Food Prices and Child Mortality in India: Cross-District Analysis of the Indian District Level Household and National Sample Surveys, 2002-2008

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Key words: food prices, mortality, child health, India

Word Count: 2,634

Abstract

Child malnutrition and mortality remain high in India. We investigated the role of rising food prices. Using the District Level Household Survey, we calculated district NNMR, IMR, CMR, and U5MR using life tables. Sociodemographic and economic controls were calculated using weighted means. Data were paired with food prices from the National Sample Survey (n=365). Prices were regressed on mortality using linear differenced regression models, and were disaggregated by Empowered Action Group (EAG) versus non-EAG states. We found a positive relationship between food prices and NNMR (b=0.48) and IMR (b=0.35). Meat prices are positively associated NNMR (b=0.33), IMR (b=0.29) CMR (b=0.31), and U5MR in EAG states. A similar pattern is observed for dairy. In non-EAG states, food prices are not significant. A negative relationship was found between cereals and NNMR (b=-0.11) and IMR (b=-0.07) in EAG states. Cereal-dominated diets may increase the risk of micronutrient deficiency and mortality.

Introduction

India has achieved tremendous economic growth over the past several decades, becoming the world's third largest economy [1], but its child and infant mortality rates rank among the worst-50 nations [2]. Although child mortality fell from 86 deaths per 1,000 births in 1985-1990 to 51 deaths per 1,000 live births in 2005-2010, India is not on track to achieve the Millennium Development Goal to reduce mortality by two-thirds by 2015 [3]. This high burden of child mortality occurs in the context of one of the worst nutritional profiles in the world [4]. Undernutrition remains a serious problem, while a double-burden of overnutrition has simultaneously begun to emerge [5,6]. It is estimated that 1 in every 3 malnourished children globally lives in India, where 47% of children under age three are underweight, 46% are stunted, and 16% are wasted [7]. According to the latest available data from 2005, about one third of all deaths in children under-5 years were attributable to low birth weight or prematurity, and a further 30% were attributable to diarrhoeal diseases [8].

It has been suggested that the increasing price of food rising faster than the rate of economic growth is impeding nutritional progress in low income countries [9]. Rising food prices may decrease overall caloric intake, worsen the quality of diets, and further result in lower dietary diversity [9]. Each of these factors has been linked to higher risks of stunting, undernutrition, and wasting [10–13].When food prices rise, households may also forgo other spending on children's clothing, schooling and healthcare to sustain food intake; risks to health may increase in the tradeoff between adequate living conditions, preventive care, and food security [14–18]. Additionally, an increase in food prices may worsen maternal nutrition, increasing risks of low birth weight. Around 36% of Indian women are estimated to suffer from chronic energy deficiency, measured as a body mass index of less than 18.5 [4], and maternal anaemia rate exceeds 50% in most states [19]. These risk factors increase the probability that the infant will be born premature and/or low birth weight [20].

Although numerous studies have documented the association between food prices and consumption of processed, high-fat foods, particularly animal fats and dairy [21,22], there is a dearth of research evaluating their potential impact on malnutrition and child survival. The few existing studies on this topic are largely based on simulations rather than empirical analyses [9,23] or focus on aggregated national trends [16], ignoring more micro-level trends that are likely to be tied to localized food prices. Yet studies of low-income countries have shown that reductions in child mortality are slower for the poor than the wealthy, and slower in rural versus urban areas [24], which studies of changing rates at the state or national level likely miss. While there is mounting evidence that substantively meaningful variation in mortality rates can be found below the state level [25], to our knowledge no district-level empirical analysis of the relationship between food prices and child mortality in India has been documented.

In this study, we test the hypothesis that rising food prices are a significant contributing factor to increased children's mortality risks in India. To assess this possibility, we systematically modelled the association between food prices and mortality by, to our knowledge for the first time, linking food price data from National Sample Survey Organization (NSSO) with life table calculations of child mortality from the Indian District Level Household Survey covering the years 2002 to 2008.

Data & Methods

Data were collected from three sources: India's nationally representative District Level Household Survey (DLHS) [26,27], the National Sample Survey Office Rural Price data (NSSO) [28] , and the Central Statistical Organisation of India, Directorate of Economics and Statistics [29]. Mortality and sociodemographic data are drawn from rounds two (2002-2004) and three (2007-2008) of the DLHS. In round 2, individual level data were collected for 507,622 currently married women aged 15-44. Of these, 57,324 had never given birth and were excluded from the sample. Data on birth and death histories for children born in the 59 months preceding the survey were used to calculate mortality rates, resulting in a final sample size of 248,843 women and 367,023 children. Round three includes individual level data for 643,945 women, including ever-married women aged 15-49 and never married women aged 15-24. Of the women in the full sample, 428,004 had not given birth since 1st January 2004, and were thus excluded. As some women had more than one child in the reporting period, the final sample for round three included data for 215,941 women and their 284,087 children.

Mortality rates were calculated based on mother's report of the child's age in months and, where applicable, age at death for all children in round 2, and children born after 1st January 2004 in round 3. Age at death was reported in days for all children living for 30 or fewer days; age at death was reported in months for all children aged at least one month. Using Stata's *ltable* function, life tables were constructed to estimate mortality for neonatal (0-30 days), infant (0-12 months), child (13-59 months), and under-five (0-59 months). These figures were calculated for each of the 601 districts on the DLHS data, and were weighted to the DLHS district weight. Additionally, district-specific weighted means were calculated for sociodemographic controls including mean parity, wealth (proportion in low and middle wealth tertiles), religion (proportion Hindu or Muslim), place of residence (proportion urban), and caste (proportion scheduled caste, scheduled tribe, or other backwards class). As a proxy for the uptake and quality of the healthcare system, district-weighted means were also included for the proportion of children who received all recommended doses of the diphtheria, pertussis, and tetanus (DPT) vaccine, and the mean number of ANC visits mothers reported for their most recent birth. Given the association between child health outcomes and women's empowerment and education found in previous literature [30], we also control for the average years of women's education.

These district level mortality and sociodemographic data were linked with 5 rounds of price data from the National Sample Survey Office Rural Hub data corresponding to the DLHS survey dates. The NSSO includes data for over 130 food items. Annual prices for each of these food items were calculated, and aggregated into 10 broad categories: all food items, cereals, pulses, meat, fish, poultry, dairy, vegetables, fruit, and sugar. Based on the calculated percentage change from wave 2 to wave 3, outliers (change >500%) were dropped from the sample, resulting in a loss of between 0 and 25 cases, with the majority of dropped cases on the mortality rates, reflecting sometimes insufficient numbers of mortality cases at the district level. Data on gross state domestic product (SDP), held constant at 1999-2000 prices in Rupees, were drawn from the Central Statistical Organisation of India, Directorate of Economics and Statistics [29]. Data were not available from either the NSSO or SDP data for Daman and Diu, Dadra and Nagar Haveli, and Lakshadweep (n = 4). The final resulting sample size for our analysis was 365 districts.

Statistical Models

We applied differenced linear regression models to test the relationship between food prices and mortality, with robust standard errors clustered by state to account for unobserved homogeneity. District level sociodemographic controls outlined above were included in all models, as shown in Equation 1.

Equation 1:

$$\Delta Mortality_i = \alpha + \beta_1 \Delta foodprice_i + \beta_2 poverty_i + \beta_3 demographics_i + \beta_4 healthcare_i + \beta_5 \Delta SDP_i + \varepsilon_i$$

Here, i is the district and Δ represents percent change; all values not included as percent change were aggregated from wave 3 of the DLHS data. Δ food prices represents the percentage change in food prices across each of the food items outlined above, modeled separately for each food item. Poverty includes the proportion of households in the low or middle wealth tertiles, as well as the log of the state domestic product in wave 3. Demographics include the mean maternal age, parity, and education, and the proportions in urban areas, Hindu or Muslim, and in scheduled tribes, scheduled castes, or other backwards classes, while healthcare includes the proportion of children who received all DPT immunizations and the mean number of ANC visits. Δ SDP is the percentage change in the state domestic product between waves 2 and 3. Models were estimated separately for NNMR, IMR, and CMR, and separately for each food item, first for the full sample, then split by Empower Action Group (EAG) versus non-EAG states. The division of the sample by EAG states is useful because EAG states have been identified as economically deprived and targeted by the Indian government for increased policy interventions.

Results

We first examined statistical models of the association between change in food prices and change in NNMR, IMR, CMR, and U5MR in the full sample (that is, not split by EAG versus non-EAG), controlling for sociodemographic and economic confounders describe. Results from this analysis suggest that an increase in food prices is associated with an increase in NNMR and IMR, but not in CMR and U5MR. Specifically, a 1% increase in the price of all food items combined was associated with nearly a half percent increase in NNMR (b=0.48; p=0.01) and a 0.35% increase in IMR (b=0.35; p=0.04). Additionally, a 1% increase in the price of vegetables was associated with a 0.33% increase in NNMR (b=0.33; p=0.05). No significant effects were found for CM R and U5MR. However, given the greater economic deprivation in EAG states, and the resultant social policy focus on these states, we split the sample by EAG versus non-EAG states to test for heterogeneity.

Figure 1 shows a forest plot of the results for neonatal mortality from the 20 statistical models of 365 districts in 24 states, split by EAG and non-EAG states. In EAG states, significant effects were found for meat, dairy, and cereals: Each 1% increase in the price of meat was associated with a one-third of a percent rise NNMR (b=0.33; p=0.02), while a 1% increase in the price of dairy was associated with a .11% rise in NNMR (b=0.11; p=0.01). Conversely, rising cereal prices were actually associated with a .11% decline in NNMR rate (b=-0.11; p<0.00). In non-EAG states, while a 1% increase in food prices overall was associated with nearly a half percent decline in NNMR (b=.049; p=0.03), there was no relationship between individual items and NNMR. In Figure 2, the results for the next 20 models, showing the relationship between food prices and infant mortality, can be seen. Similar to NNMR, in EAG states we found a positive relationship between the percent change in IMR and the percent change in meat (b=0.29; p=0.05) and dairy (b=0.09; p=0.02), and a negative relationship between IMR and the change in cereal prices (b=-0.07; p=0.02). We found no relationship between food prices and IMR in non-EAG states.

While the association between mortality and meat and dairy prices held in EAG states for CMR and U5MR, the price of cereals did not appear to be a significant predictor of mortality. As shown in Figure 3, a 1% increase in meat (b=0.31; p=0.01) and dairy (b=0.12; p=0.01) prices were associated with rises in CMR of .31% and .12% respectively. No association was found between food prices and CMR in non-EAG states. Similarly, as can be seen in the forest plot in Figure 4, while there was no relationship between food prices and U5MR in non-EAG states, meat and dairy were again significant predictors on mortality in EAG states. Specifically, a 1% increase in meat (b=0.27; p=0.03) and dairy (b=0.10; p=0.01) were associated with respective increases in U5MR of .27% and .10%. Notably, the relationships described above reflect the results of models that rigorously controlling for a wide variety of sociodemographic and economic controls, which suggests that the effect of rising food prices operates above and beyond the effect of level of deprivation at the district level. Due to the large number of models estimated for these analyses, it is not possible to present a full set of models for each individual regression. However, an example of the full models is presented in Table W1. This table provides the full set of results for the association between the percent change in dairy prices and the percent change in U5MR, split by EAG and non-EAG states.

Robustness Tests

In order to ensure the robustness of our findings, we performed several robustness checks on our models. As an alternative control for the quality and utilization of the healthcare system, we tried modelling the total number of DPT immunizations children received on average and the proportion of women who reported attending at least 1 ANC visit, both in tandem with and in lieu of the measures included in the final models. Results for food prices were unchanged. To adjust the p-value of our models for the number of comparisons being made across food items, smile plots were constructed using Stata's *smileplot* function, with a Liu correction applied [31]. Results from the smile plots are provided in the web appendix, Figures W1-W4. Results from the Liu-corrected smile plots suggest that statistically significant results are not due to error arising from the number of comparisons, and instead reflect genuine associations.

Conclusions

In this paper, we investigated the association between food prices and child mortality in India at the district level. We found that rising food prices, particularly of meat and dairy, are associated with worse mortality outcomes. The effect of food prices rises is greatest in economically deprived states, where food prices also appear to impact mortality among young children. High protein foods such as meat and dairy are especially important in these areas, while an increase in cereal prices is actually associated with declines in mortality. One possible explanation for this finding is that cereal-dominated diets low in iron-rich foods (such as meat) may increase the risk of both maternal and child iron deficiency [32], which is a leading correlate of disability and death globally [33]. It may be that the disproportionate focus of food security programs such as the Public Distribution on rice and sugar subsidies serves to increase caloric intake, but also reduces dietary diversity and thereby contributes to micronutrient deficiencies. Given the association between cereals and NNMR and IMR but not mortality in the older age groups, maternal anaemia is a particularly likely culprit in this relationship. While our models control for a variety of economic indicators, the effects of food prices remain particularly significant in economically disadvantaged states, suggesting that policies targeting food security may not be sufficient for alleviating food poverty and mitigating the negative effects of rising food prices on child health.

There are several limitations to our study. First, due to data limitations, we were only able to look at the period from 2002 to 2008, and were not able to observe the impact of the global financial crisis of 2008 on subsequent nutrition and mortality outcomes. Our findings may thus be conservatively biased, especially if, as our findings on EAG versus on non-EAG states suggest, the impact of rising food prices is greater among economically disadvantaged groups. Second, there were several districts which were missing data in at least one of our data sources, and thus had to be excluded from the sample. The exclusion of these districts may bias our conclusions if the districts which were not sampled are systematically different in terms of mortality and/or food prices. Additionally, we are not able to measure the consumption of specific food items, and thus our models do not control for differences in consumption patterns of food items across states. Finally, because the analyses were conducted at the district level, sample sizes in our models are fairly small, placing limits on the statistical power of the models. Additional research is needed to understand how social policy and household coping strategies may exacerbate or mitigate the effect of food prices on mortality.

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Figure 1. Forest plot of percent change in food prices and percent change in the neonatal mortality rate

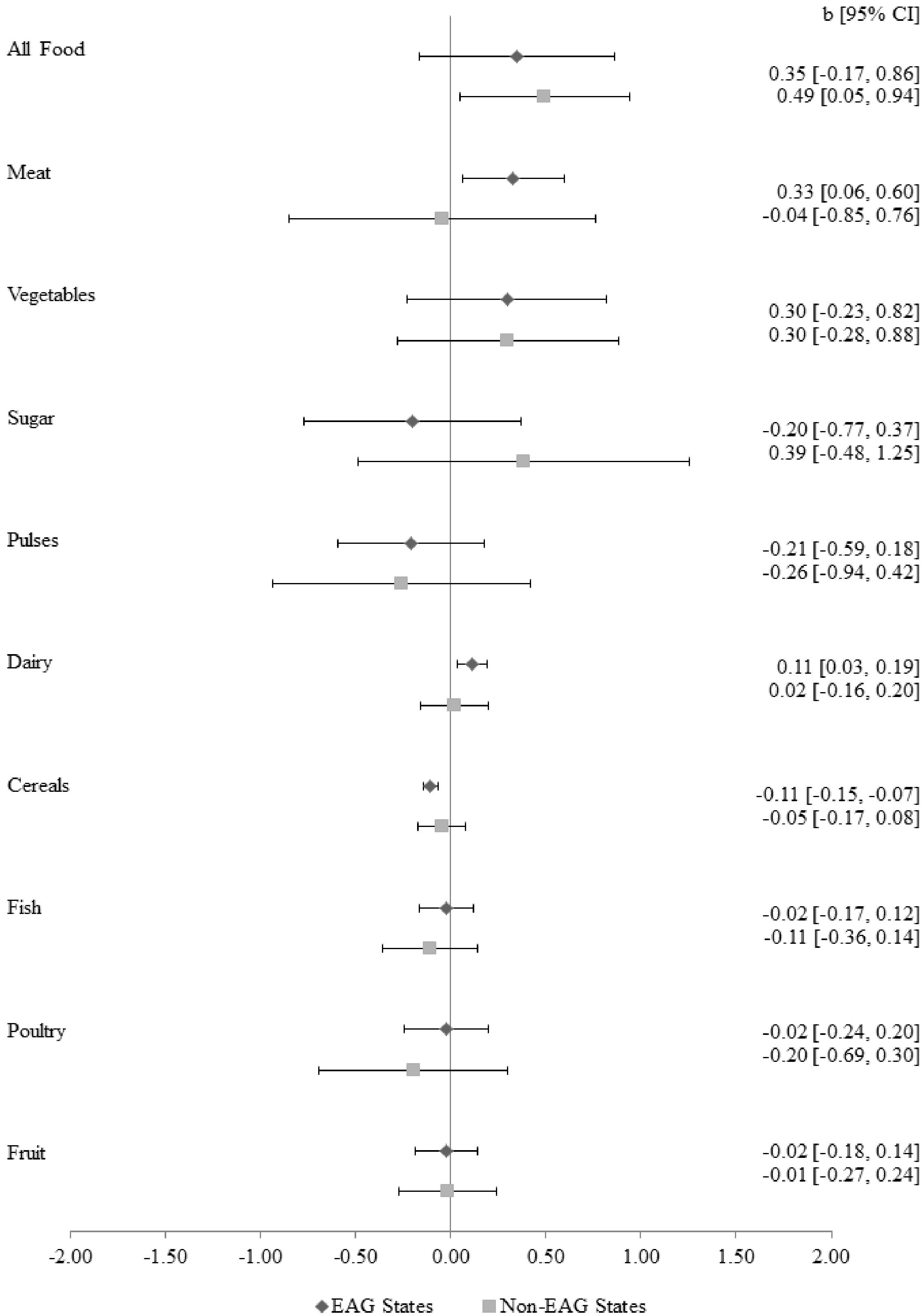


Figure 2. Forest plot of percent change in food prices and percent change in the infant mortality rate

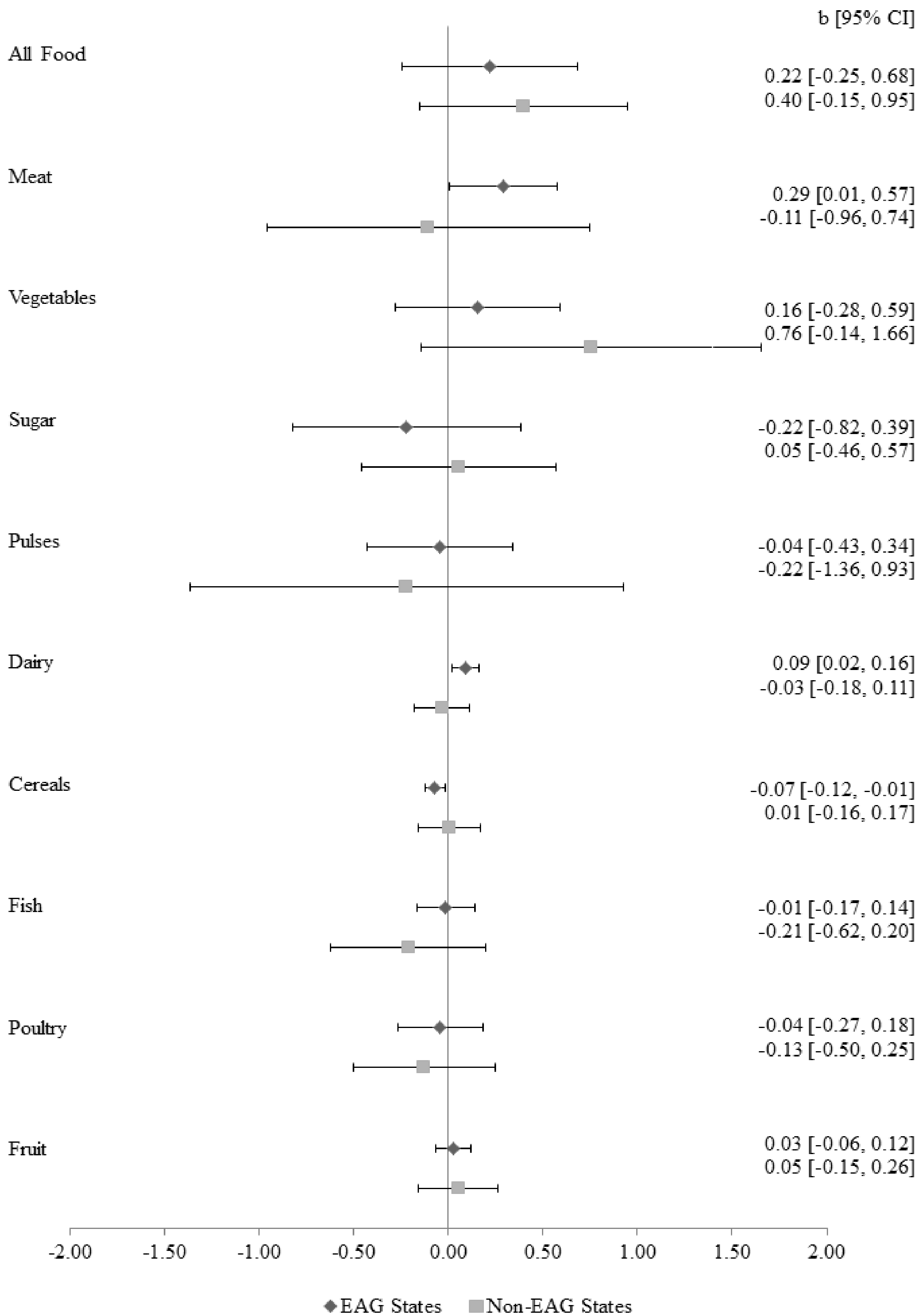


Figure 3. Forest plot of percent change in food prices and percent change in the child mortality rate

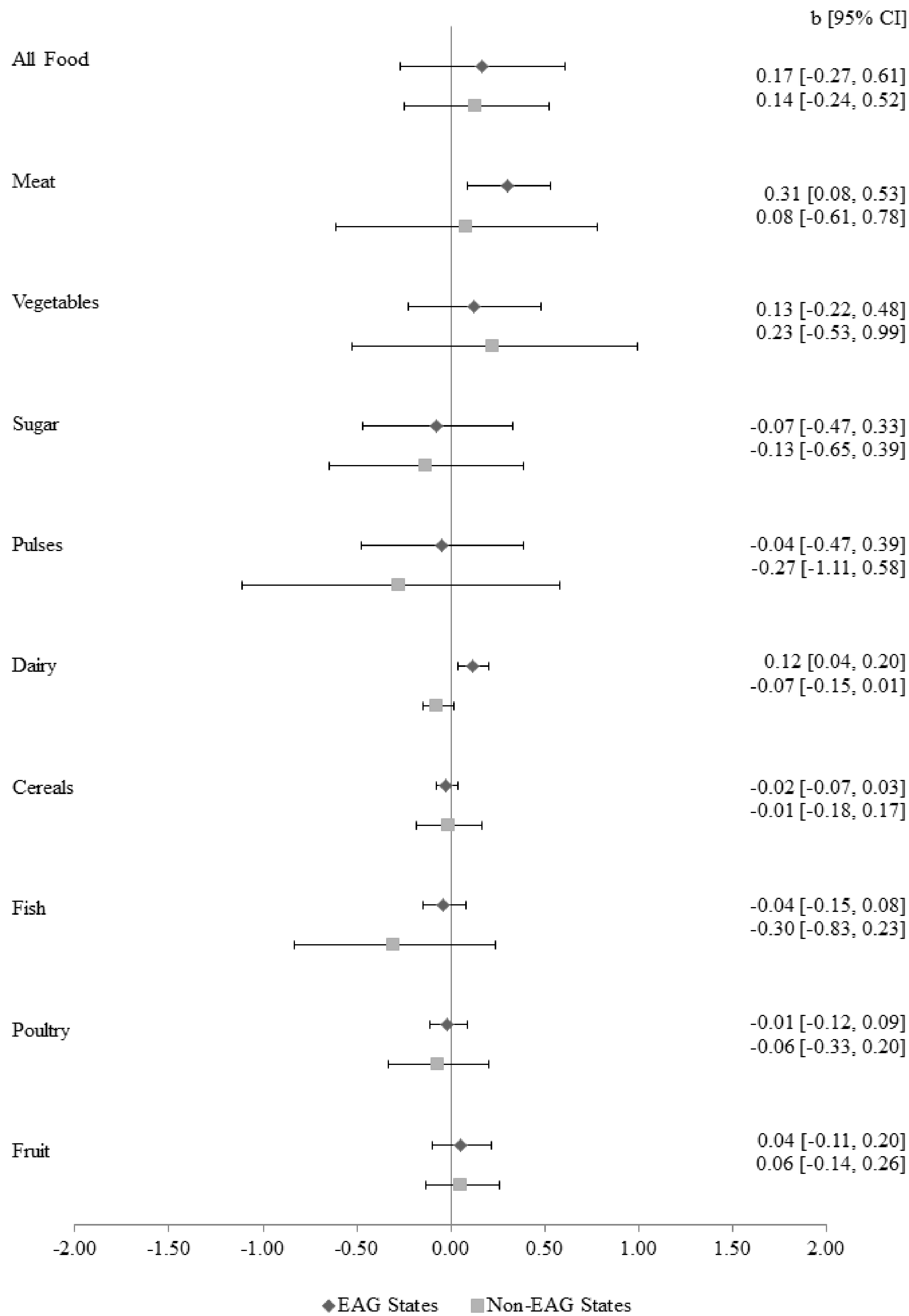
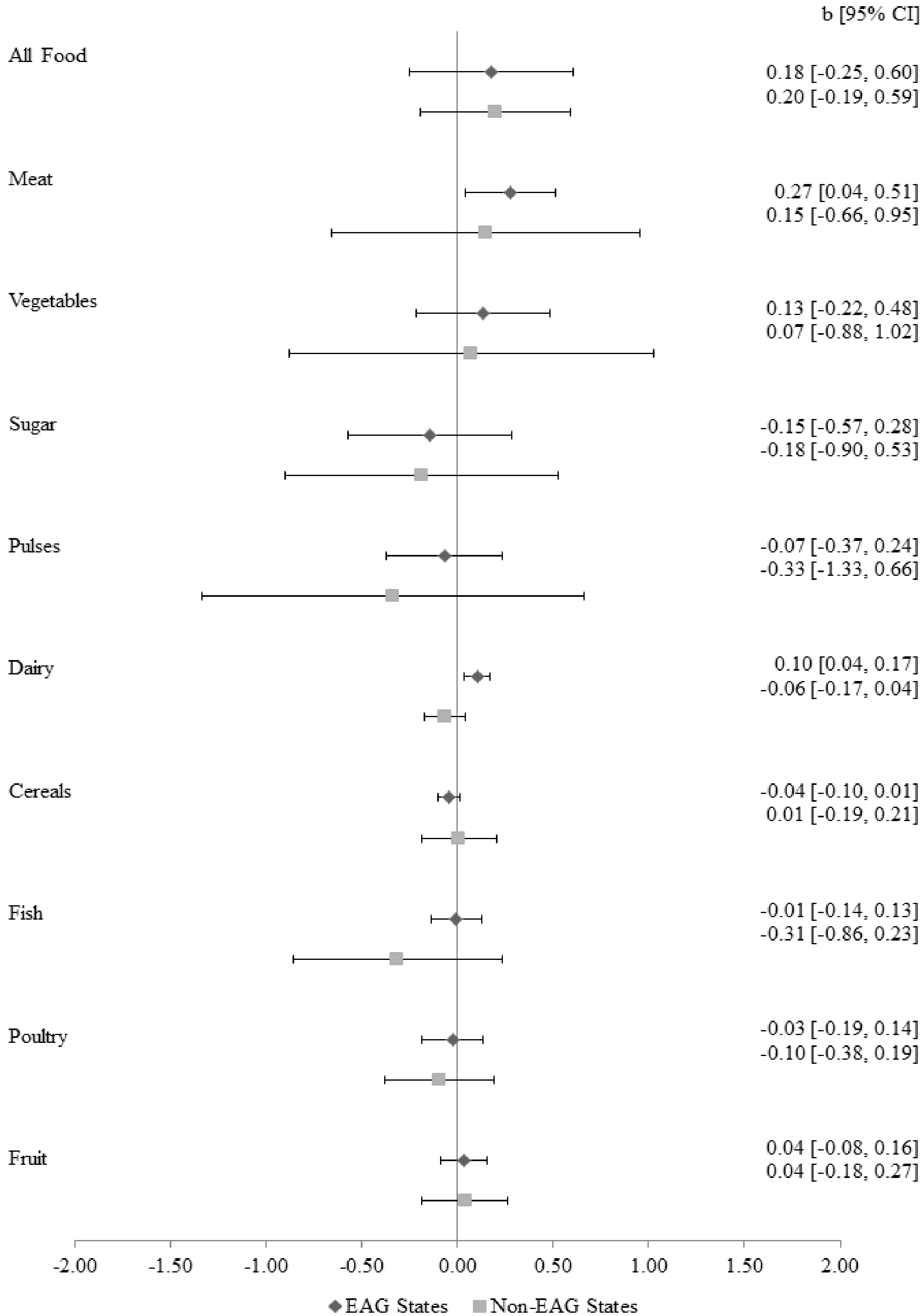


Figure 4. Forest plot of percent change in food prices and percent change in the under-five mortality rate

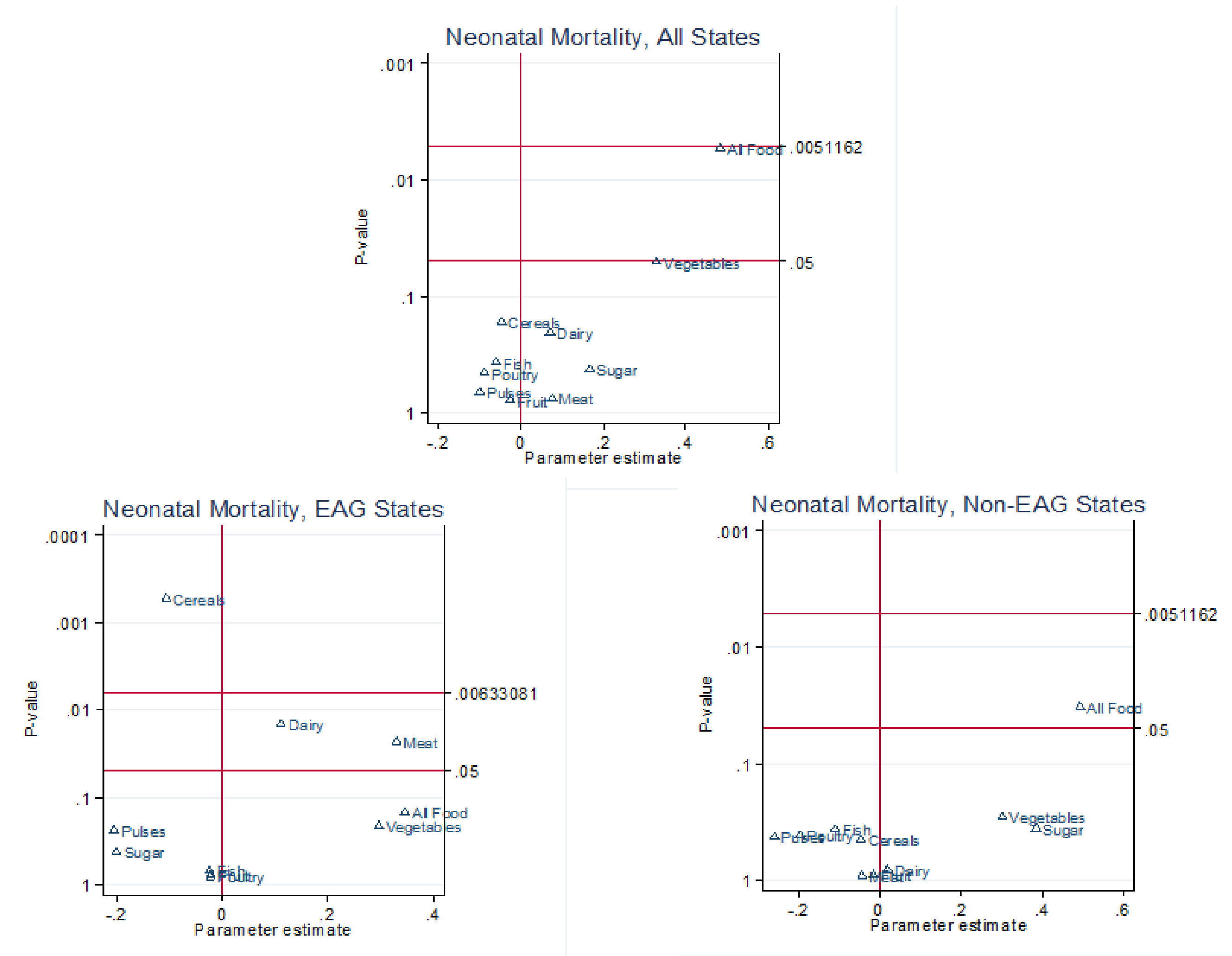


Web Appendix

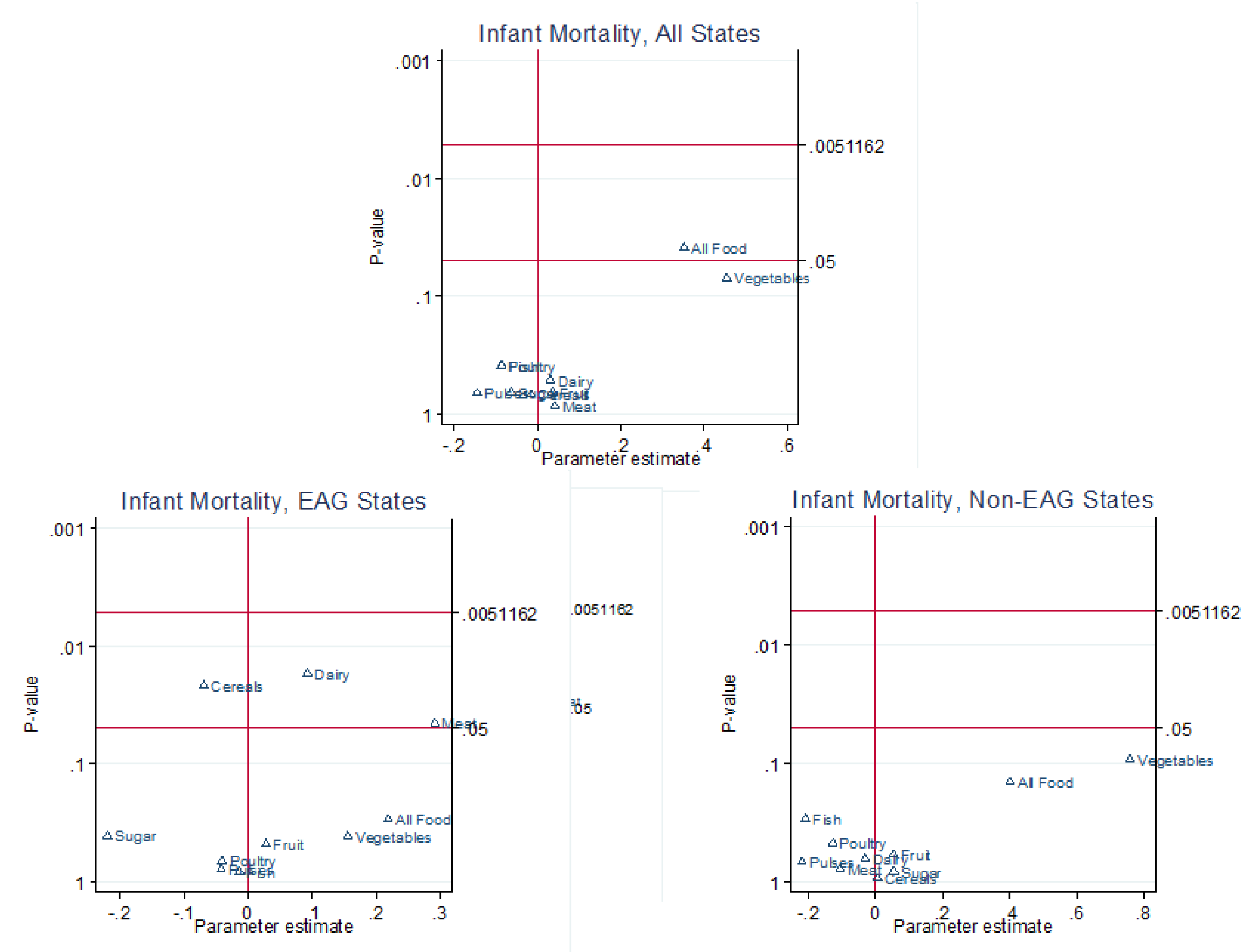
Web Table 1. Regression of % Change in Dairy Prices on % Change in Under-Five Mortality

	EAG States b(SE)	Non-EAG States b(SE)
% Change in Dairy Prices	0.10** (0.027)	-0.065 (0.050)
Proportion Low Wealth	-117.9* (35.6)	-59.6 (34.1)
Proportion Mid Wealth	-127.2 (61.6)	-17.8 (47.5)
Proportion Hindu	-21.2 (45.4)	34.0 (32.7)
Proportion Muslim	-56.6 (47.4)	37.5 (74.1)
Proportion Schedule Caste	36.0 (25.6)	-43.5 (52.9)
Proportion Scheduled Tribe	38.3 (36.9)	34.3 (27.5)
Proportion Other Backward Caste	52.2* (20.4)	53.7 (26.5)
Proportion Urban	-45.1* (15.0)	-37.6 (29.5)
Mean Maternal Age	0.56 (2.44)	0.59 (3.66)
Mean Parity	16.3 (16.7)	4.30 (43.7)
Mean Maternal Education (Years)	-4.77 (4.79)	-5.24 (4.37)
Mean Number of ANC Visits	5.49 (7.81)	4.27 (7.64)
Proportion Receiving All DPT Shots	10.3 (17.3)	-6.56 (49.6)
Logged State Domestic Product	10.4 (12.3)	-8.25 (4.95)
Change in Logged State Domestic Product	99.4 (44.0)	-340.9 (171.9)
Constant	-179.9 (164.7)	181.1 (120.4)
Observations	160	205
R-squared	0.223	0.185

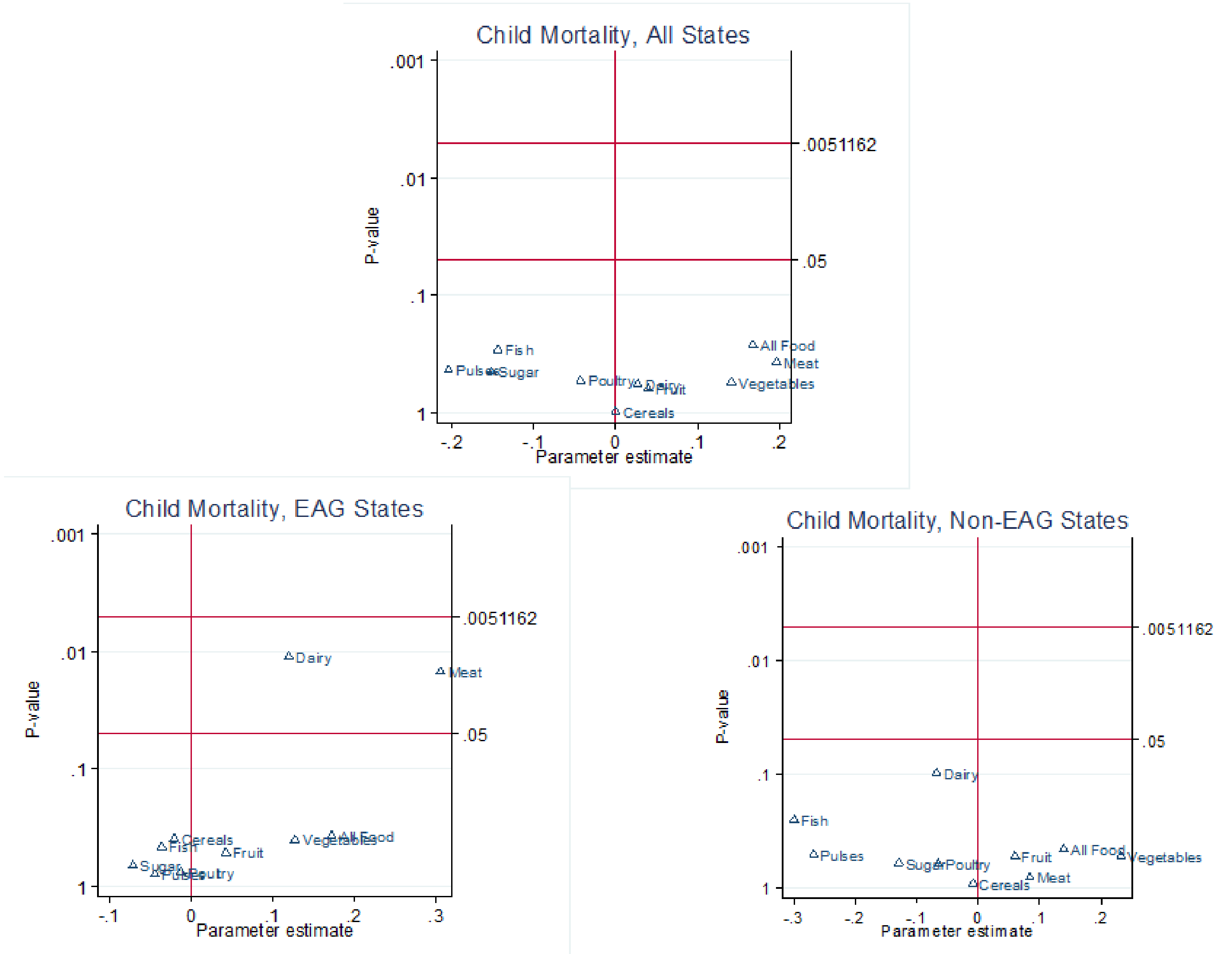
Web Figure 1. Smile plots for NNMR and food prices



Web Figure 2. Smile plots for IMR and food prices



Web Figure 3. Smile plots for CMR and food prices



Web Figure 4. Smile plots for U5MR and food prices