and consumer side. Producers react to extreme/unpredictable price volatility, under-investing or investing in “wrong projects” ([Caballero, 1991](#); [Bertola and Caballero, 1994](#); [Aizenman and Marion, 1994](#)); consumers by deviating from a smooth path of consumption ([Loayza *et al.*, 2007](#); [Montalbano, 2011](#); [Anania, 2013](#)). Furthermore, price volatility also interacts with price level in affecting welfare: the higher the price, the stronger the welfare consequences of volatility for consumers while the contrary is true for producers ([HLPE, 2011](#)).

Because of the pervasive role of prices to food security, pro-cyclical trade policies are often applied as an efficient measure to insulate domestic markets from international price turmoil. Although justifications for such trade measures can be multiple, food security has been claimed as the dominant reason for resorting to trade measures in the recent food price crises ([Rutten *et al.*, 2013](#)).

The set of trade policy measures adopted to insulate price rising varies in many respects. They include both export restrictions adoption as well as import restrictions relaxation. It is worth noting that an export tax (or import subsidy) is the equivalent of a consumer subsidy and a producer tax, while an import tax (or export subsidy) is the equivalent of a consumer tax and a producer subsidy. For a better understanding of the impacts of trade restrictions on prices, exports and welfare as well as for a correct interpretation of our empirical outcomes, please refer to section [Appendix A](#). These measures are different in their transparency and in the administrative burden involved in their implementation and have different distributional effects. The extent of the impact of these kind of policies for the world market depends on a number of factors, including the size of the country adopting them; the characteristics of world demand and supply of the specific product; whether the increase in the international price is product specific or not; the volume of the product traded internationally relative to world production ([Anania, 2013](#)). Looking explicitly at all the transmission channels and/or at all the heterogeneous factors that can have an impact on the relationship between trade policy and food security is beyond the scope of our empirical exercise. A workable method to

address properly the identification issue between changes in trade policy at the border and changes in the observable dimension of food security at the national level is to apply appropriate non-parametric methods to control for self-selection bias (i.e., controlling for unobserved heterogeneity in treatment propensity related to outcome performances) and heterogeneity in both treatment and outcome.

2.2. Are these policy measures really effective? The empirical framework

Some scholars state with empirical evidence that countries which imposed trade measures were effective in making domestic prices rise significantly less than those which did not intervene (see, among others, [Abbott \(2011\)](#); [Dawe and Timmer \(2012\)](#); [Demeke *et al.* \(2009\)](#); [Jones and Kwiecinski \(2010\)](#); [McCalla \(2009\)](#). [Abbott \(2011\)](#) and [Jones and Kwiecinski \(2010\)](#) - analysing maize, rice, soy-beans and wheat price changes in a wide set of countries - conclude that most of the countries that restricted exports experienced significantly lower price increases than those who did not. From a geographic perspective, greater price stabilisation was achieved by Asian rice exporters than by export restricting countries in Latin America and Eastern Europe ([Abbott, 2011](#); [Demeke *et al.*, 2009](#)). [Dawe and Timmer \(2012\)](#) underline how during the world rice crisis of 2008, China, India and Indonesia successfully insulated their domestic rice economies from the turmoil on world markets. Their analysis also shows how the impact on the volumes exported varies significantly across the countries that intervened to restrict them. [Jones and Kwiecinski \(2010\)](#) find that China, India, and Ukraine register significant reductions of their wheat exports, the same is true for China and Ukraine for maize, and for China and India for rice.

Other scholars ([Rutten *et al.*, 2013](#); [Anderson *et al.*, 2013](#); [Anderson and Nelgen, 2012c](#)) highlight that if many countries adopt the same measures, these measures can turn out completely ineffective also because the impact of price insulation depends on both the actions taken by the single country and the collective impact of interventions by all other countries. They emphasise how trade insulating measures push world food prices to even higher levels and, like a domino effect, drive more countries to follow thereby perpetuating high food prices, reducing both the impact of each country's initial action on its domestic price and the ability of the policy reaction by each country to yield the desired effect (as their policies will partially offset each other), and exacerbating food insecurity around the world ([Martin and Anderson, 2011, 2012](#); [Mitra and Josling, 2009](#)). In the case of small countries these measures are likely to reduce national economic welfare too. If the country is a large country, its policy intervention will affect not only the domestic price but the international one as well leading to other distortive effects (see the previous sub-section). In their analysis on wheat market, [Rutten *et al.* \(2013\)](#) find that major net exporters are generally better off when implementing export taxes for food security purposes. Large exporting countries export price instability

causing world food prices to rise further. Net importing countries lose out and have limited room to reduce tariffs or subsidise imports. When wheat trade is liberalised, it mitigates rising prices and contributes to food security, but to the detriment of production in other countries (mainly of Africa and Asia), making them more dependent on and vulnerable to changes in the world market.

According to [Anderson and Nelgen \(2012c\)](#), domestic market insulation using trade measures is also inefficient and possibly inequitable. The traditional national government trade policy reactions to food price spikes would be undesirable also because, collectively, they are not very effective in stabilizing domestic prices, and not least because they add to international price volatility by reducing the role that trade between nations can play in bringing stability to the world's food markets. Some scholars ([Martin and Anderson, 2011](#); [Anderson and Nelgen, 2012c,a](#); [Rutten et al., 2013](#); [Anderson et al., 2013](#); [Timmer, 2008](#); [Gotz et al., 2013](#)) even say that trade policies adopted by countries in order to stem the recent price spikes have even amplified both price spikes and volatility and exacerbated the already negative consequences of high prices for the food security of the population in the developing countries. [Anderson et al. \(2013\)](#) estimate how much the observed insulating actions of more than 100 countries in the period of 2006-2008 have affected international and domestic food prices of for four food items: rice, wheat, maize and edible oils. They find that the adoption of price insulation caused substantial increases in international prices that completely offset the benefits and that the actual poverty-reducing impact of insulation is much less than its apparent impact. Furthermore, they find developing countries as a group insulated more than developed countries and, as a result, parts of the price increases were "exported" to developed countries. In [Martin and Anderson \(2012\)](#) the authors examines the role of trade policies (particularly export and imports restrictions) as stabilization policies in the agricultural market. They state the use of these measures by all countries is ineffective in stabilizing domestic prices for the key staple foods of rice and wheat, while magnifying international price instability associated with exogenous shocks to food markets. Their analysis shows that in the 2006-08 surge, insulating policies affecting the market for rice explain 45 percent of the increase in the international rice price, while almost 30 percent of the observed change in the international price of wheat during 2006-08 can be explained by the changes in border protection rates. [Mitra and Josling \(2009\)](#) emphasize the negative effects caused by the adoption of export restrictions as a response to the dramatic increase in commodity prices in 2007-08. They state these measures led to further price increases by placing limits on global supply and undermining the level of buyer confidence with a consequent harmful impact on domestic food security. [Gotz et al. \(2013\)](#) analyse the impact of export restrictions on price volatility in the Ukrainian wheat market during the commodity price peaks 2007-08 and 2010-11. They find the export controls have not

significantly reduced price volatility on the domestic wheat market. On the contrary, these policy measures have substantially increased market uncertainty which led to pronounced additional price volatility in the market.

This survey of the applied literature on the efficacy of trade policy distortions on food security highlights that the relationship is ambiguous and a thorough analysis of the exact channels of transmission is a complex issue. A workable solution is to investigate empirically the overall net impact of trade insulating policies on food security. This calls for appropriate methods to look at the causal effect of different treatment intensity among observations that can be considered as similar conditional to a set of common characteristics.

3. Methodology: the GPS estimator

The GPS estimator - originally proposed by [Hirano and Imbens \(2004\)](#) and [Imai and van Dyk \(2004\)](#) - is a generalisation of the binary treatment propensity score. It is a non-parametric method to correct for selection bias in a setting with a continuous treatment by comparing units that are similar in terms of their observable determinants of “treatment intensity” within the treatment group. Hence, it does not require control groups.

Let us use index $i = 1, \dots, N$ to refer to a random sample of units. The GPS method is based on the following assumptions: for each i we postulate the existence of a set of potential outcomes, $Y_i(t)$, for $t \in T$ (the treatment) is a continuous interval of real numbers, referred to as the *unit-level* dose-response function (DRF). We are interested in estimating the *average* DRF across all units i that illustrates the expected value of the outcome variable conditional to continuous treatment as follows:

$$D(t) = E[Y_i(t)] \tag{1}$$

Estimation of the DRF uses information on three sets of data: a vector of covariates X_i , a “treatment” received, T_i and a potential outcome, $Y_i = Y_i(T_i)$. Following [Hirano and Imbens \(2004\)](#) we assume that: $Y_i(t)_{t \in T}$, T_i and X_i are defined on a common probability space; T_i is continuously distributed with respect to a Lebesgue measure on T ; $Y_i = Y_i(T_i)$ is a well defined random variable.

In this exercise we use index i to indicate countries and assume the unit-level dose-response of potential outcomes of food security, Y_{it} as a function of the treatment t , where t is the annual NRA in the commodity under investigations.

Following [Hirano and Imbens \(2004\)](#), we define GPS as:

$$R = r(t, X) \tag{2}$$

where R is the propensity score, i.e. the conditional probability of receiving a specific level of treatment given the covariates, which is estimated via the following standard normal model:

$$\hat{R}_i = \frac{1}{\sqrt{2\pi\hat{\sigma}^2}} \exp \left[-\frac{1}{2\hat{\sigma}^2} (t_i - \hat{\beta}_0 - X\hat{\beta}_1)^2 \right] \tag{3}$$

The main purpose of estimating GPS is to create covariate balancing. However, the validity of R as a measure of similarity or dissimilarity across countries depends crucially on the validity of a set of assumptions which are standard in impact evaluation literature. First of all, the randomness of the treatment, namely the assumption of “unconfoundedness” or “ignorability of the treatment”. It means in this case to avoid the likely selection bias between food insecurity (the outcome) and trade policy distortions (the treatment) due to the fact that the net food importer and exporter developing countries are more likely to adopt agricultural trade distortions during the food crisis. [Imbens \(2000\)](#) shows that if the treatment assignment is weakly unconfounded given the observed covariates, then the treatment assignment is weakly unconfounded given GPS. In other words, the GPS has the following property:

$$X \perp 1 \{T = t\} | r(t, X) \tag{4}$$

GPS removes the bias associated with differences in covariates in three steps. In the first step, the GPS is estimated and its balancing property checked. If balancing holds, countries within GPS strata can be considered as identical in terms of their observable characteristics, independently of their actual level of treatment.¹ The validity of the balancing property should be coupled with the SUTVA (Stable Unit Treatment Value Assumption) condition. Notwithstanding we are dealing with some degree of heterogeneity in terms of policy coverage, the use of a standardised measure, namely the NRA which synthesises specifically the actual impact of governmental distortions, prevents the violation of the unique treatment assumption. At the same time, working with treatment intensities reduces the risk of cross relationship across the various groups’ outcomes in terms of food security. However, in order to avoid possible additional sources of bias, in

¹Please note that as long as sufficient covariate balance is achieved, the exact procedure for estimating the GPS is of secondary importance ([Kluve et al., 2012](#)).

the aggregate case, we run the empirical analysis leaving out from the sample both the main importer and the main exporter countries.

Then, two additional steps are needed to eliminate the bias associated with differences on the covariates (see [Hirano and Imbens \(2004\)](#) for a proof). The first one is the estimation of the conditional expectation of the outcome Y as a function of two scalar, the treatment level T and the GPS R as follows:

$$\beta(t, r) = E[Y|T = t, R = r] \tag{5}$$

This is generally estimated by assuming a flexible parametric specification between the three variables at different order of the polynomial terms. The statistical significance of the GPS parameters is a sign that selection bias is actually an issue. Interaction terms between the treatment level and the GPS are usually applied to control for the marginal impact of the treatment relative to the GPS.

The final one is to estimate the average dose-response function (DRF) of the outcome (i.e., the different dimensions of food security) averaging the conditional expectation over the GPS at any different level of NRA, as follows:

$$D(t) = E[\beta(t, r(t, X))] \tag{6}$$

Furthermore, we can estimate the varying marginal effects of the treatment by estimating the treatment effect function (TEF), which is the first derivative of the corresponding DRF as follows:

$$\theta(D) = D(t + \delta) - D(t) \tag{7}$$

4. Variables and data

In this exercise we make use of three different sets of data: i) the annual Nominal Rates of Assistance to producers (NRAs) by commodity (i.e., the treatment, T_i) derived from the World Bank dataset (“Updated National and Global Estimates of Distortions to Agricultural Incentives, 1955 to 2010”) by [Anderson and Nelgen \(2012b\)](#); ii) the observable characteristics able to explain the probability to reach a specific level of NRA (i.e., the covariates, X_i) the outcome in terms of the various dimensions of food security ($Y(t)$). Table [B.2](#) in the Appendix reports a synthesis of the data applied in our empirical exercise while Table [B.3](#) provides the mean, minimum, maximum and standard deviation for the covariates.

4.1. The treatment: the Nominal Rates of Assistance

The [Anderson and Nelgen \(2012c\)](#) World Bank dataset includes a core database of NRAs to agricultural industries as well as nominal rates of assistance to producers of non-agricultural tradables, together with a set of Consumer Tax Equivalents (CTEs) for farm products and a set of Relative Rates of Assistance (RRAs) which capture the extent to which domestic prices faced by farmers relative to those for producers of non-farm tradable goods have been distorted away from prices at the country's border ([Anderson and Valenzuela, 2008](#)).

NRA is defined as the percentage by which government policies directly raise (or lower) the gross return to producers of a product above what it would be without the government's intervention. The focus is on border and domestic measures that are due exclusively to governments' actions, and as such can be altered by a political decision and have an immediate effect on consumer choices, producer resource allocation, and net farm incomes ([Anderson and Valenzuela, 2008](#)). More specifically, NRA is computed as the unit value of production at the distorted price less its value at the undistorted free market price expressed as a fraction of the undistorted price as follows:

$$NRA = [E.P(1 + d) - E.P]/E.P$$

where E is the exchange rate, d is a distortion due to government interventions and P is the foreign price of an identical product in the international market ([Anderson, 2006](#)). Positive values of NRA denote a raise of domestic producers gross return (the distorted price is higher than the undistorted equivalent, because of the presence of an output support, i.e., a consumption tax, e.g. a tariff), while negative values denote a lower gross return for domestic producers (the producers receive less than the price would be for a like product in the absence of government interventions, e.g., an export tax). It is worth noting that NRA tends to be higher for import-competing producers than for net exporters of a specific product ([Anderson, 2013](#)). To be also noted that NRA and CTE values are identical if the only government interventions are at a country's border (e.g., a tariff on imports). The high correlation between them denotes that most policy distortions actually occur at the border ([Anderson and Nelgen, 2012a](#)).

Two main hurdles, conversion and aggregation problems, need to be overcome. On the one hand, given the continuing and possibly growing importance of agricultural NTBs, protection can take many different forms - tariffs, quotas, anti-dumping duties, technical regulations - and so we need to convert the different instruments into a common metric ([Cipollina and Salvatici, 2008](#)). The WB database deals adequately with this issue undertaking careful domestic-to-international price comparisons for the key farm products

for a large set of OECD and developing countries thereby capturing also the domestic price effects of NTBs (Lloyd *et al.*, 2010). This was estimated by comparing domestic and border prices of like products (at similar points in the value chain) for each of the covered farm industries, drawing on national statistical sources supplemented - where necessary - by producer prices and unit values of exports and imports from FAO (2011).

On the other hand, trade policy is set at a very detailed level, and this information needs to be summarized in one aggregate and economically meaningful measure. The World bank's database solves these problems as follows: "the weighted average NRA for covered primary agriculture can be generated by multiplying each primary industry's value share of production (valued at the farmgate equivalent undistorted prices) by its corresponding NRA and adding across industries. The overall sectoral rate, denoted as *NRA_{ag}*, can be obtained by adding the actual or assumed information for the non-covered commodities and, where it exists, the aggregate value of non-product-specific assistance to agriculture" (Anderson and Nelgen (2012c) p. 577).

All that considered the real added value of this updated World Bank dataset is the fact that it contains the annual values of a set of standardised measures of policy related agricultural trade distortions for a total of 82 countries (that together account for over 90% of the global agricultural output) and 70 products for the overall period 1955-2011.

4.2. *The covariates*

Concerning the set of covariates, we selected the following set of pre-treatment variables (i.e., countries characteristics that are supposed not to be affected by the treatment and not interfering with the causal pathways from treatment to outcome): the log of real per capita GDP, its squared and cubic power (to control for non linearities in the anti-trade behaviour of the most advanced economies and facilitate the balancing property as suggested by Dehejia and Wahba (1999) and Dehejia (2005)); the log of total population (to control for country dimension); the log of per capita arable land (to control for the relative agricultural comparative advantage); the food production index (to control for the actual productivity of the agricultural sector); the share of the value of food import over total exports and its squared power (to control for the level of country food dependence from abroad); the absolute percentage (positive and negative) deviations from trend in food international prices (to control for the presence of asymmetric policy response to sizeable changes in price levels); a measure of international food price volatility (to control also for the second moment of the relationship between international prices' dynamics and trade distortions). Furthermore, we add a set of dummies for controlling: net exporter status, the recent food crisis (2007/2008) and a set of unobservable factors for the groups of countries belonging to the same regional area - African developing countries (base);

Asian developing countries; European Transition Economies; Latin American developing countries and high income countries. While other determinants can be considered in our matching exercise, it has to be noted that, as argued by Bryson *et al.* (2002), there is always a trade off between the increasing of the explanatory power due to the use of additional covariates and the risk of over-parametrized models that could, in turn, exacerbate the support problem and increase the variance of the propensity score estimates.

4.3. *The outcome: the dimensions of food security*

Last but not least, we should deal with the hard task to retrieve a suitable and workable measure of outcomes in terms of food security, which indeed covers a complex set of concepts and dynamics. One of the most popular definitions of food security emphasizes its multidimensionality, describing food security as the condition that “exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (CFS, 2009). Since no single indicator is able to capture all the identified dimensions that comprise the problem, there has been a proliferation of proposals for food security indicators.

In this paper we decide not to use a composite indicator of food security, rather to differentiate food security indicators according to the working concept based on the standard four dimensions (CFS, 2009), namely availability, access, utilization and stability. Availability is a measure of the amount of food physically available in a population during a certain period of time (most likely related with production and market availability) (Cafiero, 2013). The accessibility dimension embraces Sen’s framework of the capability approach emphasising that food availability does not guarantee that everyone is free from hunger (Sen, 1981). The third dimension - utilization - is a measure of a population’s ability to obtain sufficient nutritional intake and nutrition absorption during a given period. The last dimension - stability - refers to the risk component of the above three (such as natural events, man-made shocks, malfunctioning international markets, etc.) (Pangaribowo *et al.*, 2013). As underlined by Cafiero (2013); Pangaribowo *et al.* (2013) each dimension can be represented by a specific set of variables and indicators. Taking into account actual data availability we selected the following ones: supply of food commodities in kilocalories per person per year (for food availability); depth of the food deficit (for food access); infant mortality (for food utilisation) and per capita food supply variability (for stability) (see table B.2 in the Appendix) for additional details and sources’ availability.

5. Empirical results

We carried out the empirical exercise for each dimension of food security both at aggregate level and for wheat and rice. Because of data constraints in food security measures, we are forced to limit our dataset to the sub-period 1990-2010. Furthermore, to avoid additional possible sources of bias we leave out from the aggregate analysis the main importer and exporter countries (see section 3).² Hence, our sample of countries reduces to 64 countries (see Table B.1 in the Appendix for the list of countries included in our empirical exercise). Among the estimated trade distortion measures, we use NRA_{ag} for the aggregate exercise and NRA by commodity for the product level analysis (see table B.2 in the Appendix). As in [Anderson and Nelgen \(2012c\)](#) and [Anderson and Nelgen \(2012a\)](#) NRA data have been converted to a nominal assistance coefficient (NAC) = $(1 + NRA)$ in order to transform NRA 's negative values (i.e., when producers receive less than the price at the border in the absence of government intervention) into NAC values between zero and one (one becomes the threshold between a positive and negative NRA). Movements of domestic prices above the world ones, for instance through import taxes or export subsidies, lead to increases of NCA above 1 while trade liberalization is signaled by reductions in the NCA . However, when policies are aimed against domestic producers, as in the case of import subsidies or export taxes, the dynamics are reversed. In these cases, world prices are higher than domestic ones: NCA 's are lower than 1 and they would increase due to trade liberalization. The bottom line is that some care should be used in interpreting the NCA dynamics when different types of border policies are taken into account. NAC observations before the 5 percentile and after the 95 percentile have been removed from the sample in order to clean our dataset from potential outliers. Finally, a zero-skewness log transformation has been applied to normalize the NAC distribution.

5.1. Regression outcomes

We first apply a regression type analysis to control for the possibility of reverse causality between food security and trade policy distortions, notwithstanding the high risk of misspecification due to self-selection bias between incomparable observations. Specifically, we would like to avoid the risk of endogeneity bias between food availability and trade policy, i.e., the possibility that trade policy can be influenced by the level of food availability. To this end, following [Serrano-Domingo and Requena-Silvente \(2013\)](#) we apply a panel model with instrumental variables. As a valid instrument we use the simple moving average of NRA

²It is worth noting that including them does not change significantly the empirical outcomes and the corresponding DRF. The results are available from the authors upon request.

in the previous decade which is supposed to be correlated with the current level of NRA but uncorrelated with any other determinants of food availability.

Table 1: **Regression type estimates: dependent variable *food availability***

	OLS			IV		
	(1)	(2)	(3)	(1)	(2)	(3)
NAC	0.026*** (0.008)	0.142*** (0.032)	0.410*** (0.134)	0.044** (0.021)	0.159 (0.114)	-2.240 (2.59)
NAC ²		-0.041*** (0.011)	-0.234** (0.094)		-0.038 (0.039)	1.645 (1.843)
NAC ³			0.043** (0.021)			-0.370 (0.412)
lnreal pc GDP	0.419*** (0.059)	0.425*** (0.059)	0.428*** (0.059)	0.411*** (0.067)	0.392*** (0.067)	0.403*** (0.079)
lnreal pc GDP ²	-0.023*** (0.004)	-0.023*** (0.004)	-0.024*** (0.004)	-0.023*** (0.004)	-0.022*** (0.004)	-0.021*** (0.005)
lnpc arable land	0.036*** (0.008)	0.036*** (0.008)	0.035*** (0.008)	0.037*** (0.008)	0.037*** (0.008)	0.042*** (0.01)
food prod. index	0.002*** 0.000	0.002*** 0.000	0.002*** 0.000	0.002*** 0.000	0.002*** 0.000	0.002*** 0.000
pop	0.504*** (0.095)	0.515*** (0.095)	0.519*** (0.094)	0.507*** (0.097)	0.523*** (0.097)	0.458*** (0.132)
pop ²	-0.036*** (0.005)	-0.036*** (0.005)	-0.037*** (0.005)	-0.036*** (0.005)	-0.037*** (0.005)	-0.034*** (0.007)
No. of observations	1098	1098	1098	1091	1091	1091
R ²	0.579	0.586	0.588	0.578	0.581	0.423
Hausman test:				0.409	0.386	0.150
country FE	yes	yes	yes	yes	yes	yes
year FE	yes	yes	yes	yes	yes	yes

Note: $(NAC) = (1 + NRA)$

Standard errors in parenthesis. ***, **, * denote significance at the 1, 5 and 10 per cent level, respectively.

Table 1 reports both the OLS and the IV estimates of our panel analysis, with country and time fixed effects and robust standard errors.³ The coefficients of the food availability's determinants⁴ are highly significant and quite similar in both OLS and IV estimates. NAC coefficients in the OLS and IV models are both significant too, pointing to the consistency of both estimates. They loose significance in the IV model when the squared and cubic powers are introduced. The Hausman test does not reject the null hypothesis of the consistency of the parameters in the two models, confirming that the relationship between trade policy and food availability does not suffer from reverse causality.

³All the multivariate F-tests of excluded instruments reject the null hypothesis that the instruments are not correlated with the endogenous regressors. Results are available upon requests.

⁴The covariates are selected according to the empirical literature on the macro drivers of food availability (Misselhorn, 2005; Feleke *et al.*, 2005; Garrett and Ruel, 1999; Iram and Butt, 2004; Rose, 1999; Pangaribowo *et al.*, 2013).

5.2. GPS estimation and balancing property

Regression-type analyses have a high risk of misspecification, because of self-selection bias due to incomparable observations. For instance, the net food importer and exporter countries can be considered more likely to adopt agricultural trade distortions during the food price spikes and/or developing countries characterised by higher risks of food insecurity as well as the most developed countries show on average relatively higher rates of protection. To deal adequately with this issue, we apply the GPS approach. Since the joint Jarque-Bera normality test strongly supports the null hypothesis of normal distribution of our treatment variable⁵, in the first stage estimation we first regress our measure of trade distortion on a set of pre-treatment observable characteristics using an OLS approach and then estimate the GPS.

Table 2 presents the outcomes of the first stage equation for the aggregate case as well as for wheat and rice. Notwithstanding the relevance of our set of covariates, it is worth recalling here that in impact evaluation exercises the functional form of the relationship as well as the interpretation and statistical significance of the individual effects of the covariates are of minor importance than getting a powerful GPS (i.e., a GPS that works well in balancing the covariates by respecting the condition in eq. 3). At this purpose, it is not irrelevant to add that the R-squared of our first stage regressions are high and consistent with similar GPS empirical exercises (Becker *et al.*, 2012; Serrano-Domingo and Requena-Silvente, 2013; Magrini *et al.*, 2014).

Looking at the individual effects of the covariates for the aggregate exercise, it is worth highlighting that NACs tend to be higher the higher a country's per capita income (even if at a decreasing rate) and the lower the country's comparative advantage in agriculture (proxied by the percentage of arable land). A negative relationship between NAC and country dimension (proxied by the population size) is apparent as well (although not significant at the sectoral level).

The above empirical evidence is consistent with the well-known "development pattern" that richer countries tend to maintain higher protection for domestic producers, while developing countries as well as bigger countries, tend to keep lower levels of NAC. Countries characterised by high dependence from food imports with respect to their total exports tend to maintain lower levels of NAC as well since they tend to reduce the domestic prices of importables (Valdés and Foster, 2012). The "anti-trade pattern" is also confirmed since countries with a comparative advantage in agriculture as well as net food exporter tend to protect less. To be noted the asymmetry in the impacts of positive and negative deviations of international food prices from their trend. NACs are negatively correlated with positive international food

⁵The p-value is 0.611, well above the standard 5% threshold of statistical significance.

Table 2: Generalised Propensity Score Estimates

	All		Wheat		Rice	
Covariates	Coef.	SE (robust)	Coef.	SE (robust)	Coef.	SE (robust)
lnreal pc gdp	0.988**	0.456	22.015***	5.675	-4.160***	1.043
lnreal pc gdp ²	-0.117**	0.055	-3.911***	1.030	0.518***	0.127
lnreal pc gdp ³	0.005**	0.002	0.305***	0.082	-0.021***	0.005
lnreal pc gdp ⁴			-0.009***	0.002		
ln pc arable land	-0.036***	0.006	-0.033***	0.006	-0.045***	0.012
pos dev food prices	-0.531***	0.142	0.071	0.128	-0.552***	0.193
neg dev food prices	-0.343***	0.107	-0.029	0.117	0.027	0.188
food price volatility	-1.345***	0.468	-1.278***	0.328	-0.492	0.376
food crisis	-0.048***	0.015	-0.051***	0.018	-0.049	0.034
food prod. index	0.000	0.000				
group 2 -Asian DCs	-0.065***	0.017	-0.131***	0.039	0.019	0.033
group 3 - Latin American DCs	-0.062***	0.018	-0.075**	0.032	0.082**	0.042
group 4 - European Transition Economies	0.037**	0.019	-0.051	0.036	0.143**	0.066
group 5 - High-income Countries	0.014	0.028	-0.049	0.044	0.272***	0.075
net food exporter	-0.057***	0.008	-0.154***	0.013	-0.203***	0.026
food import/total exports	-0.678*	0.397	-0.106	0.073	0.173	0.111
food import/total exports ²	2.816	1.760				
pop	-0.094***	0.025	-0.058	0.039	-0.064	0.086
pop ²	0.005***	0.001	0.003	0.002	0.002	0.004
cons	-2.379*	1.285	-45.576***	11.5611	11.347***	2.884
No. of observations	1072		901		630	
R ²	0.436		0.297		0.324	

(NAC) = (1 + NRA).

All time variant variables with one lag.

Standard errors in parenthesis. ***,**,* denote significance at the 1, 5 and 10 per cent level, respectively.

price deviations from their trend, since food import restrictions tend to be eased during price spikes and export tax raised. Consistently, NACs are negatively correlated with negative international food price deviations from their trend, since overall food import restrictions tend to be stressed during price drops, while net exporter countries undertake a pro-trade behaviour (Anderson, 2013; Anderson and Nelgen, 2012c,a). On a separate note, it is worth noting that international food price volatility always impacts negatively on NACs, highlighting a strong correlation with trade distortions that imply lowering gross returns for domestic producers, likely because of the well known depressing impact on consumption behaviour of price volatility. Finally, as expected, net food exporting countries and developing countries in Asia and Latin America show, on average and *ceteris paribus*, lower NACs (i.e., higher export protection). Last but not least, lower NACs are registered, on average and *ceteris paribus*, also during the years of “food crisis”.

The first stage estimates at the product level show consistent results. The main difference stands from the fact that the country dimension and the food import dependence variables are not significant in the product level exercises. In the case of wheat, both positive and negative deviations of international prices from trend are not significant too. In the case of rice, it is worth noting the negative sign of the per capita GDP, coupled with the positive sign of the high income countries dummy. It means that while high income

countries keep their markets protected, richer developing countries tend to show a lower level of NAC in the sector (i.e., higher export taxes). Furthermore, negative deviations of international prices from trend as well as price volatility appear to be not significant.

A further step of our impact evaluation exercise is to test the “balancing property”. To this end, we compare the covariates across groups with and without the GPS correction. We first perform a series of two-sided t-tests across groups for each covariate (t-values reported in bold face indicate the presence of statistically significant differences at the 5%). Four groups of approximately the same size are formed on the basis of the actual levels of NAC (three groups in the case of wheat and rice)⁶. As it is apparent from table A.3 in the Appendix, before controlling for the GPS, there are differences across the treatment groups with respect to the covariates for all the three cases. For the aggregate case, the average t-stat is 4.85 (well above the 1.96 threshold) and 52 out of 72 tests reject the balancing assumption (37 out of 51 in the case of wheat and 26 out of 48 in the case of rice). Once we condition on the value of the GPS score - building 8 strata for the aggregate case (10 for wheat and rice) - and impose the common support condition, the improvement in the balancing of the covariates is evident. The average t-stat lowers to 0.88 (0.98 for wheat and 0.46 for rice) and the balancing is rejected only in 3 for the aggregate case (3 for wheat and 0 for rice). Table B.5 in the Appendix reports the final group-strata structure of the data. Figs. from B.2 to B.5 in the Appendix provide a quick overview of the differences in the common support before and after GPS correction (for brevity only the aggregate case is reported). Figs B.6, B.7 and B.8 show the map of sample countries with the percentage of observations excluded by the common support in the various empirical exercises.

5.3. The Dose-Response Function

The last step is to estimate a dose-response function (DRF), which illustrates, given the estimated GPS, if and how there is a causal link between NAC changes and the food security dimensions. It means to test a polynomial parametrization of the conditional expectation of the outcome as a function of observed treatment and estimated GPS as a flexible function of its two arguments (see section 3). It is useful to recall that as Hirano and Imbens (2004) point out, also the estimated coefficients in this regression have no direct economic meaning except that testing whether the covariates introduce any bias. While in fact the GPS coefficients control for selection into treatment intensities, the interaction term shows the marginal impact of the treatment relative to the GPS. If selectivity matters, we expect both the GPS and the interaction coefficients to be statistically significant. It means that GPS method highlights possible bias in outcomes

⁶We run t-tests for different numbers of groups before choosing the best combinations in terms of balancing properties

that are actually controlled by looking over GPS strata as well as across GPS strata, by using the interaction term. If GPS is statistically significant we denote the likely presence of self-selection bias (i.e., unobserved heterogeneity in treatment propensity that may be related to the variables of outcomes) for unmatched observations. As in [Bia and Mattei \(2008\)](#) to obtain standard errors and confidence intervals of the DRF that take into account estimation of the GPS and the α parameters we use bootstrap methods.

Once tested our DRF at different order of the polynomial terms, as in [Egger *et al.* \(2012\)](#) we chose to disregard those polynomial terms that turned out to be insignificant in our OLS regression estimates. The corresponding results for the parsimonious, semi-parametric dose-response functions are summarised in tables [B.6](#); [B.7](#); [B.8](#); [B.9](#) in the Appendix. It is worth noting that also in this case R-squared is relatively high given the parsimonious specification and consistent with similar GPS empirical exercises ([Becker *et al.*, 2012](#); [Serrano-Domingo and Requena-Silvente, 2013](#); [Magrini *et al.*, 2014](#)) (lower in the wheat and rice cases).

The upper panels of Figs. [2](#) and [3](#) report the graphical representation of the point estimates of the DRF for the various dimensions of food security, i.e. the non-parametric functional form of the relationships between the food security dimensions and NCAs, while the bottom panels of the same figures represent the TEF, i.e. the first derivative of the respective DRF. The corresponding standard errors and 90% confidence intervals of both functions are also reported in the Figures and estimated via bootstrapping (see section [3](#)). For brevity, all the Figures are here related to the aggregate case only (the wheat and rice cases are reported in the Appendix).

The first outcome we can derive from the DRF in the upper panels of Figs. [2](#) and [3](#) is that government policies able to distort “too much” domestic prices from international ones have, on average and *ceteris paribus*, a negative impact on all food security dimensions, with the relevant exception of food stability. The maximum levels of food availability, utilisation and access are associated with moderate protection policies (when *NAC* is around 1.2). Specifically, if we look at the 90% confidence band, we observe that the average *NCA* of XXX countries (out of 65) actually lies within the region. At the same time, we cannot underestimate that positive levels of *NACs* (between 1 and 1.2) are still significantly associated with a positive impact on all four food security dimensions, while the impact of higher levels of trade policy distortions (approximately for *NAC* higher than 1.2) are unambiguously negative in case of food availability, utilisation and access, but still positive for food stability. Please note, however, that, according to the TEFs in the right panels of the Figures the marginal impact of trade distortions on food availability, utilisation and access is negative as soon as we depart from neutrality (i.e., *NAC* levels different from 1), while it is positive only for food stability.

Figure 2: DRF and TEF: the aggregate case

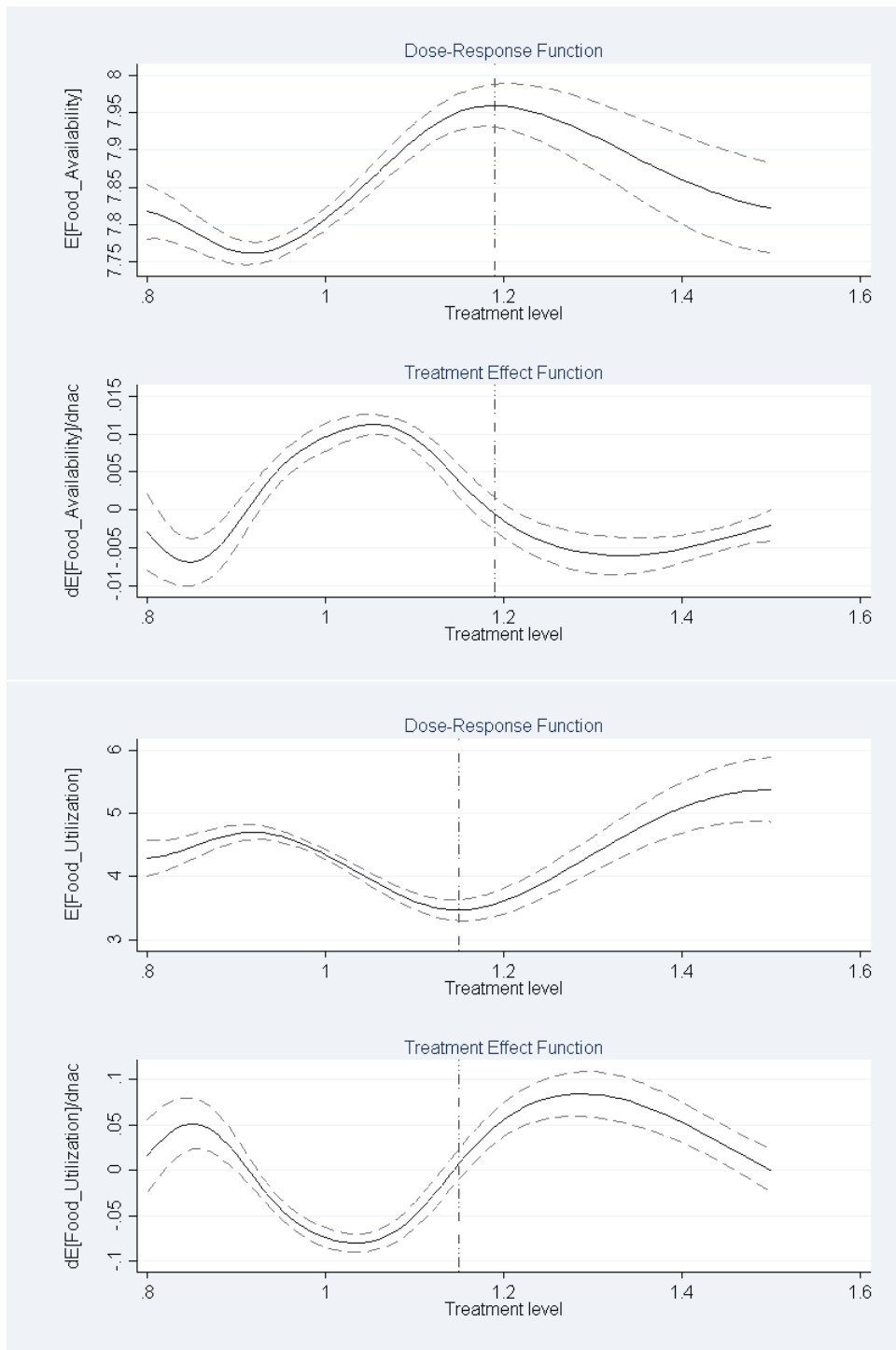
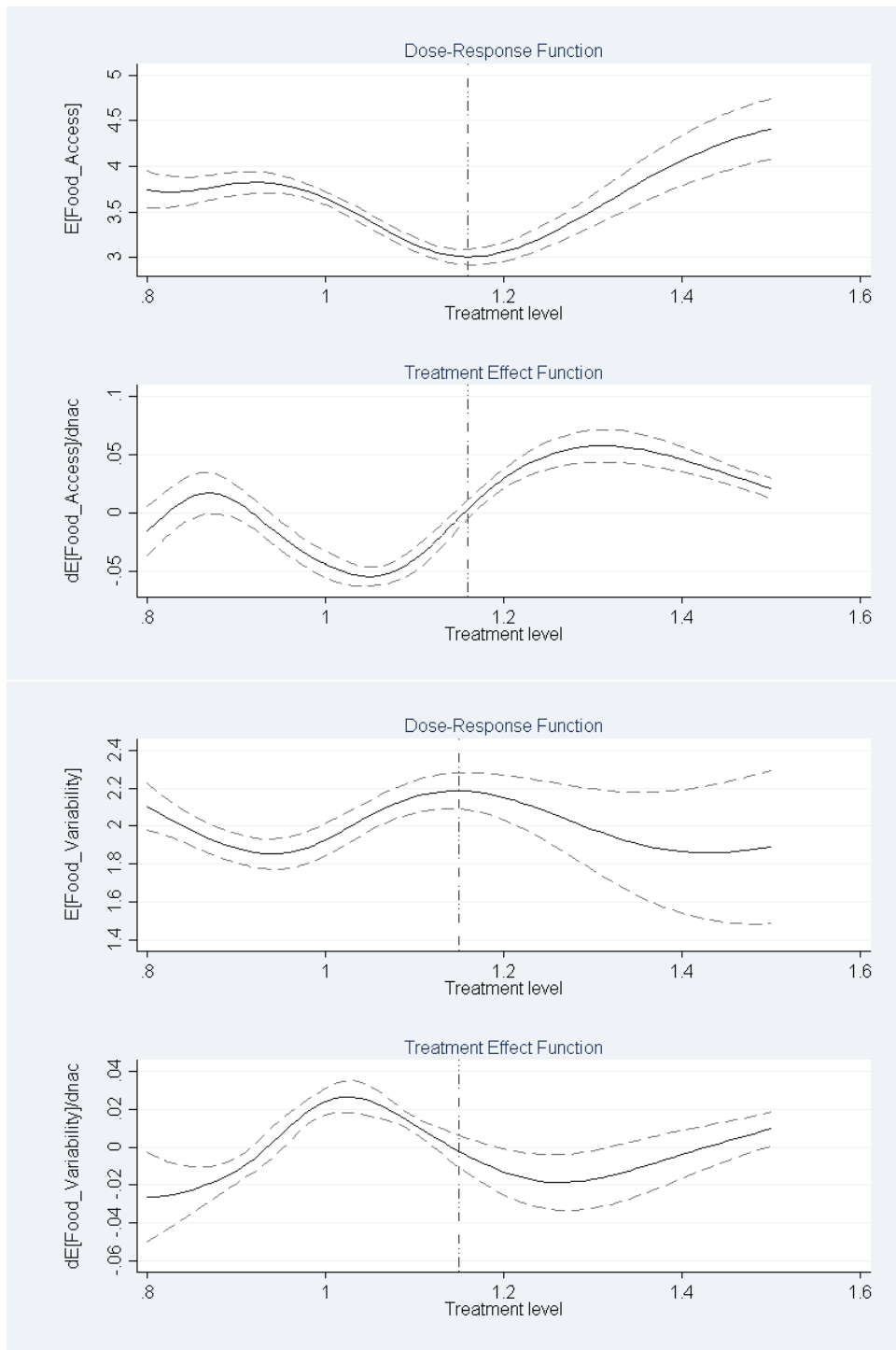


Figure 3: DRF and TEF: the aggregate case cont.d



6. Conclusions

This paper focuses on the relationship between trade policy insulation and various dimensions of food security, on aggregate and by commodities . We use a non parametric method for causal inference in quasi-experimental setting with continuous treatment under the (weak) unconfoundedness assumption. We show the likely presence of a self-selection bias in the causal relationship between agricultural trade distortions and food security, cross-country and by product. Moreover, we report the empirical evidence of a significant impact of agricultural trade policy distortions on the various dimensions of food security under analysis. The impact, though, is not consistent with the usual claims by free trade supporters arguing that any policies would do more harm than good. As a matter of fact, countries supporting the primary sector tend to be better off in all the dimensions of food security (food availability, access, utilisation and stability). However, caution should be used in drawing normative conclusions from the previous analysis. On the one hand, we cannot address the welfare implications since we do not consider the costs of the policies leading to a positive impact in terms of food security. On the other hand, there is ample evidence that governments may have the temptations to provide “too much of a good thing” since the highest level of support are associated with negative performances in terms of food security. It is certainly true, though, that taxing the agricultural never seems to be a good idea since it consistently shows negative results in terms of food security.

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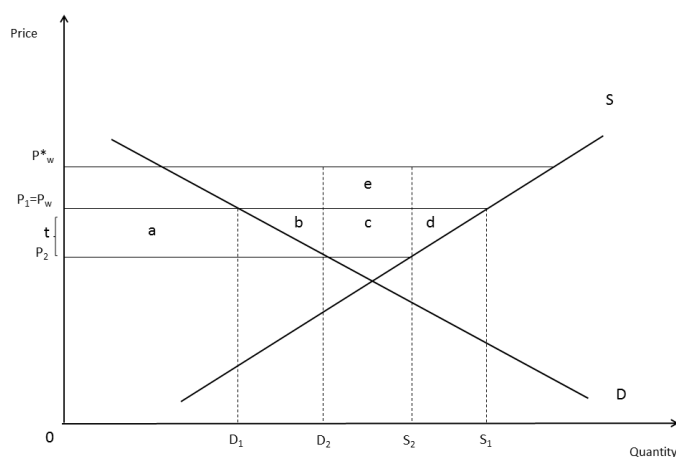
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Appendix A. A naive theoretical framework

We propose here a simple theoretical framework of the impacts of trade restrictions on prices, exports, and welfare. For brevity, we analyse only the economic effects of the adoption of export taxes - since this is the typical emergency measure adopted in reaction to soaring international prices and aiming at safeguarding food security - both in a small and in a large exporting country trading one (agricultural) good with the rest of the world (Fig. A2).

Figure A.1: **Partial equilibrium analysis of the economic impacts of export taxes**



Assuming that P_1 is the “undistorted” domestic price level - it equals international price P_w - at this price the domestic quantity demanded is D_1 , the domestic quantity supplied is S_1 and the difference ($S_1 - D_1$) is exported. Consider first the case of the adoption of an export tax t by a small country. When exports are taxed by t , the domestic price falls from P_1 to P_2 ⁷, the domestic supply falls from S_1 to S_2 and the domestic demand increases from D_1 to D_2 . Hence, the single impacts of this trade policy in a partial equilibrium analysis are the following: a reduction of exports - that now equal ($S_2 - D_2$); an increase in consumption ($D_2 - D_1$) for domestic consumers that benefit from a lower price; a reduction in supply ($S_1 - S_2$) by domestic producers penalised for the price fall; an increase of public revenues given by the export tax t . The benefit for consumers amounts to the area a (i.e. the change in the consumers surplus). The loss for producers

⁷Initially, domestic producers prefer offering their supply on the local market (untaxed) rather than on the world market (taxed). On the domestic market, supply is increased, reducing the domestic price, while the world price is unchanged. Domestic producers are hurt by this policy, as they produce and sell less at a lower price.

amounts to the area $(a + b + c + d)$ (i.e. the change in the producers surplus). The benefit for the government amounts to the area c . The overall impact of export tax is given summing the benefits and losses. The result is a net welfare loss represented by the areas b and d ⁸. However, if the policy-makers have a food security objective that implies a decrease in the domestic price, export taxes are efficient since they augment domestic consumption and reduce the local consumer price leading to an increase of the surplus of food consumers.

When the country that imposes export tax is a large country (i.e., large enough to affect world price), effects are quite similar for consumers and producers. The main differences consist of: a substantial fall of world supply (since a large country is assumed to export a significant share of world exports) that pushes the world price upwards from P_w to P_{*w} ; and an increase of public revenues (area e) due to the world price rise (which represents an improvement in the country's terms of trade). In this case, the implementation of this policy can lead to an increase of domestic welfare - under the usual *ceteris paribus* assumption - if the terms of trade gain exceeds the welfare loss (i.e. $e > [b + d]$). However, in terms of food security this policy measure implies a worsening because of the reduction of world food supply.⁹

⁸The size of the welfare loss depends on the slope of the demand and supply curves. It means that a small exporting country is always worse off when it adopts an export tax.

⁹It is noteworthy that in the long run, consequences could be different if producers in the rest of the world increased their supply in response to higher prices. As a result, the price adjusts downward from the short-run level, but still remains above the pre-restriction level. Therefore, it is quite possible that export restrictions could be beneficial in the short run while having negative consequences in the long run thanks to adjustments in the terms of trade (Mitra and Josling, 2009).

Appendix B. Tables & Figures

Table B.1: List of sampled countries (general case) and summary statistics for the aggregate NRA

Country	mean	sd	min	max	Country	mean	sd	min	max
Argentina	-0.116	0.099	-0.236	0.004	Malaysia	-0.008	0.047	-0.134	0.037
Australia	0.024	0.016	0.005	0.064	Mali	-0.020	0.028	-0.099	0.016
Austria	0.420	0.228	0.066	0.821	Mexico	0.140	0.130	-0.151	0.413
Bangladesh	-0.020	0.070	-0.154	0.138	Morocco	0.516	0.087	0.328	0.667
Benin	-0.013	0.019	-0.069	0.005	Mozambique	0.027	0.037	-0.050	0.090
Bulgaria	-0.016	0.103	-0.232	0.183	Newzealand	0.023	0.014	0.004	0.064
Burkinafaso	-0.026	0.054	-0.199	0.021	Nicaragua	-0.089	0.079	-0.229	0.052
Cameroon	-0.004	0.016	-0.030	0.049	Nigeria	0.065	0.180	-0.087	0.722
Chad	-0.006	0.012	-0.038	0.012	Norway	0.977	0.243	0.613	1.240
Chile	0.059	0.035	0.004	0.102	Pakistan	-0.027	0.076	-0.216	0.123
Colombia	0.162	0.090	-0.036	0.341	Philippines	0.202	0.129	-0.059	0.411
Coted'ivoire	-0.197	0.019	-0.233	-0.169	Poland	0.175	0.139	-0.017	0.596
Czechrep	0.212	0.118	0.066	0.484	Portugal	0.264	0.110	0.082	0.438
Denmark	0.340	0.181	0.063	0.697	Romania	0.331	0.249	0.036	0.798
Dominicanrepubli	0.036	0.132	-0.203	0.281	South Africa	0.051	0.070	-0.067	0.213
Ecuador	-0.043	0.125	-0.212	0.219	Russia	0.176	0.134	-0.197	0.419
Egypt	-0.036	0.082	-0.202	0.104	Senegal	-0.015	0.115	-0.172	0.226
Estonia	0.151	0.154	-0.196	0.488	Slovakia	0.246	0.123	0.066	0.426
Ethiopia	-0.081	0.275	-0.226	0.892	Slovenia	0.564	0.286	0.092	1.056
Finland	0.479	0.377	0.068	1.260	Srilanka	0.041	0.114	-0.221	0.192
Ghana	0.045	0.136	-0.064	0.468	Sudan	0.107	0.316	-0.209	0.826
Hungary	0.205	0.121	0.065	0.446	Sweden	0.460	0.298	0.066	1.128
Iceland	0.992	0.287	0.597	1.228	Switzerland	0.676	0.196	0.469	0.976
India	0.055	0.124	-0.128	0.260	Tanzania	-0.112	0.058	-0.174	0.000
Indonesia	-0.014	0.106	-0.218	0.138	Thailand	-0.004	0.061	-0.093	0.149
Ireland	0.572	0.263	0.078	1.051	Togo	-0.015	0.019	-0.072	0.003
Kazakhstan	0.009	0.097	-0.146	0.100	Turkey	0.247	0.113	0.013	0.432
Kenya	0.029	0.063	-0.078	0.158	Uganda	0.001	0.007	-0.022	0.009
Korea	0.924	0.285	0.483	1.244	Ukraine	-0.027	0.093	-0.192	0.135
Latvia	0.217	0.168	0.032	0.541	Vietnam	0.045	0.177	-0.231	0.322
Lithuania	0.199	0.216	-0.198	0.653	Zambia	-0.079	0.128	-0.224	0.134
Madagascar	-0.043	0.047	-0.127	0.063	Zimbabwe	-0.191	0.042	-0.227	-0.142
					Total	0.126	0.258	-0.236	1.260

Table B.2: Variables and Data

Type	Variable	Source
Trade distortions (treatment)	Nominal Rates of Assistance (NRAs) by product: sum of NRA to output conferred by border market price support, NRA to output conferred by domestic price support and NRA to inputs.	World Bank dataset (Anderson and Nelgen, 2012). *Updated National and Global Estimates of Distortions to Agricultural Incentives, 1955 to 2010*
Observable characteristics (covariates)	Aggregate Nominal Rates of Assistance (NRA _{Ag}): Value of production-weighted average NRA all (primary) Agriculture, total for covered and non-covered and non-product-specific assistance. Real per capita GDP (2005 International dollar per person).	Penn World Table (Heston, Summers and Aten, 2012, "Penn World Table Version 7.1", Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, November)
	Population (in thousands). Arable land (hectares per person).	World Bank - World Development Indicators
	Food production index (it covers food crops that are considered edible and that contain nutrients). (Country) Food imports over total exports. Deviation of international food prices from trend (positive and negative, %). International food price volatility. (Country) Net food exporter dummy. Regional group dummy: African Developing Countries (Group 1); Asian Developing Countries (Group 2); Latin American Developing Countries (Group 3); European Transition Economies (Group4); High-income Countries (Group 5). Food crisis dummy (1 if year 2007 and 2008).	FAOSTAT; IMF DOTS World Bank - GEM Commodity Price Data FAOSTAT
Food Security dimensions (outcome):	Food supply (in kcal/capita/day). Depth of food deficit (kilocalories per person per day). Mortality rate, infant (per 1,000 live births). Per capita food supply variability.	World Bank dataset (Anderson and Nelgen, 2012 Authors calculation). FAO - Food Balance Sheets World Bank - World Development Indicators World Bank - World Development Indicators FAO

Table B.3: Summary statistics of covariates

Variable	Mean	Std. dev.	Min	Max	Observations
Real per-capita GDP	9714.136	11148.370	323.260	51791.630	1072
Population	52636.59	138142.9	269	1156898	1072
Per-capita arable land	0.328	0.348	0.030	2.807	1072
Food production index	89.646	15.895	35.020	148.220	1072
Food import/total exports	0.016	0.024	0.001	0.260	1070
Pos. deviation of int.l food prices	0.010	0.030	0.000	0.142	1072
Neg. deviation of int.l food prices	0.050	0.041	0.000	0.138	1072
Food price volatility	0.021	0.009	0.006	0.050	1072
Net food exporter	0.484	0.500	0.000	1.000	1072
Group 1 - African DCs	0.332	0.471	0.000	1.000	1072
Group 2 -Asian DCs	0.170	0.376	0.000	1.000	1072
Group 3 - Latin American DCs	0.119	0.324	0.000	1.000	1072
Group 4 - European Transition Economies	0.205	0.404	0.000	1.000	1072
Group 5 - High-income Countries	0.174	0.379	0.000	1.000	1072
Food crisis	0.090	0.287	0.000	1.000	1072
Food supply	2725.312	524.468	1557.000	3826.000	1044
Infant mortality	40.190	36.564	1.900	155.100	1072
Depth of food deficit	97.958	110.173	1.000	615.000	985
Food variability	12.671	13.378	0.509	81.396	1045

Table B.4:
Differences in the treatment levels before and after balancing on the GPS: t-stats for equality of means.

Covariates	Wheat												Rice											
	Aggregate				After balancing on the GPS				Prior to balancing on the GPS				After balancing on the GPS			Prior to balancing on the GPS			After balancing on the GPS					
	Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
lnreal pc gdp	8.091	1.884	5.336	17.173	1.367	1.120	1.373	0.506	2.572	4.708	2.102	0.760	1.439	1.810	5.007	0.552	4.450	0.281	5.011	0.826	4.162	0.291	0.610	0.592
lnreal pc gdp ²	7.770	1.884	5.064	17.485	1.906	0.999	1.338	0.385	2.534	4.717	2.149	0.808	1.477	1.863	5.011	0.826	4.162	0.291	5.011	0.826	4.162	0.291	0.610	0.592
lnreal pc gdp ³	7.405	1.884	4.570	17.681	1.852	0.867	1.293	0.265	2.511	4.708	2.163	0.853	1.487	1.904	4.972	1.085	3.848	0.299	4.972	1.085	3.848	0.299	0.634	0.613
lnreal pc gdp ⁴	3.953	2.347	2.347	0.768	1.226	1.532	1.873	0.872	2.433	4.771	7.380	0.784	1.035	0.538	3.020	5.048	2.057	0.334	3.020	5.048	2.057	0.334	0.803	0.117
ln pc arable land	1.884	1.884	3.357	1.279	0.463	0.313	0.996	0.095	1.490	3.300	1.803	0.560	0.979	0.074	2.380	2.437	0.098	0.374	2.380	2.437	0.098	0.374	0.854	0.517
pos dev food prices	0.743	0.370	1.979	0.863	0.434	0.143	0.300	0.515	4.820	3.192	1.594	1.206	0.887	0.324	0.805	1.603	0.830	0.423	0.805	1.603	0.830	0.423	0.652	0.271
neg dev food prices	1.082	0.483	2.295	0.725	0.385	0.166	0.621	0.928	7.988	2.437	5.397	1.022	0.974	0.359	1.207	0.824	0.372	0.065	1.207	0.824	0.372	0.065	0.690	0.206
food price volatility	0.307	1.045	3.146	1.784	0.130	0.405	0.613	1.542	8.915	4.255	4.397	2.136	1.556	0.714	0.225	0.289	0.070	0.060	0.225	0.289	0.070	0.060	0.111	0.265
food crisis	6.334	6.356	4.523	8.227	0.150	1.115	1.371	1.008	8.915	4.255	4.397	2.136	1.556	0.714	0.225	0.289	0.070	0.060	0.225	0.289	0.070	0.060	0.111	0.265
food prod. index	3.301	0.094	0.657	4.067	0.555	0.154	0.631	0.019	1.508	2.648	1.137	0.190	1.112	1.078	7.087	3.038	3.824	0.127	7.087	3.038	3.824	0.127	0.722	0.325
group 2 -Asian DCs	2.397	2.836	5.058	4.609	0.007	1.361	1.693	0.084	0.809	0.114	0.698	0.393	0.066	0.112	5.917	0.379	5.545	0.708	5.917	0.379	5.545	0.708	0.801	0.901
group 3 - Latin American DCs	6.033	7.520	6.401	7.144	0.246	2.382	0.400	0.379	7.128	2.759	4.247	2.059	1.035	0.116	1.610	0.491	2.129	0.307	1.610	0.491	2.129	0.307	0.160	0.228
group 4 - European Transition Economies	8.973	1.210	2.708	13.604	0.988	2.010	0.530	0.479	5.716	5.304	0.394	1.896	2.058	1.233	3.266	1.989	1.232	0.325	3.266	1.989	1.232	0.325	0.583	0.570
group 5 - High-income Countries	3.905	2.048	0.352	6.393	0.673	0.405	0.958	0.159	7.379	4.378	12.510	0.438	0.537	0.715	5.896	2.184	3.590	0.369	5.896	2.184	3.590	0.369	0.152	0.803
net food exporter	5.381	6.281	4.645	7.036	1.257	1.253	1.001	0.768	0.334	4.575	4.248	0.086	1.446	1.483	0.474	1.653	1.214	0.541	0.474	1.653	1.214	0.541	0.592	0.871
food import /total exports	2.194	4.570	2.870	3.883	1.075	0.969	0.724	0.684	1.656	0.661	2.330	0.549	0.207	1.333	7.186	1.775	5.258	0.109	7.186	1.775	5.258	0.109	0.250	0.911
food import /total exports ²	6.572	1.203	1.924	7.340	1.406	1.972	0.696	1.088	1.347	0.882	2.243	0.376	0.258	1.332	7.371	1.899	5.300	0.121	7.371	1.899	5.300	0.121	0.287	0.875
pop	6.333	1.587	2.046	6.819	1.395	1.957	0.696	0.984	1.347	0.882	2.243	0.376	0.258	1.332	7.371	1.899	5.300	0.121	7.371	1.899	5.300	0.121	0.287	0.875
pop ²	268	268	268	268	243	246	217	114	302	302	297	283	283	271	207	222	201	178	207	222	201	178	209	182
No. of observations	268	268	268	268	243	246	217	114	302	302	297	283	283	271	207	222	201	178	207	222	201	178	209	182
Mean t-value						0.876				3.464				0.980		2.740		0.457		2.740		0.457		

Note: t-values reported in bold face indicate null rejections at the 5% level significance.

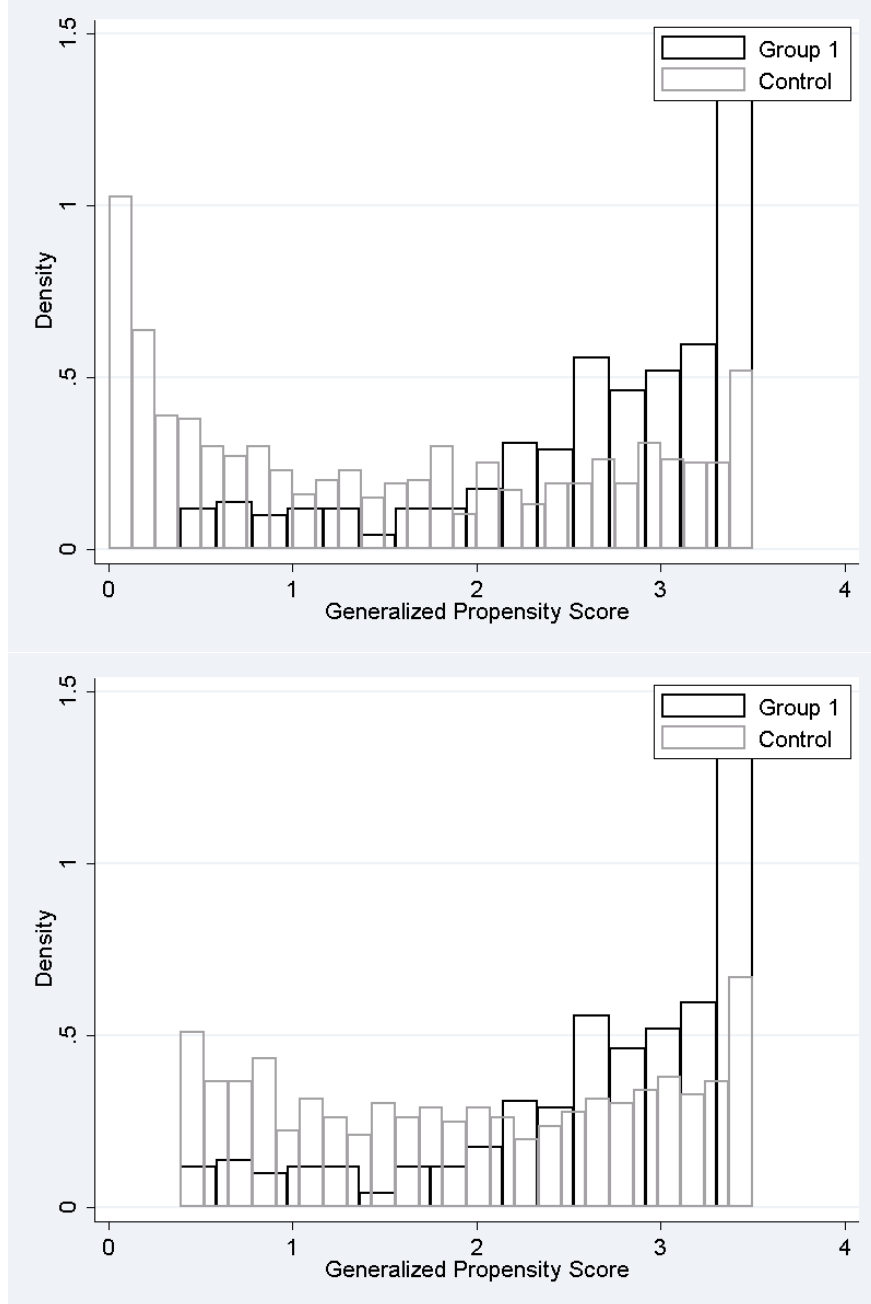
Table B.5: The final group-strata structure

Aggregate								
Strata	Control1	Group1	Control2	Group2	Control3	Group3	Control4	Group4
1	200	31	88	31	218	28	410	15
2	134	30	75	31	96	27	77	14
3	52	31	71	31	42	27	28	14
4	35	30	70	30	44	27	72	14
5	41	30	60	31	54	27	28	15
6	43	31	63	31	67	27	38	14
7	46	30	84	31	31	27	18	14
8	26	30	63	30	51	27	34	14

Wheat						
Strata	Control1	Group1	Control2	Group2	Control3	Group3
1	199	29	102	30	249	28
2	85	28	47	29	89	27
3	74	28	64	29	46	27
4	70	29	84	30	39	27
5	36	28	52	29	47	27
6	18	28	61	29	28	27
7	31	29	36	30	52	27
8	16	28	31	29	15	27
9	16	28	52	29	6	27
10	19	28	25	29	4	27

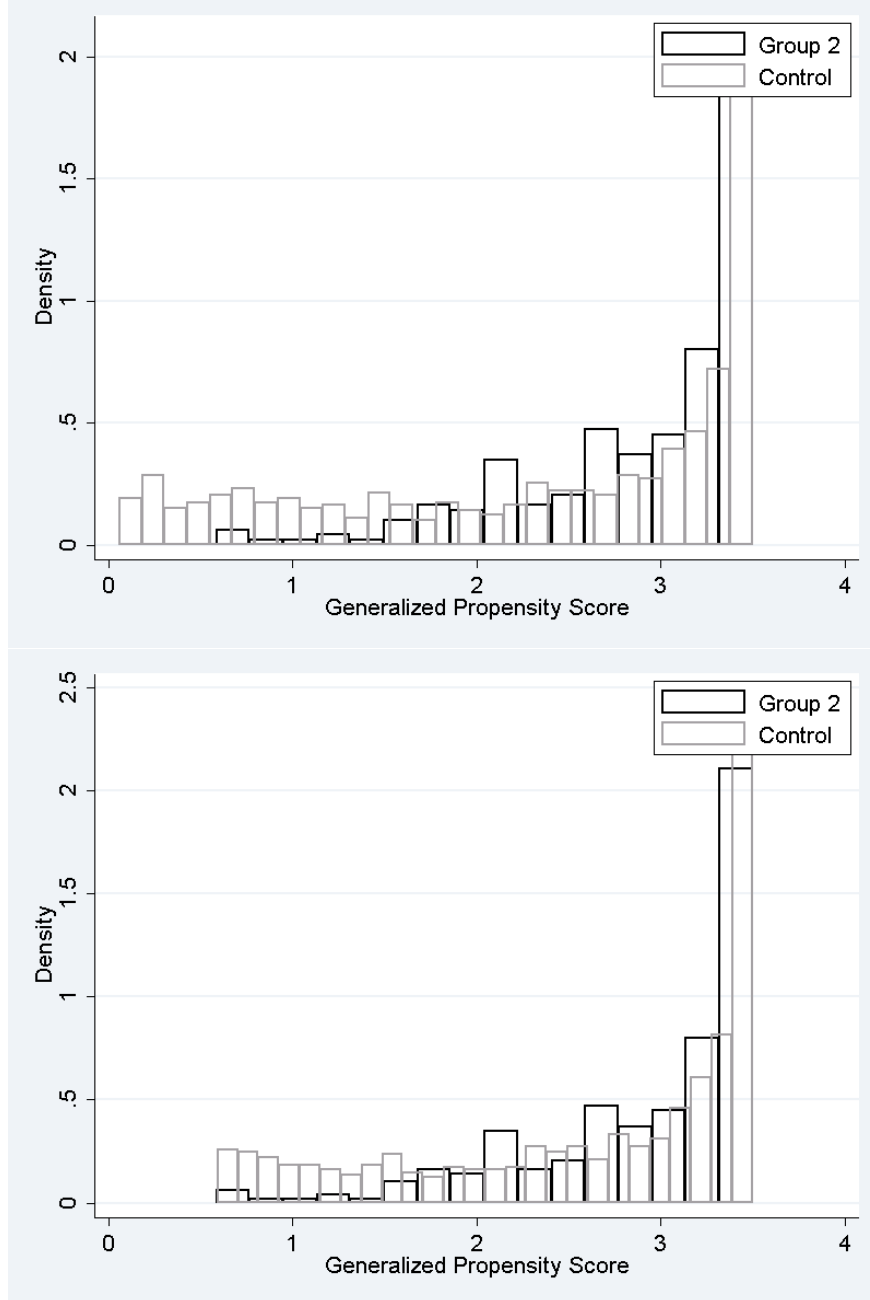
Rice						
Strata	Control1	Group1	Control2	Group2	Control3	Group3
1	128	18	104	21	100	19
2	70	18	46	21	47	18
3	40	18	31	21	80	18
4	39	18	38	21	58	18
5	39	18	23	21	30	18
6	49	18	26	21	27	19
7	14	18	19	21	25	18
8	5	18	28	21	12	18
9	5	18	23	21	3	18
10	2	17	23	20	5	18

Figure B.2: Common support before and after GPS (aggregate case): group 1



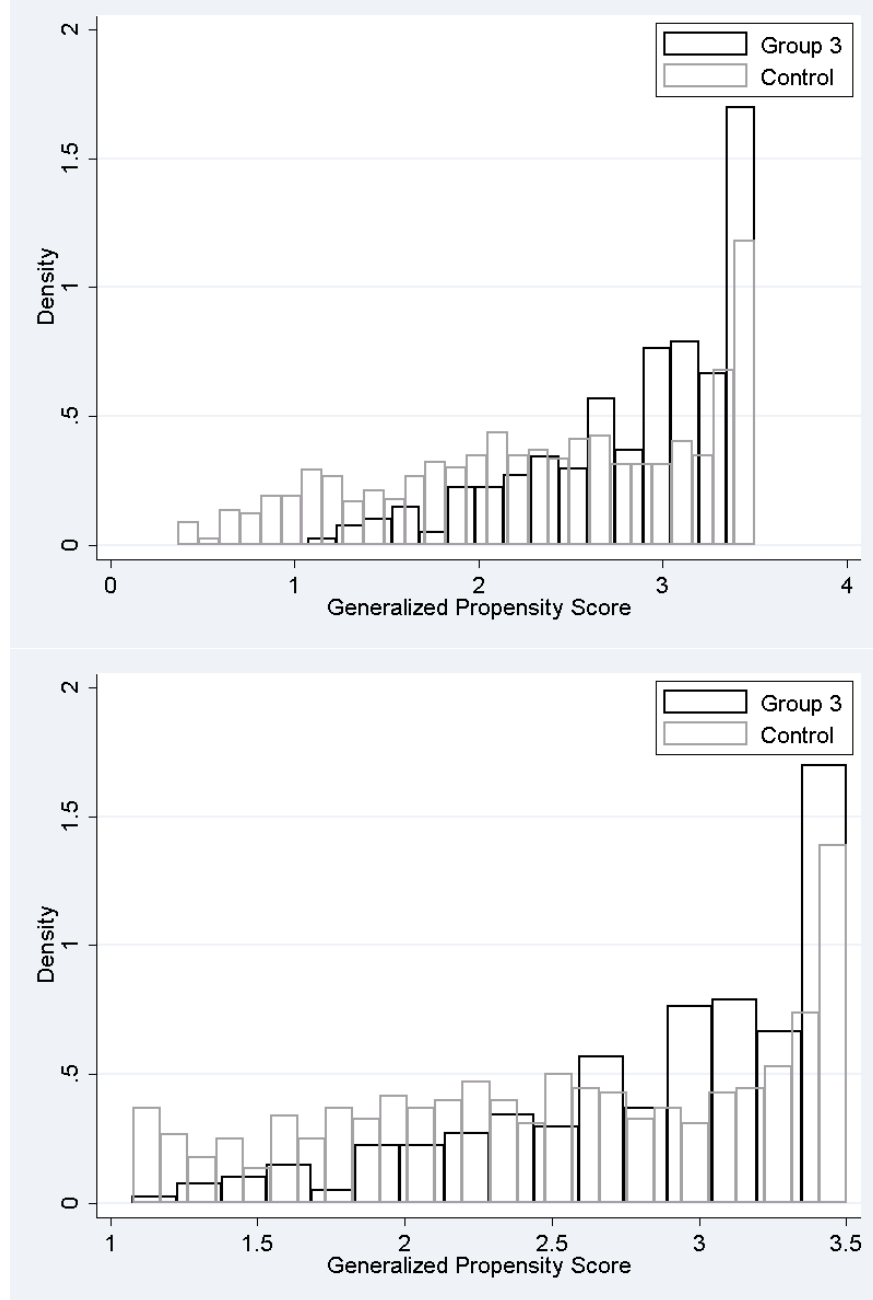
Source: Authors' calculations

Figure B.3: Common support before and after GPS (aggregate case): group 2



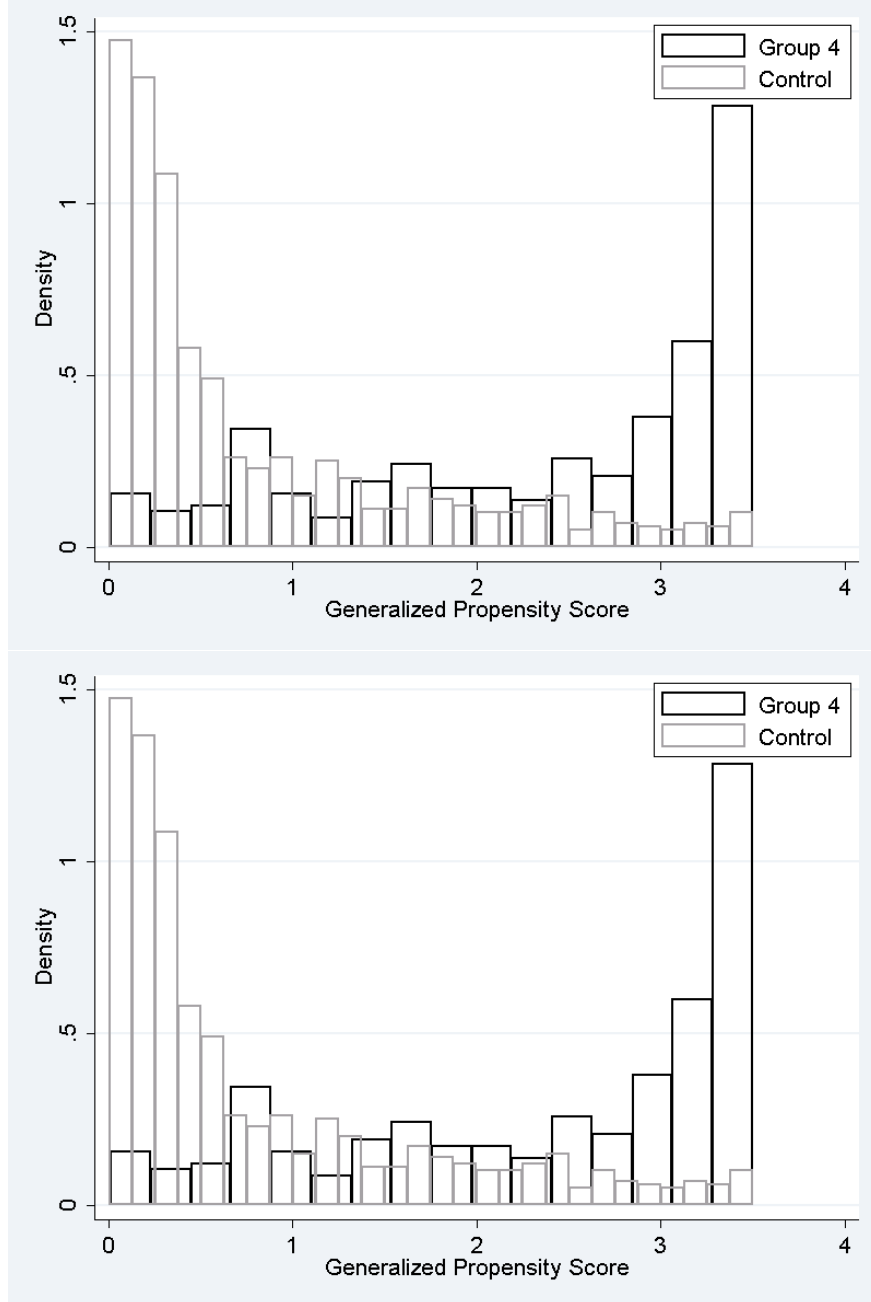
Source: Authors' calculations

Figure B.4: Common support before and after GPS (aggregate case): group 3



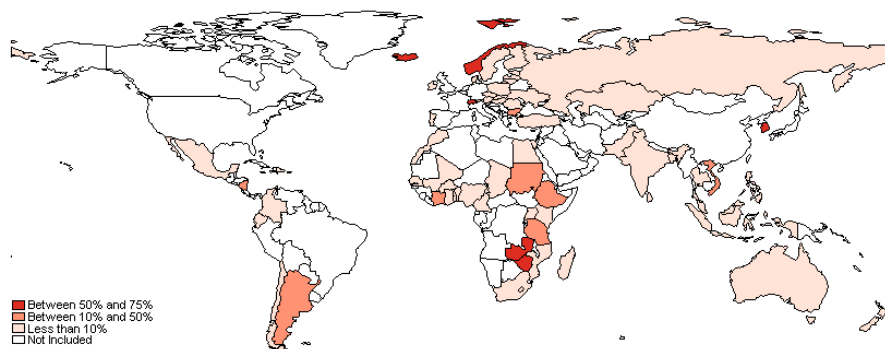
Source: Authors' calculations

Figure B.5: Common support before and after GPS (aggregate case): group 4



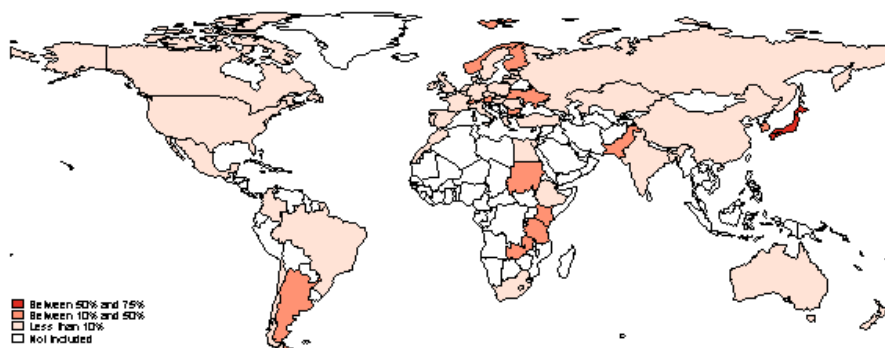
Source: Authors' calculations

Figure B.6: Map of countries (% of observations excluded by the common support: the general case)
Observations Dropped, Percentage



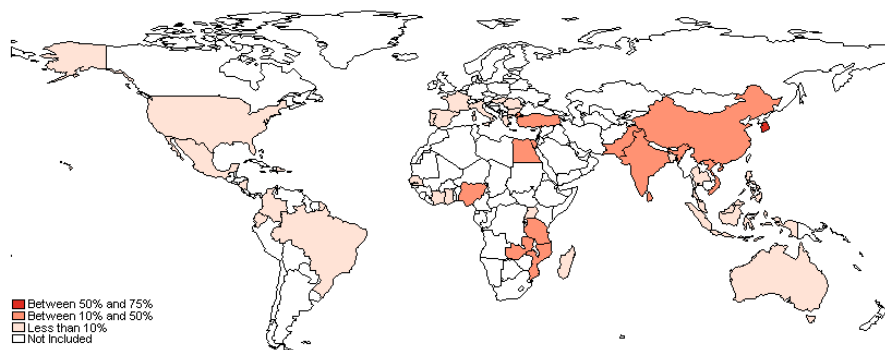
Source: Authors' calculations

Figure B.7: Map of countries (% of observations excluded by the common support: the wheat case)
Observations Dropped, Percentage



Source: Authors' calculations

Figure B.8: Map of countries (% of observations excluded by the common support: the rice case)
Observations Dropped, Percentage



Source: Authors' calculations

Table B.6: DRF estimation for food availability

Food Availability	Aggregate		Wheat		Rice	
	Coef.	SE (robust)	Coef.	SE (robust)	Coef.	SE (robust)
NAC	5.620***	1.889	-0.237	0.158	-0.938***	0.347
NAC ²	-4.640***	1.499	0.093**	0.046	0.561***	0.198
NAC ³	1.220***	0.384			-0.091***	0.035
GPS	-0.354***	0.070	0.092**	0.048	0.757***	0.157
GPS ²	-0.071**	0.040	-0.012	0.011	-0.597***	0.159
GPS ³	0.014**	0.007			0.146***	0.045
NAC*GPS	0.404***	0.034	0.000	0.029		
cons	5.704***	0.755	8.034***	0.110	8.062***	0.178
No. of observations	806		814		561	
R ²	0.3062		0.044		0.087	

Note: $(NAC) = (1 + NRA)$

***, **, * denote significance at the 1, 5 and 10 per cent level, respectively.

Table B.7: DRF estimation for food access

Food Access	Aggregate		Wheat		Rice	
	Coef.	SE (robust)	Coef.	SE (robust)	Coef.	SE (robust)
NAC	-42.914***	10.376	2.957***	0.720	1.521	1.543
NAC ²	35.971***	8.395	-1.159***	0.215	-1.211	0.858
NAC ³	-9.460***	2.191			0.224	0.145
GPS	1.468***	0.347	-0.856***	0.265	-2.782***	0.799
GPS ²	0.421**	0.195	0.067	0.059	2.335***	0.809
GPS ³	-0.061**	0.034			-0.607***	0.232
NAC*GPS	-2.104***	0.161	0.156	0.144		
cons	19.858***	4.085	1.907***	0.523	3.759***	0.780
No. of observations	820		847		570	
R ²	0.2156		0.123		0.052	

Note: $(NAC) = (1 + NRA)$

***, **, * denote significance at the 1, 5 and 10 per cent level, respectively.

Table B.8: DRF estimation for food utilization

Food Utilization	Aggregate		Wheat		Rice	
	Coef.	SE (robust)	Coef.	SE (robust)	Coef.	SE (robust)
NAC	-78.439***	23.487	2.854**	1.469	6.814**	3.161
NAC ²	70.240***	19.509	-1.076***	0.442	-4.160**	1.789
NAC ³	-19.813***	5.251			0.676**	0.307
GPS	3.236***	0.626	-0.681	0.471	-5.866***	1.528
GPS ²	0.583*	0.341	0.051	0.106	4.330***	1.559
GPS ³	-0.104*	0.058			-0.976**	0.448
NAC*GPS	-3.893***	0.278	-0.044	0.270		
cons	31.989***	9.000	2.199**	1.024	2.649	1.608
No. of observations	749		785		519	
R ²	0.2659		0.063		0.059	

Note: $(NAC) = (1 + NRA)$

***, **, * denote significance at the 1, 5 and 10 per cent level, respectively.

Table B.9: DRF estimation for food variability

Food Variability	Aggregate		Wheat		Rice	
	Coef.	SE (robust)	Coef.	SE (robust)	Coef.	SE (robust)
NAC	-6.118***	1.843	0.009	0.850	-0.520	1.544
NAC ²	2.484***	0.706	0.063	0.265	0.351	0.872
NAC ³					-0.052	0.143
GPS	-1.127***	0.187	0.371	0.240	1.462**	0.748
GPS ²		0.196	0.058	0.053	-0.958	0.737
GPS ³				0.144	0.209	0.209
NAC*GPS	1.115***	1.078	-0.348***	0.577		
cons	5.582***		2.069***		1.551**	0.728
No. of observations	808		818		570	
R ²	0.0847		0.052		0.019	

Note: $(NAC) = (1 + NRA)$

***, **, * denote significance at the 1, 5 and 10 per cent level, respectively.

Figure B.9: DRF and TEF: the wheat case

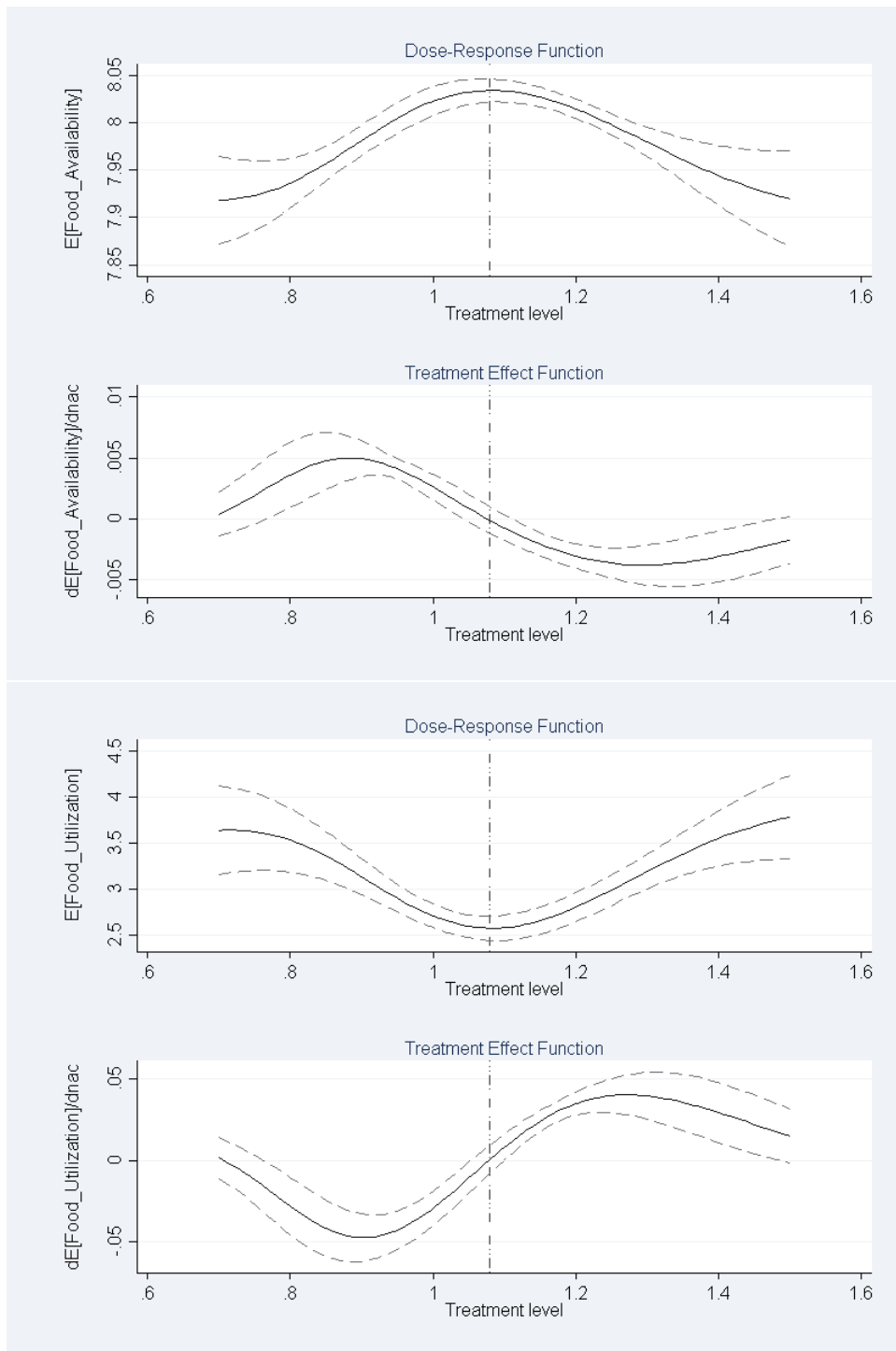


Figure B.10: DRF and TEF: the wheat case cont.d

