Agricultural trade distortions during recent international price spikes: What implications for food security?

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Abstract

This paper deals with the impact of trade policy restrictions on food security. Specifically, it focuses on restrictions to agricultural trade applied by national governments in the attempt to insulate domestic markets from international prices turmoil. The added value of the analysis is twofold: i) to test the causal relationship between trade distortion and food security using a non parametric matching technique with continuous treatment, namely the Generalised Propensity Score (GPS); ii) to control for treatment heterogeneity (by commodities) as well as outcome heterogeneity (i.e. different dimensions of food security). The outcomes of our estimates show clearly that trade distortions are, overall, significantly correlated with the various dimensions of food security under analysis but on the opposite direction than hoped for by policy-makers: countries less prone to adopt trade distortion policies tend to be better off in all the dimensions of food security (food availability, access, utilisation) with the relevant exception of food stability.

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

JEL classification: C21, F14, Q17, Q18

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1. Introduction

Countries usually adopt restrictions in agricultural trade in the attempt to insulate domestic markets from food price turmoil and preserve food security (Anderson *et al.*, 2013; Rutten *et al.*, 2013). The debate about the effectiveness of these measures is hot and timely. While most part of the literature is currently focusing on the impact on prices level and volatility (Anderson and Nelgen, 2012a,b), surprisingly less attention has been devoted to the impact of these trade restrictions on consumer' welfare and food security. Scholars agree that both food price level and volatility are the main channels of impact on food security. However, the direct and indirect impacts, positive or negative, of a specific trade policy intervention on food security have not been identified unequivocally.

To overcome the above limits we make two main contributions to previous literature. First, we apply an appropriate impact evaluation method, namely the Generalised Propensity Score (GPS), able to assess overall the causal effect of trade restrictions on selected outcome indicators of food security, by using non-parametric matching techniques able 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). More specifically, the adoption of a GPS technique permits to compare units that are similar conditional on observable determinants of "treatment intensity" as well as to derive non-monotonic relationships and flexible dose-response functions (Egger *et al.*, 2012). Second, we control for treatment heterogeneity (by commodities) as well as for outcome heterogeneity in order to discriminate causal relationships by policy coverage and various dimensions of 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, it holds on the opposite direction than hoped for by policy-makers: countries less prone to adopt trade distortion policies tend to be better off in all the dimensions of food security (food availability, access, utilisation) with the relevant exception of food stability.

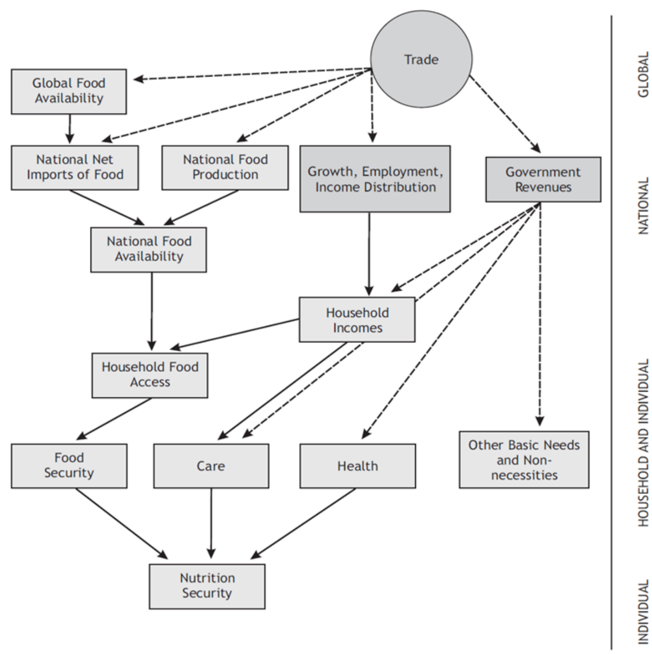
The work is organised as follows: Section 2 briefly summarises, theoretically and empirically, the links between trade and food security; Section 3 presents the GPS estimator; Section 4 describes variables and data; Section 5 shows the empirical results; Section 6 concludes.

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

2.1. The conceptual framework

Trade and food security are closely interconnected. Both trade and trade policy affect food security, directly through the impact on food availability, and indirectly through the effects on food accessibility and stability. Diaz-Bonilla *et al.* (2002) were among the first to analyse the interactions among these issues and to emphasise the variety of impacts that trade and trade policies can have on the determinants of food security. Figure 2.1 proposes a conceptual framework for food security, which 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 and trade policies influence food security is both via their 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 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. Concerning price level, high food prices can impact positively on food availability, improving food production and its access by increasing producers' incomes. At the same time, it 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).

2.2. A naive theoretical framework

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). Any country with a significant share of its population being food insecure, or bearing a high risk of becoming so, faces a strong pressure to adopt policy measures to avoid the problems due to the rise in domestic food prices (Anania, 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[1]. 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).

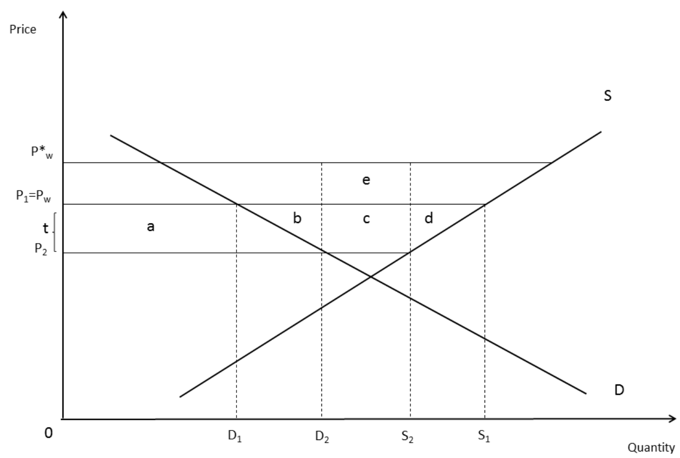
Our focus is on pro-cyclical trade distortions, mainly consisting of measures taken on the export side, since export taxes and/or quantitative restrictions, restrict rather than promote trade and prevent international

[1]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.

markets from carrying out their designated role of signalling changes in scarcity and market smoothing (Anderson, 2009).

To facilitate the understanding of the impacts of the trade restrictions on prices, exports, and welfare as well as the interpretation of our empirical outcomes, we propose a simple theoretical framework, reported in Fig.2.2. It analyses the economic effects of the adoption of export taxes - as an emergency measure 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.

Figure 2: **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 [2], 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

[2]Initially, 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 (Bouet and Laborde, 2010).

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 [3]. 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. [4]

2.3. Are these policy measures really effective? The empirical analyses

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). McCalla (2009) warns against the fiscal sustainability of this kind of measures (since countries that maintain low domestic food prices as a safety net have experienced rising fiscal costs of domestic feeding programs) and emphasises the differentiated impact across countries. 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

[3] The 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.

[4] It 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).

restrict them. Jones and Kwiecinski (2010) find that while 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 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 effects 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. It is based on the following assumptions: for each i there is a vector of covariates X_i, a "treatment" received,

$T_i \in [t_0, t_1]$ and a potential outcome, $Y_i = Y_i(T_i)$. Following Hirano and Imbens (2004) we assume: Y_i, T_i and X_i are defined on a common probability space; T_i is continuously distributed with respect to a Lebesgue measure on τ; $Y_i = Y_i(T_i)$ is a well defined random variable. For each i we postulate the existence of a set of potential outcomes, $Y_i(t)$, for $t \in \tau$ where τ is the interval $[t_0; t_1]$ referred to as the unit-level dose-response function. We are interested in the average dose-response function, across all observations i that illustrates the expected value of the outcome variable conditional to continuous treatment as follows:

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

In this exercise we use index $i = 1, ..., N$ 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:

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

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:

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

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.[5] 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, able to synthesise specifically the actual impact of governmental distortions, prevents the violation of the unique treatment assumptions. At the same time, working with treatment intensities prevents also any cross relationship across the various groups' outcomes in terms of food security.

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 as a function of two scalar, the treatment level T and the GPS $R, \beta(t, r) = E[Y|T = t, R = r]$. 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:

$$D(t) = E[\beta(t, r(t, X))] \tag{5}$$

Furthermore, we can estimate the varying marginal effects of the treatment by estimating the treatment effect function, which is the first derivative of the corresponding dose-response function.

4. Variables and data

In this exercise we make use of three different sets of data: i) the annual NRA 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 (X_i); iii) the outcome in terms of the various dimensions of food security ($Y(t)$). Table A.1 reports a synthesis of the data applied in our empirical exercise.

The World Bank dataset ("Updated National and Global Estimates of Distortions to Agricultural Incentives, 1955 to 2010") by Anderson and Nelgen (2012c) includes a core database of Nominal Rates of Assistance to producers (NRAs) to agricultural industries as well as nominal rates of assistance to producers

[5] Please 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).

of nonagricultural 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:

$$NRA = (E.P(1 + t_m)E.P)/E.P = t_m$$

where E is the exchange rate and P is the foreign price of an identical product in the international market (Anderson, 2006). Hence, 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). 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 (i.e., 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 (Lloydetal10). 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 these informations needs to be summarized in one aggregate and economically meaningful measure. The World bank's database (Anderson and Valenzuela, 2008) 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 $NRAag$, can be obtained by adding the actual or assumed information for the noncovered 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 75 countries (that together account for 92% of agricultural GDP) and 70 products for the overall period 1955-2010. In this exercise, because of data constraints in food security measures, we are forced to limit our dataset to the sub-period 1990-2010. Among the estimated trade distortion measures, we use here $NRAag$ for the aggregate exercise and NRA by commodity for the product level analysis (see table A.1). 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 NRAs 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). 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.

Concerning the set of covariates, following on Anderson *et al.* (2013) and Anderson and Nelgen (2012a) we selected the following variables: the log of real GDP per capita (to control for the anti-trade behaviour of the most advanced economies); the log of arable land per capita (to control for the relative agricultural comparative advantage); the percentage of (positive and negative) deviations from trend in the aggregate - and of the product in question - food international prices (to control for the presence of asymmetric policy response to sizeable changes in price levels). Furthermore, we include also countries fixed effects - to take into account of country level unobservables - as well as a proxy for international food price volatility - to control also for the second moment of the relationship between international prices dynamics and trade distortions.

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 emphasises 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 (approximately 200 definitions and 450 indicators of food security according to Hoddinott (1999)).

In this paper we decide not to use a composite indicator of food, 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 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) and 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: Food supply in kcal/capita/day (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 A.1 for additional details and sources' availability)

5. GPS estimation and results

We carried out our empirical exercises for each dimension of food security both at aggregate and product level. In the latter case, we focus on wheat and rice. In the first stage estimation we regress our measure of trade distortion on a set of observable characteristics, and estimate the GPS. In the second stage, we compute a dose-response function which illustrates if and how there is a causal link between the level of the various dimensions of food security and changes in the intensity of agricultural trade distortions.

Table 1 presents the outcome of the first stage equation for the aggregate case as well as for the wheat and rice net exporters (which are supposed to be the main beneficiaries of trade policies distortions during the recent price spikes). The coefficients are significant and show the expected signs (with the relevant exception of arable land). The strong and positive coefficient for the constant term shows, as expected, that food insecurity remains a feature, on average and *ceteris paribus*, also when all distortions are equal to zero. This considered, NRA tends to be higher the higher a country's income per capita (even if at a decreasing rate), while the country's comparative advantage in agriculture (proxied by the percentage of arable land) seems not to be relevant for trade distortion. To be noted the asymmetry in the impacts of positive and negative deviations of international prices from their trend. NRAs are negatively correlated with positive international price deviations from their trend, since food import restrictions tend to be eased during price spikes and export tax raised. However, the anti-trade bias of net exporter countries seems not to be relevant and statistically significant, likely because this has been a relatively recent feature (see also Anderson (2013); Anderson and Nelgen (2012c,a)). Consistently, NRAs are positively correlated with negative international price deviations from their trend, since overall food import restrictions tend to be stressed during price drops, while the pro-trade behaviour of net exporter countries is shown by an opposite sign of the same coefficient. Last but not least, it is worth noting that international price volatility always impacts negatively on NRAs, highlighting a strong correlation with trade distortions that imply lowering gross returns for domestic producers.

Table 1: **Generalised Propensity Score Estimations**

Covariates	All		Net exporters wheat		Net exporters rice	
	Coef.	SE (robust)	Coef.	SE (robust)	Coef.	SE (robust)
ln real pc GDP	3.644***	0.421	3.989**	1.879	11.045***	1.643
ln real pc GDP squared	-0.205***	0.023	-0.220**	0.094	-0.659***	0.093
ln pc arable land	-0.045	0.043	-0.094	0.166	0.840***	0.248
% pos dev. Int.l prices from trend	-31.141***	5.845	-0.007	0.211	-0.067	0.697
% neg dev. Int.l prices from trend	30.313***	7.218	-0.820***	0.271	-1.013*	0.605
Int.l prices volatility (last 12 months)	-3.054***	0.982	-2.895***	0.898	-0.134	1.570
Constant	-16.542***	1.918	-19.156**	9.416	-44.352***	7.312
Country fixed effects	yes		yes		yes	
Observations	1273		426		252	
R squared	0.725		0.335		0.644	

Note: All variables with one lag
***,**,* denote significance at the 1, 5 and 10 per cent level, respectively.

Notwithstanding the relevance of our set of covariates, it is worth noting that in impact evaluation exercises 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 regression is high and consistent with similar GPS empirical exercises (Becker *et al.*, 2012; Serrano-Domingo and Requena-Silvente, 2013).

Following the approach applied by Egger *et al.* (2012), the 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. Hence, we first perform a series of two-sided t-tests across groups for each covariate. Groups of approximately the same size are formed on the basis of the actual NRA, while 10 GPS strata are estimated. Before controlling for the GPS we obtain an average t-stat of 2.414 and the common support condition was not respected by 87 observations out of 177. After the GPS correction the average t-stat is 0.436 and the common support condition is rejected only by 5 observations (see Figs. in Appendix A).

The last step is to estimate the dose-response function (DRF), i.e., to assess the causal relationship between food security and any specific level of annual NRA, given the estimated GPS. Please note that the GPS terms in this regression controls for selection into treatment intensities, while 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 that are actually controlled by looking over GPS strata as well as - by using the interaction term - across GPS. 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. A number of polynomials can be tested for assessing the above relationship. As in (Egger *et al.*, 2012) we chose to disregard polynomial terms that turned out to be insignificant. The corresponding results for the parsimonious, semi-parametric dose-response functions are summarised in tables 2; 3; 4; 5. 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.

Table 2 shows the DRF parameters in the case of food availability. The main outcome of the table is that trade distortions always impact positively, even if at a decreasing rate, on food availability. This result is robust and significant both at the aggregate level and at the product level for net exporters in wheat and rice. Selection into treatment intensities appears to be also significant and the marginal impact of treatment intensity increases along with GPS intensities, as shown by the interaction term. To be noted that the coefficient of the constant terms is always positive and highly significant.

Tables 3 and 4 show a positive but decreasing relationship between agricultural trade distortions and both food utilisation (proxied by a reduction in the percentage of infant mortality) and access (proxied by a reduction in the percentage of depht of food deficit). Also in this case, selection into treatment intensities is highly significant while the marginal impact of treatment intensity in reducing mortality and

Table 2: **Dose-Response Function estimation for food availability**

Food supply in kcal/capita/day	All	Net exporters wheat	Net exporters rice
NAC	1.376***	1.477***	10.933***
NAC^2	-.574***	-.543***	-7.980***
NAC^3			1.826**
GPS	-.743***	-.526**	-1.310**
GPS^2		.760***	
GPS^3		-.281**	
$NAC * GPS$	0.651***		.737**
Cons.	7.095***	7.196***	3.418***
Oss	974	348	161
R^2	0.33	0.11	0.27

Note: $(NAC) = (1 + NRA)$
***,**,* denote significance at the 1, 5 and 10 per cent level, respectively.

food deficit increases along with GPS intensities. Also in this case the coefficient of the constant terms is highly significant.

Table 3: **Dose-Response Function estimation for food utilisation**

infant mortality	All	Main exporter wheat	Main exporter rice
NAC	-10.948***	-6.776***	-70.28***
NAC^2	4.574***	2.481***	53.735***
NAC^3			-12.823***
GPS	4.248***	2.461**	8.757***
GPS^2		-4.250**	-2.733**
GPS^3		1.630**	
$NAC * GPS$	-.357***		-5.194***
Cons.	9.364***	6.373***	30.649***
Oss	1004	375	168
R^2	0.29	0.21	0.28

Note: $(NAC) = (1 + NRA)$
***,**,* denote significance at the 1, 5 and 10 per cent level, respectively.

Table 5 shows that agricultural trade distortions have overall a significant impact in reducing food supply variability as well. This is given by a negative coefficient in the case of import distortions (i.e., positive NRAs) and positive in the case of export distortions (i.e., negative NRAs). However, this effect turns to be insignificant in the case of countries which are wheat net exporters. Also in this case, selection into treatment intensities is highly significant while the marginal impact of treatment intensity in reducing food supply variability increases along with GPS intensities. The coefficient of the constant term keeps always its significance.

The left panel of Fig. 3 reports the graphical representation of the DRF for the various dimensions of food security, i.e. the non-parametric functional form of the relationship between food security and annual

Table 4: **Dose-Response Function estimation for food access**

Depth of the food deficit	All	Main exporter wheat	Main exporter rice
NAC	-9.617***	-15.889***	-130.02***
NAC^2	4.239***	5.663***	95.236***
NAC^3			-21.972***
GPS	6.201***	5.406**	12.939***
GPS^2		-8.367**	
GPS^3		3.193**	
$NAC * GPS$	-6.017***		-8.470**
Cons.	9.274***	11.866***	57.590***
Oss	918	364	163
$\hat{R2}$	0.30	0.10	0.30

Note: $(NAC) = (1 + NRA)$
***,**,* denote significance at the 1, 5 and 10 per cent level, respectively.

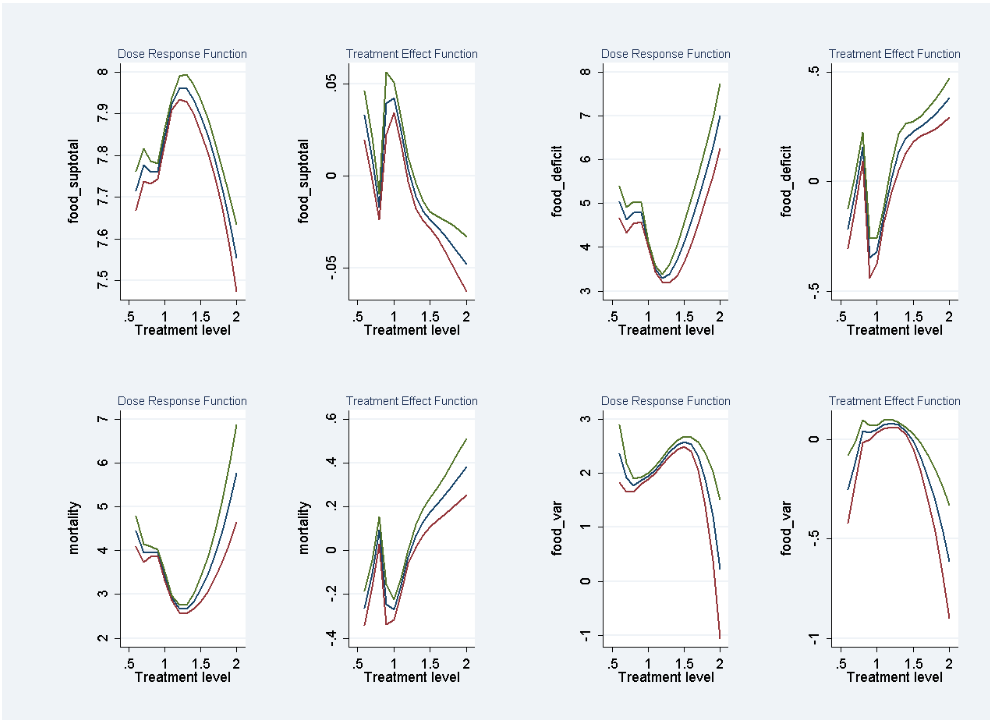
Table 5: **Dose-Response Function estimation for food stability**

Per capita food supply variability	All	Main exporter wheat	Main exporter rice
NAC	-28.902***		72.851***
NAC^2	25.815***		-56.271***
NAC^3	-7.146***		13.513***
GPS	.240***	-2.770*	-7.319***
GPS^2			
GPS^3			
$NAC * GPS$			4.463***
Cons.	11.947***	2.285*	-26.422***
Oss	981	361	168
$\hat{R2}$	0.08	0.01	0.19

Note: $(NAC) = (1 + NRA)$
***,**,* denote significance at the 1, 5 and 10 per cent level, respectively.

NCAs, while the right panel of Fig. 3 represents the treatment effect function, i.e. the first derivative of the dose-response function. The corresponding standard errors and 90% confidence intervals of both functions are also reported in the figures and estimated via bootstrapping. For brevity, both figures are here related to the aggregate case only.

Figure 3: The dose-response and the treatment effect function: the aggregate case



The first outcome we can derive from the DRF in the left panel of Fig. 3 is that trade insulation policies have, on average and *ceteris paribus*, a negative impact on all the dimensions of food security, with the relevant exception of food variability. Both positive and negative NRAs (i.e., NAC above and below 1 in the picture) are indeed associated with levels of food availability, utilisation and access that are below the maximum level, which is generally associated to trade policies very close to "neutrality" (i.e., when $NAC = 1$). Actually, if we look at the 90% confidence band, we observe that the neutrality hypothesis is not far from the region of acceptance in most of the cases when food security is, on average and *ceteris paribus*, at its maximum level. At the same time, we cannot underestimate that positive levels of food security are still significantly associated with low positive levels of NRAs in our country-year observations while the impact of higher levels of trade insulating policies (approximately for NAC higher than 1.5) is unambiguously negative in case of food availability, utilisation and access, and still positive only for food stability (food supply variability keeps reducing). Consistently, the treatment effect function in the right panels of Fig.3 shows that, for each positive level of NRA (i.e. NAC>1), food availability, utilisation and access actually worsen in correspondence of any marginal change in NAC, while food stability actually increases.

6. Conclusions

We assessed the functional form of the relationship between trade policy insulation and various dimensions of food security, on aggregate and by commodities. We used a non parametric method for causal inference in quasi-experimental setting with continuous treatment under the (weak) unconfoundedness assumption. Our results are key for policymaking. 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 distortions on the various dimensions of food security under analysis. However, we show it holds on the opposite direction than hoped for by policy-makers: countries less prone to adopt trade distortion policies tend to be better off in all the dimensions of food security (food availability, access, utilisation) with the relevant exception of food stability.

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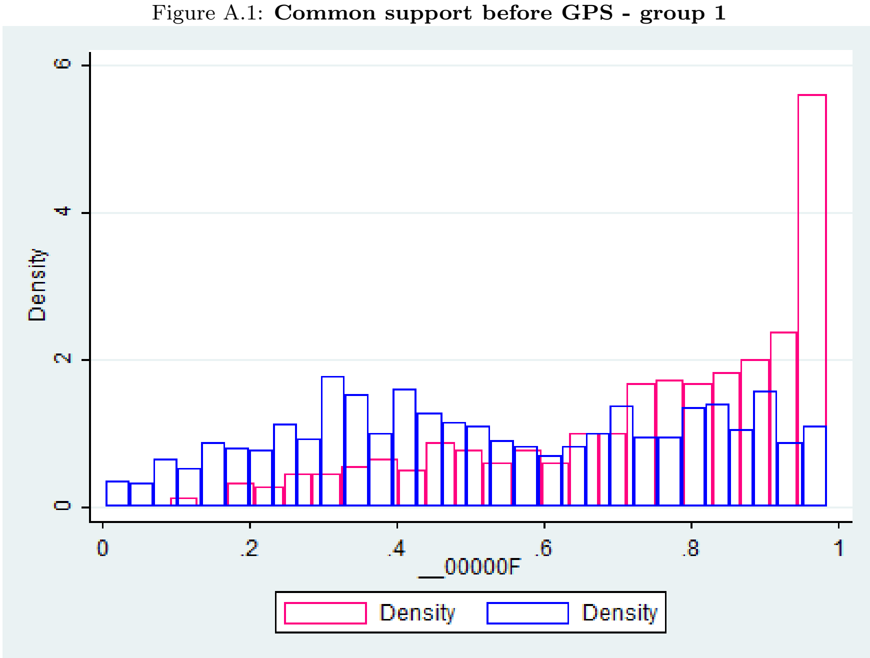
Appendix A.

Table A.1: **Variables and Data**

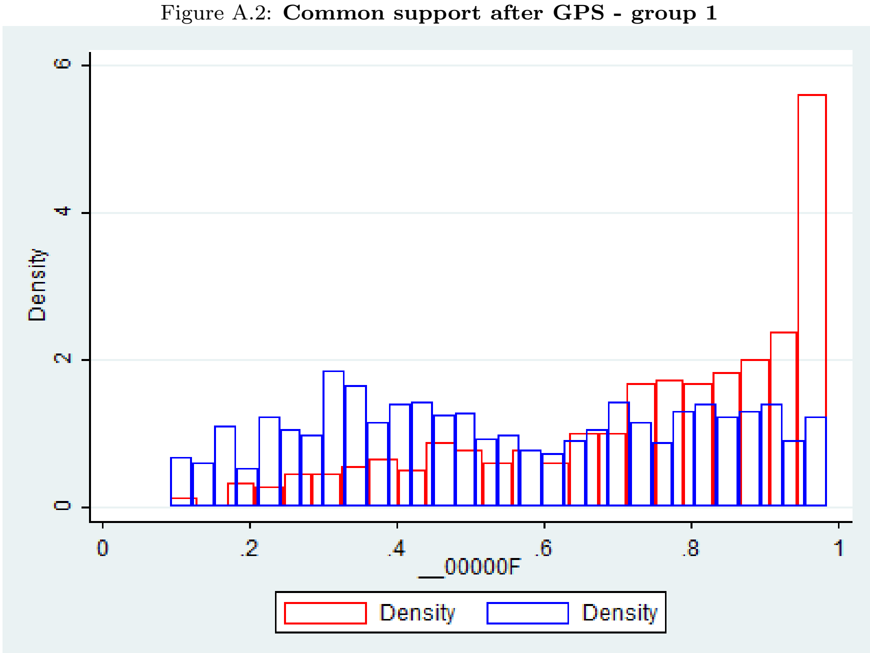
Type	Variable	Source
Trade distortions (treatment)	Nominal Rates of Assistance (NRAs) by product (given by the sum of NRA to output conferred by border market price support, NRA to output conferred by domestic price support and NRA to inputs)	World Bank dataset (Anderson and Nelgen, 2012)
	Aggregate Nominal Rates of Assistance (NRAag)= NRA All (primary) Agriculture, total for covered and non-covered and non-product-specific assistance. Value of production-weighted average.	
Observable characteristics (covariates)	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)
	Arable land (hectares per person)	World Bank - WDI
	Deviation of international food prices from trend (positive and negative, %)	World Bank - Commodity Price Data
	International food prices volatility	
Food Security dimensions (outcome):		
Availability	FAO Food Balance Sheets (Food supply in kcal/capita/day)	FAO
Access	Depth of the food deficit (kilocalories per person per day)	World Bank - WDI
Utilization	Infant mortality rate (per 1000 live births)	World Bank - WDI
Stability	Per capita food supply variability	FAO

Figure A.1: **Common support before GPS - group 1**



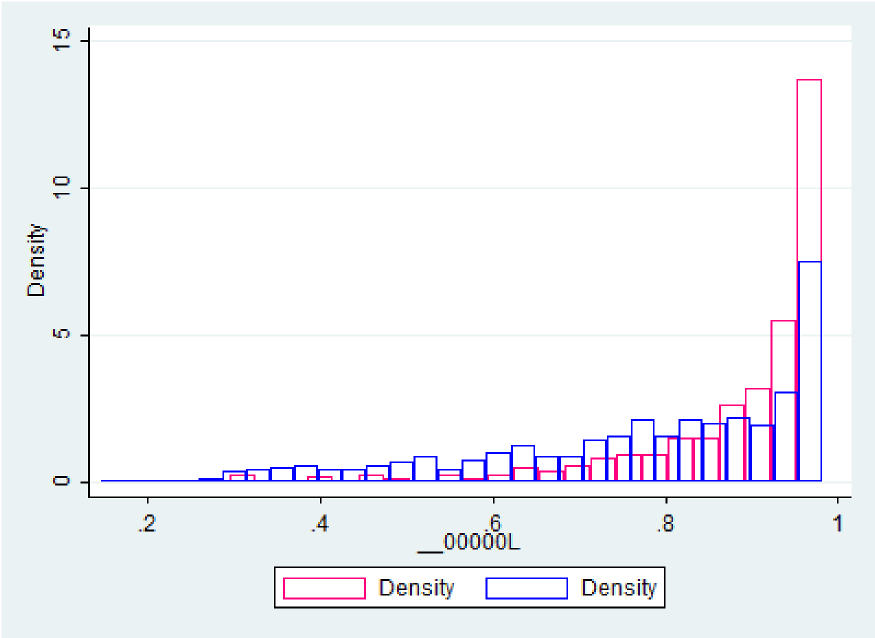
Source: Authors' calculations

Figure A.2: **Common support after GPS - group 1**



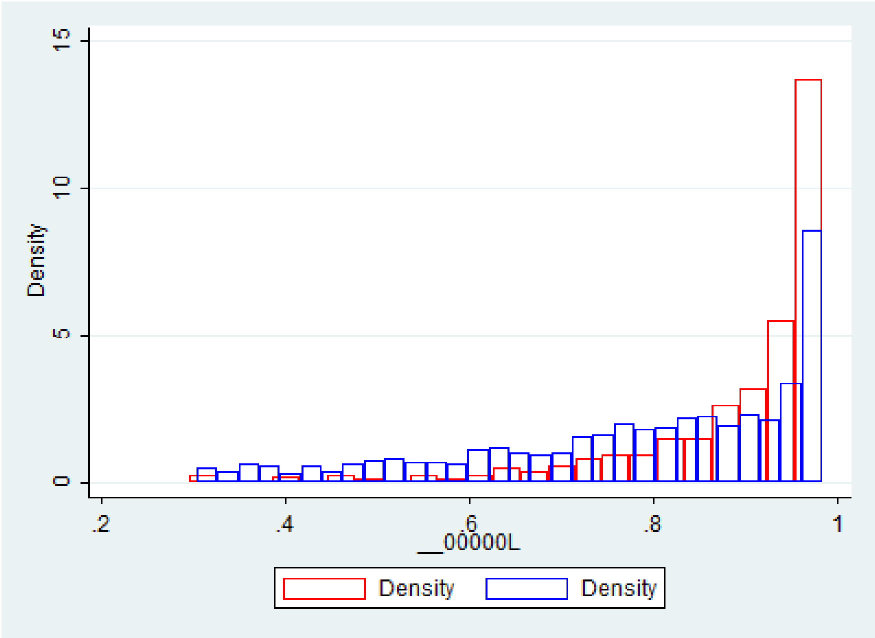
Source: Authors' calculations

Figure A.3: **Common support before GPS - group 2**



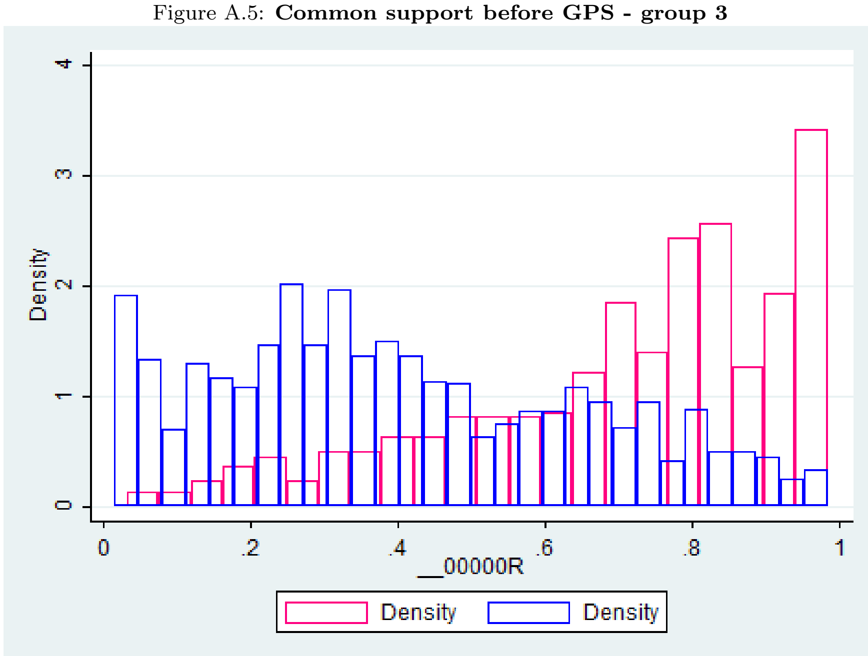
Source: Authors' calculations

Figure A.4: **Common support after GPS - group 2**



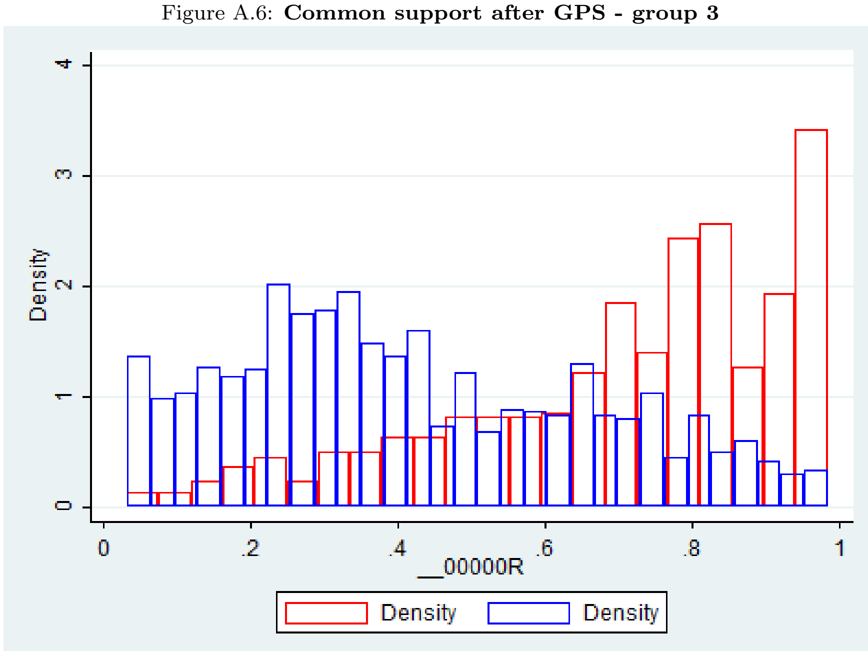
Source: Authors' calculations

Figure A.5: **Common support before GPS - group 3**



Source: Authors' calculations

Figure A.6: **Common support after GPS - group 3**



Source: Authors' calculations