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Published in:
Economics and Human Biology

DOI:
10.1016/j.ehb.2016.03.003

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Arndt, C., Hussain, M. A., Salvucci, V., & Østerdal, L. P. R. (2016). Effects of food price shocks on child malnutrition: The Mozambican experience 2008/2009. *Economics and Human Biology*, *22*(September), 1-13. https://doi.org/10.1016/j.ehb.2016.03.003

Economics and Human Biology 22 (2016) 1–13

Contents lists available at ScienceDirect

Economics and Human Biology

journal homepage: http://www.elsevier.com/locate/ehb

Effects of food price shocks on child malnutrition: The Mozambican experience 2008/2009

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ARTICLE INFO

Article history:
Received 10 September 2015
Received in revised form 10 February 2016
Accepted 1 March 2016
Available online 7 March 2016

Keywords:
Food prices
Inflation
Child malnutrition
Mozambique

ABSTRACT

A propitiously timed household survey carried out in Mozambique over the period 2008/2009 permits us to study the relationship between shifts in food prices and child nutrition status in a low income setting. We focus on weight-for-height and weight-for-age in different survey quarters characterized by very different food price inflation rates. Using propensity score matching techniques, we find that these nutrition measures, which are sensitive in the short run, improve significantly in the fourth quarter of the survey, when the inflation rate for basic food products is low, compared to the first semester or three quarters, when food price inflation was generally high. The prevalence of underweight, in particular, falls by about 40 percent. We conclude that the best available evidence points to food penury, driven by the food and fuel price crisis combined with a short agricultural production year, as substantially increasing malnutrition amongst under-five children in Mozambique.

1. Introduction

In 2008, countries around the globe experienced a dramatic food and fuel price shock. From January 2007 to June 2008 world food real prices increased by more than 60 percent (cf. FAO, 2012) while the world price of oil increased by about 125 percent. The full implications of the 2008 food and fuel price crisis are yet to be fully understood and remain an important topic of research (e.g. Ortiz et al., 2011; Abbott and de Battisti, 2011; Headey, 2011; Headey et al., 2012; Verpoorten et al., 2012). The nutritional consequences, in particular amongst children, are a primary concern (e.g. Lock et al., 2009; Keats and Wiggins, 2010; Tiwari and Zaman, 2010; Ruel et al., 2010; Christian, 2010; Brinkman et al., 2010).

The unfolding nutritional consequences of price shocks remain under-investigated due, in significant measure, to lack of data (Torlesse et al., 2003). A number of papers have examined the impact of regional or national food price crises on child nutritional status in affected areas, for example, due to drought or general economic turndown (see the next section for further references). However, most of this work has relied on yearly observations of child nutritional status and other low-frequency data or has compared nutritional outcomes before and during (or after) some crisis.

This article studies the nutritional status of children in Mozambique by quarter over a full year beginning in September 2008. These periods of the year (quarters) are

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http://dx.doi.org/10.1016/j.ehb.2016.03.003

characterized by very different inflation rates for basic food products. We are able to conduct this analysis due to a large scale household budget survey that: (a) is representative quarterly, (b) contains an anthropometrics module, and (c) took place over the period September 2008 to August 2009. This period follows directly on the peak of the world price spike for food and fuel which occurred in June 2008. The principal harvest period also occurs around June. The 2008 harvest was short with yields per hectare for principal food crops down by about 20 percent relative to more favorable seasons (MPD/DNEAP, 2010). Accordingly, prices of basic food products in Mozambique actually peaked between September 2008 and February 2009 (a few months after the world food price index peak) before declining sharply between June and August 2009 (on the arrival of the next harvest). In the same period, nonfood prices were much less affected (Arndt et al., 2015). Real food consumption expenditure seems to have largely followed the price dynamics (Arndt et al., 2012), with the potential for affecting the nutritional status of under-five children.

Using individual-level matching analysis, we are able to compare under-five children surveyed in high-inflation months with children surveyed in low-inflation months. Our hypothesis is that the former group of children would present worse contemporary malnutrition indicators compared to children in the latter group. We also expect chronic (longer term) malnutrition measures, such as height-for-age, to follow different dynamics. If our hypothesis is correct, then weight-related malnutrition indicators such as weight-for-height, weight-for-age, wasting prevalence and underweight prevalence should be worse for children surveyed in high-inflation months. Conversely, height-related malnutrition may not differ greatly among the two groups due to the longer term dynamics associated with chronic malnutrition.

We find that, compared with the first semester or first three quarters, the prevalence of contemporary malnutrition among children aged 0–59 months was significantly lower in the final quarter of the survey, when inflation rates for basic food products were lower. The same comparisons with respect to chronic malnutrition measures do not differ significantly.

The remainder of this paper is structured as follows. Section 2 reviews literature. Section 3 describes the data employed for the analysis. Section 4 provides descriptive information. Section 5 presents the approach employed and the results. Section 6 concludes that strong price movements, driven by the combination of world price increases and a short production year, significantly impacted the nutritional status of children in Mozambique.

2. Literature

Studies examining the impact of a crisis on child nutritional outcomes are plentiful, although somewhat dispersed, in the literature. With respect to prices, Torlesse et al. (2003) use yearly data collected from 1992 to 2002 to examine how changes in rice prices affect child underweight in Bangladesh. Using aggregate data, they find that rice prices are strongly correlated with underweight (corr. coef. = 0.91, $p = 0.001$). A number of other contributions study the impact of a crisis using micro data. For example, Block et al. (2004) assess the nutritional impact of Indonesia's drought and financial crisis of 1997/1998, Yamano et al. (2005) examines the effect of a shock (drought) and food aid on child growth in Ethiopia for the period 1995–1996, and Hoddinott and Kinsey (2001) investigate the impact of drought on child growth in Zimbabwe, using panel data for the period 1993–1997.

More recently, Stillman and Thomas (2008) examine the impact of the decline in economic activity in Russia between 1996 and 1998 on six dimensions of nutritional status using annual data. Miller and Urdinola (2010) investigate how child mortality in Colombia responds to fluctuations in world Arabica coffee prices and document starkly pro-cyclical child deaths, while a counter-cyclical relationship might be expected. Their analysis is also based on yearly data, hence focusing on medium to long run effects. Sweeney et al. (2013) detail the characteristics of populations that are more likely to be vulnerable to shocks in Guatemala. Finally, Hartwig and Grimm (2012) analyze the food crisis – a shortage of cereals due to adverse climatic conditions – in 2002 in Malawi relying on representative data collected before and after the crisis.

At the time of the global food and fuel price crisis, various efforts were made to simulate the effects of the crisis on the welfare of countries, sub-national regions, and households. For example, Ivanic and Martin (2008) examined the implications of the food price crisis for nine low-income African, Latin American, and South Asian countries. They found highly heterogeneous effects driven principally by the net buyer or net seller position of the household. Overall, they found that, across the nine countries considered, "the adverse welfare impact on net buyers outweighs the benefits to net sellers resulting in an increase in the number of poor and in the depth of poverty" (p. 1). Similarly, Arndt et al. (2008) focused on Mozambique and found negative implications for poverty using an economy-wide GE simulation model linked to a poverty module. This result was driven principally by fuel price increases although higher food prices also contributed to increases in poverty, particularly in urban areas.

With the passage of time, attention has shifted from simulating the impacts of the food and fuel price crisis on living standards in poor countries, to analyzing the implications of the crisis in retrospective. While in principle possible, the causal chain between substantial world price movements and welfare impacts on a population is long, complex, and highly specific to circumstance, including timing. Relatively few data sets are well suited to the task, and there are, correspondingly, relatively few ex post studies, despite the high profile of the shocks. For El Salvador, de Brauw (2011) finds a decrease in height-for-age of children under three, which he attributes to the rise in domestic food prices of 2008 that closely followed the rise in international prices. He also finds that children in families with access to remittances or with international migrants experienced lower declines in height-for-age.

Arndt et al. (2012) use a dynamic economy-wide model, linked to a poverty module, to track macroeconomic aggregates and world prices over the period 2003 to

2009. With this approach, they are able to reproduce trends in measured poverty rates from 2002/2003 to 2008/2009. They find that stagnation in consumption poverty rates in Mozambique was principally due to the near continuous real increases in international and domestic fuel prices over 2003 to 2009 and due to the combination of slow agricultural productivity growth, particularly for food crops, negative weather shocks affecting the harvest in May/June 2008, and high world prices for food which were mostly transmitted into high domestic food prices, even though local supply and demand conditions remained crucial (see Section 4).

The power of the combination of a negative shock to agricultural production and a positive shock to world food prices is also highlighted by Dercon et al. (2012). They find, for a sample of about 1500 rural Ethiopian households, that consumption poverty rates rose by 17 percentage points between 2004 and 2009, returning nearly to the level observed in 1995. They attribute this large increase to a bad harvest combined with the net buyer position of most surveyed households, and the substantial increase in global as well as local food prices.

As noted by Ivanic and Martin (2008), the net buyer/seller position of the household determines the first order impact of food price changes on household welfare. In macroeconomic terms, Mozambique is a net food importer. In their simulation analysis, Arndt et al. (2008) investigated the net buyer/seller position of households using detailed data available for 2003. This analysis showed that about 26 percent of rural households and 76 percent of urban households are net food buyers even after a good harvest. In addition, for most rural households, the net sale is very small; and rural households typically rely on own production for the large majority of their food consumption. As mentioned above, 2008 was not a good harvest, implying a higher share of households in a net buyer position. Further, while prices for food generally rose alongside international prices, Arndt et al. (2012) show that prices at the local level also reflect local supply and demand conditions with relatively high prices reflecting particularly tight supply conditions. We turn to consider whether the combination of a negative supply shock and world/domestic price shocks affected malnutrition rates.

3. Data for Mozambique

The Household Budget Survey 2008/2009 (*Inquérito aos Agregados Familiares sobre Orçamento Familiar*, abbreviated as IOF 2008/2009) (INE, 2010) contains detailed information on expenditure and consumption of food items for a stratified random sample of 10,832 households each interviewed once over the survey period. It also contains anthropometric information for more than 8000 children under-five years old from the same households. However, complete and valid anthropometric information was only available for about 7000 children.

The IOF sample is representative for the whole of Mozambique, for the rural and urban zones at national level, and for each of the ten provinces plus the capital Maputo City. As noted, it is also representative through time. The survey began in September 2008 and ended in August 2009. The sample is representative for each of the four quarters of the IOF survey. Summary statistics for key variables are found in Table 1.

We assess the nutritional status of children by combining their age, weight and height to calculate the following standard ratios: weight/age, height/age, and weight/height. This way of measuring malnutrition has the advantage that it only needs information on age, height and weight of children. These ratios are compared to the WHO's reference population that represents the expected distribution of the growth of under-five children (WHO, 2006a, 2006b; WHO and UNICEF, 2009). The degree of malnutrition is then generally measured by the so-called *Z*-score, defined as the ratio minus the reference ratio divided by the standard deviation of the reference ratio.

Three different forms of (moderate) malnutrition are usually identified, depending on the indicator that is used: (i) stunting: when height-for-age *Z*-score values are below the international reference value by more than two standard deviations; (ii) wasting: when weight-for-height *Z*-score values are below the international reference value by more than two standard deviations; (iii) underweight: when weight-for-age *Z*-score values are below the international reference value by more than two standard deviations.

Similarly, severe stunting, wasting, or underweight exist when the *Z*-scores are below minus three standard deviations. In general, while underweight or wasting may be driven by short-term factors like illnesses or food intake fluctuations throughout the year, stunting is considered an indicator of long-term malnutrition. Hence, for the purposes of this study, we expect weight-for-age and

Table 1
Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Wasting	7118	6.55	24.74	0	100
Underweight	7000	18.76	39.04	0	100
Stunting	6999	46.45	49.88	0	100
Headcount ratio	7118	59.45	49.10	0	100
Food pc consumption daily	7118	11.53	8.51	0.02	175.00
Total pc consumption daily	7118	20.95	24.65	0.61	780.31
Girl	7118	0.52	0.50	0	1
Age (in months)	7118	29.62	15.96	0.10	59.89
Number of 0–5 children in the HH	7118	1.67	0.75	1	6
Child is first born	7118	0.72	0.45	0	1
Safe water	7118	0.17	0.38	0	1
Sanitation	7118	0.49	0.50	0	1
Mother's education (in years)	7118	2.21	2.74	0	12
Household size	7118	6.23	2.67	2	34
High quality roof	7118	0.28	0.45	0	1
Female household head	7118	0.23	0.42	0	1
Rural	7118	0.74	0.44	0	1

Source: Authors' calculations from the IOF database combined with WHO (2006a).

weight-for-height Z-scores to be relatively more sensitive to food price shocks compared with those for height-for-age.

4. Descriptive information

Studying the relation between an increase in world food prices and changes in malnutrition rates in a given country requires a clear understanding of the causal chain that is likely to be in place. First of all, the consumption patterns of the country need to be analyzed together with domestic and global food price trends, and the degree of transmission of the price shocks. The net buyer/seller position of households in different areas of the country is also a useful indicator of the direction of the effect that we could expect to see. These analyses are developed in Sections 4.1–4.4. In Sections 4.5 and 4.6 descriptive information on malnutrition rates and inflation is presented. Overall, we expect high world food prices to have negatively impacted on malnutrition rates, especially given that: (i) Mozambique is a food deficit and thus a food net-importer country; (ii) the 2008 harvest was below average; (iii) important food products commonly consumed in Mozambique are either imported in substantial amounts or show a high degree of price transmission, especially upwards; (iv) most households in both urban and rural settings are net buyers of food products; v) the existing literature points to a significant impact of the 2007–2009 crisis on consumption poverty rates.

4.1. Consumption patterns

As mentioned, Mozambique relies completely on imported fuel and runs an overall deficit in food trade, which made it vulnerable to the international price shocks experienced in 2008/2009. In the same period, the export value of important commodities such as sugar, cashew nuts, and tobacco declined sharply, worsening the current account balance situation (GoM, 2008).

In 2009, Mozambique imported food for 373 million USD, of which rice and wheat constituted 41 and 28 percent, respectively. Wheat is mostly imported to produce bread. In 2009, Mozambique also imported a non-negligible amount of maize and maize flour, corresponding to more than 6 percent of total food import expenditure[1]. Maize imports are especially directed to the southern region of the country, where less maize is produced but where a lot is consumed, especially in the capital, Maputo City.

Households usually devote 60 percent or more of total consumption to food. Based on the 2008/2009 data, the most consumed products were maize flour, cassava flour, rice, fish, groundnut, poultry, cowpea, and bread. On average, more than 20 percent of total household food consumption (in value) was represented by maize flour, about 9 percent by cassava flour, 4 percent by rice, and 2 percent by bread (Cardoso, 2014). Maize and cassava are less expensive sources of calories than rice and bread and thus represent an even larger share of calories consumed, particularly for lower income households whose children are, on average, more vulnerable to malnutrition. It should be highlighted that these percentages vary a lot between urban and rural areas, and by province[2]. In particular, rice and bread tend to be consumed in urban areas and the southern region, while cassava is mostly consumed in the centre-north (MPD/DNEAP, 2010).

4.2. Prices

It should also be noted that domestic prices of most consumed products evolved in different ways during the global price crisis of 2007–2009. In particular, the price of maize increased substantially by the end of 2008 and remained high until March–April 2009 (see Fig. 1). It then declined sharply between May and August. The prices for groundnut, cowpea, butter bean, and most other commonly consumed crops show a very similar pattern (only groundnut and cowpea shown in the Figure). Differently, cassava price reached its peak a few months later, around May–July[3]. As noted immediately above in Section 4.1, these products are very important sources of calories, particularly for lower income Mozambicans; and their prices were notably volatile during the period in focus. The price of rice followed a similar pattern to maize, though with much less volatility and a less sharp decline. The price of bread (not shown in the Figure) also increased during 2007 following international inflation pressures. However, a price cap was introduced during 2008 in response to violent riots and demonstrations that occurred in Maputo.

Overall, Fig. 1 clearly illustrates the exceptional nature of the IOF survey period relative to most other years. The Figure also shows a price spike following the 2005 harvest, which was marked by a strong drought. Estimated yields per hectare of principal food crops in 2005 are slightly lower than the estimates for the 2008 harvest. The Figure also illustrates a general upward trend in food prices over the period consistent with world market prices.

Focusing on the 2008–2009 period, Fig. 2 shows total and food consumer price index (CPI) trends. Even though some important crops had a behavior not fully in line with

[1] Data available at: http://atlas.media.mit.edu/en/visualize/tree_map/hs92/import/moz/all/show/2009/, accessed 19/11/2015.

[2] In the Third National Poverty Assessment, 13 spatial domains with similar consumption patterns are identified and the consumption bundles for the computation of the 13 regional poverty lines are presented in MPD/DNEAP (2010, pp.119–132).

[3] SIMA (Agricultural Market Information System) data thus show cassava price levels as high within the quarter that is here considered treated or exposed to low food prices. A few points on this are relevant. CPI (consumer price index) data, which is restricted to the three major cities, show cassava prices rising but from decadal low levels reached in 2007–2008. As will be discussed in Section 4.4, cassava is more than 80 percent home consumed (own produced), making cassava markets somewhat thin, particularly relative to maize. Indeed, the price series for cassava presented here is only based on 390 observations coming from only a few markets, compared to 1715 observations for maize and 1798 for rice. In particular, the high prices in May–July 2009 are driven by extraordinarily high prices observed during that period in the markets of Mocuba and Quelimane both located in the central province of Zambezia. Finally, ample evidence indicates that Mozambican households substitute away from expensive foodstuffs and towards inexpensive foods (see Arndt and Simler, 2010). Hence, even if cassava prices were high in some key SIMA markets during May–July 2009, the implications for nutrition are likely very small given the relative abundance of inexpensive alternatives.

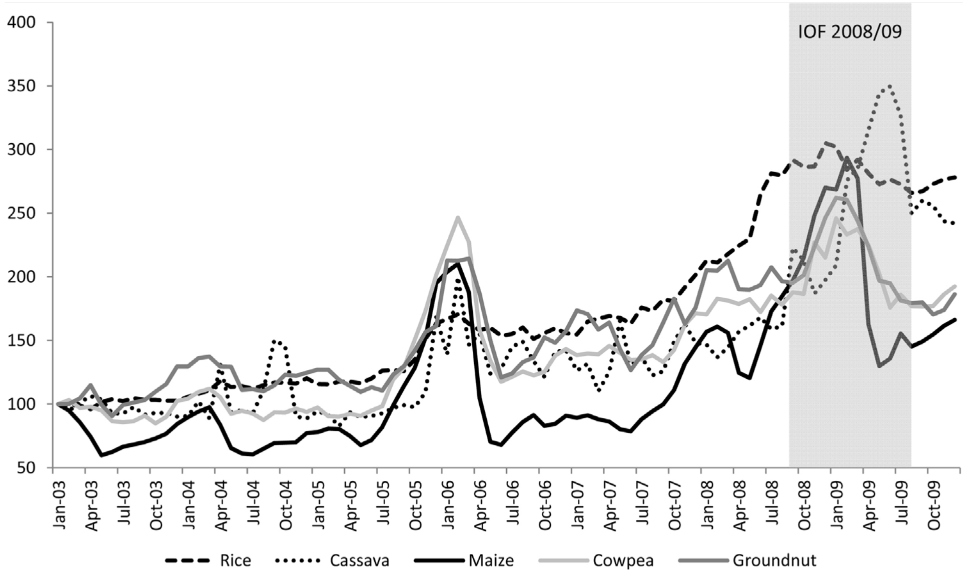

Fig. 1. Basic food price indices (2003–2009) (Jan 2003 = 100). *Source:* Authors' calculations based on SIMA (Agricultural Market Information System) data. *Note:* The period contained in the grey area are the months of the IOF 2008/09.

most other food products, overall the total and food CPI show a pattern that is more similar to that of maize and other major crops with a big increase around December–January followed by a decrease. The pattern is especially evident for food products but can be noticed for the total CPI as well because food items constitute the most important class of product in determining the national and regional CPI, accounting for about 50 percent of the total weighted sum of products used for the CPI calculations, and also accounting for most of the inflation recorded in 2008/2009 (Arndt et al., 2015).

Regarding the influence of price movements on food consumption, that is key to understanding the relation between price shocks and malnutrition, it emerges that such an influence is likely to be in place (Table 2). Considering the whole sample of households surveyed in IOF 2008/2009, the real value of total consumption is not statistically different between the first two or three quarters and the last quarter. However, real food consumption was lower, likely as a result of higher food prices. Furthermore, focusing on households with children aged 0–59 months (who are also likely to be poorer and hence more vulnerable), the difference in the value of food consumption is even bigger between the first quarters of the survey and the fourth one. Overall, it is likely that food intake was affected by the price shocks, especially for lower income households with children.

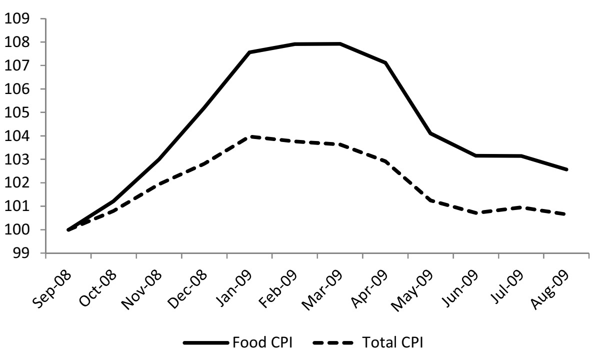

Fig. 2. Food and total CPI for Mozambique (Sep 2008 = 100). *Source:* Authors' calculations. *Note:* The National Institute of Statistics (INE) computes CPI as a weighted average of the prices observed in the three major cities of the country, Maputo, Beira, and Nampula.

4.3. Transmission

Turning to the relation between world and Mozambican prices, the relation between domestic prices and prices in South Africa is especially important in terms of international price transmission, as South Africa is Mozambique's main commercial trade partner. The southern region of the country where the capital Maputo is located is highly dependent on imports from South Africa, notably for processed foods and cereals. Acosta (2012) notes that in 2009 imports of white maize grain from South Africa accounted for 99 percent of Mozambique's total white maize imports, and Traub et al. (2010) report that maize has been consistently imported from South Africa almost every month since January 1990.

Traub et al. (2010) analyze the maize price transmission between South Africa and Mozambique. They find that while South African prices for cereals closely follow international prices, the price transmission between the South African market and other regional markets is not as straightforward. In particular, they find a huge discrepancy between the price of maize in South Africa and in Maputo around the end of 2008[4]. As Tschirley and Abdula (2007)

[4] In December 2008 SAFEX (South African Futures Exchange) (SAFEX, 2015) maize grain prices were quoted at USD 167/MT while prices in Maputo reached USD 546/MT.

Table 2
Mean comparison test of real food and total consumption expenditure over survey quarters with different inflation rates.

	Real consumption (MZN)	Test Q1–Q3 vs Q4		Test Q1–Q2 vs Q4	
		Sep 2008–May 2009	Jun 2009–Aug 2009	Sep 2008–Feb 2009	Jun 2009–Aug 2009
All households	Total	23.62	24.33	23.42	24.33
	Food	12.46	13.01**	11.97	13.01***
Households with under-five children	Total	19.51	20.72*	18.46	20.72***
	Food	10.69	11.51***	9.85	11.51***

Source: Authors' calculations. *Note:* The June 2009 to August 2009 column repeats. For each of these two columns, statistical tests are conducted relative to the column on the immediate left. MZN is the currency code for Meticais, the Mozambican currency.
* 10%, ** 5%, *** 1% significance level.

note, this can be due to the strong market dominance of two large-scale milling enterprises that control a big share of maize imports from South Africa and almost fully control the maize market in Maputo (Tschirley and Abdula, 2007).

Acosta (2012) reports the existence of a long run co-integrating relation between white maize prices in South Africa and Mozambique, but he also finds that upward price shocks are transmitted much more rapidly than downward shocks. Arndt et al. (2008) also conclude that the world price rises were transmitted to the domestic economy in 2008. This corroborates the view that the price shock experienced in Mozambique at the end of 2008 was influenced by international price increases and not only due to local circumstances. This also entails that it was not fully anticipated by most households.

4.4. Net buyer/seller and own consumption

As noted, the net buyer/net seller position of households is also important to determine whether higher prices benefit households in a first order sense. Net food seller households could have benefited from a situation of unusually high food prices, and malnutrition rates could have improved for this particular group. Arndt et al. (2008) examine this issue in some detail. They also highlight that Mozambique is a food deficit country, importing all of the wheat and about three-quarters of the rice demanded internally. At the same time, important regional differences also exist: maize is both imported by the south and exported from the north. Overall, the country is a net importer of maize. Moreover, the net benefit ratio analysis contained in Arndt et al. (2008) indicates that, in normal production years, urban households and households located in the south are generally more vulnerable to food price increases, while rural households might benefit from their net seller position, particularly those in the middle of the income distribution.

Nonetheless, they conclude that the macroeconomic and poverty impacts of the world price increases for food and fuel would be overall negative and substantial. Tschirley and Abdula (2007) reinforce this view with the finding that about 70 percent of rural households in the centre and south are also net buyers of maize. This suggests that price shocks, especially during the hungry season, are likely to have big impacts on household consumption in both urban and rural areas in all regions, and therefore on nutritional status. The reduced harvest in 2008, not observable to Arndt et al. (2008) as their analysis occurred before the publication of reliable harvest data, would convert many households, particularly rural households in the north and centre for whom production declines are most in evidence, from surplus to deficit status and thus magnify the impacts of transmitted world price increases.

As noted, households' dependence on own produced food is also important to study the effect of rising food prices on households' welfare and nutritional status. This information is summarized in Table 3 drawing on the 2008/2009 IOF data. The Table show that almost 55 percent of all food consumed is produced by the household. This own-consumption share is higher for rural areas (about 70 percent) and lowest in the urban south (about 10 percent). Cassava is mostly own consumed. Own consumption accounts for more than 80 percent of total cassava consumed over the full survey period. Conversely, only about 30 percent of the rice and effectively none of the bread consumed in the country in 2008/2009 is own produced. Maize flour, which constitutes the basic food for a large part of the population, is also mainly own produced (83 percent of the total), but this proportion varies by region and throughout the year, going from 78 percent in the months September–November to over 90 percent in the June–August post-harvest period. Overall, the reduced

Table 3
Own consumption as a share of total food consumption (percent).

	Area	North	Centre	South	Total
Sep–Nov 2008	Urban	26.5	36.5	6.1	19.9
	Rural	59.3	66.5	55.8	62.5
	Mozambique	49.0	61.1	25.7	48.6
Dec 2008–Feb 2009	Urban	34.0	16.0	11.5	19.0
	Rural	60.5	67.1	51.0	62.0
	Mozambique	53.5	54.5	29.2	47.9
Mar–May 2009	Urban	29.9	34.0	14.8	24.4
	Rural	75.9	74.2	64.7	73.1
	Mozambique	66.4	66.0	40.2	59.6
Jun–Aug 2009	Urban	35.9	31.8	9.3	24.9
	Rural	74.0	79.1	65.6	75.4
	Mozambique	63.3	69.3	39.2	60.9
Sep 2008–Aug 2009	Urban	31.3	28.9	10.1	22.0
	Rural	67.9	72.2	59.9	68.7
	Mozambique	58.2	63.1	33.8	54.5

Source: Authors' calculations based on IOF.

production levels observed for staple crops for the 2008 harvest can be expected to crimp home consumption and force an even greater share of households into a net buyer position. High prices for food products then militate against the possibility of making up for the observed staple food production decline with purchases.

4.5. Malnutrition

Here we present nutritional status information based on the IOF 2008/2009 data. It results that 18.7 percent, 46.4 percent and 6.6 percent of 0–59 months old children are respectively suffering from moderate underweight, stunting and wasting (MPD/DNEAP, 2010). In Table 4, malnutrition prevalence is presented for all provinces and survey quarters. No province is in the top or in the bottom regarding malnutrition when considering all three measures. But, Cabo Delgado (underweight), Manica (stunting) and Sofala (wasting) are among the provinces with the most malnourished children. Maputo Province and Maputo City perform best regarding both underweight and stunting. There is notable variation in malnutrition during the IOF year. Based on quarterly measurements we see that the three types of malnutrition show peaks in the second or third quarter, before falling in the fourth quarter.

This observed pattern in malnutrition largely corresponds with normal seasonal price variation whereby food from the main production year begins to become available around March with the post-harvest pass-through normally occurring around June. The 'hungry season' generally runs from about December through February. There is some evidence of seasonality in calorie consumption among rural households in the north and center driven by the seasonal pattern of price fluctuation (Arndt et al., 2005). In terms of child nutrition, data from an earlier survey covering a whole year in the period 1996/1997 (*Inquérito aos Agregados Familiares*, or IAF 1996/1997) does not point to a systematic seasonal variation in malnutrition. Nevertheless, it is possible that some seasonality exists[5].

Given the lack of data to estimate normal seasonal variation in malnutrition rates, we are not able to identify exactly the additional malnutrition associated directly with the food and fuel price crisis combined with the food production shortfall. However, both due to world price movements and a short production year nationally, the period in question does generate a spike in basic food prices that rises substantially beyond the levels that Mozambican households might reasonably have expected with associated implications for child malnutrition (see Fig. 1).

4.6. Inflation and malnutrition

Fig. 3 presents indices of basic food inflation rates, as well as malnutrition rates, by quarter and region. These indices are derived on the basis of consumption patterns derived from the household surveys combined with price data for basic foods derived from Mozambique's Agricultural Markets Information System (MINAG, 2014)[6]. From Fig. 3, one notes variations in price trends both across regions and compared with the national trends shown in Fig. 1. Specifically, food price inflation rates decline immediately after the first quarter in the southern region and in urban areas; however, they remain high until the third quarter in the central and northern regions, and in rural areas. With respect to malnutrition, wasting rates are low and only a small share of the total population of children move across the two standard deviation threshold between any two quarters. Stunting and especially underweight rates exhibit considerable intra-annual variation, with important regional differences. It is perhaps surprising that fewer children move back and forth across the wasting threshold compared with underweight, but this is consistent with recent findings from other crises, cf. e.g. de Brauw (2011), and Hartwig and Grimm (2012).

5. Approach and results

5.1. Propensity score matching

As noted in Section 3, households were interviewed only once in the IOF household budget survey. However, each quarter of the survey was designed to be representative of the whole sample. This implies that households interviewed in the first quarter should not be very different compared with households interviewed in quarters two, three, or four.

We use this feature of the survey design to compare nutritional status among under-five children in the first two or three quarters—when inflation was high—with nutritional status among under-five children in the last quarter—when inflation was generally lower. Given the negative effect of food inflation on food consumption, we expect contemporary child malnutrition – particularly wasting and underweight – to be lower in the fourth quarter when food price inflation is lower.

While we are able to control reasonably comprehensively across households based on a series of time invariant factors, our ability to control for factors external to the household is more limited. Hence, the observed differences in malnutrition rates across households represent the combined effect of differences in harvest quality, local prices, international prices, and potentially other factors.

In order to compare malnutrition rates between children interviewed in different quarters, we compute the average treatment effect on the treated (ATT) employing the propensity score matching technique (Rosenbaum and Rubin, 1983). In this case, the 'treatment' is given by

[5] Another household budget survey covering a whole year exists for 2002/03 (IAF 2002/2003), but no anthropometric information was collected in that year.

[6] Numbers presented here are based on price information from the Agricultural Markets Information System (MINAG, 2014). For this figure we use quarterly inflation, which is defined as the geometric mean, $\pi^Q_{m,t} = \sqrt[3]{\pi^A_{m,t} \times \pi^A_{m,t-1} \times \pi^A_{m,t-2}}$, of the annual inflation rate in the present month, $\pi^A_{m,t}$, and the two preceding months, $\pi^A_{m-1,t}$ and $\pi^A_{m-2,t}$. Annual inflation measures have the advantage of being relative to the prices that occurred during the preceding year, which was not strongly marked by special events and thus forms a reasonable anchor for price expectations of households. Also the advantage is that seasonal variation is taken into account.

Table 4
Moderate malnutrition prevalence in provinces over time.

Province	Obs	Share of child population (%)	Wasting (%)	Underweight (%)	Stunting (%)
Niassa	647	6.6	5.4	17.1	50.1
Cabo Delgado	483	7.1	6.2	25.5	54.1
Nampula	928	16.8	8.3	21.8	55.5
Zambezia	1172	19.2	5.2	19.1	48.6
Tete	624	10.2	9.3	24.5	52.3
Manica	548	6.6	5.1	20.6	58.4
Sofala	590	9.5	11.7	19.6	35.8
Inhambane	505	6.4	2.8	9.5	38.1
Gaza	528	7.4	4.3	14.3	32.8
Maputo Prov	503	6.2	5.0	7.5	20.2
Maputo City	590	4.0	3.7	6.8	24.1
Sep–Nov 2008	1809	24.3	5.8	16.3	42.9
Dec 2008–Feb 2009	1798	26.3	7.8	22.9	47.1
Mar–May 2009	1899	27.4	6.8	22.1	49.7
Jun–Aug 2009	1612	22.1	5.6	12.9	45.6
Total	7118	100.00	6.6	18.8	46.5

Source: Authors' calculations from the IOF database combined with WHO (2006a). *Notes:* Mozambique's population in 2008/09 was estimated to be slightly above twenty million people. Averages are based on population weights.

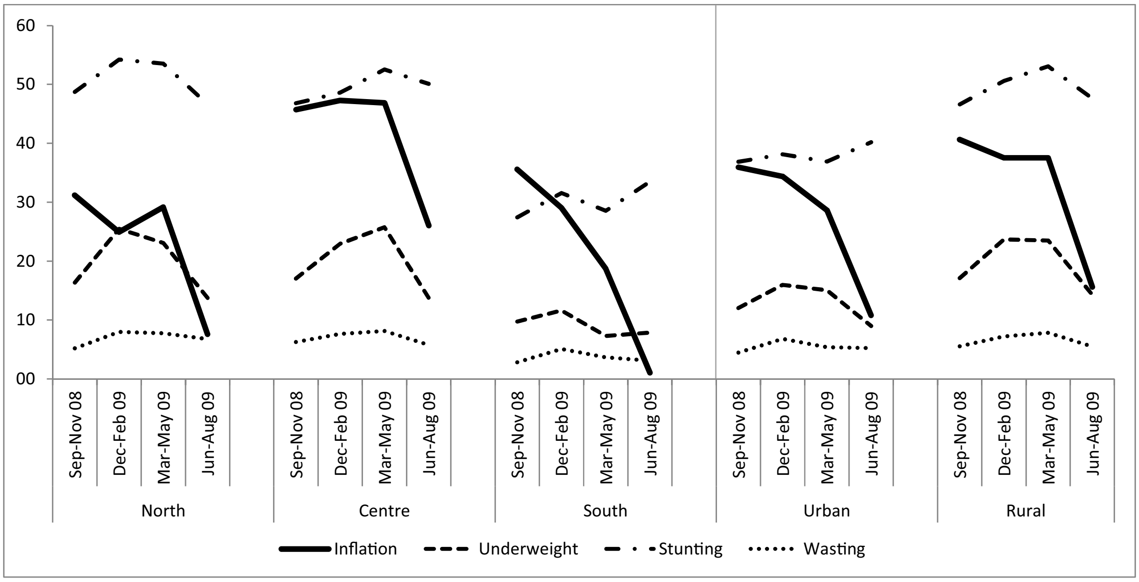

Fig. 3. Inflation and malnutrition rate developments for regions and rural/urban areas (percent). *Source:* Authors' calculations using the IOF 2008/09 and MINAG (2014).

the different level of inflation. We designate the treatment group as the group of under-five children surveyed in the fourth quarter (1592 observations). However, given that the population was not actually 'treated' in the sense of a formal experiment, we prefer to define this group of observations as 'exposed' group, rather than 'treated'.

The control group is thus the group of under-five children interviewed in the earlier survey quarters. In what follows, we present two alternative specifications with respect to the control group: first, a specification in which the control group is formed by children surveyed in the first three quarters of the IOF (September 2008–May 2009); subsequently, a specification in which the control group is formed by children surveyed in the first two quarters only (September 2008–February 2009)—i.e. the third quarter is excluded from the analysis[7]. Such a robustness check is performed because in some areas of the country – particularly in the south – the level of basic food inflation started to decrease already during the third quarter.

To compute the ATT, we assume that all relevant differences between under-five children in the first survey quarters and in the last quarter are captured by their observables and seek to select a control group from the

[7] Since we are performing a one-to-one matching procedure, the number of matched observations from the control group will be equal to the number of observations in the exposed group, i.e. 1592 observations. However, since we are using a one-to-one matching procedure with replacement, some of the observations in the control group are repeated.

non-exposed pool of observations for which the distribution of the observables is as similar as possible to the distribution of the observables in the treated group. Various matching methods exist. Here, we implement a standard one-to-one matching with replacement (Leuven and Sianesi, 2003). Robustness checks (not shown) are also performed using nearest neighbor, kernel, and radius matching, without obtaining qualitatively different results.

The observable characteristics selected as controls are child's gender and age (in months), child's age squared, the number of under-five children in the same household, a dummy for whether the child is first born, household size, gender of the household head, water and sanitation characteristics of the dwelling, roof quality, years of education of the mother, and dummies for provinces and urban/rural areas (see Table 1).

Table 5 shows that matching reduces differences in sample means between the control and treated group with respect to the observable characteristics. After matching, none of the variable means are statistically different between the control and exposed groups at 5 percent significance level[8]. Moreover, the standardized percentage difference or bias after matching is less than 5 percent for all covariates (see the column labelled "% bias"), which suggests that a good balance was obtained (Rosenbaum and Rubin, 1985). Mean and median standardized percentage bias is also reduced (Table 5, bottom). These observations apply to both the semester (September 2008–February 2009) and three quarters (September 2008–May 2009) control groups. For space reasons, only the latter control group is presented in Table 5.

Following Leuven and Sianesi (2003), we do not use sample weights to implement the matching procedure. However, sample weights are used to estimate the ATT, in order to more correctly evaluate the difference between the observed and the matched outcome.

5.2. Results

Having defined the exposed and control groups and the observable characteristics, we compute the ATT using various outcome variables: weight-for-height Z-scores, weight-for-age Z-scores, height-for-age Z-scores as well as wasting, underweight, and stunting dummy variables. These dummy variables take value 1 if the Z-score values of the corresponding continuous variables are below the international reference value by more than two standard deviations and 0 otherwise, as explained in Section 3. Checks are then performed using the consumption poverty headcount ratio, food and total consumption, and the proportion of food consumption from own production as a share of total food consumption as outcome variables.

If our hypothesis – that contemporary malnutrition was affected by different inflation levels experienced in different quarters – is correct, we expect prevalence of wasting and underweight to be lower among children surveyed in the fourth quarter (i.e. the exposed group). We also expect average weight-for-height Z-scores and weight-for-age Z-scores to be higher for this group, as this would indicate lower malnutrition levels. Height-for-age Z-scores and corresponding stunting rates are expected to exhibit more stability due to the long-term nature of this indicator. Table 6 shows the results for the

Table 5
Quality of the matching procedure.

Variable	Unmatched/ Matched	Exposed group: June 2009–August 2009 Control group: September 2008–May 2009		
		Mean		
		Exposed	Control	% bias[a]
Girl	*U*	0.51	0.51	−1.3
	M	0.51	0.51	−1.4
Age (in months)	*U*	28.39	30.02***	−10.2
	M	28.39	28.01	2.3
Age squared	*U*	1060.40	1159.00***	−10
	M	1060.40	1040.10	2.1
Safe water	*U*	0.22	0.27***	−10.5
	M	0.22	0.23	−1.5
Sanitation	*U*	0.61	0.59	4
	M	0.61	0.63	−3.7
Mother's education years	*U*	2.92	2.69***	7.6
	M	2.92	2.92	−0.2
Household size	*U*	5.98	6.35***	−14.1
	M	5.98	6.01	−1
High quality roof	*U*	0.37	0.39	−4.6
	M	0.37	0.38	−1.2
Female household head	*U*	0.25	0.25	−0.2
	M	0.25	0.23	4.5
Under-five children in the HH	*U*	1.62	1.65	−4.6
	M	1.62	1.60	3.3
Child is first born	*U*	0.73	0.73	0.9
	M	0.73	0.72	1.4
Rural	*U*	0.57	0.56	1.9
	M	0.57	0.57	1.1
Sample			Mean Bias	Med Bias
Unmatched			4.6	3.6
Matched			2.1	1.7

Source: Authors' calculations from the IOF database. *Notes:* Province dummies are not shown. Results for the September 2008–February 2009 control are qualitatively very similar.

[a] In this column the standardized percentage bias is displayed, before and after matching. The standardized percentage bias is the percentage difference of the sample means in the treated and non-treated (matched) sub-samples as a percentage of the square root of the average of the sample variances in the treated and non-treated groups (Leuven and Sianesi, 2003).
* 10%, ** 5%, *** 1% significance level.

[8] The results of the mean comparison tests performed before and after matching for each of the covariates are shown in the column "Control" of Table 5 by means of asterisks. While some of the variables have statistically different means before matching (lines indicated with a "*U*" in the "Unmatched/Matched" column), the differences become statistically insignificant after matching (lines "*M*" in the "Unmatched/Matched" column). This is true for both control groups but only shown for the September 2008–May 2009 control group in Table 5.

Table 6
Mean comparisons and average treatment effect on the treated.

Exposed group: June 2009–August 2009; Control group: September 2008–May 2009								
	(a)				(b)			
	Simple mean comparison				ATT			
Outcome variable	Obs	Exposed	Controls	Difference	Obs	Exposed	Controls	Difference
Weight-for-height *Z*-scores	6999	0.30	0.04	0.25***	3184	0.30	0.06	0.24***
Weight-for-age *Z*-scores	6999	−0.74	−0.96	0.22***	3184	−0.74	−0.96	0.22***
Height-for-age *Z*-scores	6999	−1.65	−1.73	0.08	3184	−1.65	−1.74	0.09
Wasting	6999	5.74	6.92	−1.18*	3184	5.74	7.77	−2.03**
Underweight	6999	12.19	19.86	−7.67***	3184	12.19	20.54	−8.35***
Stunting	6999	43.20	45.20	−2.00	3184	43.20	44.99	−1.79
Headcount ratio	6999	59.23	63.64	−4.41***	3184	59.23	58.31	0.92
Total consumption	6999	20.75	19.48	1.27**	3184	20.75	22.67	−1.92**
Food consumption	6999	11.48	10.63	0.85***	3184	11.48	12.00	−0.52
Consumption from own production (%)	6999	0.63	0.54	0.10***	3184	0.63	0.49	0.14***
Exposed group: June 2009–August 2009; Control group: September 2008–February 2009								
	(c)				(d)			
	Simple mean comparison				ATT			
Outcome variable	Obs	Exposed	Controls	Difference	Obs	Exposed	Controls	Difference
Weight-for-height *Z*-scores	5126	0.30	0.04	0.26***	3184	0.30	0.05	0.25***
Weight-for-age *Z*-scores	5126	−0.74	−0.93	0.19***	3184	−0.74	−0.91	0.17***
Height-for-age *Z*-scores	5126	−1.65	−1.67	0.02	3184	−1.65	−1.66	0.01
Wasting	5126	5.74	7.00	−1.27	3184	5.74	6.13	−0.39
Underweight	5126	12.19	19.05	−6.86***	3184	12.19	19.21	−7.02***
Stunting	5126	43.20	43.97	−0.77	3184	43.20	45.06	−1.86
Headcount ratio	5126	59.23	66.92	−7.69***	3184	59.23	63.81	−4.58***
Total consumption	5126	20.75	18.50	2.25***	3184	20.75	20.24	0.51
Food consumption	5126	11.48	9.90	1.58***	3184	11.48	10.69	0.79***
Consumption from own production (%)	5126	0.63	0.49	0.14***	3184	0.63	0.43	0.20***

Source: Authors' calculations from the IOF database. *Notes:* The control group (1592 observations, some of which are repeated) is under-five children surveyed between September 2008 and May 2009 in panels (a) and (b), and under-five children surveyed between September 2008 and February 2009 in panels (c) and (d). The exposed group (1592 observations) is under-five children surveyed between June and August 2009. Probit was used to estimate the propensity score.
* 10%, ** 5%, *** 1% significance level.

two alternative specifications: one in which the control group is formed by children surveyed in the first three quarters of the IOF (Table 6, panels (a) and (b)); another in which the control group is formed by children surveyed in the first two quarters only (Table 6, panels (c) and (d)).

For the two alternative specifications, we also present the results of simple mean comparison tests, i.e. a comparison of the mean of the outcome variables obtained without matching the children of the exposed group with children from the control group (Table 6, panels (a) and (c)). Comparing the means of the outcome variables without matching makes sense in our case as the IOF is representative for each quarter, and even without matching huge differences should not exist between households interviewed in different quarters.

Results for the outcome variables in focus, weight-for-height *Z*-scores, weight-for-age *Z*-scores, wasting, and underweight, are different among the two groups of children with the sign of the difference going in the expected direction. Nearly all of these differences are statistically significant and these results pertain whether one applies simple mean comparisons or ATT. These results indicate that malnutrition, as measured by the indicators in focus, was significantly lower among children in the fourth survey quarter, when inflation rates were substantially lower in all regions of the country. Height-for-age *Z*-scores and stunting levels are not statistically different among the two groups.

In terms of consumption based welfare indicators, the exposed group exhibits a significantly higher real total consumption, higher real food consumption, and lower poverty rate in three of the four cases (panels (a)–(d)) considered. This is expected as lower food consumption is postulated as one of the drivers of the observed higher rates of malnutrition. In panel (b), the control group selected under ATT is substantially better off than the simple mean control group on the basis of measured consumption even though they are very similar with respect to the control characteristics listed in Table 5. There are at least two potential explanations for this outcome. The first involves a role for other factors driving nutrition outcomes. For example, some families may succeed in maintaining real consumption levels, despite high food price inflation, through greater work effort but at the expense of time spent caring for young children at home. This interpretation is consistent with Miller and Urdinola (2010). The second reflects the considerable difficulties in estimating real consumption when prices and consumption patterns change substantially both across space and through time (MPD/DNEAP, 2010).

As expected, the proportion of food consumption from own production as a share of total food consumption is significantly higher for the exposed group, which is consistent with normal patterns of consumption/storage (Arndt et al., 2000). Results separated for urban and rural zones are presented in Table A1 in Appendix A. Both zones exhibit higher rates of malnutrition during periods characterized by rapid price increases in the cost of basic foods though the results are more pronounced in rural zones, highlighting the generally greater vulnerability of rural households and the force attributable to the combination of a down production year and very high basic food prices in rural areas.

In terms of future research, it has already been highlighted that differing dynamics for measures of chronic malnutrition, such as stunting, led to the measured insignificant differences between the two groups in the main specifications employed for this analysis. Nevertheless, some evidence of implications for chronic malnutrition can be discerned from the results presented. This is particularly true for rural households, who experienced three continuous quarters of consistently elevated basic food price levels (see Fig. 3). Compared to the first quarter, unconditional stunting rates are substantially higher in the third quarter (see Table 4). From Table A1, it can be inferred that children in rural households are the principal drivers of this result. This provides preliminary indications that the three quarters of high prices experienced in rural zones might have been enough to drive down height-for-age *Z*-scores for rural inhabitants, with some recovery in the fourth quarter as price inflation cooled. If confirmed, this finding would be in line with results from Rieger and Wagner (2015) for Senegal, who find that child health stocks can deplete relatively quickly.

6. Summary and conclusions

We employ household survey data from Mozambique to consider the implications of food price inflation for the nutritional status of children aged 0–59 months. The anthropometric data was collected from September 2008 to August 2009, which provides the possibility to shed some light on the nutritional consequences of the 2007–2009 food and fuel price crisis. For Mozambique, these world price shocks combined with a negative agricultural production shock, which reduced staple food crop yields from the principal harvest, collected around June 2008, by about 20 percent relative to favorable agricultural seasons.

We define the first three quarters of the survey, where domestic prices were generally high, as controls and the final quarter, where domestic prices were generally low, as exposed. We find that contemporary malnutrition prevalence and levels, as measured by weight-for-height and weight-for-age, are significantly worse for households interviewed in control quarters compared with the exposed quarter. This is true for both simple averages and after controlling for time-invariant observables at the household level. It also holds when the control periods are defined as the first semester. The salient difference between the exposed and control group is the rate of domestic food price inflation experienced during their respective survey quarters.

Food penury, evidenced by the strong domestic food price inflation experienced during the first two or three quarters of the IOF survey, is by far the most likely factor to have aggravated contemporary child malnutrition measures compared with the fourth quarter, where domestic food price inflation was subdued due to the arrival of the 2009 harvest. The effect of this food penury was particularly strong with respect to the weight-for-age indicator with the share of children classified as underweight falling by about 40 percent in the fourth quarter.

We stress that we are not able to explicitly untangle the effects of the global food and fuel price shocks from normal seasonal fluctuations in child nutrition indicators or from the implications of the production shortfall in 2008. At the same time, ample evidence illustrates that the food price inflation experienced by the control group, driven by the combination of high international prices and a production shortfall, was notably rapid. Also, available information from previous anthropometric surveys does not point to a strong seasonal effect on malnutrition indicators. We thus conclude that the global food and fuel price shocks in combination with a negative agricultural production shock powerfully aggravated nutrition outcomes for children aged 0–59 months in Mozambique.

An increasing volume of evidence indicates that the implications of child malnutrition can endure for the remainder of life, with consequent implications for growth and development prospects for a generation (for example, Hoddinott et al., 2008). In terms of policy, UNICEF (2014), among others, provides a host of ideas for reducing vulnerability and improving average outcomes in Mozambique, many of which are already being actively pursued. Here, we opt to highlight the benefits of broad based agricultural development. A more productive and stable agricultural sector, widely viewed as possible given Mozambique's inherent assets (MPD/DNEAP, 2010), would reduce vulnerability to price and production shocks as well as their combination.

Acknowledgements

We thank two anonymous reviewers for valuable comments. Olivier Ecker and Jörgen Levin also provided insightful comments and suggestions. Financial assistance from the Danish Consultative Committee for Development Research (FFU), DANIDA, and Swiss Development Cooperation is appreciated. The usual disclaimers apply. This study contributes to the UNU-WIDER project Growth and African Poverty Project (GAPP), directed by Finn Tarp. UNU-WIDER gratefully acknowledges the financial contributions to the research programme from the governments of Denmark, Finland, Sweden, and the United Kingdom.

Appendix A

Table A1.

Table A1
Average treatment on the treated, urban/rural level.

Exposed group: June 2009–August 2009; Control group: September 2008–May 2009								
	(a)							
	Rural				Urban			
Outcome variable	Obs	Exposed	Controls	Difference	Obs	Exposed	Controls	Difference
Weight-for-height *Z*-scores	1826	0.27	0.00	0.27***	1358	0.35	0.11	0.25***
Weight-for-age *Z*-scores	1826	−0.80	−1.10	0.29***	1358	−0.54	−0.66	0.12*
Height-for-age *Z*-scores	1826	−1.74	−1.92	0.18**	1358	−1.40	−1.29	−0.11
Wasting	1826	5.12	6.00	−0.88	1358	7.49	6.32	1.18
Underweight	1826	13.08	22.83	−9.75***	1358	9.68	12.96	−3.28*
Stunting	1826	44.75	49.58	−4.83**	1358	38.81	37.98	0.83
Headcount ratio	1826	58.78	59.19	−0.41	1358	60.50	52.76	7.74***
Total consumption	1826	20.23	21.35	−1.12	1358	22.21	25.17	−2.96*
Food consumption	1826	11.61	11.71	−0.10	1358	11.10	12.66	−1.56***
Consumption from own production (%)	1826	0.76	0.63	0.12***	1358	0.28	0.24	0.04**
Exposed group: June 2009–August 2009; Control group: September 2008–Feb 2009								
	(b)							
	Rural				Urban			
Outcome variable	Obs	Exposed	Controls	Difference	Obs	Exposed	Controls	Difference
Weight-for-height *Z*-scores	1826	0.27	0.11	0.16**	1358	0.35	0.20	0.15*
Weight-for-age *Z*-scores	1826	−0.80	−0.99	0.18***	1358	−0.54	−0.64	0.10
Height-for-age *Z*-scores	1826	−1.74	−1.85	0.10	1358	−1.40	−1.39	−0.01
Wasting	1826	5.12	6.60	−1.48	1358	7.49	5.42	2.08
Underweight	1826	13.08	19.25	−6.17***	1358	9.68	12.24	−2.56
Stunting	1826	44.75	47.46	−2.71	1358	38.81	34.65	4.16
Headcount ratio	1826	58.78	62.93	−4.15*	1358	60.50	59.53	0.97
Total consumption	1826	20.23	19.20	1.03	1358	22.21	23.14	−0.93
Food consumption	1826	11.61	10.61	1.00***	1358	11.10	12.56	−1.46***
Consumption from own production (%)	1826	0.76	0.64	0.12***	1358	0.28	0.20	0.07***

Source: Authors' calculations from the IOF database. Notes: The control group is under-five children surveyed between September 2008 and May 2009 in panel (a), and under-five children surveyed between September 2008 and February 2009 in panel (b). The exposed group is under-five children surveyed between June and August 2009 in both panels.
* 10%, ** 5%, *** 1% significance level.

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