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"*Empty Plates*": Impacts of Food Prices, Inequality and Trade on Malnutrition

"*Platos vacíos*": *Impactos de los precios de los alimentos, la desigualdad y el comercio en la desnutrición*

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Abstract

This paper studies the complex link between nutritional status and income by using panel data from 150 countries over the period 1960–2018 and employing a panel VAR approach under system GMM estimates. The causal link between nutrition intake and income may change from one income group to another due to different effects of similar factors. While hikes in food prices, unfair distributions of income and rising international trade flows lower nutrition intake in lower middle-income countries, the same factors lead to higher body weights in upper middle-income and high-income OECD countries. Therefore, Engel Curve and Efficiency Wage Hypotheses fail for a group of countries.

Keywords: Malnutrition, income inequality, food prices, panel data.

Resumen

Este trabajo estudia el vínculo complejo entre el estado nutricional y los ingresos utilizando datos de panel de 150 países durante el período 1960-2018 y empleando un enfoque VAR de panel bajo estimaciones GMM del sistema. El vínculo causal entre la ingesta nutricional y los ingresos puede cambiar de un grupo de ingresos a otro debido a los diferentes efectos de factores similares. Mientras que los aumentos en los precios de los alimentos, la distribución injusta de los ingresos y el aumento de los flujos comerciales internacionales reducen la ingesta nutricional en los países de ingresos medianos bajos, los mismos factores conducen a un mayor peso corporal en los países de ingresos medianos altos y altos de la OECD. Por lo tanto, las hipótesis de la Curva de Engel y del Salario de Eficiencia fallan para un grupo de países.

Palabras clave: desnutrición, desigualdad de ingresos, precios de los alimentos, datos de panel.

JEL Classification/ Clasificación JEL: I24, I25, O15, C23.

1. Introduction

There have been significant gains in the eradication of hunger over the past two decades, however, accesses to adequate, affordable, and nutritious food have remained one of the greatest challenges of the twenty first century. Particularly, the double burden of malnutrition, i.e. the coexistence of undernutrition and overweight and obesity, continue to plague the world (Patel, 2012). In 2018, over 820 million people suffered from hunger while more than 2 billion adults were overweight and of these over 672 million were obese (FAO 2018, WHO 2019). This data information indicates that overweight rates have now overtaken hunger rates globally, and the growing threat of malnutrition in all forms -underweight and overweight- remains as a major problem in many countries. While undernutrition has substantial consequences on the cognitive and physical development of individuals (Black et al. 2013 and McGovern et al. 2017), overweight and obesity have detrimental health effects, such as coronary heart disease, hypertension, strokes, type 2 diabetes and various cancers (Seligman et al. 2010). Furthermore, overweight and obesity kill more people than underweight (WHO, 2009).

The main obstacle behind the persistent malnutrition is unequal access to nutritious food, which can be attributable to a number of factors. First, the industrial food system, which is mostly designed to generate short-term profits for industrial food producers, promotes the consumption of unhealthy food (Elmes, 2018 and Otero et al. 2015). Second, nutrition transition that moves populations away from traditional diets (high in fibers and micronutrients) towards more highly processed, energy dense diets (high in sugar, fat, salt but low in fiber) disturbs the consumption of nutritious food (Otero et al. 2015). Third, globalization, by affecting the eating behavior and physical activity patterns, leads to a shift in the composition of food baskets towards fast foods (Lang, 1999; Hawkes, 2006, Blouin et al. 2009). Fourth, high and persistent income inequality is associated with overnutrition and undernutrition (Su et al. 2012, Elmes, 2018; Otero et al. 2015; Pickett et al. 2005; Dawson, 1998). Fifth, rising food prices have limited the access to nutritious food. Overall, unfair distribution of income, globalization and food prices are emerged as important factors in determining the production, consumption and distribution of nutritious food (Dawson (1998), FAO (2018), Reig (2012) and Wineman (2016)).

When evaluating policies aiming at fighting against malnutrition, the relationship between nutrition and income has gained a remarkable surge of interest. Most of the studies on the nutrition-income nexus has been motivated by two hypotheses: Engel Curve Hypothesis (ECH) and Efficiency Wage Hypothesis (EWH). While the former states that an increase in per capita income leads to an increase in calorie intake, the latter posits the opposite expectation - because the efficiency of workers depends on their nutritional status, an improvement in the nutritional status contributes to a rise in productivity, thereby income (Stiglitz, 1976). However, recent studies argue that EWH expectations may not be totally correct and the contribution of nutrition on income has been shadowed by the upsurge in obesity rates in developed countries. In fact, there is a mounting evidence that higher rates of obesity reduce labor market attachments, worker productivity, and earnings (Kinge, 2006, Larose et al. 2016; Goettler et al. 2017).

Under ECH, an extensive array of studies argue that income growth can alleviate inadequate calorie intake (Bouis and Haddad, 1992; Subramanian and Deaton, 1996; Gibson and Rozelle, 2002). However, Behrman and Deolalikar (1987) for South Korea, Ravallion (1990) for Indonesia; Bouis and Haddad (1992) for the Philippines, Aromolaran (2004) for Nigeria find that an increase in income may not substantially improve calorie consumptions. Thus, the empirical research in this area has been challenged by puzzling and controversial results. Furthermore, while most empirical studies in this area have investigated either ECH or EWH, majority of these studies based on the individual countries and they suffer from endogeneity, heterogeneity and lack of control variables. Therefore, there is still no clear evidence on whether income determines nutrition or nutrition determines income under the shadow of undernutrition and overnutrition.

Given this background, the main purpose of this article is to address the complex and dynamic link between nutrition and income using a sample of 150 countries in the period 1960-2018. To accomplish this aim, the article employs a panel VAR approach based on system GMM estimates to investigate the existence and direction of causality between nutritional status and income. Panel VAR approaches allow us to account for possible problems, such as endogeneity, heterogeneity and reverse causality, which could have led to the earlier puzzling empirical findings in the literature. To make a comprehensive assessment, food prices, income inequality and trade openness, all of which would play crucial roles in access to nutritious foods, are also included in the panel VAR model in addition to income and different indicators of nutrition status. In doing so, we highlight the complex dynamic nature of the link between nutritional status and income by considering many different factors that would potentially determine the amount and the quality of foods that people could eat (Hawkes 2006; Blouin et al. 2009; Elmes 2018; Otero et al. 2015 and Pickett et al. 2005). To the best of my knowledge, this is the first study that attempts to assess the dynamic association between nutrition and income by highlighting the relevance of food prices, income inequality and trade openness with a panel VAR approach to overcome methodological issues in earlier studies. In particular, this article tests the validity of ECH and

EWH jointly by considering additional factors that could potentially affect production, consumption and distribution of food. The results are expected to have many policy implications. It is especially important to appropriately evaluate the characterization of the dynamic link between income and nutrition for policy implications aiming at reducing starvation and obesity. Furthermore, we classify countries into four income groups based on the World Bank classification: low-income countries (LICs), lower middle-income countries (LMICs), upper middle- income countries (UMICs), and high-income OECD countries (HOCs). This leads us to derive different policy recommendations for different income groups because the link between nutrition and income is expected to be heterogeneous across different income groups. Also, to check the robustness of the results, two proxies for nutritional status are considered: per capita calorie intake and body mass index (bmi).

The rest of the article is structured as follows. Section 2 describes the data and methodology. Section 3 presents empirical results and discussion and Section 4 provides policy implications and concludes.

2. Data and methodology

The panel data set used in this study consists of a total of 150 countries, selected on the basis of data availability, in 5-year interval periods from 1960 to 2018. We assemble data for 150 countries spanning 58 years on real GDP per capita (gdp), calorie intake per capita (cal), body mass index (bmi), food prices (fp), GINI coefficient (gini), the degree of trade openness (trd) from World Health Organization (WHO), World Development Indicators (WDI), and Food and Agricultural Organization (FAO). Nutrition is proxied by per capita calorie intake and body mass index.

Following Hartwig (2010) and Holtz-Eakin et al. (1988), a time stationary VAR model is adopted to examine the endogenous association between nutritional status and real GDP per capita. The panel VAR model has the following form:

$$y_{it} = \alpha_0 + \sum_{j=1}^{m} \alpha_{1j} y_{it-j} + \sum_{j=1}^{m} \alpha_{2j} x_{it-j} + \sum_{j=1}^{m} \alpha_{3j} z_{it-j} + \mu_i + u_{it} \quad (1)$$

$$x_{it} = \beta_0 + \sum_{j=1}^{m} \beta_{1j} x_{it-j} + \sum_{j=1}^{m} \beta_{2j} y_{it-j} + \sum_{j=1}^{m} \beta_{3j} z_{it-j} + \eta_i + v_{it} \quad (2)$$

where y represents the log of per capita real GDP, x represents the log of nutritional measures and z represents the set of control variables. There are N countries indexed by i and T periods indexed by t. μ_i and η_i are individual fixed effects and u_{it} and v_{it} are white noise errors. m is the number of lags used in the estimation of the VAR model. In this context, the model is estimated by ordinary least squares (OLS), where the choice of the optimal lag length is determined by both Akaike Information Criterion (AIC) and Schwarz Information Criteria (SIC), which reveal 2 as optimal lag length.

According to the definition of Granger causality, a stationary time series x is said to predict another stationary time series y, if the lagged information on x provides any statistically significant information about y in the presence of lagged values of y. Within this framework, the panel VAR approach, through testing the coefficients of the lagged nutritional status, allows us to determine whether improvements in nutritional status can predict income or whether the lagged effects of income can predict improvements in nutritional status. Prior to the panel VAR regressions, standard panel unit root tests are performed to check the stationarity of variables.[1]

In order to address heterogeneity, endogeneity, serial correlation and heteroskedasticity, the parameters of the dynamic panel model given in Eqs. (1) and (2) are estimated by a system GMM estimation method (Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998). The consistency of the system GMM is mainly checked by Hansen test and Arellano Bond (2) tests. Finally, the existence of possible linkages between nutritional status and income is investigated by running Wald tests on the coefficients of the lagged nutritional status and income to check whether they are jointly statistically different from zero or not.

The robustness of the econometric analysis is explored under four circumstances. First, fixed effects (FE) are employed to estimate the parameters of equations (1) and (2). Second, to control for the influence of any outliers, robust regression techniques (RREG) are exploited. Third, the parameters of Equations (1) and (2) are re-estimated by using different lag orders. Fourth, a set of control variables in line with the previous studies and time dummies are introduced to test the sensitivity of the results[2].

3. Empirical Findings

This section presents the empirical evidence on the dual-link between per capita calorie intake and income.[3]

3.1. Simple link between nutritional status and income

The econometric evidence provided in Panel A in Table 1 reports that the coefficient of change in per capita calorie intake is positive and significant and the corresponding Wald test offers that per capita calorie intake has a predictive power for income in LICs, LMICs, and UMICs. Thus, per capita calorie intake has room to increase income in low and middle-income countries. However, the last two columns of Panel A in Table 1 reports that nutrition has no predictive

1 Due to the lack of space, the panel unit root tests are not reported but available upon request. Based on the test results showing that all variables are non-stationary at levels, they are represented in their first differences in regressions.
2 All robustness analyses are available upon request.
3 Appendix A, conducts the same set of analyses by using the *bmi* as a proxy for nutrition instead of per capita calorie intake. The findings are robust to the alternative definition of nutrition status.

power for income in HOCs. Panel B in Table 1 focuses on the possible effects running from income to nutrition where the dependent variable is the change in the per capita calorie intake. Panel B in Table 1 concludes that income has a predictive power for per capita calorie intake in LICs, LMICs, and UMICs, while income has no role to promote per capita calorie intake in HOCs.

Within this respect, findings reveal that nutrition predicts income, in turn, income predicts nutrition. In this context, both ECH and EWH are correct for low and middle-income economies. However, similar links are not observed for HOCs. For these countries, neither nutrition enhances income nor income contributes to nutrition. This in part could be explained by the fact that an increase in calorie intake may cause an adverse shift in health, given that the average body mass index is already high and close to the overweight level in HOCs. Similarly, increases in income do not raise calorie intake in these countries because individuals may prefer more expensive and healthier foods as their income improves, and as a result gain less weight. Therefore, the results show that expectations of neither EWH nor ECH is valid for the HOCs.

Most of the studies in the literature ignore the existence of control variables when examining the link between per capita calorie intake and income. Therefore, in the following analyses in order to fill this void in the literature, the roles of food prices, income inequality and trade openness in determining the characteristics of the link between income and nutrition status are examined. The set of control variables are selected on the basis of their well-documented contributions on the nutrition status (Brinkman et al. 2010; Hawkes 2006; Blouin et al. 2009; Elmes 2018, Otero et al. 2015 and Pickett et al. 2005).

3.2. Nutritional status, income, and food prices

The conflicting impact of food prices on producers and consumers has been a major policy dilemma. On one hand, higher food prices may stimulate production and increases the availability of food if producers are competent enough in agriculture. On the other hand, high prices may reduce access to nutritious foods and lead to malnutrition (Gilbert and Tabova, 2011; Headey, 2013; Cohen and Garret, 2010). Upsurges in food prices have impacted the nutritional status negatively since many low- and middle-income individuals had to reduce the quantity and the quality of their food consumption due to expensive foods (Brinkman et al. 2010). In this respect, dynamic causality between per capita calorie intake and income could act in a different manner if one considers the role of rising food prices. Furthermore, another negative effect of high food prices is that they make the value of food imports expensive, leading to larger balance of payments deficits (Gilbert and Tabova, 2011) and worse food security, especially in low-income countries. Within this respect, food prices can play a major role in production, consumption, and distribution of nutritious foods so it is important to examine food prices in the nutrition-income nexus, which has not been done in the literature before[4].

According to the Wald test reported at the end of the Panel A in Table 2, the predictive pattern running from nutrition to income is observed in LICs. On the other hand, econometric evidence shows that changing food prices has direct negative and significant effects on changes in income only in LICs. For the LMICs and UMICs, the Wald test does not support any causality running from nutrition to income. The last two columns conduct the same analysis for the HOC and reveal the negative link running from changes in per capita calorie intake to changes in income in these countries. When compared to the results in Table 1, these new results show that when the change in food prices is included as a control variable, the positive predictive power of per capita calorie intake for income disappears, thus, the expectations of EWH fail with rising food prices in the LMICs and UMICs. When there is no food price in the regression, as seen in Table 1 no significant link was observed between income and nutrition in HOCs. However, we observe a negative effect of calorie consumption on income in these countries with the inclusion of food prices, which is against the expectations of EWH.

Panel B in Table 2 shows that the coefficient of food prices is negative and significant and the corresponding Wald tests support the negative causal effect of the change in food prices on changes in per capita calorie intake in the LICs and LMICs. Thus, an increase in food prices is expected to reduce the per capita calorie intake in LICs and LMICs. Columns (5) to (8) of Panel B in Table 2 repeat the same econometric analysis for the UMICs and HOCs and the Wald test validates that a change in food prices has a positive predictive power for changes in per capita calorie intake. That is, rising food prices generates undernutrition for the LICs and LMICs but overnutrition for the UMICs and HOCs. In LICs and LMICs, upsurge in food prices reduces the per capita calorie intake since it becomes costly to purchase food. Food prices are in part responsible from overnutrition in UMICs and HOCs by increasing the per capita calorie intake since the upsurge in food prices enforce people to purchase a selection of high-calorie and cheap food baskets.

In other words, higher food prices reduce the quantity of food in LICs and LMICs, but deteriorate the quality of food in UMICs and HOCs. Therefore, rising food prices, by limiting the access to the quality and quantity of healthy food, fail the expectations of EWH, meaning that nutritional status is no longer a factor improving income.

Panel B in Table 2 presents that income has a positive causal impact on per capita calorie intake for the LICs, LMICs, and UMICs. That is, when food prices are included in the analysis, ECH still holds for LICs, LMICs, and UMICs. The last two columns of Panel B in Table 2 display that an increase in income reduces

4 It should be noted that because of the lack of data on food prices in some countries, the number of observations has decreased in the model.

per capita calorie intake in HOCs once the food prices are included. Thus, ECH fails for the HOCs.

3.3. Nutritional status, income, and income inequality

An unequal distribution of income acts as a barrier to nutritious food. It tightens the food choices of the poor and force them to eat unhealthy food for survival (Elmes 2018, Otero et al. 2015). Thus, access to nutritious food can be a privilege for those with sufficient purchasing power to buy them (Anderson, 2013). Actually, the consumption of nutritious food has become a symbol of social status (Palma et al., 2017). Darmon and Drewnowski (2008) find that fresh fruit and vegetables are associated with a high socioeconomic status, while energy-dense and nutrient-poor diets are associated with low socio-economic status. Another negative impact of inequality can be seen through increased nutritional problems as a consequence of the psychological stress of living in a more unequal and polarized society (Pickett et al., 2005 and Mathieu- Both and Wendner, 2020). Given these expectations that food consumption is in part affected by income inequality, it is important to include income inequality into the panel VAR model to study the link between nutritional status and income.

The first two columns of Panel A in Table 3 report that Wald test validates a causality running from change in per capita calorie intake to change in income in LICs. The columns (3) to (6) point out that change in per capita calorie intake has no predictive power for change in income in the LMICs and UMICs. In other words, the EWH, which highlights the effect of nutritional status to income, fails when the income inequality is included in the panel VAR model in LMICs and UMICs. Columns (7) and (8) report the econometric evidence for the HOCs and reveal that per capita calorie intake has a negative causal impact on income. Other studies in the literature have also revealed this negative impact of per capita calorie intake on income (Kelly et al. 2019).

Panel B in Table 3 shows that the coefficient of income inequality is negative and significant, and the corresponding Wald test reveals the negative causal impact of income inequality on per capita calorie intake in LICs and LMICs. That is, income inequality reduces per capita calorie intake in LICs and LMICs. Columns (5) to (8) of Panel B in Table 3 reports that income inequality has positive predictive power for per capita calorie intake in UMICs and HOCs. That is, income inequality leads to hunger in LICs and LMICs while it generates overweight and obesity in UMICs and HOCs. Within this set up, EWH fails in LMICs and UMICs once we consider the inequality of income. This could be in part explained by the negative effects of inequality on nutritional status for LMICs as it reduces per capita calorie intakes. As for the UMICs, income inequality fuels the per capita calorie intake, so it increases the possibility of being overweight and obese. Therefore, the causality running from nutritional status to income disappears. In the HOCs, the causal impact of nutritional status on income emerges significantly with a negative sign.

Panel B in Table 3 underlines the positive causal impact of income on per capita calorie intake in LICs, LMICs and UMICs. Thus, the ECH holds if income inequality is included into the model. The last two columns of Panel B in Table 4 reports that income has a negative causal impact on per capita calorie intake in HOCs.

3.4. Nutritional status, income, and trade

Most studies point out a complex relationship between trade and nutrition (Diaz-Bonillo, 2013; Mc. Corriston et al. 2013; FAO, 2016). Trade openness may increase the total amount of food and improves the nutritional diversity, thus contribute to food security (Dithmer and Abdulaij, 2017, Mary, 2019). Even though trade openness may increase the quantity and quality of the food, this does not necessarily mean that those who need it the most would benefit from open trade policies. Furthermore, high dependency on imports and volatile export policies of trading partners may leave some countries vulnerable to changing market conditions, such as international price fluctuations (Bezuneh and Veheyis 2012; FAO, 2016). Hawkes (2006) posits that globalization affects the nature of agricultural food system, thereby alters the quantity, cost, type, and desirability of foods available for consumption. Particularly, trade promotes a globalized lifestyle with an increased exposure to consumption of imported goods, which can be recognized as one of the main drivers of obesity (Miljkovic et al. 2015). Blouin et al. (2009) conclude that trade liberalization has facilitated the availability of highly processed, calorie rich, nutrient poor food, but further research is needed to better understand the impact of trade on unhealthy diets. Overall, it is not clear whether trade facilitates the access to nutritious food or not. Even though the literature has conflicting suggestions on the effects of trade on food security, it is important to discuss the impact of trade openness on EWH and ECH.

Panel A in Table 4 validates the positive predictive power of per capita calorie intake on income in LICs and LMICs. Columns (5) and (6) conduct the same exercise for the UMICs and conclude that per capita calorie intake has no causal impact on income when the degree of trade openness is included in the panel VAR model. Columns (7) and (8) reveals a negative causal impact of per capita calorie intake on income in HOCs.

According to the columns (1) to (4) of Panel B in Table 4, the Wald test does not reveal any causality running from trade openness to per capita calorie intake in LICs and LMICs. Columns (5) to (8) point out that trade openness has positive predictive power for per capita calorie intake for the UMICs and HOCs. While trade openness has no significant influence on per capita calorie intake in LICs and LMICs, it leads to a rise in per capita calorie intake and increases the possibility of being overweight in UMICs and HOCs. Overall within this framework, EWH fails for the UMICs and HOCs once the degree of trade openness is included into the analysis. This could be in part explained by the effects of trade on the consumption of high calorie, salty and sweety foods;

thus, it fuels the overweight and obesity in UMICs and HOCs. Therefore, further increases in per capita calorie intake have no role in contributions to income or can even reduce income in HOCs.

According to the columns (1) to (6) of Panel B in Table 4, ECH hold for LICs, LMICs and UMICs when degree of trade openness is included in the panel VAR model. Columns (7) and (8) point out that ECH fails for the HOCs.

4. Conclusion

Production, consumption, and fair distribution of nutritious food have become a central issue and lied at the heart of the development agenda as unequal access to adequate, affordable, and nutritious food has been the main obstacle behind malnutrition. Within this framework, numerous studies in economics have explored the relationship between nutritional status and income. Most of the studies on the nutrition-income link have been motivated by one of these two hypotheses: ECH and EWH. But the evidence is limited and inconclusive. To fill the void in the literature, this article examines and systematically compares the validity of these two hypotheses simultaneously in order to understand which hypothesis hold under which conditions and for which country income groups.

Findings of the article point out the existence of interdependencies between nutritional status and income for different income groups with or without controlling for food prices, income inequality and the degree of openness to trade. The panel VAR approach highlights two main findings. First, the effects of nutritional status on income are heterogenous among the sample of countries. Second, the impact of food prices, income distribution, and the degree of trade openness on the nutritional status has been varied according to the average level of income and calorie intake.

The econometric evidence suggests that both hunger and obesity rates are fueled by rising food prices, income inequality, and international trade flows. On the one hand, all these factors are responsible for hunger in LICs and LMICs. On the other hand, the same factors are responsible from rising overweight and obesity rates in UMICs and HOCs. While ECH, which says the positive effect of income on nutrition, still works in LICs, LMICs and UMICs; EWH, which supports the positive impact of per capita calorie intake on income, fails in LMICs, UMICs and HOCs under all estimation techniques with control variables included. The main rationale behind the failure of EWH could be in part explained by the hikes in food prices, unfair distribution of income, and rising trade flows. Improper nutritional intake due to rising food prices, unfair distribution of income, and increased degree of trade openness generates underweight in LMICs and overweight and obesity in UMICs and HOCs, and these effects melt down the contribution of nutrition on income. In HOCs, where obesity is a major health problem, an increase in per capita calorie intake lowers income. In particular, in LICs and LMIC, upsurges in food prices and low and unequal distribution of income have reduced consumption of food, thereby, led to undernutrition as a major problem. However, in the UMICs and HOCs the problem is not in terms of access to food but the quality of food. In UMICs and HOCs people have better choices for what to eat, but yet their choices for nutritious food are restricted by rising prices, unfair distribution of income, and international trade flows so individuals in those countries fill their stomach with empty calories just to satisfy hunger and in turn they become obese. Obesity limits their productivity and earnings.

The econometric evidence in this article clearly supports the conventional wisdom that low income growth can alleviate inadequate calorie intake in LICs, LMICs and UMICs in all specifications. Thus, policy interventions designed to increase per capita income are likely to improve average daily per capita calorie consumption and alleviate malnutrition in low- and middle-income countries. However, in HOCs income and per capita calorie intake move in opposite directions and negatively related. That is, individuals in HOCs, as they earn more income, may change their food choices by altering their food baskets with healthy and expensive alternatives with lower calories. Therefore, as income boosts, per capita calorie intake and incidences of overweight and obesity diminish. Income policies that have pursued an increase in food accessibility (mostly in terms of quantity in less developed countries and quality in more developed countries) in the long run will help nutritional enhancement and improved human development.

While policies focusing on improving income may help to solve some malnutrition issues, policies aiming at alleviating per capita calorie intake should not focus on increasing average income alone. An important policy implication of the findings from this study is that promoting equality and designing redistributive policies that could possibly support the access to nutritious foods should be considered to cope with hunger and obesity. Complementary policies may ensure that farmers benefit from trade liberalization and other vulnerable groups are protected from the fluctuations in the trade of agricultural products. Policies strengthening the agricultural sector and helping to increase agricultural productivity and expand food production, for example dissemination of new technologies and provision of credit with easy terms, should be components of a food security strategy. Subsidized prices of basic food supplies to fight with starvation and taxes on energy-dense food with low nourishment contents to fight with obesity should be considered for implementations. Overall, public policies should be designed to improve healthy food choices, tackle food labeling, and generate opportunities for more exercise.

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ANNEX

TABLE 1. CALORIE INTAKE AND INCOME

Panel A: Dependent Variable dgdp

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM
L. dgdp	0.224**	0.219**	0.889***	0.926***	0.757***	0.705***	0.474*	0.491*
	(0.086)	(0.098)	(0.135)	(0.121)	(0.096)	(0.109)	(0.236)	(0.288)
L2.dgdp	0.102	0.142	-0.094	-0.073	-0.229	-0.270	0.618**	0.612***
	(0.090)	(0.093)	(0.091)	(0.081)	(0.230)	(0.212)	(0.236)	(0.171)
L.dcal	0.585***	0.586***	0.481***	0.584***	0.028***	0.0294***	0.068	-0.014
	(0.133)	(0.125)	(0.176)	(0.166)	(0.006)	(0.00497)	(0.554)	(0.320)
L2.dcal	0.288	0.151	-0.154	-0.325	-0.036	0.253	0.331	0.235
	(0.228)	(0.296)	(0.192)	(0.230)	(0.400)	(0.518)	(0.306)	(0.347)
Hansen test	0.306	0.306	0.485	0.485	0.387	0.387	0.270	0.270
DH test	0.791	0.791	0.898	0.898	0.951	0.951	0.574	0.574
AB test	0.421	0.479	0.821	0.662	0.495	0.430	0.089	0.073
Wald test	0.000	0.000	0.033	0.004	0.000	0.000	0.554	0.788

Panel B: Dependent Variable dcal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
L.dgdp	0.171***	0.178***	0.161***	0.173***	0.128***	0.125***	0.032	0.031
	(0.055)	(0.056)	(0.050)	(0.062)	(0.019)	(0.023)	(0.030)	(0.039)
L2.dgdp	-0.025	-0.028	-0.016	-0.007	-0.012	-0.015	0.048	0.069
	(0.036)	(0.037)	(0.044)	(0.062)	(0.016)	(0.024)	(0.102)	(0.114)
L2.dcal	-0.158**	-0.169**	-0.115	-0.238	0.503***	0.438***	-0.176*	-0.200**
	(0.072)	(0.073)	(0.214)	(0.258)	(0.128)	(0.109)	(0.088)	(0.085)
L.dcal	0.041	0.059	0.101*	0.087*	0.009	-0.035	-0.085	-0.103
	(0.150)	(0.143)	(0.051)	(0.050)	(0.047)	(0.050)	(0.067)	(0.085)
Hansen test	0.315	0.315	0.326	0.326	0.475	0.475	0.301	0.301
DH test	0.431	0.431	0.729	0.729	0.435	0.435	0.355	0.355
AB test	0.312	0.368	0.252	0.203	0.161	0.315	0.776	0.976
Wald test	0.001	0.00	0.000	0.000	0.000	0.000	0.359	0.341

Note: dgdp: Change in real income, dcal: Change in per capita calorie intake. Standard errors are in parenthesis. Time dummies are included. Estimates for constant terms are not shown. AB test = Arellano-Bond test for AR(2) in first differences. DH: Difference Hansen test. * Significance at the 10% level. ** Significance at the 5% level.*** Significance at the1%level. AB one step SYS-GMM: Arellano Bond One Step System GMM. AB two step SYS-GMM: Arellano Bond Two Step System GMM.

Table 2. Food prices, calorie intake and income

Panel A: Dependent Variable dgdp								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM
L.dgdp	0.407**	0.479***	0.312*	0.373*	0.145	0.217	0.479***	0.487***
	(0.139)	(0.138)	(0.158)	(0.203)	(0.172)	(0.189)	(0.084)	(0.079)
L2.dgdp	0.0789	0.0361	-0.089	-0.033	0.472**	0.547**	-0.098	-0.113
	(0.0932)	(0.056)	(0.073)	(0.085)	(0.192)	(0.238)	(0.082)	(0.078)
L.dcal	0.893**	0.986**	0.129	0.065	0.131	0.06	-0.390***	-0.337**
	(0.359)	(0.358)	(0.308)	(0.221)	(0.273)	(0.356)	(0.124)	(0.159)
L2.dcal	0.707	0.513	0.0480	0.086	0.173	0.341	0.007	0.083
	(0.556)	(0.552)	(0.248)	(0.315)	(0.284)	(0.284)	(0.009)	(0.013)
L.dfp	-0.007***	-0.008***	-0.005	-0.007	0.001	0.001	-0.001	-0.015
	(0.001)	(0.001)	(0.000)	(0.095)	(0.002)	(0.001)	(0.001)	(0.014)
L2.dfp	0.003***	0.003***	0.001	0.004	-0.014	-0.009	0.003	0.010
	(0.001)	(0.001)	(0.001)	(0.001)	(0.008)	(0.009)	(0.001)	(0.001)
Hansen test	0.695	0.695	0.308	0.308	0.437	0.437	0.450	0.450
DH test	0.642	0.642	0.422	0.422	0.510	0.510	0.501	0.501
AB test	0.314	0.413	0.319	0.341	0.154	0.280	0.223	0.160
Wald test dfp	0.001	0.001	0.605	0.655	0.265	0.567	0.467	0.216
Wald test dcal	0.072	0.028	0.912	0.937	0.792	0.432	0.010	0.042
Panel B: Dependent Variable dcal								
L.gdp	0.137**	0.153*	0.284***	0.287***	0.127***	0.158***	-0.146**	-0.177***
	(0.048)	(0.084)	(0.049)	(0.074)	(0.031)	(0.035)	(0.061)	(0.058)
L2.dgdp	0.131*	0.111*	0.038	0.033	0.005	0.006	0.040	0.047*
	(0.063)	(0.052)	(0.025)	(0.027)	(0.007)	(0.004)	(0.024)	(0.023)
L.dcal	-0.641***	-0.733***	0.511***	0.489***	-0.0720	-0.107***	-0.0665	-0.016
	(0.131)	(0.161)	(0.056)	(0.0976)	(0.0485)	(0.0376)	(0.095)	(0.091)
L2.dcal	-0.175	-0.325*	0.200**	0.151	-0.290**	-0.298*	-0.220**	-0.209*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	(0.146)	(0.178)	(0.097)	(0.105)	(0.135)	(0.156)	(0.105)	(0.113)
L.dfp	-0.001*	-0.002**	-0.004***	-0.004**	0.008**	0.001**	0.001***	0.001***
	(0.007)	(0.008)	(0.001)	(0.002)	(0.003)	(0.004)	(0.005)	(0.006)
L2.dfp	-0.001**	-0.001**	0.003	0.004	0.006**	0.009**	0.001***	0.001**
	(0.006)	(0.007)	(0.001)	(0.001)	(0.003)	(0.004)	(0.004)	(0.005)
Hansen test	0.317	0.317	0.317	0.317	0.691	0.691	0.587	0.587
DH test	0.342	0.342	0.596	0.596	0.618	0.618	0.991	0.991
AB test	0.632	0.653	0.170	0.262	0.470	0.612	0.931	0.972
Wald test dfp	0.079	0.073	0.000	0.042	0.028	0.089	0.011	0.023
Wald test dgdp	0.000	0.000	0.000	0.000	0.001	0.000	0.064	0.006

Note: dgdp: Change in real income, dcal: Change in per capita calorie intake. dfp: Change in food prices. See Table1.

TABLE 3. INCOME INEQUALITY, CALORIE INTAKE AND INCOME

Panel A: Dependent Variable dgdp								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM
L.dgdp	0.258**	0.322*	0.270**	0.283**	0.282***	0.332***	0.453***	0.436***
	(0.117)	(0.161)	(0.115)	(0.128)	(0.074)	(0.099)	(0.156)	(0.130)
L2.dgdp	0.426***	0.451***	0.183***	0.178**	0.452***	0.431**	0.523***	0.469***
	(0.098)	(0.144)	(0.064)	(0.074)	(0.133)	(0.174)	(0.131)	(0.128)
L.dcal	0.916*	0.637	-0.165	-0.190	0.009	-0.107	0.206	0.135
	(0.466)	(0.497)	(0.146)	(0.198)	(0.232)	(0.294)	(0.179)	(0.210)
L2.dcal	0.040***	0.044***	0.007	-0.017	0.519	0.394	-0.587**	-0.414**
	(0.006)	(0.008)	(0.129)	(0.146)	(0.443)	(0.442)	(0.255)	(0.186)
L.dgini	0.280	0.245	-0.846**	-0.950*	0.041	0.019	-0.007	-0.004
	(0.253)	(0.295)	(0.412)	(0.489)	(0.028)	(0.038)	(0.010)	(0.007)
L2.dgini	-0.321**	-0.349**	0.893**	0.996*	-0.127***	-0.132***	0.003	0.007
	(0.122)	(0.144)	(0.414)	(0.491)	(0.035)	(0.043)	(0.006)	(0.005)
Hansen test	0.427	0.427	0.273	0.273	0.300	0.300	0.389	0.389
DH test	0.787	0.787	0.631	0.631	0.499	0.499	0.930	0.930
AB test	0.874	0.841	0.417	0.599	0.257	0.613	0.112	0.087
Wald test dgini	0.049	0.073	0.000	0.000	0.003	0.014	0.643	0.806
Wald test dcal	0.000	0.000	0.477	0.617	0.486	0.601	0.066	0.074
Panel B: Dependent Variable dcal								
L.dgdp	0.156**	0.191***	-0.024	-0.030	0.145**	0.125**	-0.038*	-0.041**
	(0.068)	(0.064)	(0.043)	(0.030)	(0.059)	(0.058)	(0.021)	(0.018)
L2.dgdp	0.041	0.023	0.133**	0.134***	0.058	0.082	-0.039*	-0.042**
	(0.056)	(0.055)	(0.052)	(0.030)	(0.054)	(0.057)	(0.022)	(0.018)
L.dcal	-0.298**	-0.330**	0.233*	0.191	0.056	0.055	-0.227***	-0.215***
	(0.113)	(0.128)	(0.133)	(0.119)	(0.094)	(0.058)	(0.062)	(0.077)
L2.dcal	-0.482***	-0.552***	-0.151	-0.159*	-0.169	-0.179	-0.176**	-0.208***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	(0.110)	(0.151)	(0.104)	(0.092)	(0.170)	(0.135)	(0.079)	(0.072)
L.dgini	-0.126***	-0.148***	-0.055**	-0.038**	0.010**	0.009***	0.012**	0.014*
	(0.037)	(0.049)	(0.0235)	(0.016)	(0.005)	(0.0026)	(0.005)	(0.007)
L2.dgini	-0.040	-0.054	0.007	0.003	0.004	0.008	0.008	0.011**
	(0.046)	(0.049)	(0.014)	(0.009)	(0.007)	(0.003)	(0.006)	(0.004)
Hansen test	0.487	0.487	0.794	0.794	0.779	0.779	0.455	0.455
DH test	0.658	0.658	0.527	0.527	0.869	0.869	0.716	0.716
AB test	0.125	0.120	0.531	0.885	0.467	0.601	0.578	0.889
Wald test dgini	0.004	0.004	0.075	0.082	0.094	0.004	0.067	0.041
Wald test dgdp	0.025	0.003	0.017	0.000	0.038	0.081	0.001	0.000

Note: dgdp: Change in real income, dcal: Change in per capita calorie intake. dgini: Change in income inequality See Table1.

TABLE 4. TRADE, CALORIE INTAKE AND INCOME

Panel A: Dependent Variable dgdp

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM	AB one step SYS-GMM	AB two step SYS-GMM
L.dgdp	0.607**	0.604***	0.701***	0.729***	0.452***	0.452***	0.518***	0.567***
	(0.223)	(0.194)	(0.083)	(0.085)	(0.146)	(0.146)	(0.094)	(0.117)
L2.dgdp	0.144	0.186	0.106	0.086	0.115	0.115	0.019	0.007
	(0.179)	(0.203)	(0.101)	(0.114)	(0.172)	(0.172)	(0.016)	(0.017)
L.dcal	0.210	0.145	0.524**	0.519**	0.304	0.304	-0.155	-0.168*
	(0.376)	(0.270)	(0.201)	(0.192)	(0.386)	(0.386)	(0.117)	(0.089)
L2.dcal	0.549**	0.474**	0.336	0.357	-0.061	-0.061	-0.685***	-0.676***
	(0.217)	(0.226)	(0.211)	(0.263)	(0.142)	(0.142)	(0.139)	(0.098)
L.dtrd	0.0006	0.0004*	0.0002	0.0004	-0.0002	-0.0002	-0.0004	-0.0001
	(0.0008)	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
L2.dtrd	0.0009	0.0001	-0.0003	-0.0001	-0.0002	-0.0002	0.0070**	0.0005**
	(0.0007)	(0.0006)	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Hansen test	0.265	0.265	0.368	0.368	0.438	0.438	0.909	0.909
DH test	0.594	0.594	0.712	0.712	0.840	0.840	0.913	0.913
AB test	0.871	0.851	0.860	0.503	0.152	0.343	0.967	0.539
Wald test dtrd	0.506	0.075	0.104	0.323	0.236	0.984	0.029	0.001
Wald test dcal	0.035	0.097	0.043	0.035	0.732	0.337	0.000	0.000
Panel B: Dependent Variable dcal								
L.dgdp	0.024	0.007	0.245**	0.276***	0.055	0.044	-0.082**	-0.083**
	(0.054)	(0.049)	(0.0908)	(0.092)	(0.046)	(0.052)	(0.034)	(0.031)
L2.dgdp	0.171*	0.132**	0.150	0.167	0.098***	0.101**	-0.044***	-0.053**
	(0.094)	(0.058)	(0.115)	(0.143)	(0.035)	(0.038)	(0.015)	(0.019)
L.dcal	0.039	0.195	0.130*	0.183**	-0.410***	-0.383***	-0.298***	-0.258**
	(0.176)	(0.263)	(0.064)	(0.084)	(0.065)	(0.061)	(0.094)	(0.113)
L2.dcal	-0.175*	-0.195*	-0.052	-0.075	-0.553***	-0.567***	-0.152**	-0.128

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LICs		LMICs		UMICs		HOCs	
	(0.096)	(0.109)	(0.051)	(0.047)	(0.098)	(0.099)	(0.063)	(0.088)
L.dtrd	0.0001	-0.0006	-0.0007	-0.0001	0.0002***	0.0002**	0.0001*	0.0001**
	(0.0004)	(0.0003)	(0.0009)	(0.0001)	(0.0008)	(0.0008)	(0.0006)	(0.0008)
L2.dtrd	-0.0008	-0.0006	-0.0006	-0.0009	0.0002**	0.0001*	0.0001**	0.0002**
	(0.0005)	(0.0003)	(0.0009)	(0.0009)	(0.0009)	(0.0008)	(0.0009)	(0.0001)
Hansen test	0.391	0.391	0.265	0.265	0.271	0.271	0.786	0.786
DH test	0.732	0.732	0.600	0.600	0.600	0.600	0.981	0.981
AB test	0.288	0.306	0.082	0.372	0.674	0.536	0.375	0.623
Wald test dtrd	0.795	0.986	0.454	0.317	0.032	0.057	0.084	0.0689
Wald test dgdp	0.020	0.004	0.017	0.000	0.026	0.024	0.002	0.0081

Note: dgdp: Change in real income, dcal: Change in per capita calorie intake. dtrd: Change in the degree of openness. See Table1.