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Poverty and Price Transmission

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Abstract

A key parameter determining the welfare impact from a world market shock is the transmission elasticity which measures the average domestic response to an international price change. Many studies have estimated price transmission elasticities for a large number of countries but the variation in these estimates is so far largely unexplored. This paper proposes a model which explains a country's domestic price response to world market shocks in terms of its demand structure. The model delivers two testable predictions; price transmission is increasing in per capita food expenditure and in income inequality. The empirical analysis of price changes during the food crises confirms these predictions with a caveat. I find significant inverse U-shaped relationships between domestic food price growth in 2007-8 and 2010-11 and per capita food expenditure. Unequal countries also experienced higher price growth but the relationship is less significant. The finding that food prices in middle-income countries increased the most during the food crises is a cause for concern in light of the fact that the majority of the world's poor today live in middle-income countries.

Keywords: Price transmission; Food crisis; Food prices; Non-homothetic preferences; Income distribution
JEL-codes: D11, D31, Q11, Q12

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1 Introduction

Within the last decade the price of internationally traded food commodities has doubled. The international price increases and the spikes of 2007-8 and 2010-11 in particular, are believed to have had disastrous consequences. Resulting domestic price increases triggered a wave of violent protests and political instability, especially in the Middle Eastern countries (Berazneva and Lee, 2013; Bellemare, 2014; Lagi et al., 2011), worsened undernourishment and impoverished hundreds of millions globally (Anríquez et al., 2013; De Hoyos and Medvedev, 2011; Dessus et al., 2008; FAO, 2011; Ivanic and Martin, 2008; Ivanic et al., 2012; Tiwari and Zaman, 2010; Wodon and Zaman, 2010; Zezza et al., 2008).[1] Many governments imposed costly interventions in 2008 in an attempt to shield domestic consumers from a loss of purchasing power (Abbott, 2010; Demeke et al., 2009; Jones and Kwiecinski, 2010; Götz et al., 2013). Importers slashed their tariff rates and exporters restricted foreign trade, some with outright export bans. The net result was a further increase in world market prices, making it even more difficult for governments to stabilize domestic prices (Abbott, 2011; Anderson and Nelgen, 2012; Anderson et al., 2013a,b; Martin and Anderson, 2011; Rutten et al., 2013; Tokgoz et al., 2011).

Although domestic food prices increased in most countries during the 2007-8 and 2010-11 international price spikes, the cross-country variation in domestic food inflation rates (and consequently the expected poverty impact) is substantial (Abbott and de Battisti, 2011; Headey and Fan, 2008; De Hoyos and Medvedev, 2011; Minot, 2010). Of course, this is to some extent expected given that some governments, in principle, were in a much better position than others to limit domestic price increases by imposing export bans, for example. Governments of net importing countries did not have this option and therefore had to rely on a combination of other instruments such as tariff cuts, price controls and social safety nets (Abbott, 2010; Demeke et al., 2009; Jones and Kwiecinski, 2010). There are also some structural characteristics, unrelated to policy, which we expect would influence price transmission. These structural characteristics include imperfectly competitive markets and poor infrastructure implying high transport costs and non-integrated markets. Furthermore, if international and domestic good are differentiated, then relative prices not only respond to international shocks but also domestic supply and demand shocks. If we consider the response of a domestic price *index*, not a single price, then compositional differences in the consumption basket and the substitution patterns in demand will determine its reaction to a world market shock. Lastly, nominal price changes reflect general domestic inflation as well as relative price

[1] Headey (2013) and Verpoorten et al. (2013) take a more critical stand to the poverty and nutritional impact issues.

changes. Part of the variation in domestic price changes must therefore be attributed to such factors (De Hoyos and Medvedev, 2011; Headey and Fan, 2008; Minot, 2010; Poulton et al., 2006).

From a policy perspective it is crucial to know the main sources of a country's food price changes, if its population is vulnerable to such changes. This is because the appropriate policy response depends on the nature of the domestic price change. Release of public stocks, for example, might be an effective option only if domestic prices are driven by domestic supply fluctuations.[2] Knowledge of country characteristics determining the responsiveness of domestic food prices could also prove useful in global early warning systems as such a knowledge makes it possible, in principle, to focus monitoring efforts and aid flows where they are most needed when international food prices are on the rise.

Based on the considerations above, the purpose of this paper is to analyze a single, mostly overlooked, determinant of price transmission from international to domestic food markets, namely income related differences in consumption patterns. Agricultural economists have long studied the relationship between income and food prices in developing countries but from the opposite perspective. Mellor (1978), for example, points out that food price changes have a strong short run, or direct, effect on real income of low income households who generally spend a large share of their budget on food and derive much of their income from agriculture. Traditionally, the goal has therefore been to quantify the causal welfare effects of an exogenous food price change, taking the domestic price response as given (e.g. De Hoyos and Medvedev, 2011; Ivanic and Martin, 2008; Ivanic et al., 2012). The existence of well established methods to calculate welfare impacts from food price changes[3] contrasts sharply, however, with the lack of an economic framework in which the domestic price response itself can be analyzed.

In principle, with differentiated goods the domestic aggregate food price response - a crucial input in the poverty impact literature - will depend on the initial income distribution. Vulnerability to international price shocks, at the country level, is thus not necessarily a monotonically decreasing function of the income level as common sense would suggest. The poorest households are the most sensitive to domestic food price increases because they spend a large share of their income on food. But the aggregate domestic food price response to an international commodity price shock depends on domestic demand and ultimately on the distribution of income. There are therefore reasons to believe that food prices in middle income countries are more responsive to such international price spikes than those in low income countries. The simple argument

[2] Optimal food price stabilization policies are discussed by Gouel and Jean (2013) and Gouel (2013a,b), among others.

[3] Deaton (1989) and Ravallion (1990) are two of the seminal papers in this genre.

formalized below is that the consumption share of tradable food goods is increasing in a country's income level.

The hypothesis that price transmission is increasing in income is derived from the predictions of a model featuring households with heterogeneous budgets, non-homothetic preferences and a traded as well as a non-traded food good. With these assumptions the domestic price response depends on the share of the population consuming the traded good and the distribution of income within and across the two groups. Essentially, the larger the share of rich households and the higher the average rich households's income, the higher the consumption share of the traded good and the more responsive the price level will be to an international price change. Differentiated domestic and imported goods, as formalized by Armington (1969), is a standard assumption in the international trade literature. Trade theorists have also recently started to focus on the consumption side of the economy and are now able to explain some of the 'trade puzzles' in terms of per capita income differences and non-homothetic preferences (Markusen, 2013; Reimer and Hertel, 2010).

The mechanism relating price transmission to the income distribution is choice of quality. There is ample evidence that the quality of food goods purchased by households, as measured by calorie unit values, depends on income. Subramanian and Deaton (1996), for example, document how Indian consumers move from cheap to expensive calories as their incomes increase (in a cross section). Households with per capita incomes in the top decile of the distribution pay almost twice as much for their calories as those at the bottom decile.[4] Demont (2013) in his study of 19 African rice markets reaches similar conclusions from a somewhat different perspective. He argues, quoting Seck et al. (2010), that domestic rice is typically of a lower quality than imported rice due to poor harvesting, threshing, drying and storing practices at the farm and outdated processing technologies and infrastructure. In addition, some consumers apparently prefer imported rice simply because its 'foreignness' which is perceived to be a quality attribute in itself (see also Batra et al., 2000; Opoku and Akorli, 2009). The consequence is that willingness to pay for imported rice is higher than for domestic rice which is mainly eaten in rural areas (populated by mainly low income households).

Whether households in developing countries respond to price changes with quality substitution is more contentious. The problem is that the household surveys, the data from which is used to estimate food demand, typically do not include prices. Instead, inference must be based on spatial variation in unit values calculated from quantity and expenditure data. Unit values, however, reflect both a good's price and its quality and common sense suggests that households respond to price changes along the quantity as well as the quality margin. If households really do respond to price increases by

[4] See also Gibson and Kim (2013a) and Yu and Abler (2009).

choosing a lower quality, then price elasticity estimates based on average prices will be biased (towards zero) if substitution is not somehow controlled for. Early findings suggested that quality up- and downgrading is not prevalent but recent studies have questioned this result (Chung, 2006; Deaton, 1988, 1990; Gibson and Rozelle, 2005; Gibson and Kim, 2013b; McKelvey, 2011).

Quality substitution along the price as well as the income margin is at the core of the model laid out in the following section. There are two types of food goods, or varieties, to choose from in the economy; one that is imported, or more generally tradable, and one that is produced solely for domestic consumption. The two varieties are differentiated and households, by assumption, prefer the imported variety whose price is determined exogenously on the world market. Low income households therefore spend most of their food budget on the domestic variety whose price depends on the price of the imported variety as well as on domestic supply and demand. Households from the upper end of the income distribution, on the other hand, spend most of their food budget on the traded variety.

The paper is related to two literatures. First, a number of case studies discuss the welfare impact of the recent international food price spikes taking into account various aspects of the heterogeneity across households such as own production, country-specific dietary preferences, availability of local staple alternatives and substitution possibilities, wage-earning opportunities and social safety nets etc. (Arndt et al., 2008; Attanasio et al., 2013; Balagtas et al., 2014; Dimova and Gbakou, 2013; D'Souza and Jolliffe, 2014; Ferreira et al., 2013; ul Haq et al., 2008; de Janvry and Sadoulet, 2010; Warr, 2008; Wood et al., 2012). These use similar methods as the global impact studies mentioned above but are able to go into greater detail about specific aspects determining the welfare impact. My own contribution to this literature consists of a novel analysis of demand related determinants of price transmission and ultimately the welfare impact, based on a formal economic model.

Secondly, there is a vast empirical literature studying the price relationships between spatially separated markets (see Fackler and Goodwin, 2001). Within this field we can distinguish between two strands of studies. First, there are studies assessing the connectedness or degree of integration characterizing different markets within the same country or region or across a large number of countries.[5] Recent papers focusing on the food crisis period include Baquedano et al. (2011), Baquedano and Liefert (2014), Cudjoe et al. (2010) and Minot (2010). A common thread among these is the use of actual commodity prices in an attempt to test whether the "law of one price" holds or, more generally, whether the domestic and world market prices are cointegrated. The

[5]Ravallion (1986), Baulch (1997), Goodwin and Piggott (2001) and Barrett and Li (2002) are some of the seminal papers.

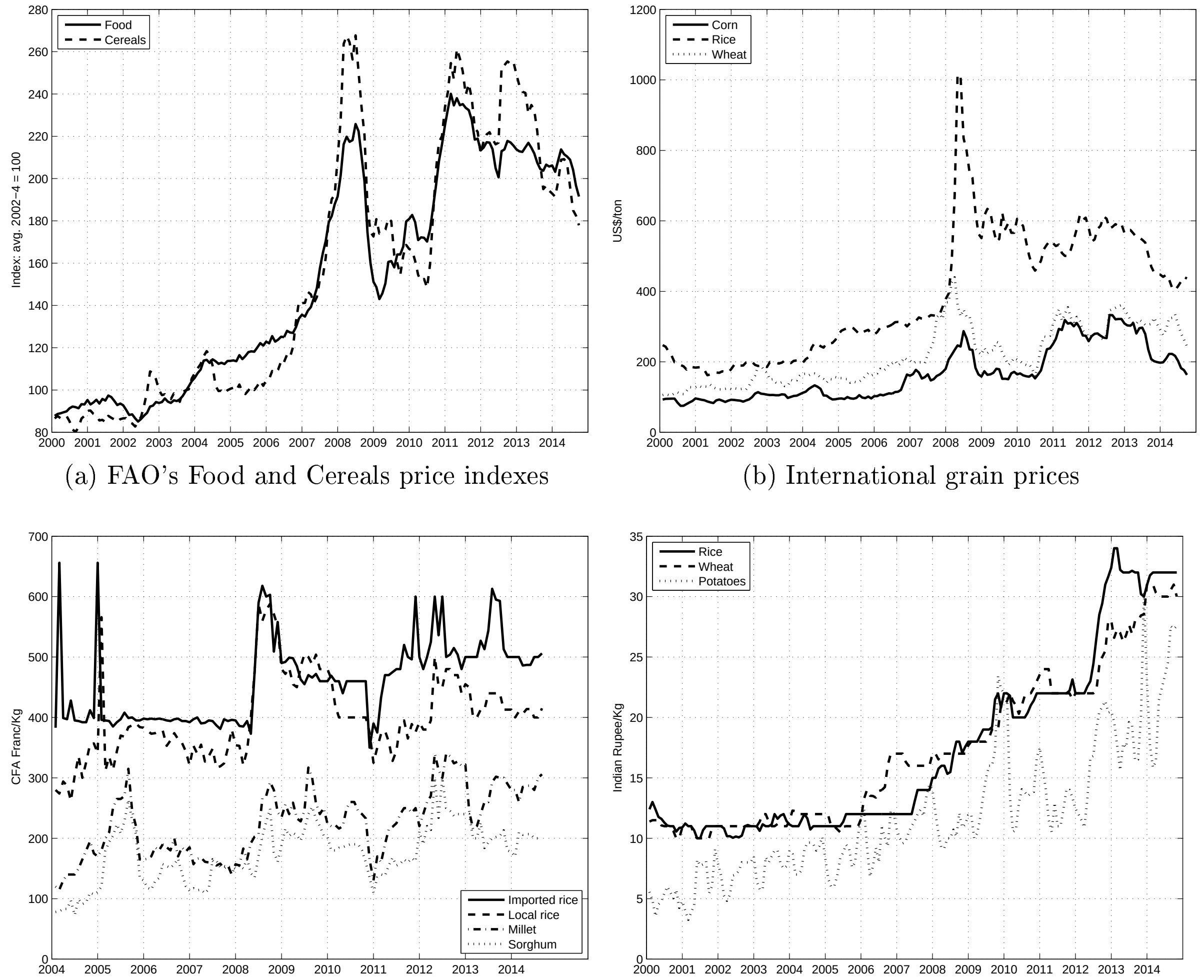
other strand of studies consider the response of the domestic aggregate (food) price level to a world market oil or food price shock such as the one in 2007-8, rather than the comovement of individual agricultural commodity prices. Notable papers from this literature include IMF (2011), Ianchovichina et al. (2014), Jongwanich and Park (2011), Lee and Park (2013) and Kalkuhl (2014). Of particular relevance is Lee and Park (2013) who find a negative relationship between price transmissions and income. My contribution to this latter literature consists of an empirical analysis of price transmission during the 2007-8 and 2010-11 food crises using aggregate food price data from more than 100 countries. Unlike most previous studies, the analysis is based on predictions from a formal economic model emphasizing demand side factors. The price database which is used to test the predictions, although public, has not been utilized much in the literature so far. I find tentative evidence of the model's predictions, namely that food prices in low-income countries seem to react less to world market price shocks than food prices in middle-income countries. Prices in high-income countries, however, responded less to the food crisis than those in middle- and even low-income countries. The model therefore seems to capture aspects of the food price price dynamics among the developing countries only. To be able to explain food price changes across the entire income spectrum we probably need to somehow account for the low commodity content of retail goods in developed countries relative to that in developing countries.

The paper now proceeds as follows. Section 2 reviews recent food price developments. Section 3 presents the model. Section 4 tests the model's main predictions on domestic aggregate food price data and, finally, section 5 concludes. A list of countries going into the empirical analysis can be found in the appendix.

2 The food crises of 2007-8 and 2010-11

This section reviews the price development on the international grain markets around the time of the twin food crises of 2007-8 and 2010-11. It also provides a couple of illustrative examples of domestic food price changes in the same period. The reason for doing so is to make the link between international and domestic prices, which is analyzed from a theoretical perspective in section 3, more concrete.

The upper left panel of figure 1 illustrates the FAO food price index along with the cereals sub-index in the period January 2000 to September 2014. The latter is a major driver of the former and, as can be seen, the food price peaks in 2008 and 2011 were to a large extent a result of increases in the price of grain in those periods. That being said, there are some factors, global excess demand in particular, which affect all commodity prices and the food price spike of 2007-8 was indeed part of larger commodity boom. Likewise, the following plunge across the board was no doubt associated with the global



(a) FAO's Food and Cereals price indexes

(b) International grain prices

(c) Retail prices of grain in N'Djamena

(d) Retail prices of different food items in Chennai

Figure 1: Food price developments since year 2000

financial crisis and its negative effects on the real economy.[6]

Between January 2007 and June 2008 the food and grain price indexes, which are based on nominal US$ prices and normalized with respect to the 2002-4 average, rose by 91 and 127 points to index 226 and 268, respectively, corresponding to relative price increases of 68 and 90 percent. From the first peak in mid-2008 and to their their respective throughs in February and September 2009 the two indexes fell by 82 and 113 points before rising back up to index 240 and 261 in February and April 2011, respectively.

According to IMF's commodity price database, the international price of corn[7] rose by 122 US$/ton or 74 percent to 287 US$/ton between January 2007 and June 2008,

[6]Baumeister and Kilian (2014), Byrne et al. (2013), Headey and Fan (2008), Gilbert (2010) and Wright (2014) offer different perspectives on these issues.

[7]U.S. No.2 Yellow, FOB Gulf of Mexico.

cf. the upper right panel of figure 1. International wheat prices[8] peaked in March 2008 at 440 US$/ton, up 244 US$/ton or 124 percent from January 2007. The largest increase, however, was in the international price of rice[9] which went up by no less than 702 US$/ton or 224 percent from January 2007 to its peak in April 2008 at which point traders had to pay more than 1000 US$ for a ton of rice shipped out of Bangkok.

As mentioned in the introduction, the domestic price responses to these international food price increases were highly heterogeneous. The two lower panels of figure 1 provide an illustration of this stylized fact. In the lower left panel the four time series represent the price of imported and domestically produced rice as well as domestically produced millet and Sorghum in N'Djamena, Chad.[10] The price of imported and domestic rice follow each other quite closely and the price of imported rice is typically higher than local rice. The two domestic varieties, millet and and sorghum, are cheaper per kilo than rice and have very similar prices. All these prices seem to covary and the 2008 spike stands out, especially for the rice series. From April to August 2008 the price of imported rice increased from 373 to 600 CFA Franc per kilo or 61 percent. In the same period the price of domestic rice increased by 178 CFA franc per kilo or 45 percent. Millet and sorghum increased by 78 and 85 CFA franc per kilo, respectively, in the same period corresponding to 41 and 60 percent, respectively. As the lower right panel of figure 1 clearly shows, the food price development in India (Chennai) is completely different from that in Chad. The prices of the two main grains, rice and wheat, did start to go up around 2007-8, but they did not spike as in Chad or on the international markets. Rather, they steadily continued to increase. The price of the third staple shown, potatoes, has also been trending upwards, but the yearly fluctuations are much more pronounced.[11]

The differences between the two markets reflect differences in food policy, particularly government involvement in consumer and producer markets, taste and preferences, climate and growing conditions, as well as monetary and fiscal policy resulting in differences in inflation rates. Therefore, in summary, any analysis comparing the price responses of many countries to the food crisis needs to at least account for the differences in consumption and underlying inflation rates.

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[8] U.S. No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico.

[9] 5 percent broken milled white rice, Thailand nominal price quote.

[10] According to FAO, millet and sorghum are the two main staples in Chad accounting for 15 and 18 percent, respectively, of the total dietary energy supply (DES) in 2005-7. Rice, on the other hand, only accounts for 3 percent on the DES. N'Djamena is the main urban area in Chad where the most of the imported grains are consumed. Chad's self sufficiency ratio for rice millet and sorghum is 69, 108 and 112 percent, respectively (2004-8 average). See http://www.fao.org/giews/pricetool/.

[11] Again, according to FAO, Rice and wheat are the two main staples in India accounting for 31 and 22 percent of , respectively, of the total DES in 2005-7. Chennai is an important rice producing area. Wheat is not produced here but it is consumed in urban areas. Potatoes accounted for only 1% of the DES in 2005-07.

One obvious way to to address the problem of consumption differences across countries is to base the analysis on food price indexes, representing the entire food basket of a typical consumer, instead of individual food crops such as rice, wheat, beans or potatoes. This is the approach taken by De Hoyos and Medvedev (2011) and IMF (2011), among others, and the one that I will pursue in this paper. A simple way to account for inflation differences is to use real, rather than nominal prices.

3 A model of a country's food price level

This section lays out an illustrative model of price transmission. Section 3.1 discusses the basic structure of the model and its setting. Section 3.2 specifies the demand and supply sides of the market and how food demand depends on the distribution of income. Finally, section 3.3 analyzes how price transmission, in this setting, depends on the income distribution.

3.1 Basic assumptions

The economy consists of n households with heterogeneous incomes that follow a given distribution.[12] Each household bases its consumption decisions on a two stage budgeting procedure. Specifically the consumption choice involves the allocation of income among, at the first stage, food and non-food goods and, at the second stage, imported and domestically produced food goods. That is, preferences are separable over a composite non-food good z and the set of food goods $x = \{x_d, x_i\}$, where x_d and x_i signifies 'domestic' and 'international' respectively. Separable preferences over food and non-food goods is a strong assumption but it is standard in the literature. Whereas x_i is traded on the world market implying that its price, p_i, is exogenous to the domestic market[13], x_d is a non-tradable good whose price, p_d, depends on domestic supply and demand. We can think of x_d as a composite food good or basket containing locally produced crops such as millet, teff, sorghum, cassava etc., which are important staples in many developing countries. We can also include the major grains, wheat, maize, and rice, assuming these are less than perfect substitutes for their internationally traded counterparts. More generally, x_d may represent a unit of calories produced solely for domestic consumption and x_i a unit of calories whose price is determined on the world market. Households prefer the the international good in a sense that will be elaborated below. Possible reasons why x_i is considered superior to x_d include differences in perceived quality and degree of homogeneity, dietary characteristics such as nutrient and

[12]Technically, the economy consists of a continuum of households of measure n.
[13]We are assuming that the country considered is small relative to the world market.

vitamin content, required preparation and cooking time, etc.

Separability implies that a consumer's utility function can be written $u = f(g(x), z)$, where $g(x)$ is the food sub-utility function. Let m denote household expenditure on food. For simplicity I assume fixed budget shares of food and non-food goods. This allows us to ignore consumption of non-food goods all together so, without loss of generality, we can assume that the good z expenditure share is zero. Income in the model is thus equal to food expenditure and I shall therefore switch between the two terms.

3.2 Equilibrium and distribution of income

A household's food sub-utility function is assumed to be quasi linear with a concave x_d component. That is $g(x) = x_i + v(x_d)$, where $v' > 0$, $v'' \leq 0$. Being quasi linear and concave in x_d the sub utility function yields a corner solution, $x_i = 0$, when the household's food budget is lower than some cut-off level $\tilde{m}$ which depends on the function v and the international price, p_i. Above the income threshold, $\tilde{m}$, x_d is a necessity good whereas x_i, is a luxury good and the budget share and income elasticity of the domestic good, x_d, therefore goes from one to zero as expenditure increases beyond the threshold value and vice versa. More specifically, households with incomes less than $\tilde{m}$ spend their entire income on x_d. Households with incomes higher than $\tilde{m}$ spend $\tilde{m}$ on x_d and the remaining income on x_i. In order to ease the exposition I shall refer to the former group of households as 'poor' and the latter as 'rich' (enough to buy x_i). Quasi linearity is a special case of quasi homotheticity which is a common assumption, especially in the early applied studies, as it offers a convenient characterization of demand in terms of total expenditure.

Average or per capita consumption is denoted $\bar{x}_j$, $(j = i, d)$. This is not only a useful representation of market demand, it is also key component of the price index introduced below. Furthermore, when we are considering average instead of individual household demand discontinuous jumps in demand of the marginal consumer associated with the marginal change in p_i are much easier to handle analytically.

Per capita expenditure on the two food goods is denoted $M_j \equiv p_j \bar{x}_j$, $(j = i, d)$. With a continuous income distribution that is exogenous to prices it follows that the amount by which M_i decreases and therefore also the amount by which M_d increases following a marginal increase in p_i is given by

$$\frac{\mathrm{d}M_d}{\mathrm{d}p_i} = -\frac{\mathrm{d}M_i}{\mathrm{d}p_i} = [1 - F(\tilde{m})] \frac{\partial \tilde{m}}{\partial p_i}, \tag{1}$$

where $F(\tilde{m}) = \Pr(m < \tilde{m})$ is the proportion of poor households such that $1 - F(\tilde{m}) = \Pr(m > \tilde{m})$ is the proportion of rich households. The basic result (1) reflects the fact that poor households do not adjust their expenditure in response to price changes. First, poor consumers do not consume x_i so they are not directly affected by a change in p_i. Secondly, any knock-on effect on p_d from an increase in p_i results in an offsetting change in consumption such that expenditure remains constant. Rich households, on the other hand, reallocate expenditure from x_i to x_d by the amount $\frac{\partial \tilde{m}}{\partial p_i}$ in response to a marginal increase in p_i.

At this point it will prove useful to assume specific functional forms characterizing household utility, production and the economy's income distribution. First, for analytical convenience, let v be a scaled logarithmic function

$$v\left(x_d\right) = \rho \ln\left(x_d\right), \tag{2}$$

where $\rho > 1$. In this case the cut-off budget is $\tilde{m} \equiv \rho p_i$ and therefore only households with incomes $m > \rho p_i$ will demand good i. That is, a household with income m has Marshallian demands given by

$$x_d = \min\left[\frac{m}{p_d}, \frac{\rho p_i}{p_d}\right]; \quad x_i = \max\left[0, \frac{m}{p_i} - \rho\right]. \tag{3}$$

Secondly, for simplicity per capita supply of the domestically produced good is assumed to be unitary elastic in its own price, $\bar{q}_d = p_d$. This leads to general expressions for the equilibrium price and per capita consumption of good d given by

$$p_d = \bar{x}_d = M_d^{\frac{1}{2}}, \tag{4}$$

such that the income elasticity of the equilibrium good d price and demand is $1/2$.[14] Thirdly, let the distribution of income and food expenditure be from the Pareto family with tail index $\alpha > 1$ meaning that the proportion of the population with incomes larger than m (the tail distribution) is governed by the power law

$$1 - F(m) = (\underline{m}/m)^{\alpha}, \ m > \underline{m}, \tag{5}$$

where $\underline{m} > 0$ still represents the economy's minimum food expenditure and where $F(m)$ is the cumulative distribution function evaluated in m. Then, per capita food expenditure depends on both parameters according to the expression

$$M = \frac{\underline{m}\alpha}{\alpha - 1}. \tag{6}$$

[14] In general, a constant price elasticity of supply equal to β leads to an income elasticity of the equilibrium price equal to $\gamma = \frac{1}{1+\beta}$ and an income elasticity of demand equal to $1 - \gamma$.

In the Pareto distribution, when the tail index, α, decreases towards 1 the distribution becomes more "fat-tailed" and the mean increases. As the value of α increases, the distribution becomes more tightly distributed around the minimum, $\underline{m}$, and the mean decreases. The tail index, α, is closely related to the Gini coefficient, which is a standardized measure of inequality.[15] In fact, the Gini coefficient for the Pareto distribution is an inverse function of α given by

$$G = (2\alpha - 1)^{-1}. \tag{7}$$

The Gini does not depend on the second distribution parameter, $\underline{m}$ and it is therefore simple to reparametrize the model from α to G. Also note that $\alpha = 1$ implies perfect inequality.

Per capita consumption of good i and expenditure on good d (determining the price and per capita consumption) can now be written

$$\bar{x}_i = \frac{\rho}{\alpha - 1}\left(\frac{\underline{m}}{\rho p_i}\right)^{\alpha} \quad \text{and} \quad M_d = \frac{\underline{m}}{\alpha - 1}\left(\alpha - \left(\frac{\underline{m}}{\rho p_i}\right)^{\alpha-1}\right), \tag{8}$$

respectively. From these expressions the following comparative statics can be deduced. First, a marginal increase in p_i increases the equilibrium price and aggregate consumption of good d and decreases aggregate consumption of good i as it should. Secondly, p_d, $\bar{x}_d$ and $\bar{x}_i$ decreases in α because average expenditure, M decreases as α. Thirdly, a positive shift to the lower bound $\underline{m}$, the location parameter in the Pareto distribution, increases M and thus also $\bar{x}_d$, p_d and $\bar{x}_i$.

3.3 Aggregate food prices and price transmission

As noted in the introduction, the literature on price transmission can be divided into two strands. Studies from the first strand consider how world market or import price changes are transmitted to domestic prices. The second type of price transmission measures the response of a domestic *price index* to a world market price shock. In our setting here the first type of price transmission measures the response of the domestic price to a change in the international price

$$r = \frac{\mathrm{d}p_d}{\mathrm{d}p_i} = \frac{\rho}{2}\left(\frac{\underline{m}}{\rho p_i}\right)^{\alpha} M_d^{-\frac{1}{2}}. \tag{9}$$

The domestic price response (9) decreases towards zero in α and increases in $\underline{m}$. The reason is that households from a poor economy with a low degree of inequality will

[15] See Lubrano (2014) for an introduction to the Pareto distribution and the Gini coefficient.

consume mostly the domestic good and only a few wealthy households will reallocate expenditure towards from the international good to the domestic one, c.f. (1), thus limiting the impact on p_d.

This effect, however, is not of primary interest here. What I am interested in is the response of a country's food price index (FPI) to an exogenous world market shock, namely

$$\Pi = \left(\frac{P(p_0, p_{t_2}; x_0)}{P(p_0, p_{t_1}; x_0)} \right)^{\frac{1}{t_2 - t_1}} - 1, \tag{10}$$

where the ratio is the value of the food price index, P, at time t_2 relative to time t_1. The two vectors p_0 and x_0 consist of base period prices and quantities and the price of the traded good has been exposed to a discrete shock, $p_{i,t_2} = cp_{i,t_1}$, $c > 1$, resulting in an increase in p_d as well. Food inflation, Π, is a measure of the average increase across all food goods, which depends on transmission between varieties, (9). There are two reason for focusing on (10) in stead of (9) directly. First, it is hard to find price data related to traded and non-traded food goods. Although FAO now provides public data on individual domestic food prices for a large number of countries it is usually not clear whether these refer to tradable or nontrable goods. A discussion of the model's empirical relevance must therefore be based on price index data. Secondly, it is more convenient to base a poverty impact analysis on the aggregate food price response, rather than the individual price responses (see De Hoyos and Medvedev, 2011). As discussed in section 2, food crises are characterized by increases in international food prices in general, not individual prices in isolation. Furthermore, the welfare impact on a household depends on how much the price of its food basket increases, rather than a single food item. For both reasons it can be misleading to focus on bivariate price relationships in this context.

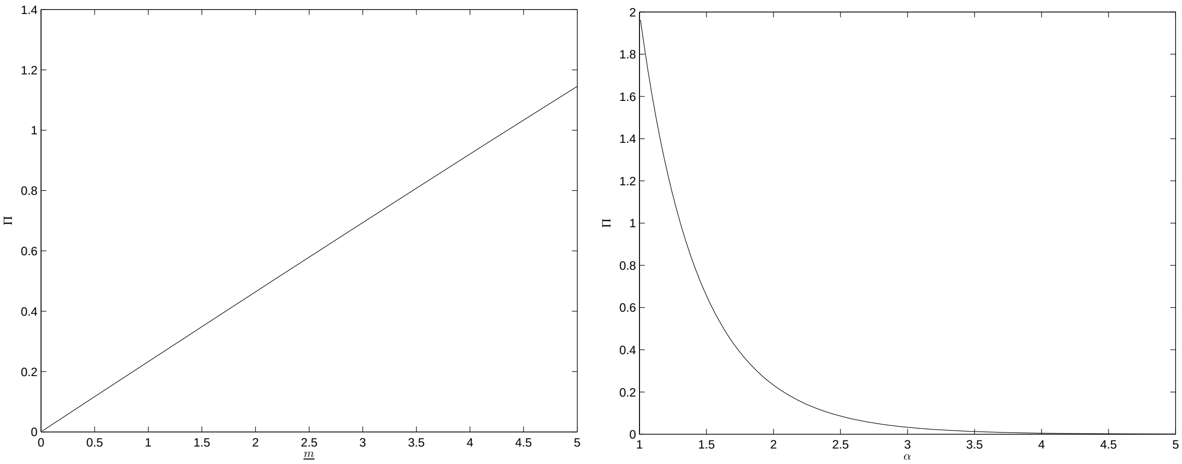
For concreteness, and because this is the type that is used by most statistical offices, I shall consider the Laspeyres price index which, for our two variety food economy, is written

$$P_L(p_0, p_t; x_0) = \frac{p_{i,t}\bar{x}_{i,0} + p_{d,t}\bar{x}_{d,0}}{p_{i,0}\bar{x}_{i,0} + p_{d,0}\bar{x}_{d,0}} = s_{i,0}\frac{p_{i,t}}{p_{i,0}} + s_{d,0}\frac{p_{d,t}}{p_{d,0}}. \tag{11}$$

The shares $s_{j,0}$, $j = (d, i)$, refer to the proportion of the food budget spent on each good in the base period, measured in the period 0 prices, $s_{j,0} = \frac{M_{j,0}}{M}$. I.e., the Laspeyres index, P_L, is a base period expenditure share weighted average of the two price ratios, or relatives, $p_{i,t}/p_{i,0}$ and $p_{d,t}/p_{d,0}$.

Our goal is to find out how food inflation, Π_{t_1,t_2}, caused by a world market price shock depends on the income distribution. Using (11) and (10), we can write food inflation as

$$\Pi + 1 = \frac{c\bar{x}_{i,0} + p_{d,t_2}\bar{x}_{d,0}}{\bar{x}_{i,0} + p_{d,t_1}\bar{x}_{d,0}} = s_{i,0}c + (1 - s_{i,0})\frac{p_{d,2}}{p_{d,0}}, \tag{12}$$



(a) Π vs. $\underline{m}$. (b) Π vs. α.

Figure 2: Price transmission as a function of $\underline{m}$ and α. Note: $\rho = 5$, $p_i = 1$, $c = 3$. In panel (a) $\alpha = 2$. In panel (b) $\underline{m} = 1$.

assuming $\Delta t = 1$ and $p_{i,0} = p_{i,1} = 1$.

It can be shown that $\frac{\partial s_{i,0}}{\partial \underline{m}} > 0$, $\frac{\partial s_{i,0}}{\partial \alpha} =< 0$, $\frac{\partial (p_{d,2}/p_{d,0})}{\partial \underline{m}} > 0$ and $\frac{\partial (p_{d,2}/p_{d,0})}{\partial \alpha} < 0$. Furthermore, it holds that $c > p_{d,2}/p_{d,0}$ because p_d is a concave function of p_i. The inflation response to a relative price change therefore decreases in α and increases in $\underline{m}$. The intuition behind the first two comparative statics should be clear. A household's expenditure share on the international good is increasing in its income level. Therefore, since average income is increasing in $\underline{m}$, the aggregate expenditure share on good i is also increasing. An increase in α has the opposite effect. The latter two comparative statistics just shows that the responsiveness of p_d to an increase in p_i, i.e. between goods price transmission, r, is increasing in average income, c.f. equation (9). This also makes sense intuitively. A poor population has a large proportion of households who only consume the domestic good and therefore are unresponsive to changes in p_i. Given that consumption patterns are basically unaffected in this case by an increase in p_i the domestic price, p_d, will not change much either.

Figure 2, which is based on some specific parameter values, clearly illustrates this feature of the model. Because per capita income is increasing in $\underline{m}$ and decreasing in α the model predicts a positive correlation between per capita income and price transmission. Recall from (7) that α is inversely related to the Gini coefficient, G. A larger G for a given $\underline{m}$ therefore implies a more unequal (and, on average, more affluent) economy.

To sum up, the following two predictions can be derived from the model:

1. Countries with unequal income or food expenditure distributions, i.e. countries with large Gini coefficients, have FPIs that react more strongly to international

price shocks than equal ones, i.e. countries with low Gini coefficients.

2. Rich countries, in terms of per capita income or food expenditure, have FPIs that react more strongly to international price shocks than poor ones.

Note that the model allows us to vary per capita income, M, via $\underline{m}$, independently of the Gini coefficient of the income distribution (which is solely determined by α. The opposite, however, is not the case. We *cannot* vary α independently of the per capita income level, c.f. equations (6) and (7)).

4 Empirical analysis

This section assesses the model's predictions using food inflation data from 2007-8 and 2010-11. The goal is to find out whether the distribution of domestic food price changes in these periods varies systematically with per capita income and income inequality and whether the variation is consistent with the model's predictions. I start out by introducing the data going into the statistical analysis.

4.1 Data on domestic food prices

The domestic price index data analyzed below is sourced from the International Labor Organization (ILO).[16] ILO maintains the most comprehensive database of domestic food price indexes (FPIs) and consumer price indexes CPIs which is used to monitor the cost of living and real wages.[17] The ILO food price database is not widely used, for good reasons, despite a broad country coverage and series going all the way back to the 1970s in some cases. A major issue with this data is that the historical series are not recalculated whenever a new base year is introduced. The same applies when other changes are made such as the inclusion or exclusion of certain items such as beverages or tobacco from the index. This means that many of the series have discrete level shifts associated with these changes. Another issue with the data is that some countries report several series. In some cases one series replace another after a period of overlap. Finally, many of the series contain missing values. To "tidy up" the raw data I carried out the following operations. First, I restricted the sample to the period 2007:1-2010:12. Secondly, overlapping series were spliced and in cases where multiple series were available from the same country, a single one was selected. Thirdly, series with missing values were discarded. Finally, and most critical for the analysis below, level shifts caused by "technical structural breaks" associated with base year changes

[16] see http://laborsta.ilo.org/

[17] The FPI is a component of the the CPI.

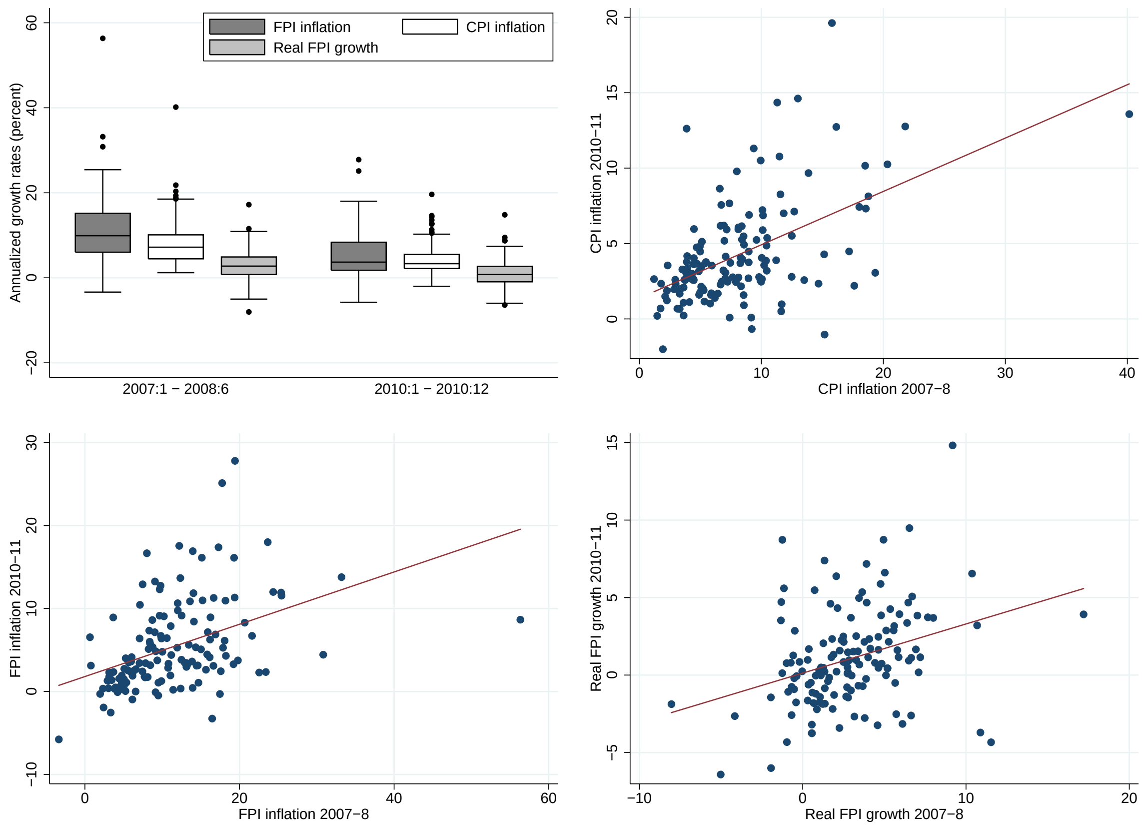


Figure 3: Domestic price changes in 2007-8 and 2010-11

etc. were identified and removed.[18] In total 140 countries have complete price series in the 2005-10 period considered. 126 of these have ISO country codes and a list of these countries can be found in table 4 in the appendix. An important last thing to know about this data is that most of the low income countries' price indexes derive from prices collected from one or two major markets in the capital. Weights and selected items are derived from household expenditure surveys. Differences in consumption patterns around the world of course translate into differences in weights and in the composition of the food baskets themselves. This is probably the largest drawback of using index data in a cross section analysis of price transmission, especially if based on coefficients from individual time series models relating the domestic price level to an commodity price index such as FAO's which represent internationally traded food goods.

The boxplot in figure 3 depicts the empirical distribution of these countries' headline (CPI) inflation, their food (FPI) inflation as well as the change in their FPI relative

[18]Concretely I added the change in the break point from the previous value to the break point and all points succeeding it. The value of the adjusted series at the break point is thus the same as the one preceding it. A script containing the code used to implement these operations is available from the author upon request.

to the CPI, termed real FPI growth, over the two time periods 2007:1-2008:6 and 2010:1-2010:12. As discussed above, the nominal food price level is not only driven by exogenous world market shocks, it also includes a stochastic trend which it shares with the non-food price level, representing underlying general domestic inflation. By dividing the FPI with the CPI, we obtain an FPI which is purged of headline inflation. The median country experienced an annualized rate of food and headline inflation of 9.9 and 7.2 percent, respectively, in 2007-8. Real FPI growth, which is approximately the difference between the two, was 2.7 percent for the median country in that period. Price increases were generally lower in the second period. The median country experienced food and headline inflation rates of 3.7 and 3.3 percent implying a modest real FPI growth of 0.8 percent. In both periods the variation in inflation rates is substantial. The standard deviation and interquartile range of 2007-8 food inflation is 7.4 and 9.2 percentage points, respectively, versus 5.4 and 6.6 percentage points in 2010-11. Although median real FPI growth is lower in the second period the variation is similar in both periods (standard deviations of 3.3 and 3.2 and interquartile ranges of 4.1 and 3.6, respectively).

The three remaining panels contain alternative representations the same data. What they show us that there is some systematic variation in the food prices to be explained. As the (statistically significant) regression lines indicates, a country hit by a large nominal and real FPI shock in 2007-8 is more likely to be hit by a relatively large shock again in 2010-11 and vice versa. This suggests that there are indeed characteristics which influences a country's reaction to a world market shock. In the next section I will provide some tentative statistical evidence that a country's income distribution is one such determining factor, as argued in section 3.

4.2 Regression results

Tables 1-3 summarize the results from the regression analysis. Each of the columns refer to a regression of FPI inflation or real FPI growth on a set of predictor variables related to the parameters of interest in the theoretical model. FPI inflation and FPI growth in particular are considered proxies for the type of food price transmission analyzed in section 3.3. Alternatively, I could have estimated transmission elasticities from international and domestic food price data in a first step and used these estimates as dependent variables in the second step regressions. However, I prefer the simpler setup below because the resulting estimates are easier to interpret and I also avoid problems related to potentially misspecified or unstable first-stage time series models. The fact that consumption patterns differ across countries is only a problem to the extent that these unobserved differences are correlated with the explanatory variables.

The covariates are a country's per (PPP adjusted) capita food expenditure level, its Gini index and a dummy indicating whether or not the country is a so called Small Island Developing State (SIDS). Small island states are dependent on imports of especially especially land intensive agricultural products and are therefore not in a position to use export restriction as way of stabilizing domestic prices. Because of this vulnerability to international food price fluctuations we would expect to find a stronger domestic price reaction among the SIDS to the two international price spikes discussed above.[19] Based on the model predictions from section 3 we would also expect food price inflation to be increasing in per capita food expenditure as well as in the Gini index. It is not obvious that specific consumption patterns should correlate with any of these explanatory variables so not controlling for such differences should lead to serious omitted variable bias. On the other hand, general characteristic of a country's vulnerability to agricultural price shocks such as the share of staples in total food consumption, tend to be highly correlated with its income level and there is therefore no point in including them in the regressions.

Table 1 considers domestic food price changes in the 2007:1-2008:6 period, i.e. the first of the recent food crises. Column (1) relate a country's annualized FPI inflation rate in that period to its per capita food expenditure level. What we see is that average food inflation during the 2007-8 food crisis is increasing in a country's per capita food expenditure level up until a certain point after which it starts to decrease. More specifically, as illustrated in the first panel of figure 4, for Non-SIDS countries with a 2005 per capita food expenditure level of 269 [exp(5.59)] PPP adjusted dollars or less there is a positive relationship between expected FPI inflation and food expenditure. After that point the predicted marginal effect becomes negative among the non-SIDS countries. 24 out of the 109 countries for which we have data on food prices as well as expenditure have food expenditures lower than that. For SIDS countries the turning point is at 222 [exp(5.40)] dollars and there are 19 countries in the sample with a per capita food expenditures lower than that.

Column (2) focuses on the relationship between average food expenditure and expected real FPI growth in the 2007-8 period. Again there is a significant quadratic relationship between the two which is illustrated in the second panel of figure 4. For SIDS and non-SIDS countries with per capita food expenditures less than 259 and 355 and PPP adjusted dollars (32 and 21countries, respectively) there is a positive relationship between food expenditure and real FPI growth. For countries with food

[19] Data on food expenditure and Gini coefficients are sourced from the World Bank's website. It is the International Comparison Project (ICP) which is behind the food expenditure estimates which refer to year 2005. The Gini index refers to the 2000-2005 average (ignoring years with missing values) in order to increase the number of observations. A list of SIDS can be found on the website; `http://www.sidsnet.org/`.

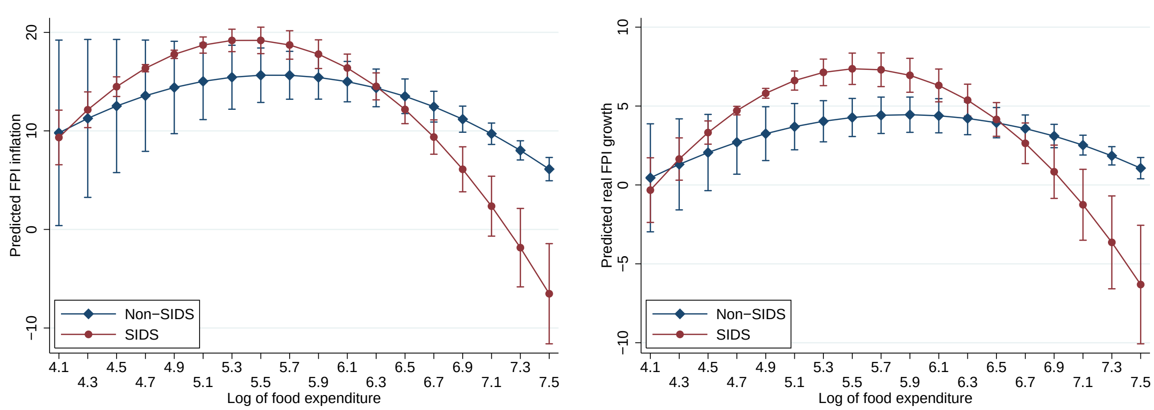
Dependent variable	(1) FPI inflation	(2) Real FPI growth	(3) FPI inflation	(4) Real FPI growth
sidsdum	-84.8**	-65.1***		
	(42.6)	(23.7)		
lfood	29.4***	15.0***		
	(10.4)	(4.43)		
sidsdum × *lfood*	33.8**	25.3***		
	(14.1)	(8.26)		
lfoodsq	-2.63***	-1.28***		
	(0.80)	(0.35)		
sidsdum × *lfoodsq*	-3.22***	-2.35***		
	(1.16)	(0.71)		
gini			0.11	0.058**
			(0.084)	(0.028)
constant	-66.6*	-39.5***	7.95**	0.76
	(33.8)	(13.8)	(3.99)	(1.25)
N	109	109	97	97
R^2	0.257	0.172	0.015	0.024

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: *lfood*: log of per capita food expenditure, *lfoodsq*: log of per capita food expenditure squared, *gini*: Gini coefficient, *sidsdum*: dummy (SIDS country = 1). The countries included are subsets of those listed in table **4** for which expenditure and Gini index data are available.

Table 1: Domestic food price changes 2007-8 and income



(a) Predicted FPI inflation 2007-8

(b) Predicted real FPI growth 2007-8

Figure 4: Predicted domestic food price changes 2007-8. Note: Vertical bars indicate 95 % confidence intervals.

Dependent variable	(1) FPI inflation	(2) Real FPI growth	(3) FPI inflation	(4) Real FPI growth
sidsdum	-315.7***	-203.6***		
	(78.8)	(57.9)		
lfood	19.4**	15.8***		
	(8.13)	(3.93)		
$sidsdum \times lfood$	115.4***	76.6***		
	(28.2)	(20.9)		
lfoodsq	-1.71***	-1.30***		
	(0.63)	(0.32)		
$sidsdum \times lfoodsq$	-10.3***	-6.97***		
	(2.47)	(1.85)		
gini			0.046	0.040
			(0.051)	(0.028)
constant	-47.2*	-45.5***	4.07*	-0.37
	(25.8)	(12.0)	(2.18)	(1.22)
N	109	109	97	97
R^2	0.226	0.223	0.006	0.014

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: See table 1 for a description of the variables.

Table 2: Domestic food price changes 2010-11 and income

expenditures higher than that, the relationship becomes negative. Middle income countries therefore generally experienced the largest food increases during the 2007-8 food crisis, whereas poor and especially rich countries were affected less. Notice also that low and middle-income SIDS countries have higher predicted food price increases compared to non-SIDS as expected, although the difference is only statistically significant for the middle income countries.

In columns (3) and (4) a country's 2007-8 FPI inflation and real FPI growth, respectively, is regressed on its income Gini coefficient. As predicted, more unequal countries experienced higher food price shocks on average in that period. Only the latter estimate is statistically significant from zero though and the R^2 is very low in both cases.

Table 2 considers domestic food price changes during the 2010:1-2010:12 period, i.e. during the second recent international food price spike. As can be seen, qualitatively, the results from table 1 carry through. For the Non-SIDS countries, the turning points where the slopes of the estimated relationships between expected FPI inflation/real FPI growth and food expenditure go from positive to negative occur at 295 and 435 dollars, respectively. For the SIDS countries the turning points are at 277 and 266 dollars, respectively. For the Non-SIDS countries the estimated parabola is much less curved though in the second period. That is, among these countries the per capita food

	(1)	(2)	(3)	(4)
Dependent variable	FPI inflation	Real FPI growth	FPI inflation	Real FPI growth
lfood	8.77	2.30		
	(9.14)	(3.53)		
lfoodsq	-1.47**	-0.42		
	(0.71)	(0.29)		
$sidsdum \times lfoodsq$	-1.76**	-0.53		
	(0.86)	(0.45)		
gini			-0.085	0.0056
			(0.37)	(0.093)
constant	17.6	6.21	12.6	1.93
	(29.2)	(10.8)	(14.9)	(3.75)
N	228	228	173	173
R^2	0.306	0.135	0.002	0.000

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: See table 1 for a description of the variables.

Table 3: Domestic food price changes 2007-8 and 2010-11. Fixed effects regressions

expenditure level does not have much influence on the degree of domestic food price changes. In the second period there no statistically significant relationship between domestic food price changes and inequality.

Lastly, the ICP has recent released updated expenditure estimates for the year 2010. As a robustness check I added these to the dataset and ran some fixed effects regressions in which domestic food price changes from 2007-8 and 2010-11 were coupled with per capita food expenditure in 2005 and 2010, respectively, as well as Gini coefficient averages for 2000-5 and 2006-9. Estimation results based on the fixed effect estimator and the additional data on the explanatory variables are presented in table 3. The estimated relationships are qualitatively similar to those in table 1 and 2 but the coefficients related to real FPI growth are not statistically significant individually.

5 Conclusion

In times of rapidly increasing international food prices as in 1972-74 and more recently in 2007-08 and 2010-11 there is a natural concern that the purchasing power of millions of poor households comes under pressure with potentially fatal consequences. The welfare impact of food crises depends crucially on the domestic price response to the international price hike of which we know curiously little. This paper therefore contributes with a novel analysis of demand related determinants of price transmission from international to domestic food markets. The theoretical model, based on the principle of quality substitution, contains positive relationships between per capita food expenditure, income inequality and price transmission.

I test these predictions on aggregate price data from the 2007-8 and 2010-11 food crisis periods. The regression analysis shows that high and low food expenditure countries, on average, experienced lower food increases than middle income countries. There is also some evidence that unequal countries, on average, experienced higher price transmission than equal ones although the statistical significance of this finding is weak. The model therefore seems to be a useful description of the international-domestic food price dynamics in developing countries.

Why does the theory model only fit data from developing countries? First, it does not make sense to speak of traded and non-traded food commodities in the same way for high income as for low income countries. The food sector in high income countries is as commercial as any other sector and its companies are often multinational. Secondly, in high income countries the commodity content of food prices is often negligible and more so the more affluent a country becomes. At a certain point, along the development path the importance of quality substitution therefore starts to decline and food price dynamics must be explained by other factors. The model's inability to capture this aspect makes it unable to explain price transmission patterns across the entire income spectrum.

That the model only describes food markets in developing countries is not really a problem, though, because price transmission to from international to domestic food markets is only something to worry about for low- and middle-income, not high-income countries. In fact, given that most of the world's poor now live in middle-income countries (Sumner, 2010) the finding that these experienced the highest food inflation during the recent international price spikes all the more worrying. In future work it could be interesting to analyze whether the observed inverted U-shaped relationship between domestic food inflation and expenditure can be explained by commodity content differences across countries.

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Appendix

Country	SIDS	Country	SIDS	Country	SIDS
Albania		Guyana	+	Nigeria	
Argentina		Hong Kong		Nicaragua	
Armenia		Honduras		Netherlands	
Austria		Croatia		Norway	
Azerbaijan		Haiti	+	Nepal	
Belgium		Hungary		Oman	
Benin		Indonesia		Pakistan	
Burkina Faso		India		Panama	
Bangladesh		Ireland		Peru	
Bulgaria		Iran		Philippines	
Bosnia and Herzegovina		Iceland		Poland	
Brazil		Israel		Portugal	
Barbados	+	Italy		Paraguay	
Botswana		Jamaica	+	Rwanda	
Canada		Jordan		Saudi Arabia	
Switzerland		Japan		Senegal	
Chile		Kenya		Singapore	+
China		Cambodia		Sierra Leone	
Cote d'Ivoire		South Korea		El Salvador	
Congo		Kuwait		San Marino	
Colombia		Laos		Yugoslavia	
Cyprus		Sri Lanka		Slovak Republic	
Czech Republic		Lesotho		Slovenia	
Germany		Lithuania		Sweden	
Denmark		Luxembourg		Seychelles	+
Dominican Republic	+	Latvia		Syria	
Algeria		Macau		Chad	
Ecuador		Moldova		Togo	
Spain		Madagascar		Thailand	
Estonia		Maldives	+	Trinidad and Tobago	+
Ethiopia		Mexico		Tunisia	
Finland		Macedonia		Turkey	
Fiji	+	Mali		Taiwan	
France		Malta		Uganda	
Gabon		Myanmar		Uruguay	
United Kingdom		Montenegro		United States	
Ghana		Mozambique		SVG	+
Guinea		Mauritania		Vietnam	
Gambia		Malawi		Samoa	+
Guinea-Bissau	+	Malaysia		Yemen	
Greece		Namibia		South Africa	
Guatemala		Niger		Zambia	

Note: SVG is short for Saint Vincent and the Grenadines.

Table 4: Country list