ESSAYS ON DRIVERS OF DIETARY CHANGES IN INDIA

by

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A thesis submitted for the degree of Doctor of Philosophy in Economics

Oct 2018

Acknowledgments

This thesis marks a significant milestone in my life. This work would not have been completed or even written without the support and understanding from several important people.

First of all, I would like to express my sincere gratitude to my thesis supervisors, Prof. Iain Fraser and Dr. Matloob Piracha, for their tremendous academic support and valuable guidance. Thank you for giving me the freedom to work in my own way while helping me to overcome the setbacks in this PhD journey. I thankfully acknowledge the financial support from the University of Kent for my research study.

I would also like to thank Dr. Alejandro Riaño, my master supervisor in the University of Nottingham for believing in my ability to pursue a research degree in Economics. I would not have applied without his incredible encouragement and help. I cannot overstate the impact which he has upon my academic career to date, for which I am extremely grateful.

Many thanks to Dr. Mia Mikic and Dr. David Hallam for giving me the opportunity to work in the UNESCAP and FAO, which enabled me to grow as an independent researcher and prepared me for a future career in economics.

I also have to thank participants in European Trade Study Group Conference in Helsinki, Expert Meeting on Trade and Nutrition at the Food and Agricultural Organisation, Royal Economic Society Annual Conference in Bristol, Globalisation and Economic Policy Postgraduate Conference in Nottingham, and Global Food Symposium in Göttingen. Their comments have greatly benefited the analysis in Chapter 2 of this thesis.

My life as a PhD student has been made a lot easier with the company and help of my fellow postgraduate students in Canterbury, Andreas, Florian, Sevgi, Sashana, Yongo and Daniel. I will never forget the times we shared our joys and stresses in the PhD journey and the discussion we had on things other than our papers.

Special thanks to all my friends back in Hong Kong. Thank you for showing me that distance does not matter in true friendship.

My very profound gratitude goes to my family who have been patient, encouraging and supportive. I am forever indebted to my hard-working mother, Janice, for all the sacrifices she

made to provide me and my brother the best childhood we could ever asked for. She has taught me to try my best in everything that I do, the key to my academic and life achievements. I must also thank my brother, Roger, for taking care of all family matters so that I could further my studies in the UK.

Finally, I wish to express my deepest heartfelt thanks to Aled, my husband and life buddy, who has always stood by me throughout all the ups and downs in the last few years. He discussed research ideas with me and proofread my writing on many occasions. He also never complained when I spent all our weekends on STATA and R. Thank you for putting up with my crazy moments, enduring my anxiety and tempers with love and trusting me even when I did not trust myself. I would not have made it without you.

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Chapter 1

Introduction

1.1 Food and nutrition

From the nutritional point of view, the Sustainable Development Goals (SDG) adopted in 2015 are a much wider and ambitious set of target than the proceeding Millennium Development Goals (MDGs). In addition to the MDG's target of eradicating hunger, the SDGs also aimed to end malnutrition in all forms, including reducing stunting, wasting and overweight among children and addressing the nutritional needs of adolescent girls, pregnant women and older persons. This shift of attention in the international community is largely a response to the evolution of nutritional challenges faced by the developing world.

Over the last few decades, economic growth and the productivity improvements in agriculture and food systems that follow have greatly improved food availability and helped in achieving the MDG's objective of reducing hunger. However, health problems associated with undernutrition remains a widespread issue in the developing societies. From 1990 to 2010, the estimated prevalence of children under 5 years of age affected by wasting only decreased by 2.8% in South Asia and 0.9% in Sub-Saharan Africa (SSA) respectively. The speed of stunting reduction has also been slow, particularly in SSA (Haddad 2013). Meanwhile, these countries face an emerging burden from other facets of malnutrition. The incidence of being overweight have increased rapidly over the last 25 years (Kimenju and Qaim 2016). The number of overweight children under 5 years old quadrupled in low income countries from 1990 to 2011 (Haddad 2013). There is also rising incidence of diet-related chronic diseases. Over 80% of cardiovascular and diabetes now occur in developing countries (Islam et al. 2014). What is more is that not only are the affluent classes in these countries suffering from the diseases that are linked to overnutrition but also the lower socio-economic classes (Shetty 2013). With these emerging health issues, the nutritional challenge of developing countries is no longer simply reducing hunger but addressing the double burden of over and under nutrition simultaneously.

One underlying cause behind this change in nutritional challenges is the 'nutrition transition', a global phenomenon identified and documented by Popkin (1993). It is the shift of the dietary

pattern from traditional diets which are rich in cereals and fibre towards the one with higher shares of calorie intake from animal source products as well as processed foods. Many studies have pointed out that the both low and middle income countries have been experiencing a decline in the per capita direct use of cereals for food along with a definite increase in consumption of livestock products (Alexandratos and Bruinsma 2012; Popkin et al. 2012; Pingali 2015). For instance, while there were no increase in their cereal intake, the per capita meat consumption doubled to 80 kg per year in Brazil and tripled to 53kg per year in China from 1980 to 2007. Similar changes in different magnitudes have been observed in other developing countries, such as Ethiopia by Worku et al. (2017), the Pacific Islands by Thow et al. (2011) and, Hughes and Lawrence (2005) as well as Egypt, India, Mexico and the Philippines by Shetty (2013). According to the projection of Alexandratos and Bruinsma (2012), 36 out of 98 developing countries will consume more than 50kg meat per capita each year by 2050 while only 19 of them reached this level of consumption in 2005-2007.

On the one hand, higher intake of animal based products may increase the risk of obesity and diet-related non-communicable diseases such as diabetes and cardiovascular disease as these foods tend to be sources of macronutrients that may not be desirable to human health like saturated fatty acids and cholesterol. In addition, meat consumption has been associated with a higher risk of colon cancer in several studies (Murphy and Allen 2003). On the other hand, animal products are dense and palatable sources of energy and high-quality protein. They provide a variety of essential micronutrients, some of which, such as vitamin A, vitamin B12, riboflavin, calcium, iron, zinc and various essential fatty acids, are difficult to obtain in adequate amounts from plant-based foods alone and are often deficient in diets in low and middle income countries (Gill et al. 2015; Herrero et al. 2013). Deficiency in these nutrients can lead to adverse health outcomes like anaemia, diminished work capacity, night blindness and poor growth. By increasing the intake of these micronutrients, the dietary shift towards higher intake of animal products are likely to benefit vulnerable groups, including infants, children, pregnant and nursing women. However, when intake levels rise further, these nutrient benefits decline rapidly and the associated risk of obesity and other diet-related diseases increases. There is, thus, a fine line in the nutrition transition between ensuring nutrient adequacy while avoiding excessive consumption, making it more difficult and complicated for the governments to address the double burden of malnutrition through food policy.

In much of the developing world, the food system has neglected the decline in dietary importance of cereals. With the focus on combating hunger, the current social protection in these countries is designed to ensure the access of basic staples rather than to promote a nutritionally balanced diet. For instance, the Egyptian government has been providing price subsidy on baladi bread, wheat flour, sugar and cooking oil at a subsidised price since 1991. Asfaw (2007) examines the impact of this program on mothers'weight and finds that the predicted body mass index of mothers increases as the price of baladi bread decreases. He argues that the food subsidy program aggravates obesity in Egypt by greatly reducing the per calorie prices of food items that contain disproportionately high amounts of carbohydrates but inadequate amounts of essential

micronutrients in relation to other energy-dilute but nutrient-dense diets. In their study on the Indian Targeted Public Distribution System (TPDS), Kaushal and Muchomba (2015) find the provision of subsidised wheat and rice to poor Indian families has very limited effect on their calorie and protein intake. While both of these schemes impose a significant cost burden on the government, they are falling behind in coping with the nutrition transition and the evolving nutritional challenges.

On top of consumer price subsidies, tremendous government efforts have also been put into increasing agricultural productivity in the developing world, especially for the big three cereal crops rice, wheat and maize. This has hampered diversification of food production system. For example,in the Philippines intensive rice monoculture systems led to the loss of wild leafy vegetables and fish that the poor had previously harvested from rice paddies (Pingali 2012). In their multi-country study on the response to food prices, Pinstrup-Andersen (2015) provide evidence that agricultural policy was, in most cases, driven by the desire to manage food prices at the farm and consumer level rather than a concern about the nutritional aspects of food security. Indeed, the gap between grain production and the amount used for human food consumption has been widening steadily in recent decades. From 1970 to 2010, the surplus of staple cereal crop production over food consumption increased from around 10 million tons in 1970 to 60 million tons in 2010 in South Asia, in which 60% of the surplus were rice and wheat (Pingali 2015). This heavy focus on staple cereal grain production has inadvertently constrained the ability of agricultural policies to promote positive nutritional outcomes, making it slow to respond to the recent dietary shift from cereals to animal products and is also ineffective in tackling the persistent problem of undernutrition as well as the emerging burden of overnutrition.

To tackle the double burden of malnutrition, food policy in the developing world needs to move away from its current emphasis on staple grain and calorie sufficiency towards nutritionally balanced diets. However, such a policy redirection is not feasible without a thorough understanding of why there was a dietary shift from traditional staple in the first place. In this regard, this thesis uses econometric analysis to examine the factors influencing the dietary habits of the population in the context of India. Due to its growing population and thus the strong influence on global development, India has been a popular case study in the food and nutritional literature, particularly with regard to the nutrition transition. Through comparing the food consumption patterns between 1975 and 1995, Shetty (2002) finds while there was a gradual reduction in cereal grain consumption, the average energy intake did not decrease owing to the rise in consumption of animal products and edible oils. The decline in cereal consumption is reaffirmed in Deaton and Drèze (2009) which documented that per capita calories intake from cereals has decreased more rapidly than that from all foods from 1983 to 2004-05 in both sectors. In addition, Meenakshi (2016) illustrates that the dominance of cereals in budget share is decreasing even among the poorest tercile with an increase in shares of animal products. Hence, there is a recognition in literature that Indian food consumption has shifted from traditional staples to animal products in the last few decades.

Despite the rapid economic growth in India, its progress in dealing with malnutrition reduction

has been slow. According to the Global Hunger Index, provided by the International Food Policy Research Institute in 2017, the hunger situation of India remains serious.[1] Half of the world's underweight children are in India (Bentley et al. 2015). There are also high rates of stunting among Indian children. In addition to these undernutrition problems, the prevalence of childhood and adolescent overweight in India is increasing, with recent estimates of around 20% to 25% in urban areas (Thow et al. 2016). Furthermore, the problem of overnutrition is no longer confined to the urban domain but appear widespread in rural areas as well (Meenakshi 2016). Diabetes prevalence ranges from 3% in rural areas to over 8% in urban areas, with a total of 62.4 million Indians living with diabetes (Thow et al. 2016). In 2008, noncommunicable diseases accounted for 53% of the deaths. Economic losses in India due to cardiovascular disease have been estimated at US$2.25 trillion from 2012 to 2030 (Khandelwal and Reddy 2013). With this co-existence of over and under nutrition, combined with its growing population and recent dietary trends, India represents a relevant and important setting for us to investigate the drivers behind the nutrition transition.

Additionally, the current Indian food policy has been criticised for its heavy focus on staple grains. As mentioned before, the social protection scheme of India is heavily biased towards wheat and rice. Even food-based assistance programs that have health and education objectives, such as the Integrated Child Development Scheme (ICDS) have morphed into conduits for the supply of subsidised grains rather than allowing food provision to vary by local preferences and nutritional requirements (Pingali et al. 2017).[2] There is also limited evidence that ICDS has improved child nutritional status in India (Balarajan and Reich 2016). Its sole focus on staple crops as food assistance has been argued by Banik (2016) as one of the major reasons why this scheme has not been effective in reducing malnutrition. The findings from this thesis will shed light on how Indian food policy can address the double burden of malnutrition within the country through redirecting its current focus on staple grains to one that is more nutrition sensitive.

1.2 Thesis overview

This thesis primarily uses the household consumption data from multiple rounds of the National Sample Survey (NSS) which were conducted on a national scale by the government of India from 1987-88 to 2011-12. In each NSS round, Indian households are asked to recall their expenditure in rupee and physical quantity whenever appropriate on over 100 food items along with other non-food items within a specified reference period. The NSS provides comprehensive information on household demographics and also the socio-economic characteristics of the members. But as in other expenditure surveys, it does not collect data on the market prices of various items. To account for this data limitation, we first obtain unit values of food items by dividing the expenditure with quantity purchased and then correct these values for measurement errors and quality effect based on Majumder et al. (2012). The resulted quality and demographically adjusted unit

[1] Available at http://ghi.ifpri.org/

[2] ICDS aims to provide balanced nutrition for pregnant and lactating mothers and children under six years of age.

values are used as the proxy for market prices of food items. Refer to Data Appendix for a more detailed description of the NSS data.

In terms of specific research issues addressed, we present three empirical studies.

Study 1: Trade liberalisation and nutrition

Trade liberalisation has been identified in many studies as one of the key causes of the adoption of non-traditional diet in developing countries (e.g. Pingali and Khwaja (2004); Thow and Hawkes (2009); Kearney (2010); Blouin et al. (2009)). However, these studies only provide descriptive evidence on the linkage between trade and diet. In Chapter 2, we perform an econometric analysis with instrumental variables to investigate how trade has actually affected food consumption patterns. Specifically, we examine whether the difference in consumption of cereal and animal products across Indian rural regions before and after the trade reforms in 1991 can be attributed to their differential degree of exposure to tariff cuts. Pooling from the NSS data, this study uses a geographical repeated cross-section dataset to examine this trade-diet link. The measure of regional exposure to trade liberalisation is constructed using Indian Census, product and industry level tariff data obtained from multiple sources. This study not only establishes the trade-diet link, but also investigates the possible channels behind this link. The estimates reveal that food tastes are an important channel in addition to income and prices.[3]

Study 2: Consumer tastes and nutrition

The importance of food tastes as a channel between trade and diet found in Chapter 2 suggests that income and food prices are not the only factors driving the nutrition transition. Indeed, Deaton and Drèze (2009) argue that there have been important changes in Indian food habits that are not easily explained by changes in income and food prices. They point out that a simple explanation for the dietary shift from cereals is the changes in 'consumer tastes'. In Chapter 3, we investigate how changes in food preferences have contributed to the nutrition transition in India. A demand system approach is used to estimate time-varying income and price elasticities for cereals in order to infer changes in household preferences for cereals. Our estimates show that Indian demand for cereals have become less responsive to income growth and more responsive to changes in cereal prices. Cereals are found to have become a substitute rather than a complement to animal products in household diets, suggesting that cereals have become less preferred than before.

[3]We extend this study to the rich and poor households in the Extension Analysis.

Study 3: Food policy and nutrition

As discussed before, the Indian food system has been criticised for its heavy bias on staple grains. Among all food assistance programs, the Midday Meal Scheme (MDMS) is often considered to be the most successful one implemented by the Indian government, at least in terms of outreach (Singh et al. 2013). It is a nationally mandated program which provides free cooked meals to primary students in public schools across all states in the country. These meals are composed mainly of local staples and supplemented with other foods occasionally. In Chapter 4, we look into the whether the provision of free school meals has brought nutritional benefits to Indian households in spite of its focus on calorie and protein sufficiency. In addition to the NSS data, this study also employs data from the District Information System for Education (DICE) to capture the schooling situation faced by households residing in different districts. Through applying propensity score matching (PSM) methods, we find that as compared to households who did not benefit from MDMS, recipient households enjoy a more diverse diet and have a higher daily calorie acquisition. The magnitude of these nutritional gains is shown to differ greatly across households in different social groups.

1.3 Summary

The last chapter of this thesis summarises the findings from the above three empirical analyses and offers insights into how food and nutrition policies can be adjusted to tackle the contemporary challenges of over- and under-nutrition.

Chapter 2

Unintended consequence of trade on regional dietary patterns in rural India[1]

Abstract

This paper investigates how trade liberalisation has contributed to a dietary shift from one dominated by traditional staples to one high in animal products, a trend that is associated with both improved intake in micronutrients, and higher rates of obesity and other diet-related diseases in developing countries. In the context of Indias trade liberalisation in 1991, we examine whether the difference in consumption of cereals and animal products across rural regions before and after the reforms can be attributed to their differential degree of exposure to tariff reductions. The estimates reveal that trade reforms have a negative impact on cereal consumption through reducing edible oil prices and a positive effect on the consumption of animal products through enhancing consumer tastes towards these foods. These findings provide evidence for the role of trade in supporting dietary diversity and highlight the need for complementary policies to enhance the coherence between trade policy and nutrition actions.

[1]This chapter has been revised and submitted to the *World Development* as a single-authored paper and is currently under review.

2.1 Introduction

Many developing countries consider international trade of great importance for achieving economic growth. In recent years, increasing attention has been paid to the effect of trade policy on population health. One key pathway identified in the literature is the unintended relationship between changes in trade policy and the outcome on diets and thus nutrition (Blouin et al. 2009; Hawkes et al. 2010) . In the developing world, there has been a dietary shift from one dominated by traditional staples to one high in animal products and other non-cereal food. Some studies claim that the adoption of a non-traditional diet is partly driven by trade liberalisation (Shetty 2002; Pingali and Khwaja 2004; Thow and Hawkes 2009; Kearney 2010). However, the role played by trade reforms in this dietary transition, which we refer to as the trade-diet link, has been little researched in literature. The issue is further complicated by the fact that trade impacts on dietary patterns may not only pass through standard economic factors, such as income and food prices, but also tastes and preferences for different types of food. Nonetheless, little is known of the linkage between trade reforms and food tastes.

The decline in cereal consumption is the key feature of the dietary transition as cereals are the traditional preferred food and the major source of nutrients in many developing countries. This trend signals that diet has become more diversified than before, which contributes to a lower incidence of micronutrient deficiencies and hence improves health outcomes such as lower risk of maternal and infant mortality at birth and higher resistance to infections (Rashid et al. 2011). Another important characteristic of the transition is the rise in consumption of animal products. This trend has led to growing health concerns due to its association with obesity and diet-related non-communicable diseases (Kearney 2010; Popkin et al. 2012). These two trends are apparent in the developing world. For instance, many researchers have documented a shift in Indian dietary pattern away from cereals to animal products and other foods (Rao 2000; Shetty 2002; Mittal 2007; Oldiges 2012). According to the Food and Agricultural Organisation (FAO), the calorie intake from cereals in India decreased from 1556kcal to 1461kcal from 1989 to 1998 while that of animal products and edible oils increased from 337kcal to 400kcal. In light of the nutritional and health implications, this paper addresses the identified gap in the literature by investigating how trade policy impacts the consumption of cereals and animal products.[2]

This paper utilises an exogeneous trade policy shift in India to identify the trade-diet link. In 1991, Specifically, an extensive trade liberalisation policy was launched in India in which tariff barriers were progressively reduced over the next few years. Unlike many other trade reforms, this liberalisation was sudden and largely externally imposed (Topalova 2007). This implies that Indian households were unlikely to have expected these trade policy changes and adjusted their food consumption in advance. This ensures that any trade-diet link identified is therefore the outcome of trade liberalisation rather than changes driven by the anticipation of policy changes. Given its unanticipated nature, coupled with the dietary changes in recent decades, Indian trade

[2]Apart from these two trends, dietary transition in developing countries is also characterised by the rise in consumption of processed food. However, it is not feasible to investigate the trade impact on Indian processed food demand due to data limitations.

liberalisation in 1991 provides a clean, relevant and hence unique context for examining the role of trade in the dietary transition.

Our identification strategy builds on the work of Topalova (2007) which establishes a causal link between the Indian trade liberalisation and changes in poverty through exploring regional heterogeneity in the exposure to trade reforms. Under the liberalisation, each Indian region experienced different levels of reduction in trade protection because they had different pre-reform industrial compositions and tariffs for different industries were not cut uniformly. The overall tariff at a regional level can therefore be measured by the interaction term between the tariffs faced by industries and the share of a region's worker employed in these industries in 1991 (Topalova 2007). Apart from poverty, this approach has been employed to identify the unintended impact of the Indian trade liberalisation on development outcomes such as school attendance among children and relative female survival rate (Edmonds et al. 2010; Chakraborty 2015). This paper extends this approach to establish the trade-diet link in the context of rural India. Note that under this approach, we cannot evaluate the overall impact of tariffs on Indian diet. Rather, we investigate whether the changes in regional food consumption can be attributed to the reduction of trade protection at regional level.

The empirical analysis is divided into 2 parts. The first section establishes the linkage between Indian trade liberalisation and the consumption of cereals and animal products. With control for food availability, regional characteristics and time shocks, it is found that regions facing greater reductions in tariffs are likely to consume less cereals and more eggs, fish and meat. The average tariff cut (14.8 percentage points) is correlated with a 1.01 percentage point increase in food budget share on animal products and a 0.53 percentage point decrease in that on cereals (relative to the national trend). This trade-food consumption link provides solid evidence for the role of trade reforms in facilitating diet diversification and hence driving some of the observed dietary shift in rural India.

The second part of the analysis uncovers the underlying mechanisms between trade reforms and the consumption of cereals and animal products, which are income, food prices and food tastes. Income and prices impose constraints on the amount of goods that can be obtained by a consumer while food tastes determine the utility that he/she will receive from the goods. We capture food tastes for cereals and animal products using the regional component of the food budget share equation which cannot be explained by prices, income and household characteristics. The estimates indicate that the Indian trade reforms are likely to have negatively affected cereal consumption by reducing the price for edible oils since they are regarded as a substitute for cereals. For animal products, the trade impact is channelled mainly through the enhancement in food tastes. Regions exposed to larger tariff declines appear to have stronger tastes for eggs, fish and meat, which in turn contributes to the relatively higher consumption of animal products.

The present paper contributes to an underdeveloped strand of the empirical literature on the linkage between trade and diet. For example, only a few studies have attempted to empirically relate trade policy changes to beverage consumption. Schram et al. (2015) and Baker

et al. (2016) show that a reduction in trade and investment barriers may have increased sales of sugar-sweetened carbonated beverages in Vietnam and encouraged soft-drink production in Peru respectively.[3] We provide evidence for the unintended trade outcome on consumption of cereals and animal products, an area that has not been empirically addressed in the literature. It highlights the role of trade in encouraging diversification of diets from cereals towards eggs, fish and meat. To our knowledge, this paper is the first to identify the trade impact on food tastes. Our findings stress that apart from income and food prices, food tastes do play a key role behind the trade-diet link although the relative importance of these channels may vary from case to case.

The evidence on the dietary outcome of trade is of crucial importance to policymakers. In the 2014 Rome Declaration of Nutrition, governments from around the world acknowledged that '*trade policies are to be conductive to fostering food security and nutrition for all*' (FAO and WHO 2014). Through investigating the exogenous Indian trade liberalisation in 1991, this paper offers evidence on the potential incoherence between trade policies and nutrition objectives. Our results reveal that while trade can promote good nutrition outcomes through enabling households to diversify their diets from cereals, it may also undermine the effectiveness of nutrition actions by encouraging higher consumption of animal products. This points to the need for complementary public policies to manage these unintended dietary outcomes of trade. Furthermore, the analysis on the mechanisms behind the trade-diet link provides policymakers a clearer picture on the channels through which trade can facilitate the diversification of diet and hence enable them to make better-informed policy decisions regarding achievement of nutrition targets.

The reminder of this paper is organised as follows. The next section reviews literature on the linkages between trade, diet and health. Section 3 provides the background of trade liberalisation in 1991 and explains the exogeneity of the reforms. Section 4 describes the data and the diet diversity across Indian regions. Section 5 presents the empirical strategy and the results of the main specification. Section 6 investigates the importance of income, food prices and tastes as the channels behind the trade-diet link and Section 7 concludes.

2.2 Trade, diet and health: Review of related literature

Trade liberalisation has been widely recognised as a crucial factor in driving the dietary shift from one dominated by traditional staples to one higher in animal products. Different developing country examples have been employed to illustrate the potential linkage between trade policy and the dietary transition. Thow (2009) demonstrates a trend towards reduced consumption of staples and an increase in consumption of meat and meat products, eggs and oils in China in the early 1990s when tariffs and non-tariff barriers were reduced markedly. Popkin et al. (2012) show that prices of vegetables oils in China have been significantly reduced with the decline in the barriers to edible oil imports. This is consistent with the argument of Drewnowski et al. (2009) which states that world trade has reduced the relative cost of dietary energy and hence increased the consumption of energy-dense food. In India, Pingali and Khwaja (2004) observe that adoption

[3]We are grateful to a referee for pointing us to these studies.

of diets that no longer conform to the traditional local habits with the increasing influence from globalisation. Indian consumers now exhibit strong taste for meat, fish and temperate zone fruits. Vepa (2004) also argues that globalisation has increased the consumption of high-calorie food and the incidence of obesity in the middle and higher-classes of India.

Looking at other continents, Thow and Hawkes (2009) find that trade policy changes have directly affected the availability and prices of meat and processed food in Central American countries. They also point out that the consumption of such foods has been rising in these countries. According to Martorell and Khan (1998), this dietary shift is associated with the increasing burden of obesity and non-communicable diseases reported in the region. The linkage between trade, diet and health has also been identified in the Pacific islands. Thow et al. (2011) illustrate that trade policy changes in Fiji and Samoa have contributed to a reduced availability of traditional staples and increased availability of meat, fats and other processed foods.[4] Cassels (2006) notes that the ease of global food trade has contributed to a higher consumption of animal products and processed food, a lower consumption of carbohydrates and increased rates of obesity in the Federated States of Micronesia. Other research on the Pacific countries have also demonstrated the potential link between displacement of traditional diets and the concomitant increase in obesity rates and chronic diseases (Blouin et al. 2009).

Overall, there is agreement in literature that trade liberalisation has played a vital part in the shift of food consumption patterns from cereals to animal products in developing countries. This dietary development is likely to be further exacerbated with the continued increase in international trade (Thow and Hawkes 2009). While the above case studies shed light on the potential connection between trade and diet, they provide limited insight on the causality due to the use of a descriptive methodology. This reflects that there is a gap in our knowledge on the effect of trade policy on dietary patterns (Rayner et al. 2006; Popkin et al. 2012). Furthermore, research on Central America and the Pacific has stressed the association between dietary transition and the risks of obesity and other diet-related diseases. Blouin et al. (2009) argue that the shift in dietary patterns is a vital pathway of the linkage between trade and health. This implies that the unintended consequence of trade on food consumption has a profound impact on the health development of people, which further highlights the need for empirical research on the trade-diet link.

2.3 Indian trade liberalisation in 1991

2.3.1 Background

The trade environment of India was highly restrictive in the early 1980s. The shift of development strategy to export-led growth was largely triggered by the double deficit faced by the Indian government in the late 1980s. The fiscal deficits reached 10.1 percent of the GDP due to the rapid expansion of government expenditure (Panagariya 2008). The credit rating of India

[4]We thank a referee for bringing this paper to our attention.

was therefore downgraded, which severely hit the confidence of investors and led to the surge of capital outflows. On the external front, the Gulf War in the Middle East caused a significant decline in the demand from key trading partners and also the remittance from Indian workers (Topalova 2010). Coupled with the spike in oil prices, India was close to a balance of payment crisis. The external debt rose threefold from $20.6 billion in 1980-81 to $64.4 billion in 1989-90 (Panagariya 2008).

In 1991, the Indian government unexpectedly turned to the International Monetary Fund (IMF) for assistance with its external payment. To fulfil the conditions for the IMF financial aid, India announced a series of sweeping trade reforms under the Eighth Five-Year Plan. These reforms came as a surprise to the Indian society owing to the several earlier attempts to avoid IMF loans and the associated conditionalities, the large number of members of the new cabinet who had been cabinet members in the past governments with inward-looking trade policies and the heavy reliance on tariffs as a source of revenues (Hasan et al. 2007).[5] The average effective tariff rate was slashed from about 86% in 1989-90 to about 40% in 1991 and the maximum tariff was cut from 400% to 150% (Hasan et al. 2007). The tariffs across industries were greatly reduced and harmonised over the next few years. The government also eased the quantitative restrictions for many non-agricultural goods.

For the agriculture sector, while the restrictions on exports were reduced in the reforms, the structure of protection on imports was relatively untouched. From 1991 to 1997, livestock and fish cultivating industries in India experienced around 45% decrease in average tariff while that for cereals and oilseeds industries was less than 20%. In 1994, with the conclusion of the Uruguay Round trade negotiations, India committed to bind its tariffs on most commodities at rate ranging from 0% to 300%. The resulting Agreement on Agriculture took effect in January 1995. This agreement had limited real effect on Indian agricultural trade as the applied tariff rates at that time were considerably lower than the bound rates. More importantly, imports of some agricultural products, including cereals and animal products remained under either quantitative restrictions or the control of state trading enterprises.

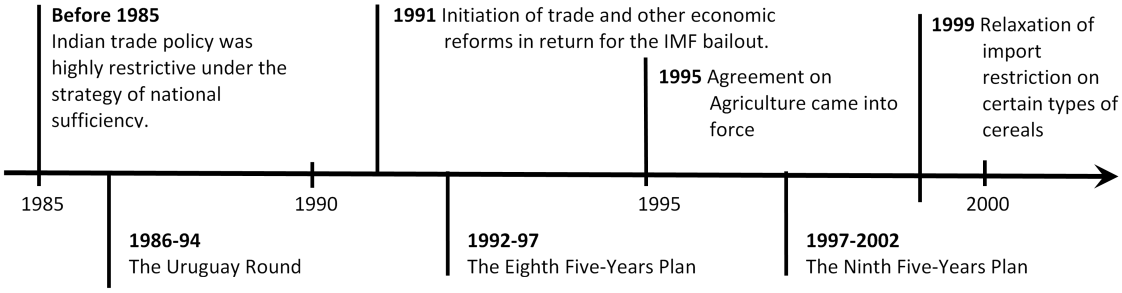
Further changes in trade policy were implemented in the Ninth Five-Year Plan (1997-2002) although the external pressure was no longer present. Many of the non-tariff barriers on agricultural imports were removed in this period. For instance, in 1999, imports of common varieties of rice with 50 percentage or more broken were allowed freely. The timeline in Figure 2.1 provides a summary of the major macroeconomic events in India from 1985 to 2002.

2.3.2 Endogeneity concerns of trade policy

A common concern over investigating the impact of trade policy changes is that industries with higher import penetration are likely to lobby for greater protection, in other words, lower tariff reduction (Trefler 1993). This endogeneity issue would undermine the efficiency of an

[5] See Topalova (2007) for a more detailed discussion on the extent to which trade liberalisation was unanticipated by the society.

Figure 2.1: Timeline of the trade liberalisation in India, 1985-2002



empirical strategy in estimating the trade impact. However, this is unlikely to be a problem for the Indian trade reforms due to two reasons. First, as mentioned in the last section, the liberalisation was initiated under external pressure from the IMF and was unlikely to have been anticipated by society. The chance that firms could adjust their consumption and production decision in advance was very slim. Second, the radical changes in tariffs were not confined to a specific group of industries, mitigating the concerns that structure of trade reforms was shaped by the lobbying of more productive industries.

To assess the exogeneity of Indian trade liberalisation, Topalova (2010) conducts several checks on the structure of the tariff reduction from 1987 to 2001. She finds that the changes in trade policy did not appear to have been selectively manipulated by policymakers as the movements of tariffs at the disaggregated product level were highly uniform until 1997. There is also no significant association between current productivity and future tariffs for the years 1989-96 in her correlation analysis. It should be noted that the evidence on uniformity in tariff movement and correlation between current productivity and future tariff were only seen for the period until 1997. In view of the potential policy endogeneity in the second wave of trade liberalisation (1997-2002), this paper does not investigate the trade impact on regional dietary patterns beyond 1997.

2.4 Data and diet diversity across Indian regions

2.4.1 Data

The primary data in this study is the Indian household expenditure data from the 43rd and 45th to 53rd rounds of the National Sample Survey (NSS), covering 11 consecutive years from 1987 to 1997. We aggregate over 100 food items into several food groups and focus on regional consumption of cereals and animal products which consist of eggs, fish and meat.[6] In total, over 70 Indian rural regions are studied.[7] We do not investigate the urban sector due to the endogeneity

[6]Milk is not counted in animal products since it plays a very different role compared to eggs, fish and meat. According to Sen (2004), milk is considered to be a pure food in Hindu religious rituals. It is one of the foods taken by Muslims to break the Ramadan fast. Moreover, it serves as the key source of protein in Indian traditional diet

[7]The NSS regions are used as the geographical unit of analysis since some survey rounds do not record the districts (a higher disaggregated unit than regions) where household resides. Moreover, the district samples from multiple surveys may not be consistent over time as the boundary of districts is sometimes redefined across rounds (Panagariya 2008).

concern raised by Topalova (2010) over simultaneous reforms and pre-existing trends in urban areas, and the fact that the urban sector is likely to have much more exposure to foreign culture and food prior to the liberalisation, given the colonial history of India. For each rural region, we compute the average of food prices, food budget shares and monthly per capita expenditure (MPCE). The results of each year are then pooled to form a geographically repeated cross-section dataset of food expenditure patterns across Indian regions.

Calculating the exposure of trade reforms faced by each region requires data on the tariff rates in each industry and the industry composition of the region prior to the start of liberalisation. The latter is acquired from the Indian Census carried out in 1991, which gives the number of workers in each region at 3 digit industry level. Tariff data comes from multiple sources. Manufacturing tariffs are adopted from Aghion et al. (2008) which map tariff data at a 6 digit level of the Harmonised System (HS) to the 3 digit industry codes using the concordance of Debroy and Santhanam (1993). For trade protection faced by the primary sector, we match the product-level tariff rate from Topalova (2010) to the industries based on Debroy and Santhanam (1993). Since this dataset does not cover all the 6 digit items listed in Debroy and Santhanam (1993), we utilise the HS tariff data from the World Integrated Trade System (WITS) database to fill in the gap.[8]

With limited disaggregated data on non-tariff barriers (NTBs), it is not feasible to construct a time-varying measure of NTBs across regions and hence they are not accounted for in the empirical analysis. While this may reduce the precision of the estimated impacts of tariff reduction in this paper, it does not undermine the empirical strategy because of the highly positive correlation between NTBs and tariffs revealed in research for other developing countries (Topalova 2007). The ignorance of NTBs only implies that some of the trade effect captured is attributed by the decline in NTBs instead of tariff cuts.

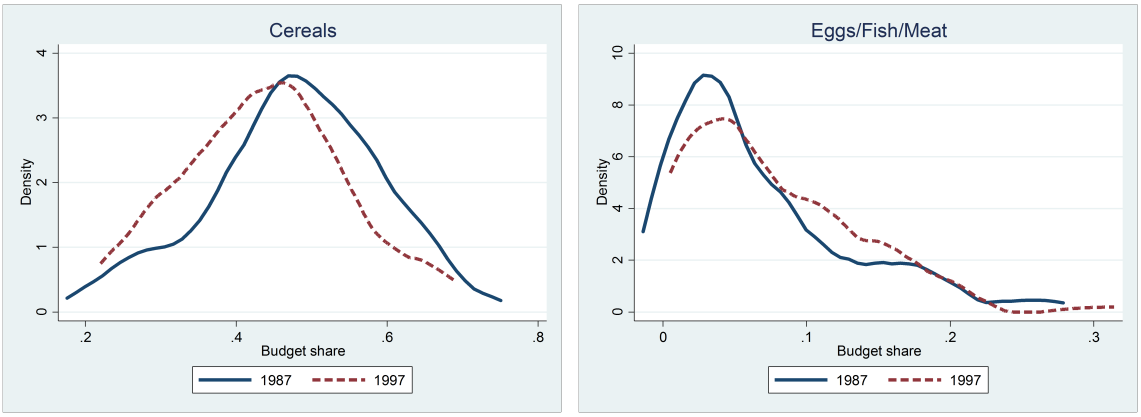
During the period of liberalisation, the Indian government also reformed foreign direct investment (FDI) policy and de-licensed many industries. The rate of foreign investment increased from 40% to 51% for high technology and high investment industries in 1991. According to Arnold et al. (2016), the scope of foreign ownership in major service sectors was improved but remained limited. FDI in agricultural sector continued to be highly regulated. Under the Industries (Development and Regulation) Act of 1951, industries in the manufacturing sector were required to obtain a license for various production activities such as the establishment of a new factory and product lines (Aghion et al. 2008). In 1991, the licensing requirement for most industries was abolished with the exception of some strategic sectors. To isolate the effect of trade liberalisation from these contemporaneous reforms, we construct regional indicators of FDI reform and industrial delicensing with data from Aghion et al. (2008). Summary of data sources and descriptive statistics can be found in the Appendix.

[8]The trend of tariffs reduction for the ones covered in Topalova (2010) is matched with that of the uncovered items if they share the same tariff rates in 1990, 1992 and 1999. Despite the data difference, our tariff measure is comparable with the district-level estimates in Topalova (2010) and the state-level estimates in Hasan et al. (2007).

2.4.2 Regional diet diversity

While cereals have always been at the centre of the traditional India diet, there are many variations in dietary habits across regions (Sen 2004). Wheat is the basic meal for regions in the North, which are characterised by the dominance of wheat cultivation. But rice is the key staple for the rice producing regions in the South and East. Vegetables and animal products are added to complement the flavour and nutritional value of the main grain (Sen 2004). In spite of the common belief, the majority of Indians are non-vegetarian. In 1994, less than 20% of the total population did not eat meat, fish and eggs at all. This figure varies from 5% to 69% across Indian states (Achaya 1994). There are also massive regional differences in terms of consumption of eggs, fish and meat. For example, in 1987-88, fish took up 10.6% in food budget of Southern Kerala but less than 1% in Western Rajasthan (Atkin 2013).

Figure 2.2: Distribution of regional average budget share on cereals and EFM, 1987 and 1997

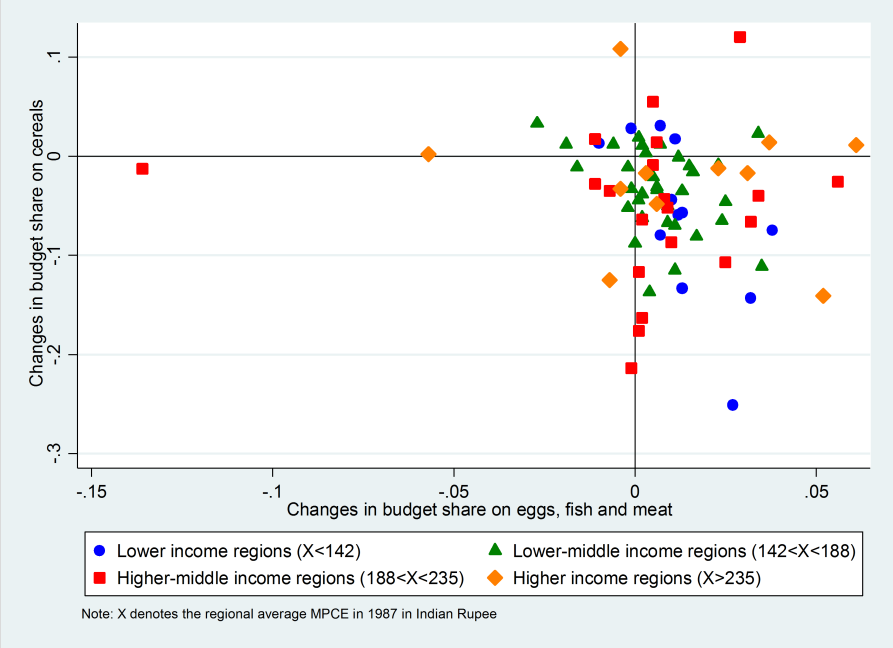


A look at the data reveals that there are obvious shifts in the pattern of regional diet diversity in the sample period. Figure 2.2 compares the kernel density functions of regional food budget shares on cereals, and eggs, fish and meat in 1987 and 1997. As one would expect, a higher proportion of food expenditure is spent on staples rather than animal products. Over the years, cereal consumption at regional level has become less diverse and shifted to the left (i.e. decreased) and that of animal products has moved to the right (i.e. increased). This reflects the increase in the dietary importance of eggs, fish and meat relative to cereals, which is in line with the dietary shift documented by the literature on Indian food consumption.

The scatter plot in figure 2.3 shows the difference in budget shares on cereals and animal products of each region between 1987 and 1997. The rural regions are classified into 4 income groups based on their average MPCE in 1987. There are considerable variations in the dietary changes across regions. Most of the regions are located in the lower right quadrant of the plot, suggesting that they consumed more eggs, fish and meat and fewer cereals in 1997 than in 1987. While the richer regions tend to have more dramatic changes in their average budget shares on cereals and animal products, there is no conclusive relationship between the regional income at baseline and their changes in food consumption.

To further illustrate the regional diversity in food consumption, dietary changes of a few se-

Figure 2.3: Changes in regional food consumption in rural India from 1987 to 1997



lected regions are given in Table 2.1. Northern Orissa and Delhi were the poorest and richest regions in 1987 respectively. In general, richer regions tend to consume less cereals and more animal products, with the exception of Delhi. Among all regions in our sample, Southern Rajasthan experienced the largest decline in cereal consumption. From 1987 to 1997, its average share of food expenditure on cereals had decreased from 47% to 22%. The increase in animal product consumption was most obvious in Lakshadweep in which the food budget share on eggs, fish and meat rose from 23% to 29%.

Table 2.1: Changes of budget share on cereals and animal products of selected regions

Region	MPCE in 1987 (in Indian rupee)	Cereals			Eggs, fish and meat		
		1987	1997	Change*	1987	1997	Change*
Northern Orissa	108	0.684	0.698	0.013	0.055	0.045	-0.01
Southern Rajasthan	132	0.470	0.218	-0.251	0.014	0.041	0.027
Coastal and Ghats of Karnataka	219	0.416	0.390	-0.026	0.081	0.137	0.056
Mozoram	254	0.320	0.428	0.108	0.176	0.172	-0.004
Lakshadweep	272	0.245	0.256	0.011	0.226	0.287	0.061
Delhi	340	0.185	0.173	-0.012	0.033	0.056	0.023

*in absolute term

Coastal and Ghats of Karnataka was the region most affected by the trade reforms as its industries faced relatively larger tariff reductions.[9] From 1987 to 1997, its food budget share on cereals had decreased by 3% while that on animal products increased by 6%. On the other hand, Mozoram, the region least exposed to the liberalisation, experienced a 11% increase in its food expenditure share on cereals and a less than 1% decrease in that on eggs, fish and meat from 1987 to 1997. Coupled with the exogeneous trade policy shift, the diverse dietary patterns within India present an ideal environment for exploring the impacts of trade reforms on the consumption

[9]The degree of exposure to trade reforms is measured by the regional tariff calculated in Section 5.

of cereals and animal products.

2.5 Trade and the dietary composition in rural India

This section explains the empirical strategy used to identify the regional trade impacts on the Indian food consumption of cereals and animal products. We first exploit the regional difference in industrial composition prior to the reforms in measuring the changes in tariff protection faced by rural regions. We move on to discuss the baseline specification used to study the linkage between trade liberalisation and regional food consumption. The estimation results show that regions more exposed to tariff reductions consume relatively less cereals but more eggs, fish and meat, after controlling for the regional difference in food availability. The last part in this section establishes the robustness of results.

2.5.1 Measuring trade exposure

Following Topalova (2007), the exposure to foreign trade faced by a region can be captured by the interaction between the share of the region's population employed by various industries on the eve of the economic reforms and the reduction in tariff barriers in these industries. The regional tariff, $tariff_{rt}$, is thus:

$$tariff_{rt} = \frac{\sum_n Worker_{rn,1991} \cdot T_{nt}}{TotalWorker_{r,1991}} \tag{2.1}$$

where T_{nt} is the nominal ad valorem tariff faced by industry n at time t. $Worker_{rn,1991}$ indicates the number of workers in industry n in region r in 1991, which is divided by the total number of workers in region r ($TotalWorker_{r,1991}$). Non-traded industries, including services, trade, transportation, construction and industries involved in growing cereals and oilseeds, are assigned zero tariffs for all years.[10] The control variables for FDI reform (FDI_{rt}) and industry delicensing ($Delic_{rt}$) are constructed in a similar manner.[11]

Owing to the assignment of zero tariffs, $tariff_{rt}$ is dependent on the share of people involved in non-traded sector. In India, the majority of people working in non-traded industries are cereal and oilseed growers. So in regions with a larger non-traded sector, traditional staples are locally abundant and relatively inexpensive. These regions are, therefore, likely to consume disproportionately more traditional staples, implying that the regional tariff is correlated to initial food consumption levels through non-traded sector. Besides, these regions tend to record a lower

[10] As argued by Topalova (2007), the treatment of industries growing oilseeds and cereals as non-traded industries is justified by that fact that the imports of all the product lines of these industries were only allowed to the state trading monopoly until 2000.

[11] $FDI_{rt} = \sum_n \omega_{rn} \cdot FDI_{nt}$ where ω_{rn} is the share of worker in industry n in total employment in manufacturing sector and FDI_{rt} is the number of 6 digit products within industry n that were opened to automatic approval of foreign equity up to 51 percent at time t. For delicensing, $Delic_{rt} = \sum_n \omega_{rn} \cdot Delic_{nt}$ where $Delic_{nt}$ is a dummy variable which takes the value of unity if the industry has been delicensed. Note that FDI_{nt} is only available for the manufacturing sector. This is unlikely to cause substantial bias because FDI in other sectors continued to be highly regulated and FDI in secondary sector constituted over 80% of the FDI stocks in the sample period (Chakraborty and Nunnenkamp 2008).

reduction in trade protection since their initial level of $tariff_{rt}$ is lower, which constitute a potential negative bias in the tariff estimates. To address this concern, we follow Topalova (2007) to instrument $tariff_{rt}$ with a non-scaled tariff, $nstariff_{rt}$:

$$ntariff_{rt} = \frac{\sum_n Worker_{rn,1991} \cdot T_{nt}}{TotalTWorker_{r,1991}} \tag{2.2}$$

in which the denominator is now replaced by the total workers in traded industries in region r ($TotalTWorker_r$). As workers in non-traded industries are ignored in computing the total number of workers, this measure is not sensitive to the size of non-traded sector. Table 2.2 presents the first stage regression of the IV approach, which shows that $nstariff_{rt}$ is strongly correlated with $tariff_{rt}$. The high value of the F-statistics on excluded instruments rejects the presence of weak instruments. Hence, the non-scaled tariff is a valid instrument for the regional tariff.

Table 2.2: First stage regression for rural India

	Tariff
Non-scaled tariff ($ntariff_{rt}$)	0.195***
	(0.011)
F-statistics	309.96
Observations	821
R-squared	0.929

Note: The regression is estimated with constant, regional and time dummies. Robust standard errors clustered at state-year level are given in parenthesis. F-statistics are calculated for the significance of the excluded instrument in the regression. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

This measure of regional tariff would, however, be problematic if factors were reallocated across Indian regions in response to trade policy changes. As highlighted by Topalova (2010), the portion of population who moved for economic or employment reasons was minimal from 1983 to 1999. There was no visible change in the pattern of internal migration after the reforms of 1991. Furthermore, domestic markets in India were far from integrated due to high state tariffs and poor transport infrastructures (Atkin 2013). Hence, with the limited mobility of factors in India, this regional measure of trade protection will give an insightful answer to the question of whether regions more exposed to tariff reduction experienced more changes in their consumption of cereals and animal products.

It is important to emphasise that the above regional tariff accounts for reforms in both food and non-food related industries. This general measure has two advantages over a food-related or agricultural tariff variable. First, as discussed in Section 3.1, the Indian manufacturing sector experienced more radical reduction in trade barriers than the agricultural sector during the period of interest. This implies that neglecting reforms in non-food related industries are likely to greatly underestimate the extent of the Indian trade liberalisation. Second, trade reforms in the manufacturing sector can have important influence on dietary patterns. It may alter the relative prices between food and non-food and hence trigger resource reallocation across industries within a region. For instance, a cut in tariff on textile machinery can improve the productivity of the cotton textile industry, which increases the demand for cotton and encourages farmers to use more land to cultivate cotton instead of food crops. This can potentially cause changes in food prices

and therefore affect food consumption. In addition, liberalisation in the manufacturing sector may also influence dietary patterns through the income or taste channel. For example, workers in non-food related industries may benefit from an increase in income as a result of greater trade opening, which enables them to adjust their food consumption pattern. Manufacturing trade may also affect their interaction with foreign culture, motivating Indian households to adopt a diet (more diverse) different from the traditional ones. Hence, to fully capture the dietary impact of trade liberalisation, this paper considers both food and non-food related industries when measuring the regional exposure to trade reforms.[12]

2.5.2 Baseline regression

The next step is to establish whether there is a linkage between trade liberalisation and the observed shifts in Indian dietary patterns. This can be achieved by testing if regions facing larger tariff cuts experienced greater changes in their consumption of cereals and animal products. For each food group f , the following reduced form equation is estimated:

$$W_{rt} = \alpha + \beta_1 tariff_{rt} + \beta_2 tariff_{rt} \cdot lnFPI_{rt} + lnFPI_{rt} + d_r D_r + \tau_t + \varepsilon_{rt} \tag{2.3}$$

Following the main stream food literature, food consumption is measured by W_{rt}, the regional average percentage of food expenditure spent on food group f at time t.[13] This measure accounts for changes in total food consumption caused by an increase in non-food expenditure or a decline in calories need and therefore serves as a better measure of the relative dietary importance than quantity consumed. α is the constant term, which captures the level of budget share spent on food group f when other explanatory variables equal zero.

$tariff_{rt}$ is the regional measure of exposure to trade liberalisation discussed above. It is interacted with regional food price index (FPI), a weighted sum of real prices of food groups, to allow the trade impact to differ across regions with various degrees of food availability.[14] Considering two regions which experienced the same degree of tariff cuts, households living in one region may find it easier to adjust their food consumption than the ones in another region if food is widely available and therefore could be obtained at lower economic costs. Nevertheless, data on actual food availability is rare. Alternatively, we proxy overall food availability with FPI, which captures the relative position of market supply and demand for food. An increase in FPI indicates that the supply of food decreases relative to the demand for food in the region, in other words, food becomes relatively scarce and expensive, which makes it harder for Indian household to alter their diet in response to trade policy changes. Therefore, regional differences in FPI can influence the magnitude of dietary impact of trade. In (2.3), β_1 represents the main effect of

[12] In supplementary materials, we show that the use of a food-related tariff does not change our results.

[13] Following items are dropped in the calculation of total food expenditure due to the difficulty in unit conversion and their insignificance in consumption patterns: ice-cream, other milk products, other meat, other birds, other egg products, other fresh fruits, other dry fruits, salt, spices, processed food and beverages. The total food expenditure calculated in this paper constitutes 91% of the actual total expenditure reflected in the data in 1987.

[14] For each food group, the prices for the regional average unit value are adjusted for measurement error, quality effects and households size using the methodology purposed by Majumder et al. (2012). We deflate the prices using the consumer price index (CPI) data from the World Bank World Development Indicator Database

trade reforms whilst β_1 captures the interaction effect between regional tariff and FPI.

The estimation would, however, be biased if FPI is endogenous with the tariff measure, in which case, the interaction term will capture the trade impact on food availability instead. In the appendix table A1.3, we regress FPI with instrumented regional tariff and show that the coefficient of regional tariff is not statistically significant even after controlling for other reforms. This confirms the exogeneity of FPI empirically.[15]

The heterogeneity across regions, such as agricultural production capacity, diet tradition and religion composition is controlled by the inclusion of regional dummies (D_r). A time fixed effect (τ_t) is included to account for average changes in food budget shares across all regions and also any macroeconomic shocks in year t. The coefficient of $tariff_{rt}$ thus does not capture the aggregate effect of Indian tariff reforms on food consumption but rather the relative impact on regions with different degrees of trade exposure. Standard errors are clustered by state-year level for all estimations.

Table 2.3: Trade liberalisation and food consumption in rural India

	Cereals			Eggs. fish and meat		
Definition	Tariff_{rt}	IV-Tariff_{rt}	IV-Tariff_{rt}	Tariff_{rt}	IV-Tariff_{rt}	IV-Tariff_{rt}
Of tariff	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.053	0.279**	0.260*	-0.030	-0.256***	-0.258***
	(0.083)	(0.135)	(0.152)	(0.054)	(0.075)	(0.079)
Tariff*Ln FPI	0.005	-0.133**	-0.137**	0.014	0.110***	0.116***
	(0.040)	(0.058)	(0.065)	(0.024)	(0.035)	(0.037)
Ln FPI	-0.133***	-0.116***	-0.125***	0.060***	0.048***	0.051***
	(0.024)	(0.022)	(0.022)	(0.017)	(0.013)	(0.013)
FDI reform			0.166***			-0.064**
			(0.036)			(0.026)
Delicensing			0.02			-0.003
			(0.021)			(0.009)
Observation	821	821	821	821	821	821
R-squared	0.943	0.942	0.944	0.936	0.932	0.934

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

In table 2.3, columns 1 and 4 report the result of equation (2.3) estimated by ordinary least squares (OLS) in which the coefficients of the tariff measure are statistically insignificant. The use of instrumented regional tariff, greatly improves their significance, as seen in other columns. The preferred specification of this paper is given in columns 3 and 6 in which controls for other reforms are added into the estimation.[16] Regions with a higher concentration of industries that were more exposed to losses in trade protection are found to have relatively lower cereal consumption but higher animal product consumption. This evidence supports the role of trade liberalisation in promoting dietary diversity and hence driving the observed shifts in Indian diet. The highly

[15] We are aware that there remains a possibility of endogeneity bias in theory as trade liberalisation may have affected regional food availability through changing food prices. In this regard, we re-estimate equation (2.3) with lagged FPI in the appendix table A1.4. Both the sign and statistical significance of the estimated trade impact remain consistent with the main findings reported in table 2.3.

[16] For brevity, we report the IV estimates with no interaction term in table A1.3 of the Appendix.

significant interaction terms reflect that the trade-diet link is generally stronger in regions with lower food price, in other words, higher food availability. These findings are robust to the inclusion of FDI reform and industrial delicensing. We evaluate the estimates in columns 3 and 6 at sample mean and find that 10 percentage point decrease in regional tariff decreases the budget share spent on cereals from 0.413 to 0.401 and increases that on eggs, fish and meat from 0.073 to 0.074.

2.5.3 Robustness Checks

Though the approach advocated by Topalova (2007) has been applied to various contexts, it has been criticised by Hasan et al. (2007) and Panagariya (2008) on the assignment of zero tariffs to non-traded industries. They argue that goods may be non-traded due to prohibitively high tariffs and hence that approach underestimates protection in areas intensive in the production of non-traded goods. To test whether the above result is sensitive to how the tariff measure is constructed, we follow Hasan et al. (2007) to refrain from using non-tradable employment weight in the computation of regional tariff. The resulting variable is equivalent to the non-scaled tariff calculated with equation (2.2). Column 1 in table 2.4 presents the corresponding OLS estimates. The contrasting trade impact on regional cereal and animal product consumption is consistent with the preferred specification and remains significant.

Given that changes in trade policy take time to implement and trade exposure may be affected by other simultaneous shocks which are not captured by the time dummies and control variables, we replicate the main specification with lagged tariff and FPI and report the result in column 2. Both sign and significance of tariff measure and the interaction term with FPI are similar to main findings.

One concern over the estimates in table 2.3 is that they may pick up a common trend between tariff reduction and dietary patterns, such as the development in mass media and communication technology in 1990s, rather than the actual trade effect on food consumption. We perform two falsification tests in table 2.4 to address this issue. In column 3, we follow Topalova (2007) to test if changes in dietary patterns prior to the reform (from 1987 to 1991) are correlated with the post-reform changes in the tariff measure (from 1992 to 1997). The coefficients on regional tariff and its interaction with FPI are statistically insignificant. Column 4 gives the result of the second falsification test in which the budget shares on cereals or eggs, fish and meat at time t is regressed on trade shock evaluated between $t+1$ and $t+6$. Only observations prior to 1992 are used in this column. The results have the opposite signs to the main findings and are statistically insignificant. These test results therefore demonstrate that our results are unlikely to be biased by the underlying factors that correlate with both trade liberalisation and dietary changes.

Next, we employ median budget shares on cereals and eggs, fish and meat in the regions as dependent variable so as to take account of potential outliers. Our results in column 5 show that the coefficients on regional tariff and its interaction with FPI are not sensitive to the outliners in the household level data.

Table 2.4: Robustness checks

Dependent variable	Average budget share				Median budget share	Ln(Calorie)
Definition of tariff	Non-scaled Tariff_{rt}	IV-$\text{Tariff}_{r,t-1}$	IV-Tariff_{rt}	IV-Tariff_{rt}	IV-Tariff_{rt}	IV-Tariff_{rt}
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: Regional consumption of cereals			
Tariff	0.060*	0.224	0.447	-0.442	0.390**	0.356
	(0.035)	(0.150)	(0.804)	(0.338)	(0.167)	(0.392)
Tariff*LnFPI	-0.032**	-0.148**	-0.467	0.351	-0.208***	-0.020
	(0.015)	(0.061)	(1.134)	(0.392)	(0.072)	(0.166)
LnFPI	-0.124***	-0.005	0.039	-0.019	-0.121***	0.010
	(0.021)	(0.019)	(0.071)	(0.025)	(0.022)	(0.041)
Observation	821	744	73	371	821	821
R-squared	0.946	0.937	0.081	0.949	0.939	0.788
			Panel B: Regional consumption of eggs, fish and meat			
Tariff	-0.059***	-0.132**	0.035	0.137	-0.204***	-1.403
	(0.017)	(0.062)	(0.397)	(0.165)	(0.077)	(1.163)
Tariff*LnFPI	0.027***	0.067***	0.052	-0.119	0.111***	0.964*
	(0.008)	(0.026)	(0.515)	(0.187)	(0.035)	(0.545)
LnFPI	0.051***	0.007	-0.024	-0.003	0.046***	0.142
	(0.012)	(0.009)	(0.044)	(0.011)	(0.013)	(0.118)
Observation	821	744	73	371	821	819
R-squared	0.939	0.928	0.077	0.924	0.935	0.825

Note: All regressions are estimated with constant, regional and time dummies and controls for other reforms. Tariff is instrumented by non-scaled tariff in column 2 to 6. In column 3, the dependent variable is budget share in 1991 minus budget share in 1987 and the tariff measure and FPI are measured as the difference between 1997 and 1992. For column 4, only observations prior to 1992 are used and the different between regional tariff, FPI and their interaction from $t+6$ and $t+1$ are the regressors. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Apart from budget share, food consumption is often measured by calorie intake from the corresponding food. We convert the quantity of food consumed into calorie intake and use its logarithm form as the outcome variable for robustness check. The conversion is done by multiplying the quantity consumed of each food item with its calorie value and then adding together these results across all food items. Data on calorie content of each food item is obtained from the NSS report on nutritional intake in India published in 1996.[17] As reported in column 6, the trade estimates on calorie intake for cereals and animal products share the same sign as previous results reported in table 2.3 although not always statistically significant.

Finally, tables A1.5-A1.7 in the Appendix provide the sensitivity check of our findings against several alternative samples. One potential bias arises from the use of both 'thick' (i.e. 43rd and 50th) and 'thin' rounds of NSS data in the construction of our dataset. Since the sample size of the thin rounds is considerably smaller than the thick ones, there have been concerns over their representativeness. In regard to this, we replicate the analysis with a sample restricted to data from the 'thick' rounds. The contrasting trade outcome on regional consumption of cereals and animal products continues to hold. We also examine whether the trade impact on regional diet

[17]It is available at http://catalog.ihsn.org/index.php/catalog/2622/download/39007.

is sensitive to data from a particular year. The results are consistent with our main findings, implying that potential bias from the difference in survey designs across NSS rounds is minimal. These robustness checks provide solid support for the contrasting and opposing trade impact on regional food consumption for cereals, and eggs, fish and meat.

2.6 Mechanism behind the trade-diet link

How do trade reforms affect consumption of cereals and animal products? Standard Neo-Classical economic theory suggests that consumers make their consumption decision by maximising the utility that they can receive from the good subject to their budget constraint. The ability to purchase food is determined by food prices and income. Hence, regions may exhibit different dietary trends if the trade liberalisation in India has heterogeneous effects on their level of prices and income. On the other hand, with differential degrees of exposure to trade liberalisation, regions may develop different tastes for cereals and animal products, affecting the utility they receive from consuming those goods and hence their food consumption decision.

In this section, the Topalova (2007)'s approach illustrated before is employed to investigate how trade may affect regional food consumption through food prices, income and tastes. We find no evidence to support income as an important channel in the case of rural Indian diet. Although trade liberalisation does not contribute to the regional difference in food prices for cereals and animal products, regions facing larger declines in the sectoral employment weighted tariff are shown to have relatively lower prices for edible oils but higher for other food. Moreover, it is found that the association between trade reforms and regional food tastes is highly significant in the case of eggs, fish and meat. The implication of these results on the observed dietary shift is discussed at the end of this section.

2.6.1 Income effect

An increase in income potentially motivates households to consume better food and thus triggers dietary adjustment (Fabiosa 2013). Earlier research on Indian food consumption has shown that food is a normal good in general, implying that households will increase their consumption of food along with a rise in income. The income elasticity of demand for eggs, fish and meat is found to be higher than that of cereals in both Mittal (2007) and Kumar et al. (2011). This indicates that if regions composed of industries with higher exposure to tariff cuts experience a higher increase in income, households residing in these regions are likely to consume relatively more animal products and fewer cereals, contributing to the observed dietary shift.

The relationship between trade reforms and income is well-established by literature. Using a cross-country dataset, Frankel and Romer (1999) provide evidence on the positive impact of trade on income per person. This is later confirmed by Irwin and Terviö (2002) in which the endogeneity of trade is controlled. While the country-wide effect of trade liberalisation on income tends to be positive, it may have diverse impacts at regional level. Through comparing regional

income in 1987-88 with that in 1999-2000, Topalova (2007) and (2010) evidence that Indian rural districts which were more exposed to Indian trade reforms experienced slower progress in poverty reduction. In the contrary, with additional data in 1993-94, Hasan et al. (2007) find no evidence of a negative link between trade and consumption at both state and regional level.

In this paper we focus on the annual regional variation across 11 years rather than the overall difference, such that the relationship between income and tariff measure may not be the same as the ones estimated in earlier papers. Additionally, those papers assign a tariff rate in 1997 to measure the trade openness in 1999-2000, which may lead to bias in the estimates as tariff rates continued to decline during the second wave of trade liberalisation after 1997. To identify the annual trade effect on income at regional level, the following equation is estimated:

$$lnMPCE_{rt} = \alpha + \beta_3 tariff_{rt} + d_r D_r + \tau_t + \varepsilon_{rt} \tag{2.4}$$

where $lnMPCE_{rt}$ is the logarithm of regional mean of real MPCE, which is used as a proxy for income since the NSS did not collect data on household income.[18] As in the main analysis, the regional tariff is instrumented by the non-scaled tariff, $nstariff_{rt}$, to overcome the endogeneity problems induced by the assignment of zero tariff.

Table 2.5: Trade liberalisation and total expenditure in rural India

	Log real MPCE		Log real MPCNE	
	(1)	(2)	(3)	(4)
Tariff	0.064	0.033	-0.075	-0.094
	(0.192)	(0.193)	(0.311)	(0.315)
FDI reform		0.201		0.159
		(0.127)		(0.202)
Delicensing		-0.013		-0.085
		(0.062)		(0.106)
Observations	821	821	821	821
R-squared	0.966	0.966	0.926	0.927

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

The first two columns in table 2.5 report the IV estimates of equation (2.4). Although the coefficients of MPCE are statistically insignificant, they share the same sign as the ones in Topalova (2007) and (2010). Apart from the direct impact on income, trade reforms may also affect dietary patterns by reducing the amount of income needed to spend on non-food items and hence allowing households to allocate more on food consumption. To account for this potential income channel, we regress the logarithm of real monthly per capita non-food expenditure (MPCNE) on the regional tariff. The coefficients on tariff measure reported in columns 3 and 4 suggest no significant correlation between trade liberalisation and regional difference in MPCNE. Therefore, income is unlikely the channel which the regional trade impact on Indian food consumption came through.

[18] Like food prices, it is adjusted for the inflation rate calculated from the CPI.

2.6.2 Price effect

The Indian trade reforms may have increased or decreased the prices of cereals and animal products, depending on whether they are imported or exported. With the increase in foreign supply, prices of imported food are likely to decline with tariff cuts. Exported food tends to be more expensive after liberalisation due to the rising demand from global market. According to UN Comtrade data, Indian exports of cereals had been increasing at a much faster rate than its imports between 1988 and 1997. This signals an increase in international demand for the traditional staples produced in India, which may make them more expensive for local households. The price of animal products is less likely to have gone up following the trade reforms as the growth rate of imports was faster than that of exports. Additionally, as pointed out by Thow (2009), the decreased costs of animal feeds from developed countries have increased the availability of feed in developing countries, which facilitate increased animal production at a lower cost and thus reduces the relative price of animal products. If these trade-induced price changes are found at regional level, it would help explain the impact of tariff cuts on regional food consumption.

However, the trade induced price changes at regional level could be minimal due to imperfect price transmission to domestic markets. As stated by Winters et al. (2004), price changes at the border may have no influence on local prices in some rural areas as the local market is isolated from the rest of the economy. This is consistent with the findings of Marchand (2012) in which tariff changes are not perfectly transmitted to state-level domestic prices in rural India. Indeed, as the trade of cereals and animal products was heavily restricted in the period of interest and the Indian government had been subsidising traditional staples to ensure food security, local prices of cereals and animal products might not be affected by the reduction in tariffs discussed in earlier section.

To identify the trade impact on regional food prices, we replace the dependent variable of equation (2.4) with real price of food groups (proxied by regional adjusted unit values based on Majumder et al. (2012)). These prices are discounted for inflation using consumer price index (CPI) obtained from the World Bank Development Indicators Database. Apart from cereals and eggs, fish and meat, we also estimate the trade impact on regional food prices of edible oils and other food for comparison purposes.[19] Edible oils are separated from other foods due to the fact that it is a key import of India and its prices increased at a much slower rate than that of other foods during the sample period.

There are a few ways in which the general tariff measure may affect the real price of a particular food item. First, the tariff cut on this item can have a direct impact on its price in local market and the magnitude of this effect is subject to the effectiveness of price transmission. Second, tariff changes in other food or manufacturing goods may alter the real price of that food item through influencing the average price of consumer goods in Indian market. Third, the trade impact on food prices may go through input-output linkages. By enhancing the access to cheaper or higher quality inputs, opening of input trade may reduce unit production cost of certain types of food

[19] Other food includes pulses, vegetables, fruits and milk.

and thus lower their prices in domestic market.

Table 2.6: Trade liberalisation and food prices in rural India

	Cereals		Eggs, fish and meat		Edible oils		Other food	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff	-0.006	-0.033	-0.344	-0.394	0.730***	0.615***	-0.644**	-0.718***
	(0.138)	(0.138)	(0.264)	(0.262)	(0.245)	(0.231)	(0.261)	(0.261)
FDI reform		0.144		0.288*		0.698***		0.390***
		(0.100)		(0.163)		(0.158)		(0.138)
Delicensing		0.049		0.063		0.073		0.180***
		(0.040)		(0.066)		(0.054)		(0.066)
Observations	821	821	821	821	821	821	821	821
R-squared	0.978	0.978	0.946	0.947	0.951	0.955	0.965	0.966

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10 % level.

Looking at table 2.6, the estimates in columns 1 to 4 do not support a trade effect on prices of cereals and eggs, fish and meat at regional level. These results are unsurprising because of the strict government controls on cereal and animal product trade. Given that India is dependent on imports for edible oils, it is expected that we should observe a positive relationship between regional tariff and edible oil price. This is confirmed by the results in columns 5 and 6 which reveal that regions experiencing greater exposure to the trade reforms enjoy a relatively lower price of edible oils. On the other hand, other food in these regions appears to be more expensive (column 7 and 8). How these associations have contributed to the relationship between trade liberalisation and food consumption for cereals and animal products is subject to the substitutability among these goods for Indian households, which will be addressed in the later part of this section. Overall, while the results in table 5 show a possible linkage between trade reforms and the prices of edible oils and other food, there is no evidence for a price difference in cereals and animal products across Indian regions facing differential degrees of reductions in trade protection.[20]

2.6.3 Taste effect

Recent trade literature have pointed out that trade integration may contribute to the evolution of tastes because goods are not only consumed for their functional utility value but also for their symbolic meaning in terms of cultural identity and social values (e.g. Bala and Van Long (2005), Maystre et al. (2014)). Through increased interaction with foreign culture, a demonstration effect may be created by opening of trade. This effect encourages local people to imitate food consumption patterns of more advanced countries on the grounds that the others have better information or higher social status (James 1987). Indeed, as argued by Hawkes et al. (2010), trade is a main driver of westernisation of diet because it makes food choices which are already attractive to consumer even more so. Western dietary pattern is often characterised by relatively higher consumption of meat, eggs, dairy products and potatoes. Consequently, by encouraging the imitation of western diet, trade liberalisation may have enhanced the food tastes towards

[20]The estimation results of trade impact on budget share for edible oils and other food are available upon request.

animal products and thus increased the consumption of these foods.

In addition, Thow (2009) states that the opening of trade has in some ways skewed the incentive of food consumption through improving the availability and affordability of animal products. Undeniably, trade liberalisation has greatly enhanced households' access to varieties of food that were not previously available to them (Pingali and Khwaja 2004). Their food choices are no longer constrained to local produce. Households may diversify their food consumption from traditional staples since greater variety in diets is generally perceived as more palatable and pleasant (Ruel and Garrett 2004). Cereals may therefore be viewed as less desirable and become more likely to be substituted by other foods.

Tastes are hard to observe and quantify. We follow Atkin (2013) to attribute the across-region difference in household demand to regional food tastes (θ_r). This indicator is obtained by estimating the linear approximate almost identical demand system (LA/AIDS). For each year, the following budget share equation is estimated separately for cereals and eggs, fish and meat with OLS:[21]

$$w_{if} = \theta_{rf} D_r + \sum_f \gamma_f ln P_f + \beta_f ln \frac{m_i}{P_r^*} + \zeta_f Z_i + \varepsilon_{if} \tag{2.5}$$

The dependent variable (w_{if}) is share of food expenditure that household i spent on food group f. m denotes the monthly per capita food expenditure (MFE). To make demand system linear, the price index (P_r^*) is approximated by a Stone index ($lnP_r^* = \sum_f \bar{w}_{if} lnP_{fr}$). A vector of household characteristics, Z, is added as control variables, which includes age and gender of household head, household size, proportion of adult males and adult females in the household and the share of times that meals are consumed outside home by that household. Regional dummies (D_r) are added to create regional taste indicators. The coefficients, θ_{rf}, are essentially the regional component of the budget share equation which cannot be explained by prices, total food expenditure and household demographics.[22]

We estimate the trade impact on food tastes by using regional food tastes as the outcome variable in equation (2.4) and report the results in table 2.7. The positive sign for tariff measures in the first two columns suggests that tastes for cereals are likely to be weaker in regions more exposed to tariff declines. However, this association is not statistically significant. In contrast, for animal products, the estimates reveal a strong association between tariff cuts and regional food tastes in rural India. Regions whose workers are on average more exposed to foreign competition are shown to prefer animal products more than other regions. This result supports food tastes as a key channel through which trade liberalisation encouraged the dietary transition observed in India.

[21] Refer to Atkin (2013) for a detailed explanation of the demand system.

[22] With the large number of regional dummies, it would be very computationally demanding and thus not feasible to estimate equation (2.5) of various food groups simultaneously. We, therefore, use an equation-by-equation approach, which assumes that the budget share spent on one food group is not correlated to that on another food group and gives rise to a potential bias on regional food tastes. This bias is, however, likely to be captured by the region and time fixed effects and therefore have minimal impact on the estimated trade effects in table 2.7.

Table 2.7: Trade liberalisation and regional food tastes in rural India

	Cereals		Eggs, fish and meat	
	(1)	(2)	(3)	(4)
Tariff	0.051	0.042	-0.113***	-0.105***
	(0.124)	(0.122)	(0.029)	(0.029)
FDI reform		0.036		-0.049*
		(0.059)		(0.027)
Delicensing		0.050		-0.008
		(0.037)		(0.011)
Observations	821	821	821	821
R-squared	0.994	0.994	0.983	0.984

Note: Contemporary tastes are measured by θ_{rf}, the regional component of the budget share equation which cannot be explained by prices, total food expenditure and household characteristics. All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

2.6.4 The combined effects

The above analysis reveals that regions experienced larger reductions in trade protection tend to enjoy cheaper edible oils, face a higher price for other food and have stronger tastes for animal products. By regressing the food budget share on cereals and animal products against MPCE, food prices and the corresponding food tastes, we check whether these results are consistent with the trade impacts on regional food consumption shown in table 2.3. If the regional components in food budget share do capture the contemporary tastes across regions, one would expect to observe positive coefficient estimates. This is apparent in both specifications in table 2.8.

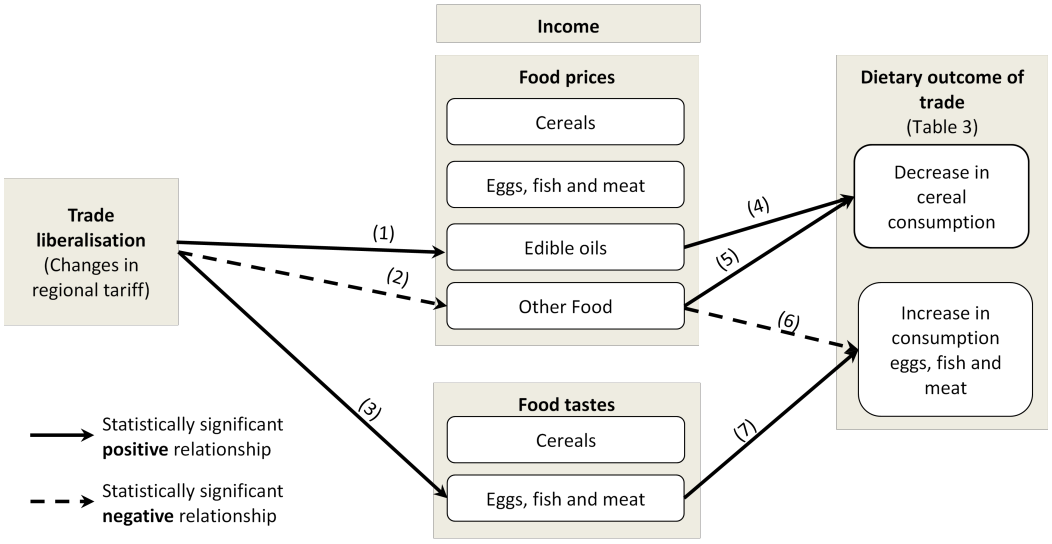
Table 2.8: Determinants of dietary patterns of Indian rural households

	Budget Share (Cereals)	Budget Share (Eggs, fish and meat)
	(1)	(2)
Log real MPCE	-0.053***	0.008***
	(0.009)	(0.003)
Log real price		
Cereals	0.071***	-0.027***
	(0.024)	(0.003)
Eggs, fish and meat	-0.028***	0.005**
	(0.006)	(0.002)
Edible oils	0.025*	0.003
	(0.013)	(0.004)
Other food	0.032***	-0.020***
	(0.007)	(0.003)
Contemporary tastes		
Cereals	0.446***	
	(0.023)	
Eggs, fish and meat		0.766***
		(0.028)
Observations	821	821
R-squared	0.976	0.987

Note: Contemporary tastes are measured by θ_{rf}, the regional component of the budget share equation which cannot be explained by prices, total food expenditure and household characteristics. Robust standard errors clustered at state-year level are given in parenthesis. All regressions are estimated with constant, regional and time dummies.. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

In figure 2.4, we articulate the results in table 2.5 to 2.7 with the estimates in table 2.8 to illustrate how the channels identified previously contributed to the observed dietary shift. The

Figure 2.4: Mechanism behind the trade-diet link in the case of rural Indian regions



Note: Refer to table 2.5-2.8 for the statistical results of the mechanism.

coefficients on food prices in column 1 of table 2.8 suggest that edible oils and other food are considered as substitutes to cereals by rural households. Given that their edible oil price is relatively lower after the reforms, regions experiencing higher tariff cuts are likely to consume relatively fewer cereals (lines 1 and 4 in figure 2.4). On the other hand, with the price of other food being relatively higher in regions more exposed to reductions in trade protection, the regional consumption of cereals is likely to be higher as a result (lines 2 and 5 in figure 2.4). This dietary outcome of trade is, however, offset by the trade-induced change in edible oil price, causing the overall trade impact on regional cereal consumption to be negative (table 2.3).

For eggs, fish and meat, the coefficient for price of other food is negative and statistically significant in column 2 of table 2.8, indicating a complementary relationship between these foods. This implies that regions more exposed to tariff cuts are likely to consume relatively less animal products because of the trade-induced increase in the price of other food (lines 2 and 6 in figure 2.4). But this association is likely to be counteracted by the positive linkage between trade reforms and tastes for animal products. Regions with employment concentrated in industries losing tariff protection are likely to have stronger tastes for animal products, which makes them consume more eggs, fish and meat as reflected by the positive coefficient for food tastes (lines 3 and 7 in figure 2.4). Hence, compared to income and prices, food tastes are a more important channel of transmission between trade and regional consumption of animal products in rural India.

Overall, the mechanism analysis reveals that the trade liberalisation in 1991 has had a negative impact on cereal consumption through reducing edible oil price and a positive effect on the consumption of animal products through enhancing the food tastes towards them. While the relative importance of these channels is likely to vary from case to case, our findings are consistent with Deaton and Drèze (2009) who argue that that some changes in Indian food habits are not easily explained by standard factors like changes in income and prices. It also reaffirms the findings of Herrmann and Roder (1995). Through investigating the absolute and relative difference in food

consumption across OECD countries between 1978 and 1988, they show that food tastes are more influential than food prices and income on changes in dietary patterns over time.[23]

2.7 Conclusion

Motivated by the dietary shift from a traditional staple based diet to one with higher intake of animal products in developing countries, this paper investigates the unintended dietary outcome of trade in the context of Indian liberalisation in 1991. Our findings reveal a statistically significant linkage between the trade reforms and the regional food consumption in rural India. Regions with a higher concentration of industries that were more exposed to tariff reductions are shown to consume relatively less cereals and more eggs, fish and meat. This evidence provides support to the argument that trade liberalisation has played a role in supporting diet diversity and thus driving the observed shift in dietary patterns. We also examine the possible channels behind this trade-diet link. The estimates indicate that Indian liberalisation reduces the cereal consumption largely by lowering the price of edible oils since they are viewed as substitute to cereals. On the other hand, the positive trade impact on the consumption of animal products is mainly driven by the enhancement in food tastes.

Our results provide valuable insights on the nutritional implications of trade liberalisation. Through reducing consumption of cereals and increasing that of animal products, trade can have both positive and negative influences on the health development in developing countries. While the newly developed diet is likely to provide a higher variety of micronutrients, it is also associated with increased risk of obesity and other diet-related non-communicable diseases. Rather than pointing to the use of trade policy in addressing nutritional and health goals, which is likely to be inefficient and restricted by the World Trade Organisation (WTO) commitments, this paper highlights the need for identifying complementary policies to manage these unintended dietary outcomes of trade. In particular, the importance of food tastes as a channel behind the trade-diet link implies that apart from income and price policies, more attention should be given to education and other information policies so as to enhance the coherence between trade and nutrition actions.

One caveat is that with the use of regional tariff and time dummies, this paper does not identify the overall effect of trade opening on the consumption of cereals and animal products in India, which would have been useful in assessing the relative importance of liberalisation versus other socio-economic factors, such as income growth and urbanisation, in driving the observed dietary shift (Popkin 2002; Kearney 2010).[24] Nevertheless, the regional outcome of trade is of significant interest to policymakers since the problem of malnutrition differs greatly across regions in developing countries. For example, in India, the percentage of underweight women (BMI <18.5) was 47% in Orissa but 11% in Sikkim while the figure for overweight women (BMI >23) was 10% and 29% respectively. Through comparing the dietary impact of trade across regions, the findings

[23] In unreported result, we examine the channels behind the trade-diet link using the alternative samples discussed in the Section 5.3. The results are largely consistent with our findings in table 2.5-2.8.

[24] Identifying the trade impacts on Indian diet at national level is difficult due to limitation of tariff data and the concern on isolating the overall trade impacts from other macroeconomic shocks.

of this paper shed light on one of the potential causes of these regional malnutrition problems and thus serve as an important input for the formulation of food and health policies.

In consideration of the huge dietary diversity in India, a potential extension of this study is to examine whether the regional dietary impact of trade is uniform across household segments that have different food consumption habits. In particular, studies have documented that affluent households in India consume relatively less cereals and more animal products than their impoverished counterparts (Shariff and Mallick 1999; Deaton and Drèze 2009). In this regard, we present a extension analysis in which we disentangle the regional trade impact on the diet of rich and poor households in rural India. We find that while the trade reforms in India have enabled both household groups to diversify their diet towards animal products, it has only discouraged the cereal consumption among the rich. These results provide further evidence for the role of trade in supporting dietary diversity of households across income groups.

Appendix

Table A1.1: Data source

Variables	Disaggregation level	Data Source
Food consumption, food prices, MPCE, Socio-economic demographics	Household	National Sample Survey (43^{rd} and 45^{th} to 53^{th} round)
Tariffs	Product/ industry	Topalova (2010), Aghion et al. (2008) World Integrated Trade System,
FDI reform and industrial delicensing	Industry	Aghion et al. (2008)
Industrial composition in 1991	District	Indian Census in 1991

Table A1.2: Summary statistics for selected years

	1987	1992	1997
Regional level variables			
Average share of food expenditure (%)			
Cereals	0.433	0.429	0.393
Eggs, fish and meat	0.067	0.073	0.077
Median share of food expenditure (%)			
Cereals	0.439	0.435	0.399
Eggs, fish and meat	0.053	0.059	0.061
Calorie intake (kcal)			
Cereals	1643	1486	1354
Eggs, fish and meat	30	31	30
Real income/ expenditure (in Indian rupee)			
MPCE	188	438	1104
MPCNE	89	193	570
Real food prices (Indian rupee per kilogram)			
Cereals	2.86	7.70	17.17
Eggs, fish and meat	20.36	49.79	127.67
Edible oils	26.61	56.9	90.81
Other food	4.61	12.16	28.78
Food price index	7.03	17.20	36.37
Reform variables			
Tariff	0.192	0.095	0.043
Non-scaled tariff	0.880	0.419	0.191
FDI reform	0.000	0.045	0.044
Delicensing	0.250	0.736	0.734
Household level variables			
Age of household head	44.24	44.46	43.9
Proportion of female household head	0.100	0.108	0.098
Household size	5.451	5.334	4.939
Proportion of adult female	0.326	0.328	0.329
Proportion of adult male	0.330	0.339	0.361
Share of meals consumed outsides	0.027	0.022	0.026
No of rural regions	74	74	75

Table A1.3: Trade liberalisation, FPI and budget share in rural India

			Budget share	
	Food price index		Cereals	Eggs, fish and meat
	(1)	(2)	(3)	(4)
Tariff	-0.243	-0.307	0.018	-0.031
	(0.189)	(0.188)	(0.064)	(0.023)
FDI reform		0.347***		
		(0.096)		
Delicensing		0.133***		
		(0.041)		
Observations	820	820	821	821
R-squared	0.977	0.978	0.942	0.932

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A1.4: Robustness check using lagged FPI to address endogeneity concerns

	Cereals		Eggs, fish and meat	
	(1)	(2)	(3)	(4)
Tariff	0.310**	0.320**	-0.182***	-0.185***
	(0.128)	(0.141)	(0.059)	(0.066)
Tariff*Ln FPI_{t-1}	-0.181***	-0.193***	0.087***	0.090***
	(0.063)	(0.068)	(0.029)	(0.032)
Ln FPI_{t-1}	0.005	-0.001	0.003	0.005
	(0.015)	(0.015)	(0.007)	(0.007)
Other reform controls	No	Yes	No	Yes
Observations	744	744	744	744

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10 % level.

Table A1.5: Robustness check using thick round samples

	Cereals		Eggs, fish and meat	
	(1)	(2)	(3)	(4)
Tariff	0.400*	0.260	-0.220**	-0.196**
	(0.208)	(0.224)	(0.096)	(0.089)
Tariff*Ln FPI	-0.007	0.002	0.079**	0.095***
	(0.073)	(0.08)	(0.036)	(0.037)
Ln FPI	-0.124***	-0.151***	0.048*	0.055**
	(0.041)	(0.035)	(0.025)	(0.023)
Other reform controls	No	Yes	No	Yes
Observations	297	297	297	297

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A1.6: Robustness check using alternative samples

Year excluded in the sample	1987	1988	1989	1990	1991	1992
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Regional consumption of cereals						
Tariff	0.312*	0.036	0.361**	0.258	0.231	0.200
	(0.176)	(0.138)	(0.184)	(0.159)	(0.157)	(0.152)
Tariff*Ln FPI	-0.197***	-0.063	-0.177**	-0.146**	-0.111	-0.100
	(0.076)	(0.056)	(0.077)	(0.067)	(0.070)	(0.064)
Observation	747	747	746	746	746	747
Panel B: Regional consumption of eggs, fish and meat						
Tariff	-0.288***	-0.190***	-0.287***	-0.270***	-0.249***	-0.255***
	(0.099)	(0.064)	(0.092)	(0.084)	(0.078)	(0.078)
Tariff*Ln FPI	0.141***	0.087***	0.126***	0.126***	0.113***	0.114***
	(0.047)	(0.028)	(0.043)	(0.039)	(0.038)	(0.037)
Observation	747	747	746	746	746	747

Note: All regressions are estimated with constant, FPI, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A1.7: Robustness check using alternative samples

Year excluded in the sample	1993	1994	1995	1996	1997
	(1)	(2)	(3)	(4)	(5)
Panel A: Regional consumption of cereals					
Tariff	0.287*	0.313**	0.269*	0.310**	0.263
	(0.156)	(0.159)	(0.161)	(0.150)	(0.163)
Tariff*Ln FPI	-0.153**	-0.163**	-0.141**	-0.143**	-0.118*
	(0.068)	(0.068)	(0.067)	(0.063)	(0.068)
Observation	746	746	746	747	746
Panel B: Regional consumption of eggs, fish and meat					
Tariff	-0.260***	-0.268***	-0.252***	-0.278***	-0.231***
	(0.080)	(0.081)	(0.080)	(0.080)	(0.080)
Tariff*Ln FPI	0.117***	0.121***	0.112***	0.120***	0.100***
	(0.038)	(0.038)	(0.037)	(0.037)	(0.037)
Observation	746	746	746	747	746

Note: All regressions are estimated with constant, FPI, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Supplementary materials

In this document, we present some additional robustness checks in regard to the above findings in Chapter 2. First, we examine whether they are sensitive to the use of a food-related tariff and the replacement of FPI with a measure of land endowment. Second, we re-estimate the main specification in the form of long run differences and Tobit model. The results reported in the main analysis are generally robust to the above alternative specifications. Lastly, we illustrate how the dietary effect of trade changes when the channels of transmission between trade and diet are controlled progressively. We thank an anonymous referee for pointing us to these useful sensitivity checks.

S1 Food-related tariff

As stressed in the main analysis, the regional tariff variable accounts for reforms in both food and manufacturing industries. We check whether our results are sensitive to the use of a food-related tariff in table S1 and S2. This variable is calculated using a formula similar to that of the general tariff (i.e. equation (2.1)). It is captured by the interaction term between the tariffs faced by food-related industries (i.e. the agricultural sector and food-processing industries) and the employment share of these industries in 1991. Again, we instrument it with a non-scaled food-related tariff to account for the endogeneity bias caused by the assignment of zero tariff.

Looking at columns 3 and 6 in table S1, both the signs and significance levels of the food-related tariff are consistent with the main findings estimated with the general tariff although there are some differences in the magnitude of coefficients. We next examine if the mechanism analysis is sensitive to the inclusion of food-related tariff. The results, which are presented in table S2, again have consistent signs and significance as the ones estimated with the general tariff. This suggests that the dietary impact of trade estimated in the main analysis is partly driven by the reforms in food-related industries. Nevertheless, the differences in coefficients between table S1 and table 2.3 indicate that trade reforms in non-food sector also have an impact on regional food consumption. As this effect would be neglected with the use of food-related tariff, we argue that the general tariff is a better variable for this study.

Table S1: Trade liberalisation and food consumption in rural India (Based on food-related tariff)

	Cereals			Eggs, fish and meat		
Definition	$FoodTariff_{rt}$	IV-$FoodTariff_{rt}$	IV-$FoodTariff_{rt}$	$FoodTariff_{rt}$	IV-$FoodTariff_{rt}$	IV-$FoodTariff_{rt}$
Of tariff	(1)	(2)	(3)	(4)	(5)	(6)
FoodTariff	0.065	0.244*	0.329**	-0.029	-0.147**	-0.176***
	(0.057)	(0.125)	(0.143)	(0.022)	(0.059)	(0.066)
FoodTariff*Ln FPI		-0.090*	-0.139**		0.058**	0.075**
		(0.051)	(0.058)		(0.026)	(0.03)
Ln FPI		-0.111***	-0.117***		0.049***	0.053***
		(0.025)	(0.024)		(0.015)	(0.014)
Other reform controls	No	No	Yes	No	No	Yes
Observations	821	821	821	821	821	821

Note: All regressions are estimated with constant, regional and time dummies. Food-related tariff is instrumented by non-scaled food-related tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table S2: The mechanism betweeen trade-diet link

	Income		Food prices				Food taste	
	lnMPCE	lnMPCNE	Cereals	Eggs. fish and meat	Edible oils	Other food	Cereals	Eggs. fish and meat
FoodTariff	-0.057	-0.254	-0.013	-0.271	0.448**	-0.438**	0.138	-0.096***
	(0.159)	(0.263)	(0.111)	(0.191)	(0.199)	(0.170)	(0.099)	(0.026)
Observation	821	821	821	821	821	821	821	821

Note: All regressions are estimated with constant, regional and time dummies, controls for FDI reform and industrial delicensing. Food-related tariff is instrumented by non-scaled food-related tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

S2 Interacting regional tariff with a measure of land abundance or crop suitability

In his study on how habit formation can affect the calorie gains from trade, Atkin (2013) argues that local food tastes are developed towards crops that are relatively well-suited to the local agro-climatic endowments (such as soil characteristics) as these food are relatively cheaper. Given that these food tastes determine household consumption response to external shock, the effect of trade-induced changes in prices is therefore subject to the land characteristics of region where the household resides. In this sense, changes in land abundance or crop suitability may also influence the dietary impact of trade. As pointed out by an anonymous referee, the use of food price index may not capture this effect of land characteristics.

Table S3: Trade liberalisation and consumption of cereals and animal products

	Cereals	Eggs, fish and meat
Tariff‘	-0.086	-0.051**
	(0.081)	(0.025)
Tariff*LFC	0.078	0.054
	(0.098)	(0.036)
LFC	-0.088***	0.001
	(0.024)	(0.007)
Observation	644	644

Note: All regressions are estimated with constant, regional and time dummies and controls for FDI reform and industrial delicensing. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. LFC indicates the percentage of area in the region used for food crop cultivation. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

In this section, we attempt to account for this mechanism through a measure of land characteristics using data from the Village Dynamic Studies in South Asia (VDSA). This dataset provides yearly data on the area used for various crop productions across Indian districts since 1966. It is the only time-series dataset available that is consistent with our study because other datasets either only provide data for the most recent years or are at state level, which is a higher aggregated level than the regional level used in this study. The measure, land endowment for food crop cultivation (LFC), is the proportion of land used for food crop production within a region, which is obtained by first summing up the area used for producing food crops across the districts in that particular region and then dividing the sum by its total area. The results are given in table S3 in which trade liberalisation is shown to have a positive and significant impact on the consumption of animal products. However, the trade impact on cereal consumption is no longer significant.

It should be noted that the sample size in table S3 is far less than the ones using FPI because of two data issues. First, since the VDSA does not cover all the districts within a region, the LFC measure may therefore only capture a partial picture of land characteristics in the region. In particular, some regions are dropped in the estimation as none of the districts in these regions are covered in the dataset. Second, while VDSA aims to provide time-series data on agricultural production, there are missing data for some years.

Besides, as in Atkin (2013), it is not possible to match animal products to data on cropland. Land endowment for food crops is therefore an imperfect measure, at least for this piece of research, as it is not linked to production of animal products and hence does not fully capture changes in food availability. An alternative measure is the historical agro-climatic endowment used in Atkin (2013). However, these variables are time-invariant and hence will be absorbed by the region fixed effect. Besides, it is unlikely for land abundance or crop suitability to have changed greatly within the 11 years of the period of interest. Land characteristics, therefore, have limited influence on the dietary impact of trade studied in this paper.

Due to the above limitations, we argue that land characteristics is a less preferred proxy than FPI. In fact, the changes in land use for food crops are indirectly captured by FPI. Improvement in crop suitability enhances the availability of food crops. This increases the supply of food in the region and thus drives down FPI.

S3 Additional robustness check for the main specification

Considering that the budget shares spent on cereals and animal products are a fraction and their distribution are skewed, we test whether our findings are sensitive to the use of a non-linear estimator. Table S4 report the Tobit estimates of the main specification in which the regional tariff is instrumented by the non-scaled tariff. The coefficients of tariff variable remain the same for both cereal and animal product consumption.

Table S4: Tobit estimation of the main specification

	Cereals	Eggs, fish and meat
	(1)	(2)
Tariff	0.260**	-0.258***
	(0.122)	(0.060)
Tariff*Ln FPI	-0.137***	0.116***
	(0.053)	(0.026)
Ln FPI	-0.125***	0.051***
	(0.013)	(0.006)
Observations	821	821

Note: All regressions are estimated with constant, regional and time dummies, and controls for FDI reform and industrial delicensing. Tariff is instrumented by non-scaled tariff in columns 1 and 2. Other reform controls are FDI reform and industrial delicensing. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table S5 provides the results of the main specification using difference before and after the first wave of Indian trade liberalisation (changes between 1991 to 1997). Following Topalova (2010), we control for initial conditions through a vector of regional variables, which include the

percentage of workers in a region employed in agriculture, employed in manufacturing, employed in services, the share of district's population that is schedule caste/tribe and the percentage of literate population. To account for the influence of simultaneous reforms, controls for FDI reform and industrial delicensing are added. The trade impacts on consumption of cereals and animal products are of the same sign as the ones estimated with the full sample. Considering with the small number of observations, it is unsurprising that the coefficients of regional tariff are not statistically significant.

Table S5: Difference in trade liberalisation and regional diet between 1997 and 1991

	Changes in budget share between 1997 and 1991	
	Cereals	Eggs, fish and meat
$\Delta\text{Tariff}_{1997\text{-}1991}$	0.321	-0.65
	(3.171)	(1.693)
$\Delta\text{Tariff}_{1997\text{-}1991}$ *ΔLn $\text{FPI}_{1997\text{-}1991}$	-1.337	0.903
	(3.104)	(1.769)
ΔLn $\text{FPI}_{1997\text{-}1991}$	-0.034	0.063
	(0.280)	(0.168)
Observation	75	75

Note: All regressions are estimated with constant and controls for initial regional characteristics used in Topalova (2010) and the reforms in FDI and industrial delicensing. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

S4 Additional robust check for the mechanism analysis

In this section, we present the results of the mechanism analysis in an alternative way to highlight the importance of different channels in explaining the dietary impact of trade. In table S6, we add demand determinant variables (i.e. MPCE, food prices, tastes) progressively to the main specification. As shown in column 2, the significance of regional tariff variable on cereal consumption disappear after the inclusion of real food prices. For animal products, the trade protection estimate becomes statistically insignificant with the inclusion of regional food tastes (column 6). These results are consistent with our discussion in the main analysis.

Table S6: Determinants of dietary patterns of Indian rural households

	Cereals			Eggs, fish and meat		
	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	0.261*	0.148	0.018	-0.258***	-0.219***	0.005
	(0.147)	(0.119)	(0.087)	(0.078)	(0.059)	(0.035)
*Tariff*Ln FPI*	-0.135**	-0.093*	-0.021	0.115***	0.105***	0.016
	(0.062)	(0.050)	(0.037)	(0.036)	(0.026)	(0.015)
Ln FPI	-0.106***	-0.231***	-0.140***	0.046***	0.139***	0.006
	(0.021)	(0.022)	(0.013)	(0.013)	(0.017)	(0.007)
Log real MPCE	-0.069***	-0.068***	-0.046***	0.017***	0.016***	0.007***
	(0.012)	(0.011)	(0.007)	(0.006)	(0.005)	(0.003)
Log real price						
Cereals		0.089***	0.082***		-0.027***	-0.027***
		(0.025)	(0.024)		(0.006)	(0.003)
Eggs, fish and meat		0.000	-0.001		-0.019***	0.003
		(0.009)	(0.006)		(0.006)	(0.002)
Edible oils		0.097***	0.066***		-0.069***	-0.001
		(0.019)	(0.014)		(0.010)	(0.005)
Other food		0.083***	0.081***		-0.059***	-0.023***
		(0.013)	(0.008)		(0.008)	(0.003)
Contemporary tastes						
Cereals			0.395***			
			(0.019)			
Eggs, fish and meat						0.755***
						(0.031)
Observations	821	821	821	821	821	821

Note: Contemporary tastes are measured by θ_{rf}, the regional component of the budget share equation which cannot be explained by prices, total food expenditure and household characteristics. Robust standard errors clustered at state-year level are given in parenthesis. All regressions are estimated with constant, regional and time dummies.. ***Denotes significant at the 1% level, **at 5% level, *at 10 % level.

Extension analysis: Indian trade liberalisation and the regional diet of rich and poor

In a country as large and diverse as India, dietary habit is likely to vary considerably across households in different segments. Previous studies on food consumption have shown that the rich cohort in India allocates their food budget differently from their poor counterpart. Shariff and Mallick (1999) show that the cereals are a less important source of nutrition for wealthier households in India. Deaton and Drèze (2009) highlight that the richer households spent more per calorie than their poor counterpart as they switch their expenditure from cereals to fattier and sweeter foods, such as edible oils, meat, and sugar. Because of their dietary differences, the dietary impact of trade we found in Chapter 2 may not be uniform across the affluent and impoverished cohorts. Using the same methodology as in our earlier analysis, this extension investigates whether the reduction in trade protection at regional level contributes to dietary changes of the rich and poor in rural India from 1987 to 1997.

E1 Methodology and data

E1.1 Estimation strategy

Following Chapter 2, we exploit the exogeneous trade shock in 1991 to estimate the regional dietary impact of trade on the rich and poor in rural India from 1987 to 1997. For each year, the household samples are divided into two cohorts based on their monthly per capita expenditure (MPCE). Households from 30^{th} percentile or below are classified as the poor while the one at the 70^{th} percentile or above are labelled as the rich. These percentile thresholds are selected to maximise the number of households included in each cohort while ensuring sufficient difference in the MPCE between the two groups. To estimate the regional trade impact on their diet, we regress their average consumption level of cereals and animal products, composed of eggs, fist and meat, on regional tariff, food price index (FPI), the interaction term between regional tariff and FPI, time and regional dummies as well as controls for other reforms occurred during the same period, which were foreign direct investment reform and industrial delicensing. This is equivalent to equation (2.3) in Chapter 2 with the dependent variable being the average budget share spent on cereals and animal product of the rich or poor rather than that of all households. We do not repeat the construction of regional tariff and controls for other reforms here as it has been discussed in details in Chapter 2. To eliminate the endogeneity bias arisen from the assignment of zero tariff to non-traded industries, we continue to employ the instrumental variable approach proposed by Topalova (2007).

E1.2 Data

Similar to the earlier analysis, this study relies on household consumption data from the NSS, Indian Census and tariff data from Topalova (2010), Aghion et al. (2008) and WITS. Summary

statistics for the rich and poor household groups is provided in Table E1, which confirms the observation of Shariff and Mallick (1999) as well as Deaton and Drèze (2009). In 1987, compared to their richer counterparts, poor households on average spent a larger percentage of their food expenditure on cereals but smaller on eggs, fish and meat. This difference in dietary patterns across income groups continues to exist in 1997. For both cohorts, the importance of cereals in the food budget has decreased from 1987 to 1997. There has also been an increase in the proportion of food expenditure spent on animal products in both household groups.

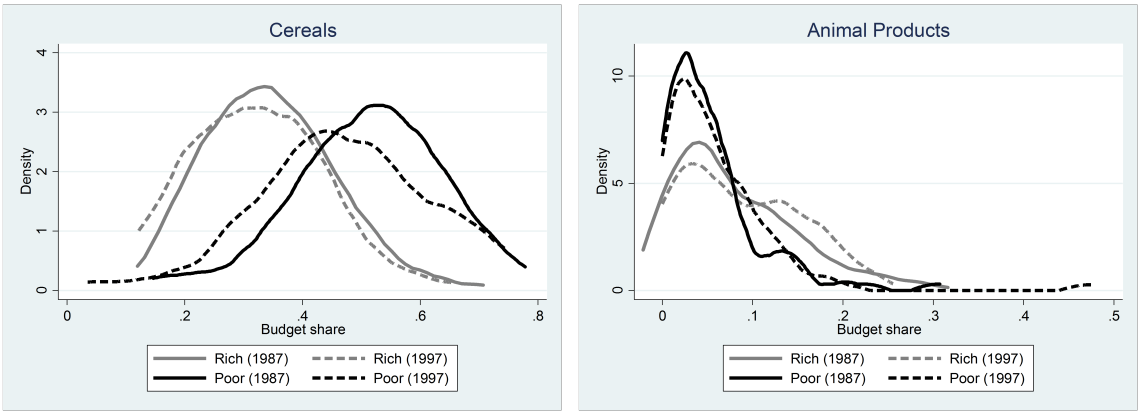
Table E1: Summary statistics

	Rich		Poor	
	1987	1997	1987	1997
Regional level variables				
Average share of food expenditure (%)				
Cereals	0.343	0.322	0.513	0.465
Eggs, fish and meat	0.082	0.089	0.054	0.060
Median share of food expenditure (%)				
Cereals	0.344	0.321	0.513	0.477
Eggs, fish and meat	0.081	0.075	0.054	0.048
Calorie intake (kcal)				
Cereals	1872	1492	1365	1165
Eggs, fish and meat	43.74	44.53	16.20	16.45
Real MPCE (in Indian rupee)	306	1779	545	545
Household level variables				
Age of household head	45.28	44.40	43.16	43.10
Proportion of female household head	0.10	0.12	0.10	0.09
Household size	4.86	4.15	5.99	5.98
Proportion of adult female	0.35	0.35	0.30	0.29
Proportion of adult male	0.39	0.42	0.28	0.29
Share of meals consumed outsides	0.03	0.04	0.03	0.03
No of rural regions	74	75	73	74
Regional level variables that are the same for both the rich and poor				
Real food prices (Indian rupee per kilogram)	2.86	17.17		
Cereals	20.36	127.67		
Eggs, fish and meat	26.61	90.81		
Edible oils	4.61	28.78		
Other food	7.03	36.37		
Food price index	2.86	17.17		
Reform variables				
Tariff	0.193	0.043		
Non-scaled tariff	0.878	0.191		
FDI reform	0	0.115		
Delicensing	0.249	0.734		

These dietary differences across income cohorts can be further illustrated by figure E1 in which we plot the kernel density functions of the regional average share of food budget spent on cereals and animal products for the rich and poor households in 1987 and 1997. There have been obvious dietary shift for both household groups. Looking at the left panel, at the regional level, the cereal consumption of the rich and poor have both shifted to the left, in other words, decreased over time. The decrease is more apparent in the case of the poor who also spend a higher share of their food budget on cereals. For animal products, as shown in the right panel,

there is a rightward shift in the regional intake for both household groups. These trends indicate that the dietary importance of animal products has increased relative to cereals for households across income groups. They are in line with the stylised facts highlighted in previous studies on Indian food consumption. For example, Kumar et al. (2011) point out that from 1983 to 2000, the per capita annual intake of edible oils, vegetables, fruits, milk, meat, fish and eggs increased greatly in both upper and bottom income groups. Deaton and Drèze (2009) show that average per capita cereal calorie consumption has decreased in the top and bottom quartiles of MPCE.

Figure E1: Regional consumption of cereals and animal products for the rich and poor, 1987 and 1997



E2 Dietary impact of trade on the diet of the rich and poor

The trade liberalisation in 1991 has a contrasting impact on regional cereal and animal product consumption of the affluent households as shown by table E2. The coefficient of regional tariff in column 1 suggests that the rich households residing in regions which are more exposed to trade reforms consume relatively less staples than those living in the less exposed regions. The opposite is true for eggs, fish and meat. In column 3, the coefficient of regional tariff indicates that the liberalisation (i.e. reduction in tariff rates) has a positive impact on the rich households'intake of animal products. The interaction terms between regional tariff and FPI are statistically significant for both types of food, suggesting that dietary response of the affluent households to the trade reforms is subject to the availability of food within the region. These results continue to hold even with the inclusion of controls for FDI reform and industrial delicensing (columns 2 and 4).

Next, we turn to the dietary impact of trade on the impoverished, presented in table E3. Trade liberalisation does not seem to have a significant impact on their staple consumption at regional level (columns 1 and 2). However, there is evidence that the poor living in regions more exposed to tariff cuts tend to spend relatively more on animal products than those residing in the less exposed regions (columns 3 and 4). This positive trade impact does not differ across regions with different levels of food availability as indicated by the insignificant interaction term between regional tariff and FPI. Overall, our results reflect that trade policy changes can have heterogeneous impacts on the dietary patterns of the affluent and impoverished households. While tariff cuts are associated with an increase in dietary importance of animal products and a decrease of that in cereals for the rich at regional level, the latter impact is not observed in the case of

Table E2: Dietary effect of tariff cuts on the rich at regional level

	Cereals		Eggs. Fish and Meat	
Definition	IV-Tariff$_{rt}$	IV-Tariff$_{rt}$	IV-Tariff$_{rt}$	IV-Tariff$_{rt}$
Of tariff	(1)	(2)	(3)	(4)
Tariff	0.297**	0.319**	-0.252***	-0.272***
	(0.131)	(0.144)	(0.060)	(0.067)
Tariff*Ln FPI	-0.106**	-0.126**	0.098***	0.110***
	(0.053)	(0.059)	(0.027)	(0.030)
Ln FPI	-0.015	-0.02	0.025***	0.025**
	(0.021)	(0.021)	(0.009)	(0.010)
Reform controls	No	Yes	No	Yes
Observation	819	819	819	819

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

the poor cohorts. Thus, the 1991 Indian trade liberalisation is found to have encouraged both household groups to diversify their diet towards animal products.

Table E3: Dietary effect of tariff cuts on the poor at regional level

	Cereals		Eggs. Fish and Meat	
Definition	IV-Tariff$_{rt}$	IV-Tariff$_{rt}$	IV-Tariff$_{rt}$	IV-Tariff$_{rt}$
Of tariff	(1)	(2)	(3)	(4)
Tariff	0.002	(0.038)	-0.167*	-0.205**
	(0.193)	(0.224)	(0.086)	(0.103)
Tariff*Ln FPI	0.081	0.093	0.037	0.063
	(0.090)	(0.100)	(0.041)	(0.047)
Ln FPI	-0.143***	-0.151***	0.048***	0.049***
	(0.021)	(0.021)	(0.009)	(0.010)
Reform controls	No	Yes	No	Yes
Observation	784	784	784	784

Note: All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

E3 Robustness checks on the dietary impact of trade on the rich and poor

As in Chapter 2, we perform several robustness checks to ensure the validity of the estimated dietary impact of trade on the affluent and impoverished cohorts. In table E4, we re-estimate the baseline specification with alternative measures of regional tariff: (1) using non-scaled tariffs as regressor directly rather as an instrument to ensure that the estimates are not biased by the assignment of zero tariff (columns 1 and 5)[25]; (2) using lagged regional tariff and FPI to account for the concern of simultaneous bias and the potential time lags in the implementation of trade policy and the adjustment of food consumption decision (columns 2 and 6). We also test whether the results are sensitive to how food consumption is measured by replacing the dependent variable with median budget share (columns 3 and 7) and logarithm of average calorie intake (columns 4 and 8). The estimates of regional tariff are generally consistent with the above findings.

[25] Hasan et al. (2007) and Panagariya (2008) argue that the employment of highly protected industries should be excluded in the computation of regional tariff as the assignment of zero tariffs to these industries underestimates the level of protection faced by the regions.

Table E4: Robustness check for dietary impact trade on the rich and poor at regional level

Dependent variable	Rich				Poor			
	Average budget share		Median budget share	Ln (Calorie)	Average budget share		Median budget share	Ln (Calorie)
Definition of tariff	Non-scaled $Tariff_t$	IV-$Tariff_{t-1}$	IV-$Tariff_t$	IV-$Tariff_t$	Non-scaled $Tariff_t$	IV-$Tariff_{t-1}$	IV-$Tariff_t$	IV-$Tariff_t$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Regional consumption of ***cereals***								
Tariff	0.076**	0.352**	0.281*	0.073	-0.011	0.343	-0.098	-0.028
	(0.035)	(0.162)	(0.153)	(0.414)	(0.057)	(0.246)	(0.226)	(0.625)
Tariff*	-0.032**	-0.150**	-0.125**	-0.008	0.020	-0.154	0.112	0.252
LnFPI	(0.015)	(0.068)	(0.057)	(0.179)	(0.026)	(0.108)	(0.103)	(0.250)
LnFPI	-0.023	0.023	-0.052***	-0.164***	-0.153***	0.010	-0.234***	-0.197**
	(0.021)	(0.018)	(0.018)	(0.056)	(0.036)	(0.031)	(0.041)	(0.090)
N	819	742	819	819	784	708	784	784
Panel B: Regional consumption of ***eggs, fish and meat***								
Tariff	-0.065***	-0.267***	-0.210***	-3.609***	-0.049*	-0.232**	-0.277***	0.137
	(0.017)	(0.080)	(0.072)	(1.326)	(0.026)	(0.107)	(0.090)	(1.260)
Tariff*	0.028***	0.129***	0.104***	1.332**	0.017	0.088*	0.124***	0.271
LnFPI	(0.008)	(0.033)	(0.030)	(0.597)	(0.012)	(0.049)	(0.042)	(0.595)
LnFPI	0.028***	-0.007	0.031***	0.205	0.053***	0.010	0.065***	-0.18
	(0.010)	(0.009)	(0.008)	(0.253)	(0.017)	(0.013)	(0.014)	(0.210)
N	819	742	819	811	784	708	784	756

All regressions are estimated with constant, regional and time dummies and controls for other reforms. Tariff is instrumented by non-scaled tariff in columns 2 to 4 and 6 to 8. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Two placebo exercises are performed in table E5 to ensure that the above estimates do not capture the underlying factors that correlate with both the trade reforms and the dietary changes of rich and poor households like advancement in communication technology. The first test examines if pre-reform dietary changes from 1987 to 1991 are correlated with the post-reform tariff changes from 1992 to 1997 (columns 1 to 4). The second exercise uses only observation before 1992 and test if the food budget share at time t is correlated to the trade shock evaluated between $t+1$ and $t+6$ (columns 5 to 8). In all cases, the coefficient on regional tariff and its interaction term with FPI are statistically insignificant, suggesting that our findings on dietary impact of trade are not driven by common trend between tariff cuts and dietary patterns.

To address the concerns over the use of 'thin' round data, we replicate the above analysis with data from the 'thick' rounds only (i.e. the 43rd and 50th rounds covering 1987-88 and 1993-94) in table E6. The contrasting regional impact of trade on the rich households' cereal and animal product consumption remain statistically significant. Nevertheless, for the poor cohorts, while their intake of animal products at regional level continue to be positively linked to tariff cuts, this linkage becomes statistically insignificant. This suggests that the dietary impact of trade on the poor is relatively sensitive to the data samples. In columns 5 to 8, we interact the regional

Table E5: Placebo tests for the trade-diet link for the rich and poor

Dependent variable	Change in share of food budget from 1987 to 1991				Share of food budget at time t			
	Rich		**Poor**		**Rich**		**Poor**	
	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff	0.199	0.090	2.826	-0.331	0.283	0.116	-0.208	-0.010
	(0.974)	(0.291)	(2.039)	(0.615)	(0.368)	(0.133)	(0.650)	(0.182)
Tariff* LnFPI	-0.173	-0.046	-3.816	0.645	-0.434	-0.093	0.133	0.053
	(1.370)	(0.387)	(2.703)	(0.850)	(0.439)	(0.155)	(0.755)	(0.211)
Ln FPI	0.026	-0.026	0.046	-0.024	-0.035	-0.017	-0.073	-0.006
	(0.102)	(0.026)	(0.150)	(0.059)	(0.028)	(0.011)	(0.065)	(0.022)
Observation	73	73	71	71	370	370	356	356

Note: All regressions are estimated with constant, regional and time dummies and controls for other reforms. Tariff is instrumented by non-scaled tariff. In columns 1 to 4, the tariff measure and FPI are measured as the difference between 1997 and 1992. For columns 5 to 8, only observations prior to 1992 are used and the different between regional tariff, FPI and their interaction from $t+6$ and $t+1$ are the regressors. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

tariff variables with lagged food price index instead of the one in current year. For both rich and poor cohorts, the positive trade impact on the consumption of eggs, fish and meat continue to be statistically significant and hence is consistent with the findings in tables E2 and E3. This indicates that this dietary impact of trade is unlikely to be biased by the potential correlation between trade liberalisation and current FPI.

Finally, we check how the dietary effects of tariff cuts may differ along the MPCE distribution. In table E7, the estimation is replicated for the richest 25 and 40 percent and the poorest 25 and 40 percent households in rural India.[26] The dietary impact of tariff reduction at regional level does not change when moving up the distribution. Regardless of the percentile used, the affluent living in the regions which are more exposed to the trade liberalisation consumes relatively less cereals and more animal products compared to those living in the less exposed regions. For the poor, the significant and positive effect of trade on the intake of animal products disappears when only the poorest 25% households are considered. While this, on one hand, indicates that the effect of trade on dietary patterns is sensitive to the classification of the poor households, it may also imply that the trade liberalisation does not affect the poorest households who are often isolated from the rest of the economy.

[26]Using lower MPCE percentile as threshold would further reduce the number of households and thus lower the number of regions considered in each year. This reduction in sample size implies that the results would be less comparable to the main findings. In unreported results, we re-estimate the equation (2.3) for the richest 20 percent and the poorest 20 percent and the sign of the estimated dietary impact of trade is consistent with main results although they are not always significant.

Table E6: Robustness check with alternative samples and lagged food price index

	Thick round samples				Lagged food price index			
	Rich		**Poor**		**Rich**		**Poor**	
	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff	0.386**	-0.151*	-0.283	-0.165	-0.697	-0.706**	-0.941*	-0.532***
	(0.180)	(0.082)	(0.283)	(0.134)	(0.456)	(0.285)	(0.530)	(0.194)
Tariff* LnFPI	-0.094	0.096***	0.306***	0.012				
	(0.066)	(0.034)	(0.090)	(0.051)				
$Tariff_t$* $LnFPI_{t-1}$					0.384*	0.472***	0.542**	0.349***
					-0.197	-0.126	-0.226	-0.086
LnFPI	-0.028	0.003	-0.216***	0.077**				
	(0.029)	(0.013)	(0.056)	(0.030)				
$LnFPI_{t-1}$					0.049**	0.038***	0.013	0.021***
					(0.021)	(0.011)	(0.026)	(0.007)
Observation	296	296	288	288	742	742	708	708

Note: All regressions are estimated with constant, regional and time dummies and controls for the FDI and delicensing reforms. In column 1 to 4, Only data from the thick rounds are used, covering 1987, 1988, 1993 and 1994. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis..
***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table E7: Dietary impact of trade across MPCE percentiles at regional level

	Richest 25%		**Richest 40%**		**Poorest 25%**		**Poorest 40%**	
	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff	0.326**	-0.292***	0.324**	-0.254***	-0.128	-0.146	0.122	-0.215**
	(0.146)	(0.074)	(0.134)	(0.066)	(0.259)	(0.116)	(0.195)	(0.087)
Tariff* LnFPI	-0.121**	0.118***	-0.144***	0.104***	0.119	0.042	-0.013	0.075*
	(0.059)	(0.033)	(0.055)	(0.028)	(0.112)	(0.051)	(0.085)	(0.039)
LnFPI	-0.025	0.027**	-0.030	0.023**	-0.167***	0.042***	-0.105***	0.038***
	(0.021)	(0.011)	(0.020)	(0.009)	(0.039)	(0.014)	(0.028)	(0.013)
Observation	818	818	820	820	777	777	801	801

Note: All regressions are estimated with constant, regional and time dummies and controls for the FDI and delicensing reforms. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

E4 Channels behind the trade-diet link for the rich and poor

With the above heterogeneous dietary impacts of trade in mind, we move on to examine the underlying mechanisms of these trade effects. Previous studies have shown that trade has a distribution effect on income and consumption. In their survey of evidence, Goldberg and Pavcnik (2007) observe that income inequality increased in China, Hong Kong and several Latin-American countries after reforming their trade protection structure. Hence, if the trade liberalisation in India has an non-uniform impact on the ability of the rich and poor to purchase food, the adjustments they make to their food consumption bundles may not be the same. In fact, even if trade has a uniform effect on their income, their response toward the income changes can still differ due to the difference in their income elasticity of demand (YED) for food. Since many of the poor still live at near subsistence levels, their YED for food, particularly cereals, is likely to be

higher than their rich counterparts. The cereal consumption of the poor is therefore more likely to increase relative to the rich in response to the same level of trade-induced income changes.

In addition, affluent households are more capable of reducing their reliance on local produces and increasing the variety of food consumed. This is because they tend to be more resourceful and have better access to market. This implies that with the opening of trade, they are likely to be more exposed to western food culture as well as other food varieties that are made available by trade. In this sense, the food tastes of the rich could be more responsive to the changes in trade policy.

Trade liberalisation may also have an unequal effect on diets via the relative price of goods that are consumed at different intensities by the affluent and impoverished consumers (Fajgelbaum and Khandelwal 2016). As food tends to occupy a higher proportion of the total expenditure for the poor, the changes in relative food price may have a bigger impact on their food consumption decision than that of their richer counterpart. Additionally, the rich may benefit more from the cheaper imported goods as they are likely to have better access to the market while the poor rely heavily on locally produced food. Hence, subject to the composition of their food bundles, the rich and poor may respond differently to the relative price changes caused by trade reforms.

We apply the same approach as in Chapter 2 to examine the importance of income, prices and food tastes in explaining the unequal dietary impact trade on the rich and poor. Table E8 reports how tariff cuts may have affected their income and food tastes at regional level. The first two columns demonstrate that trade liberalisation in India has a distributional effect on household income. The estimate in column 1 indicates that the rich have become wealthier on average with the opening of trade as the linkage between tariffs and the mean MPCE is negative and strongly significant. On the other hand, the income effect of trade on the poor cohort is close to zero and insignificant (column 2).

Table E8: Regional impact of tariff cuts on income and food tastes of the rich and poor

Dependent variable	Income		Contemporary tastes			
			Rich		Poor	
	Rich	Poor	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat
	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.676***	-0.006	0.422***	-0.152***	-0.122	-0.071*
	(0.231)	(0.159)	(0.127)	(0.049)	(0.111)	(0.041)
Observations	819	784	819	819	784	784

Contemporary tastes are measured by the regional component of the budget share equation which cannot be explained by prices, total food expenditure and household characteristics. All regressions are estimated with constant, regional and time dummies. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

The estimates in columns 3 and 4 suggest that the regional tariff has a significant association with the regional food tastes of the affluent cohort. Rich households living in regions exposed to a higher degree of tariff cuts tend to have stronger preferences for animal products but a weaker one for cereals. This linkage between food preferences and regional tariff is consistent with the contrasting regional impact of trade on their consumption of cereals and animal products. In the

Table E9: Regional impact of tariff cuts on food prices

	Cereals	Eggs, fish and meat	Edible oils	Other food
	(1)	(2)	(3)	(4)
Tariff	-0.033	-0.394	0.615***	-0.718***
	(0.138)	(0.262)	(0.231)	(0.261)
Observation	821	821	821	821

Note: All regressions are estimated with constant, regional and time dummies and controls for the FDI and delicensing reforms. Tariff is instrumented by non-scaled tariff. Robust standard errors clustered at state-year level are given in parenthesis. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

case of the poor households, there is some evidence for a positive linkage between reduction in trade protection and their preferences for animal products at regional level (column 6).

The regional impacts of trade on food prices are reported in table E9. As indicated by the first two columns, there is no significant association between regional tariff and the regional price of cereals, and eggs, fish and meat (columns 1 and 2). Yet, we find evidence for trade impacts on regional prices of edible oils and other food. Edible oils are found to be relatively cheaper in regions experienced a higher degree of reduction in trade protection while other foods are more expensive in these regions. How these price effects influence the diet of the rich and poor is subject to the complementarity and substitutability of these food groups with cereals and animal products, which will be explained next.

Table E10: Determinants of the dietary patterns of the rich and poor cohorts

	Rich		**Poor**	
	Cereals	Eggs, fish and meat	Cereals	Eggs, fish and meat
	(1)	(2)	(3)	(4)
Log real MPCE	-0.017**	-0.003	-0.066	0.001
	(0.007)	(0.003)	(0.048)	(0.004)
Log real price				
Cereals	0.041***	-0.012***	0.027	-0.010*
	(0.015)	(0.004)	(0.021)	(0.006)
Eggs, fish and meat	-0.013***	0.002	-0.025***	0.006***
	(0.005)	(0.003)	(0.006)	(0.001)
Edible oils	0.010	0.007	-0.021*	0.000
	(0.015)	(0.007)	(0.012)	(0.003)
Other food	0.044***	-0.027***	-0.099***	-0.001
	(0.005)	(0.003)	(0.014)	(0.002)
Contemporary taste				
Cereals	0.603***		0.704***	
	-0.037		-0.045	
Eggs, fish and meat		0.713***		0.905***
		(0.028)		(0.018)
Observations	819	819	784	784

Note: Contemporary tastes are measured by θ_{rf}, the regional component of the budget share equation which cannot be explained by prices, total food expenditure and household characteristics. Robust standard errors clustered at state-year level are given in parenthesis. All regressions are estimated with constant, regional and time dummies.. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table E10 reveals the demand determinants (i.e. income, food prices and food preferences) of the regional food consumption patterns of the rich and poor in rural India. As one expects, for both cohorts, contemporary tastes for cereals and animal products are significantly and positively linked to the budget share spent on the corresponding food group. For the purpose of uncovering channels of trade-diet links, we focus our discussion on the determinants which are found to be

significantly linked with the regional tariff in tables E2 and E3.

In column 1 of table E10, the price of other food is found have a positive and significant association with cereal consumption, in other words, they are considered as substitute by the affluent cohort. The significant increase in regional price of other food by tariff reduction found in table E9 is therefore likely to have encouraged them to consume relatively more cereals. In spite of this positive trade effect, the cereal consumption of the rich is negatively linked to tariff cuts at regional level (column 2 in table E2). This is partly because of the positive income changes induced by trade liberalisation (column 1 in table E8). The negative coefficient of MPCE in Column 1 in table E10 indicates that cereals are inferior good for the rich, implying their cereal consumption decreases with the increase in income triggered by trade. This negative trade effect on cereal consumption are further enhanced by the trade-induced decline in cereal tastes. Hence, in the case of rural India, trade reforms have contributed to a decline in regional cereal consumption of the rich households via increasing their income and weakening their preference towards cereals.

As reflected by the coefficient of MPCE in column 2 of table E10, the regional animal product consumption for the rich is not sensitive to income changes. Unlike cereals, their mean budget share on animal products is negatively linked to price of other food. Given that other food is relatively more expensive in regions more exposed to trade reforms and they are complements to animal products, the affluent households residing in these regions are likely to consume less animal product. On the other hand, the coefficient of food tastes reveals that their average intake of eggs, fish and meat is likely to be increased by the trade reforms through the enhancement in food preferences towards these foods. This strong taste effect is likely to have cancelled out the effect of tariff cuts on prices of other food, leading to the overall positive trade impact on the regional animal product intakes of the rich cohort (column 4 in table E2).

With the absence of evidence of trade effect on the poor's income and cereal preferences, we focus on the linkage between food prices and their cereal intake in column 3 of table E10. Both edible oils and other food are deemed to be complements to cereals by the impoverished households. With edible oil being relatively more expensive in regions experienced a larger tariff cuts, the poor living in these regions are likely to consume less cereals. The trade reforms also trigger an increase in the regional price of other food, leading to a decline in cereal consumption of the poor. Since these two dietary effects of trade counteract each other, it is not surprising that significant trade impact on cereal intake of the impoverished cohort is not observed in table E3.

As suggested in table E8, the trade reforms have triggered a positive development of food tastes towards animal products among the impoverished group. Combined with a strong and positive link between the food taste for eggs, fish and meat, and the corresponding intake shown in column 4 in table E10, the poor living in regions more exposed to reduction in trade protection consume relatively more animal products than those residing in the less exposed regions. Their regional intake of eggs, fish and meat is found to be not sensitive to price changes in edible oils and other food. Food preferences are thus the main channel which the positive impact of tariff

cuts on the poor's intake of animal products passes through.

E5 Conclusion

Using the 1991 Indian trade liberalisation as the focus of this study, this paper demonstrates that the dietary effect of trade is heterogeneous across households in different income groups. Rich households living in regions more exposed to tariff cuts consume relatively less cereals and more animal products, compared to those residing in the less exposed region (after the tariff cut). A similar positive trade impact is also observed on the poor's intake of animal products although these results are shown to be sensitive to the NSS rounds used to conduct our analysis and the effects disappear when the data sample is restricted to the poorest 20 percent.

Following Chapter 2, we also explore the underlying channels behind these estimated trade-diet links. The negative trade impact on cereals for affluent households at regional level pass via rising income and making cereals less desirable. For both rich and poor cohorts, trade liberalisation encourages the consumption of eggs, fish and meat through enhancing preferences towards these foods. These results are consistent with the mechanism analysis in Chapter 2, reaffirming the role of trade liberalisation in facilitating diversification of diet and hence contributing to the nutrition transition in developing countries.

A few words of caution are in order when interpreting the estimated dietary effect of trade. In this extension, we utilise all the household surveys available from 1987 to 1997 to capture the changes in food consumption of the rich and poor in India. For some regions in certain years, the number of household observations available is rather small as the NSS data used are from the less representative thin rounds. As seen from the above sensitivity checks, our results are largely robust to use of 'thin' round data, with the exception of the regional trade impact on the poor's intake of animal products. In the view of this limitation, the above findings should not be taken as a conclusive answer on the magnitude of the dietary impact of trade across income groups. Rather, the diverse trade impact on the diet of the rich and poor provides evidence that trade does support dietary diversity and hence facilitate the process of nutrition transition in developing countries. It is, also, crucial to stress that these dietary outcomes of trade are by no means distributional as it is unclear whether the households' welfare had increased or decreased with the newly developed dietary patterns and an exploration of this aspect of the trade reform is beyond the scope of this extension analysis.

Chapter 3

Nutrition transition and changing food preferences in India

Abstract

We present empirical evidence on how changes in food preferences have contributed to nutrition transition, a phenomenon in which the dietary patterns of households shift away from traditional staples. Using household level time series cross-section survey data, we estimate time varying demand elasticities, revealing evidence of declining importance of cereals in Indian household diets. The estimates show that Indian demand for cereals have become more income inelastic and price elastic. We also find that cereals are a substitute rather than a complement to animal products in household diets. Since changes in elasticities can only be attributed to variation in utility parameters, this indicates that cereals are losing favour with Indian households. These findings have implications for Indian government in regard to food policy design and implementation.

3.1 Introduction

Improving food security and nutrition intake remains a key policy concern in developing countries and India is no exception. The government has implemented, mostly recently via the 2013 National Food Security Act (NFSA), an extensive set of public policy measures to ensure that sufficient food is available to the poorest and most vulnerable in society (Narayanan and Gerber 2017). For example, the Public Distribution System (PDS) is a food safety-net program that provides poor households quantities of rice or wheat at below market prices (Kishore and Chakrabarti 2015). In addition, there are also the Integrated Child Development Scheme (ICDS) and the Mid-Day Meal Scheme (MDMS) that help ensure access to food at household level (Pingali et al. 2017). However, while these policies have been in place, there has been a decline in cereal consumption in India. Between 1987-88 and 2011-12, the per capita daily calorie intake from cereals has fallen from 1,323 kcal to 1,182 kcal in urban India and from 1,684 kcal to 1,336 kcal in rural India.[1] At the same time the consumption of edible oils and animal products increased significantly. This structural shift of food consumption away from cereals and towards a more fat intense diet is known as the nutrition transition, a phenomenon observed in many developing countries (Drewnowski and Popkin 1997).

Income and prices are the standard factors used to explain this shift in food consumption patterns and the associated calorie intake. According to Bennet's Law, the share of calories from starchy staple declines with household income (Timmer et al. 1983; Fuglie 2004). But if income growth were the only cause, it would imply a negative relationship between income and cereal consumption in India. Given that cereals are a traditional staple and major source of nutrients, this negative relationship is hard to explain. In terms of prices, cereal consumption would be in decline if prices have risen, but according to Pingali et al. (2017) cereals have become cheaper relative to other nutritious food like pulses, fruits and vegetables. Thus, income growth and changing food prices do not fully explain the declining dietary importance of cereals in India.

One key determinant, under-researched within the literature which we examine in this paper, is consumer preferences. Past studies on nutrition transition indicate that food preferences have been significantly influenced by the progress of economic development (Popkin 1999; Thow 2009; Kearney 2010). In particular, urbanisation and trade liberalisation increase the variety and availability of food products and thus enable households to diversify their diet. Similar arguments have been made in the case of India. Shetty (2002) argues that economic development has altered Indian dietary habits towards a Western-type diet. Pingali and Khwaja (2004) also state that globalisation along with economic growth has triggered Indian household adoption of a food culture that is different from the traditional ones. However, preferences are hard to observe and quantify. Existing studies account for changes in food preferences by adding time trends (Banks et al. 1997), extrapolating data given parameter estimates (Dong and Fuller 2010) or correlating time-varying demographic characteristics which are used as proxy variables for consumer preferences with consumption (Moro et al. 2000). These approaches have been criticized extensively

[1] Another widely discussed trend in Indian food consumption is the decline in calorie intake. See Deaton and Drèze (2009) and Smith (2015) for a detailed account of this puzzle.

in the literature (Gao et al. 1997), so we follow an alternative empirical strategy proposed by Chavas (1983) who observes that changing consumer preferences alter demand elasticities over time. To date several studies have assessed structural dietary shifts through estimating time-varying demand elasticities over time. For example, Guo et al. (2000) and Hovhannisyan and Gould (2011) show that food demand elasticities have changed over time in China. For India, Mittal (2007) reports that changes in food preferences contributed to 0.1% decline in per capita cereal intake from 1983 to 1999. Gaiha et al. (2013) demonstrate that there are significant shifts in food price elasticities for fats, calories and protein, which are not determined by changes in price, income and household characteristics.

In this paper, we capture changes in food preferences in the rural and urban context by estimating time varying household level price and expenditure (income) elasticities of demand for four time periods from 1987-88 to 2011-12. We have taken this approach for two main reasons. First, there is evidence that the key elasticities of interest are not constant over time and understanding the evolution of these parameters is important. Second, in examining the evolution of the elasticity estimates over several data periods we can assess if specific years of the data might be providing estimates that are less to do with a trend in the data and more as a result of an unobserved idiosyncratic feature that are unique to a specific year of the data. The potential importance of this, especially for demand projections, will be revealed by simulation results we generate.

Not only do we generate standard elasticity estimates but we also estimate preference-based elasticities. By holding household characteristics, prices and income constant (at base year levels), any changes we observe in elasticities can be assumed to be independent of changes in these variables and hence can only be attributed to the underlying utility parameters. We are to compare them to standard elasticities so that we can in turn understand the extent to which demand responsiveness to price and income changes are influenced by changes in food preferences.

Our expectation is that there have been changes in demand elasticities for cereals in India over our sample period. Specifically, if cereals are becoming less favored by Indian households, the expenditure elasticity (YED) for cereals is expected to decline over time as households are likely to spend proportionally less on them as income increases. Weaker preferences for cereals will also make Indian households less resistant to changes in their relative prices. Thus, we anticipate an increase in the price elasticity of demand (PED) for cereals over time. Also, it is expected that the demand for cereals has become more sensitive to price changes in substitutes but less to that of their complements. If our priors are met, this indicates that the preferences of Indian households have shifted away from cereals, contributing to the nutrition transition being observed in India.

To undertake our analysis we use India's National Sample Survey (NSS) from four time periods which are 1987-88, 1993-94, 2004-05, 2011-12. This household level survey data is analysed following Ecker and Qaim (2011) who employ a two-stage demand estimation procedure. In the first stage, the Working-Leser model is used to analyse how households allocate total expenditure among food and non-food items. Then in the second stage, we examine the composition of

food bundle consumed by Indian households with the quadratic almost ideal demand system (QUAIDS) proposed by Banks et al. (1997).[2] Our demand equations are estimated using a two-step procedure advocated by Shonkwiler and Yen (1999) to account for the sample selection bias from zero expenditure data. Also, as unit values are used as a proxy for the unobserved market prices, we mitigate the potential bias from measurement error and quality effects by implementing an adjustment following Majumder et al. (2012). Together with the results from the Woking-Leser model, these QUAIDS estimates give the combined demand elasticities for cereals, which can be used to infer the changes in food preferences in recent decades.

Overall, our results demonstrate that the preference-based demand elasticities for cereals are in line with our prior beliefs. Holding income, food prices and demographics constant, rural demand for cereals has become more sensitive to changes in income. In addition, urban demand for cereals has become more price elastic over time. It is also found that cereals have become a substitute rather than a complement for animal products. There is also evidence for a declining complementary relationship between cereals and other food groups. These trends continue to exhibit in the standard demand elasticities, clearly revealing the impact of changing preferences on the responsiveness of cereal demand to income and price changes in recent decades. As demonstrated in our simulation exercises, these changes in demand elasticities play a important role in driving the nutrition transition in India. From these findings, one can deduce that cereals are no longer the only key to food security in India. With the declining dietary importance of cereals, there is a need for Indian food system to transit from its current heavy focus on staples to one that enhances accessibility and availability of a diversified basket of food.

This paper is structured as follow. In Section 2 we describe our data as well as the adjustment of unit values. Then in Section 3 we detail our estimation methodology. Section 4 presents the various demand elasticity estimates. In Section 5, we perform two simulation exercises to understand how these changes in elasticities affect food consumption behaviour. We highlight the limitations in Section 6 and conclude in Section 7.

3.2 Data

3.2.1 The Indian National Sample Survey

This study uses household consumption expenditure data from four rounds of India's National Sample Survey (NSS) covering the periods 1987-88, 1993-94, 2004-05, 2011-12, yielding data on 265,770 rural and 174,067 urban households from over 70 Indian regions.[3] The NSS adopts a two-stage stratified sampling method in data collection. In the first stage the sampling units are villages and urban frame blocks for rural and urban sectors respectively. In the second stage, households are selected from the sampling units. Importantly, the survey has a wide coverage of food items at a disaggregated level, from basic staples to various types of vegetables

[2] QUAIDS has been used to examine Indian food consumption by Meenakshi and Ray (1999) and Mittal (2007).

[3] For more details of these surveys, see http://www.mospi.gov.in/national-sample-survey-office-nsso.

and fruits. Like previous studies on Indian food demand (e.g., Mittal (2007) and Kumar et al. (2011)), we divide the food items into six groups: cereals; eggs, fish and meat; edible oils; pulses; vegetables and fruits; and other food.[4] As income data is not collected in the NSS, we proxy household income with monthly per capita expenditure (MPCE). Expenditure and income are used interchangeably thereafter.

Table 3.1: Descriptive statistics

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
MPCE (in Indian rupee)	310	575	1113	2561	181	327	689	1599
MFE (in Indian rupee)	132	229	382	751	98	172	315	598
Share of food in total expenditure	0.51	0.48	0.42	0.37	0.58	0.57	0.52	0.43
Household size	4.90	4.57	4.61	4.32	5.44	5.17	5.10	4.80
Share of adult female	0.39	0.40	0.40	0.41	0.33	0.34	0.35	0.37
Share of adult male	0.32	0.33	0.35	0.37	0.33	0.34	0.35	0.37
Age of household head	42.97	43.33	45.22	46.29	44.48	44.65	46.21	47.05
Share of meals consumed outside	0.05	0.05	0.05	0.06	0.02	0.02	0.03	0.04
Household size	4.90	4.57	4.61	4.32	5.44	5.17	5.10	4.80
Food consumption (per capita calorie intake per day)								
Cereals	1323	1220	1225	1182	1684	1501	1426	1336
Eggs, fish and meat	43	45	42	44	32	32	35	35
Edible oils	190	191	202	237	114	127	160	199
Pulses	124	110	99	109	107	96	88	98
Vegetables and fruits	133	134	126	121	101	112	114	108
Other food	354	365	316	342	268	287	272	294
No of households	79303	68342	78819	59306	43166	45098	44543	41260

Table 3.1 presents descriptive statistics of MPCE, household characteristics and food consumption for our sample. Compared to the rural sector, households in urban India are generally richer and have higher MPCE. Rural households tend to allocate more budgets on food than their urban counterparts. Despite the increase in monthly per capita food expenditure (MFE) over time, Indian households spent relatively less on food in 2011-12 than 1987-88, with the average share of food in total expenditure falling from 51% to 37% for urban households and from 58% to 43% for rural households.

In term of food consumption, we see from table 3.1 that rural households purchase relatively more cereals while urban households have a more diverse diet. Even with the extensive set of government policies in place to distribute food grains to the poor, cereal consumption recorded the largest decrease among all the food groups. From 1987-88 to 2011-12, the average calorie intake from cereals of urban and rural households decreased by 141 kcal and 348 kcal respectively. Similar decline in the dietary importance of cereals has been observed in previous studies on Indian food consumption (Deaton and Drèze 2009; Smith 2015).

[4]Other food includes milk, milk products, cereal substitutes, dry fruits, nuts and sugar

3.2.2 Quality adjusted unit values (prices)

Like most food surveys, the NSS does not collect market prices for food items faced by households. Therefore, the common practice is to proxy prices with unit values obtained by dividing expenditure with quantity brought. This approach can exaggerate actual price differences across markets since product quality is not captured in the data. Unit values may also exhibit measurement error due to the failure of households to accurately recall expenditure and quantity consumed. Thus, unit values need to be corrected before being used as a proxy for market prices.

Following Majumder et al. (2012), we adjust the initial unit values calculated from the NSS survey, using the following Ordinary Least Squares (OLS) model:

$$v_i - (v_i^{ur})_{median} = d_{i1}D_r + d_{i2}D_u + d_{i3}D_s + \theta_i food + \eta_i Z + \varepsilon_i \tag{3.1}$$

where v_i is the unit value of food group $i(i = 1, , n)$ in Indian Rupee per kilogram faced by each household and $(v_i^{ur})_{median}$ is the median unit value of that item in sector u and region r in which a household resides. D_r and D_u denote regional and urban sector dummies respectively.[5] We extend the Majumder et al. (2012)'s approach by adding a set of dummy variables, D_s, to indicate the quarter of the year (i.e. sub-round of the survey) when the household is interviewed to account for the variation in market prices resulting from seasonal changes in food availability. The variable $food$ represents MFE. A vector of household characteristics, Z, (i.e., age and gender of household head, household size, proportion of adult males and females in the household, and share of times that meals are consumed outside by that household) are added as control variables. In particular, the share of meal consumed outside of home is employed as a proxy for the degree of market access to food enjoyed by that household. ε_i is the residual in the regression. We then assume that households in the same sector of the same region face the same vector of food prices, p_i and it is obtained by summing the median unit value with the median estimated residual of the sector in each region.[6] Table 3.2 presents the average quality and demographically adjusted unit values of food groups.

The values reported in Table 3.2 are similar to those in Majumder et al. (2012), with eggs, fish and meat being the most expensive food group and vegetables and fruits being the cheapest in the 2000s. Food prices are generally higher in the urban sector than the rural sector with the exception of edible oils for which the price differential is minimal. Other food and pulses recorded the fastest rise in adjusted unit values in the urban and rural sectors respectively. In contrasts, edible oils have become relatively cheaper in both sectors as the rate of growth in prices is the

[5] In Majumder et al. (2012), prices are modified to the district level by adding district dummies and using the median unit value in each district. However, information on Indian districts is not available in earlier surveys. For estimation consistency, prices used in this study are adjusted to the regional level, following Cox and Wohlgenant (1986).

[6] Since other food includes a high variety of food items, the price faced by households is largely subject to their consumption pattern and thus differs greatly within sectors and regions. To eliminate the influence of extreme unit values and ensure positivity of the adjusted price, outliners are dropped on the basis of Cook's distance in the price adjustment regression for other food. Our results are generally robust to the case when regional median unit values are used in demand estimation.

Table 3.2: Average quality-adjusted prices of food groups

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
Cereals	3.44	6.42	10.75	21.34	3.00	5.57	9.14	17.45
Eggs, fish and meat	24.06	41.70	62.93	113.77	20.12	35.85	57.24	109.46
Edible oils	25.67	35.14	55.23	81.99	26.13	33.82	55.63	80.37
Pulses	9.04	16.54	28.97	61.48	8.04	14.90	27.58	58.00
Vegetables and fruits	3.15	6.33	10.31	23.09	2.56	4.78	8.47	18.35
Other food	5.00	10.22	15.16	44.68	4.30	8.40	12.03	30.83

Note: Prices are in Indian Rupee per kilogram. For items which consumption is reported in numbers, they are converted into kilograms based on the following weights: 1 liter milk=1 kilogram; 1 coconut=1 kilogram; 1 egg = 0.058 kilograms; 1 lemon = 0.06 kilograms; 1 banana = 0.1 kilograms; 1 pineapple = 1.5 kilograms; 1 orange=0.015 kilograms.

lowest among all food groups. Importantly, there is evidence of a general increase in the relative price of cereals. Cereal prices recorded a percentage increase higher than that of eggs, fish and meat. While this may reflect that price subsidies were not sufficient to counteract the upward pressure from market forces, it may also be driven by the likelihood that Indian households have been substituting low cost cereals (i.e. coarse grains) for high cost ones (i.e. rice and wheat) (Chand 1999; Mittal 2007).

3.3 Econometric methodology

3.3.1 Two-stage demand system

In the first stage, a household decides how total expenditure is allocated across food and non-food commodities. Then in the second stage, the household allocates total food expenditure across six food groups. Together with the assumption that the price indices of food groups do not vary significantly with the expenditure level, the allocation of total expenditure will be approximately correctly estimated (Edgerton 1997). The two-stage demand systems are estimated separately for the rural and urban sectors for each round of the NSS considered.

Stage 1: The Working-Leser Model

Due to data limitations with the NSS, we follow Ecker and Qaim (2011) and employ the Working-Leser model to study the allocation of household food and non-food expenditure as follow:

$$w_F = \alpha_F + \beta_F \ln P_F + \gamma_F \ln M + \varepsilon_F \tag{3.2}$$

w_F is the share of food (F) in total expenditure. P_F is the median of average weighted food prices in each region, with the weights being equal to the proportion of total food expenditure that a household spends on each food item. To avoid price endogeneity, households in each region are assumed to face the same general food price level. M denotes household income which is proxied by MPCE and ε_F is error term. Finally, a vector of household characteristics (Z) are added as control variables through linear demographic translation (Ecker and Qaim 2011). This vector of variables is same as the one employed in the price adjustment estimation with the exception of

age of household head and household size, which enter in equation (3.2) in logarithm form for better model fit.

Stage 2: QUAIDS

With the assumption that an individual decision to consume is as a result of utility maximisation subject to a budget constraint, Banks et al. (1997) uses the following indirect utility function (V) to derive the QUAIDS:

$$\ln V = \left\{ \left[\frac{\ln m - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1} \tag{3.3}$$

where m denotes the MFE and $\ln(a(p))$ takes the translog form:[7]

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \tag{3.4}$$

and $b(p)$ is the Cobb-Douglas aggregator function of the price vector (p) defined by:

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \tag{3.5}$$

and $\lambda(p)$ is a price aggregator function which is homogeneous of degree zero in prices given in the following form:

$$\lambda(p) = \sum_{i=1}^{n} \lambda_i \ln p_i \tag{3.6}$$

Equations (3.3) to (3.6) together define the QUAIDS specification. It can be seen that, apart from income and prices, the utility that a consumer receives from consuming a good, is determined by the parameters α_i, γ_{ij}, β_i and λ_i. By capturing changes in these parameters, demand elasticities provide the best way to interpret how consumer preferences have changed as well as providing valuable insights into how consumer behaviour is affected by these changes in food preferences.

After applying Roys identity to equation (3.3), the budget share of food group $i(w_i)$ is derived as follow:

$$w_i = \alpha_i + \sum_{j} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{m}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \ln \left[\frac{m}{a(p)} \right] \right\}^2 + \varepsilon_i \tag{3.7}$$

The higher order income term in equation (3.7) marks the key difference between QUAIDS and the almost ideal demand system (AIDS) introduced by Deaton and Muellbauer (1980). The inclusion of this term allows the budget share Engel curve to be non-linear. In other words, goods can be a luxury for the poor but a necessity for the rich. To conform to the first budgeting stage, we allow the intercept to depend on the same set of household characteristics. Demand

[7] Following Deaton and Muellbauer (1980) and Banks et al. (1997), α_0 is chosen to be just below the lowest value of the logarithm of MFE (i.e. minus by 0.1).

theory implies that following restrictions are required in the estimation of QUIADS:

Adding up:

$$\sum_{i=1}^{n} \alpha_i = 0, \sum_{i=1}^{n} \beta_i = 0, \sum_{j=1}^{n} \gamma_{ij} = 0, \sum_{i=1}^{n} \lambda_i = 0, \tag{3.8}$$

Homogeneity:

$$\sum_{i=1}^{n} \gamma_{ij} = 0 \tag{3.9}$$

Symmetry:

$$\gamma_{ij} = \gamma_{ji} \tag{3.10}$$

Estimation of probit model

In the collection of household survey data, it is common to record zero purchases for commodities. They can be a 'true' zero, indicating that households do not consume these items for reasons such as inability to afford or low preferences towards them. For example, beef is often not consumed among Indian households because cow is deemed as a sacred animal by Hinduism. Zero consumption might also be driven by the fact these items are not available during the time that the household is surveyed. Alternatively, a zero could occur where households just happen to not make any purchase within the reporting period even though they normally consume that commodity (Deaton 1997). These zeros are considered as 'false' zeros, causing a downward bias to the observed expenditure.[8]

To deal with this issue, we follow Shonkwiler and Yen (1999) and employ a two-stage estimation procedure.[9] The demand system of equations is first modelled as follow:

$$\begin{aligned} \omega_i^* &= z_i' \kappa_i + \upsilon_i \\ \omega_i &= \begin{cases} 1 & \text{if } \omega_i^* > 0. \\ 0 & \text{if } \omega_i^* \leq 0. \end{cases} \\ w_i &= \omega_i w_i^* \end{aligned} \tag{3.11}$$

where w_i indicates the observed budget share of food group i and ω_i is the binary outcome which equals one if that item is consumed by the household, and zero otherwise. Their corresponding unobservable latent variables are indicated by w_i^* and ω_i^*. z_i' denotes the set of independent variables determining the consumption decision, which includes the logarithm of food group prices, logarithm of MFE and the household characteristics used in first stage demand estimation. υ_i is a random error.

In implementing this procedure, we compute the household-specific standard normal proba-

[8] The proportion of zero observations is given in table A2.1.

[9] Banks et al. (1997) deal with thid sample selection bias by estimating the demand system using GMM. As households in the NSS data are not sampled repeatedly, this technique is not feasible in our study.

bility density function $\Phi(z_i'\kappa_i)$ and cumulative distribution function $\phi(z_i'\kappa_i)$ for each food group using a probit model, which are then incorporates into the budget share equation (3.7), such that:

$$w_i = \Phi(z_i'\kappa_i)w_i^* + \varphi_i\phi(z_i'\kappa_i) + \varepsilon_i \tag{3.12}$$

With this correction for zero observation, the right-hand side of equation (3.12) does not add up to one in the demand system. Hence, the adding-up restriction defined above no longer holds, which removes the need for dropping one arbitrary equation in the QUAIDS estimation (Ecker and Qaim 2011). [10]

3.3.2 Demand elasticities

To identify changes in the underlying utility parameters, demand elasticities for all rounds are evaluated based on the representative urban and rural households in 1987-88 (i.e. who faced the mean values of food prices and had average income and household characteristics). Average budget share of food (w_F) is therefore held constant at the 1987-88 level in the following equations. From equation (3.2), the preference-based demand elasticities for food can be calculated as follows:

YED:

$$E_F^x = 1 + \frac{\gamma_F}{w_{F,8788}} \tag{3.13}$$

Uncompensated PED :

$$E_F^u = \frac{\beta_F}{w_{F,8788}} - 1 \tag{3.14}$$

Compensated PED (i.e. using the Slutsky equation):

$$E_F^c = E_F^u + w_{F,8788}E_F^x \tag{3.15}$$

Next, with the procedure given in Banks et al. (1997) and the formula from Edgerton (1997), the preference-based demand elasticities for aggregated food groups are derived as:[11]

YED:

$$\begin{aligned} \mu_i \equiv \frac{\partial w_i}{\partial \ln m} &= \left[\beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{m_{8788}}{a(p)}\right]\right\}\right]\Phi(z_i'\kappa_i) \\ E_i^x &= E_F^x\left(\frac{\mu_i}{w_{i,8788}} + 1\right) \end{aligned} \tag{3.16}$$

[10] Although the adding up restriction no longer holds with the correction for sample selection bias, the sum of predicted budget shares should still be one in theory. For each survey round, we predict food budget shares using estimates from equation (3.12) and check whether the average sum of shares equals one. The adding up condition is not rejected for most survey rounds. In cases where it is rejected, the average sum is found to be not statistically different from either 0.9999 or 1.0001.

[11] Carpentier and Guyomard (2001) citicise that Edgerton (1997)'s formulas only satisfies symmetry condition when sub-utility functions are homothetic. They propose an alternative set of PED formulas and show that their PEDs are different from the ones calculated based on Edgerton (1997). Considering that the differences are rather small, the potential bias arisen from using Edgerton's formulas is likely to have minimal impact on the trends of cross-price elasticities.

Uncompensated PED and cross price elasticity of demand(XED):

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \left[\gamma_{ij} - \mu_i\left(\alpha_j + \sum_k \gamma_{ik} lnP_{k,8788}\right) - \frac{\lambda_i \beta_j}{b(p)}\left\{\ln\left[\frac{m_{8788}}{a(p)}\right]\right\}^2\right]\Phi(z_i'\kappa_i)$$
$$E_{ij}^u = \left(\frac{\mu_{ij}}{w_{i,8788}} - \delta_{ij}\right) + E_i^x w_{j,8788}[1 + E_F^u] \tag{3.17}$$

Compensated PED and XED:

$$E_{ij}^c = \left(\frac{\mu_{ij}}{w_{i,8788}} - \delta_{ij}\right) + w_{j,8788}\left(\frac{\mu_i}{w_{i,8788}} + 1\right) + E_i^x w_{j,8788} E_F^c \tag{3.18}$$

where P_k is a price index calculated as the arithmetic mean of prices for all k food groups. δ_{ij} is the Kronecker delta which equals to one if $i = j$ and zero if $i \neq j$. Note that mean values of food prices, income and household demographics in 1987-88 are used in the computation of price indices ($a(p)$ and $b(p)$), and constant (α_j). The decision to consume (i.e. $\Phi(z_i'\kappa_i)$) is also evaluated based on the representative urban and rural households in 1987-88. This leaves changes in utility parameters the only possible cause of any variation in the estimates of preference-based demand elasticities. For the purpose of comparison, we also compute the standard demand elasticities using the mean data point of current survey period.

3.4 Empirical results

3.4.1 Food expenditure decision

The estimates of the Working-Leser model provide strong evidence supporting that households in both sectors allocate relatively less additional income to food when income increases.[12] The coefficients of shares of meals consumed outside home are significant and negative, which are in line with the finding of Ecker and Qaim (2011). Using distance to the nearest daily market as a parameter, they find that Malawian households spend proportionally more on food if they live farther away from the market. In the case of India, the level of market access, proxied by the share of meals consumed outside home, has a larger negative impact on the food budget share of rural households than those in the urban sector. The positive and significant coefficients of the share of adult female and male in both sectors reflect that adults have a higher calorie need and hence households with more adults spend relatively more on food. In addition, older household heads tend to spend more on food than the younger ones.

3.4.2 Demand elasticities for food

In table 3.3, we report two forms of demand elasticities for food of urban and rural India: (i) columns 1 and 2 give the preference-based elasticities, which are computed using the mean data point in 1987-88; (ii) columns 3 and 4 provides the standard elasticities calculated with the mean

[12]The regression results are reported in the Appendix.

data point of current period. Since the period 1987-88 is the reference point, the preference-based and standard elasticities are exactly the same in this period. All these elasticities are strongly statistically significant.

Table 3.3: Demand elasticities for food

	Preference-based		Standard	
	Urban	Rural	Urban	Rural
	(1)	(2)	(3)	(4)
YED				
1987-88	0.727	0.822	0.727	0.822
1993-94	0.714	0.809	0.698	0.806
2004-05	0.715	0.760	0.660	0.730
2011-12	0.748	0.791	0.651	0.717
Uncompensated PED				
1987-88	-0.843	-0.922	-0.843	-0.922
1993-94	-0.940	-1.009	-0.937	-1.009
2004-05	-0.904	-0.941	-0.885	-0.934
2011-12	-0.921	-0.961	-0.891	-0.947
Compensated PED				
1987-88	-0.475	-0.443	-0.475	-0.443
1993-94	-0.579	-0.538	-0.601	-0.546
2004-05	-0.542	-0.498	-0.605	-0.555
12011-12	-0.543	-0.500	-0.653	-0.638

Note: The preference-based demand elasticities are calculated using the mean data point in 1987-88 while the standard elasticities are computed based on data of current period. All estimates are statistically significant at the 99% confidence level. Standard errors are not reported to save space.

Preference-based elasticities for food

For both urban and rural sectors, the preference-based YED for food is smaller than unity. This conforms to the fact that food is a necessity, and Engel's Law which states that the proportion of total expenditure spent on food is greater for poorer households. As predicted by demand theory, the sign of uncompensated and compensated PEDs for food is negative. The rural demand for food is shown to be more income and price elastic than that of urban households. For both sectors, there are limited changes in the value of preference-based YED and PED over the survey rounds, suggesting the preferences for food are reasonably stable over the period of interest.

Standard elasticities for food

Next, we look at standard demand elasticities for food in columns 3 and 4. While these estimates also confirm to Engel's law and demand theory, they display more variations than the preference-based ones. From 1987-88 to 2011-12, the rural and urban standard YEDs decreased from 0.727 to 0.651 and 0.822 to 0.717 respectively, indicating that the proportion of additional income allocated to food expenditure decreases with income increase. In both sectors, the demand for food has become more sensitive to changes in food price as suggested by the rising trend of PEDs.

The estimates of standard demand elasticities for food indicate that although food remains a necessity, its importance to within household budget in both rural and urban India has declined. These results are consistent with the observation of Deaton and Drèze (2009) in which they find

limited real change in per capita expenditure on food in spite of the rising MPCE. As shown by the trend of standard YED, the rise in total expenditure of Indian households triggers a less than proportional increase in expenditure on food and the magnitude of this increase tends to fall over time. Deaton and Drèze (2009) also show that real price of calorie increased from 1987-88 to 1999-2000. The estimates of PED suggest that the increase in calorie prices causes a rising negative substitution effect over time, making it more likely to cancel out the falling positive income effect and leaving the real food expenditure unchanged.

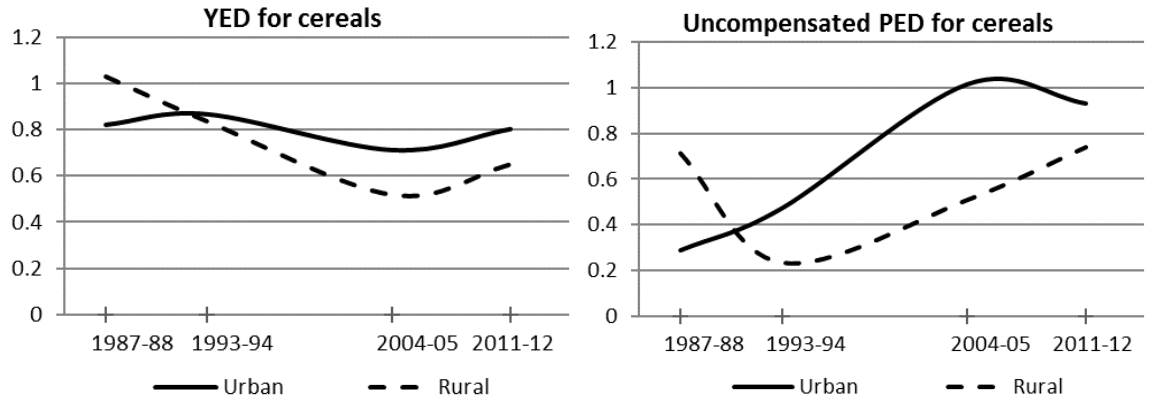
3.4.3 QUAIDS estimates

The QUAIDS is estimated with the iterative feasible generalised non-linear least square estimator through the NLSUR command in STATA. To keep the analysis focused on the nutrition transition, we report the estimates in the Appendix and only discuss the key results here. For both urban and rural sectors, most of the parameters estimated are statistically significant. The highly significant quadratic term of income (λ) supports the non-linearity of the budget share Engel curve of Indian households for their consumption of various food groups and thus establishes the superiority of QUAIDS over AIDS. The QUAIDS results also signal the importance of correction in zero consumption as the coefficients of probability density functions (ϕ) are mostly statistically significant.

3.4.4 Demand elasticities for cereals

The preference-based and standard demand elasticities for cereals for urban and rural sectors are presented in table 3.4.[13] These statistically significant elasticities capture the short run (i.e. a year) demand response to changes in income and prices and therefore tend to be smaller than one in absolute value. In other words, the demand for cereals is generally income and price inelastic in India. In addition to table 3.4, we provide a series of graphs to illustrate the trends of demand elasticities for cereals and highlight their inference on the food preferences pf Indian households.

Figure 3.1: Preference-based income and price demand elasticities (in absolute value) for urban and rural India



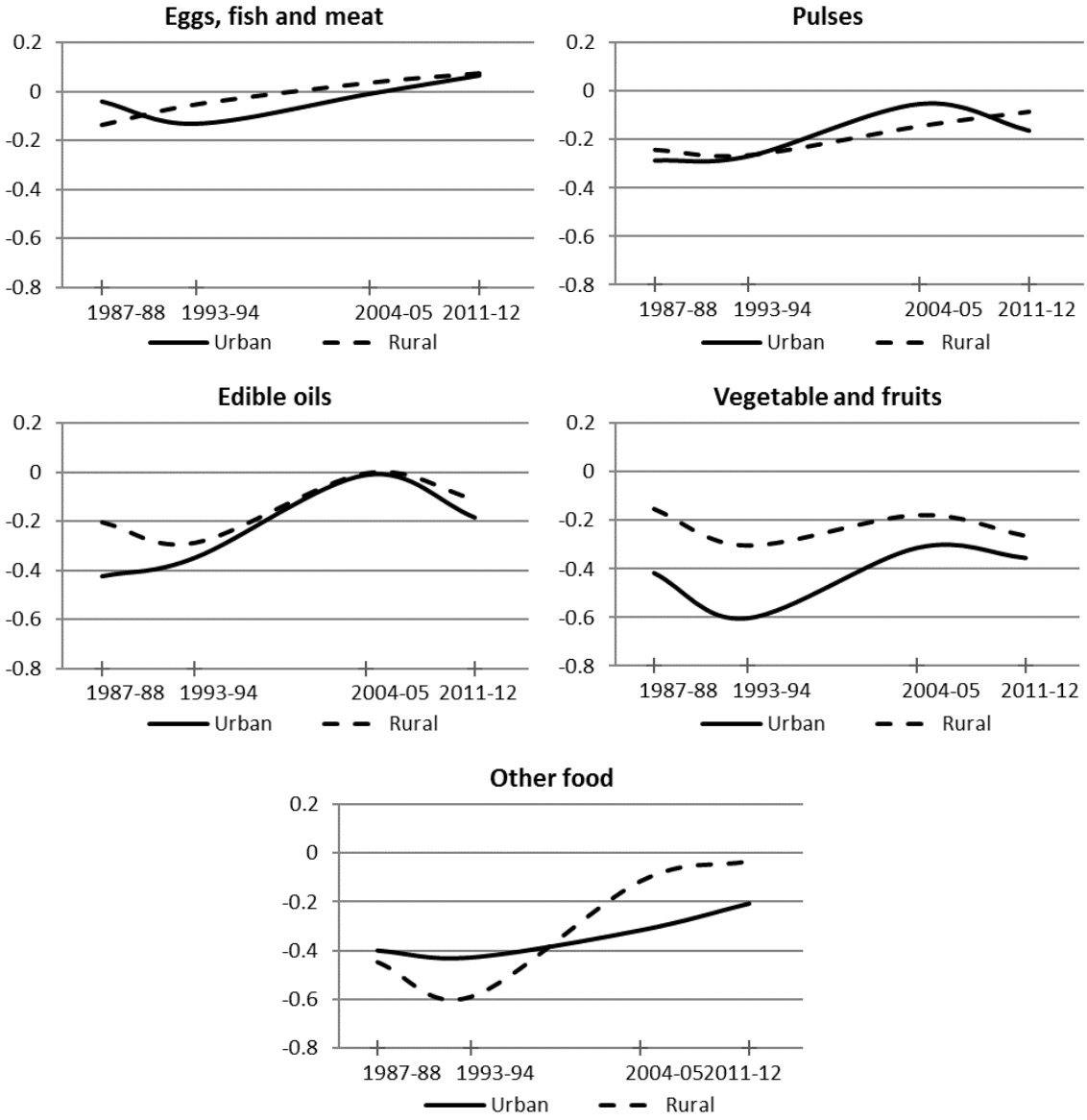
[13] We report the estimated demand elasticities for other food groups in the Appendix.

Table 3.4: Demand elasticities for cereals

	Preference-based		Standard	
	Urban	Rural	Urban	Rural
	(1)	(2)	(3)	(4)
YED				
1987-88	0.820	1.027	0.820	1.027
1993-94	0.865	0.834	0.875	1.108
2004-05	0.712	0.516	0.688	0.723
2011-12	0.802	0.648	0.499	0.708
Uncompensated PED				
1987-88	-0.286	-0.711	-0.286	-0.711
1993-94	-0.470	-0.232	-0.457	-0.539
2004-05	-1.015	-0.507	-1.025	-0.662
2011-12	-0.930	-0.737	-0.874	-0.682
Compensated PED				
1987-88	-0.151	-0.433	-0.151	-0.433
1993-94	-0.327	-0.007	-0.326	-0.267
2004-05	-0.898	-0.367	-0.932	-0.519
2011-12	-0.797	-0.561	-0.824	-0.588
XED in response to price changes of eggs, fish and meat				
1987-88	-0.040	-0.137	-0.040	-0.137
1993-94	-0.131	-0.053	-0.147	-0.127
2004-05	-0.009	0.035	-0.019	0.003
2011-12	0.066	0.074	0.120	0.081
XED in response to price changes of edible oils				
1987-88	-0.424	-0.204	-0.424	-0.204
1993-94	-0.348	-0.288	-0.342	-0.422
2004-05	-0.010	-0.003	-0.013	-0.072
2011-12	-0.184	-0.110	-0.101	-0.180
XED in response to price changes of pulses				
1987-88	-0.287	-0.243	-0.287	-0.243
1993-94	-0.269	-0.265	-0.283	-0.325
2004-05	-0.052	-0.144	-0.050	-0.196
2011-12	-0.163	-0.084	-0.177	-0.147
XED in response to price changes of vegetables and fruits				
1987-88	-0.416	-0.155	-0.416	-0.155
1993-94	-0.603	-0.304	-0.656	-0.338
2004-05	-0.312	-0.180	-0.367	-0.321
2011-12	-0.354	-0.265	-0.183	-0.456
XED in response to price changes of other foods				
1987-88	-0.400	-0.448	-0.400	-0.448
1993-94	-0.429	-0.591	-0.457	-0.759
2004-05	-0.316	-0.116	-0.319	-0.289
2011-12	-0.206	-0.035	0.062	-0.233

Note: The preference-based demand elasticities are calculated using the mean data point in 1987-88 while the standard elasticities are computed based on data of current period. All estimates are statistically significant at the 99% confidence level.

Figure 3.2: Preference-based cross price demand elasticities for urban and rural India

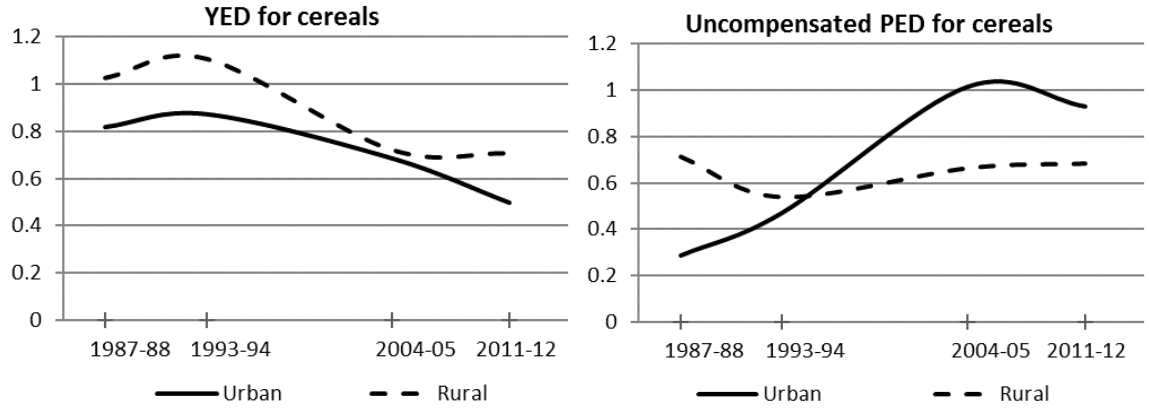


Preference based elasticities for cereals

The preference-based elasticity estimates in columns 1 and 2 of table 3.4 show that urban demand for cereals have become more income and price elastic than that of the rural sector since 1990s. As seen from the left panel of figure 3.1, the urban YED is relatively stable over the period of interest. In contrast, the rural preference-based YED has decreased from 1.027 to 0.648 from 1987-88 to 2011-12. This decrease in the responsiveness of cereal demand towards income changes confirms our hypothesis that cereals are losing the favour of rural households. Consequently, less additional income has been allocated to the consumption of these commodities over time.

The right panel of figure 3.1 reveals that cereal demands in both sectors have become more price elastic as a result of the changes in food preferences. During the survey period, the absolute value of urban PED for cereals increased from 0.286 to 0.930. For rural households, their PED

Figure 3.3: Standard income and price demand elasticities (in absolute value) for urban and rural India



for cereals rose from 0.232 to 0.737 in absolute value from 1993-94 to 2011-12. This increasing trend of preference-based PEDs provides support to our proposition that the decline in consumer preferences for cereals has made Indian households more willing to adjust their cereal consumption in response to the rise in cereal prices.

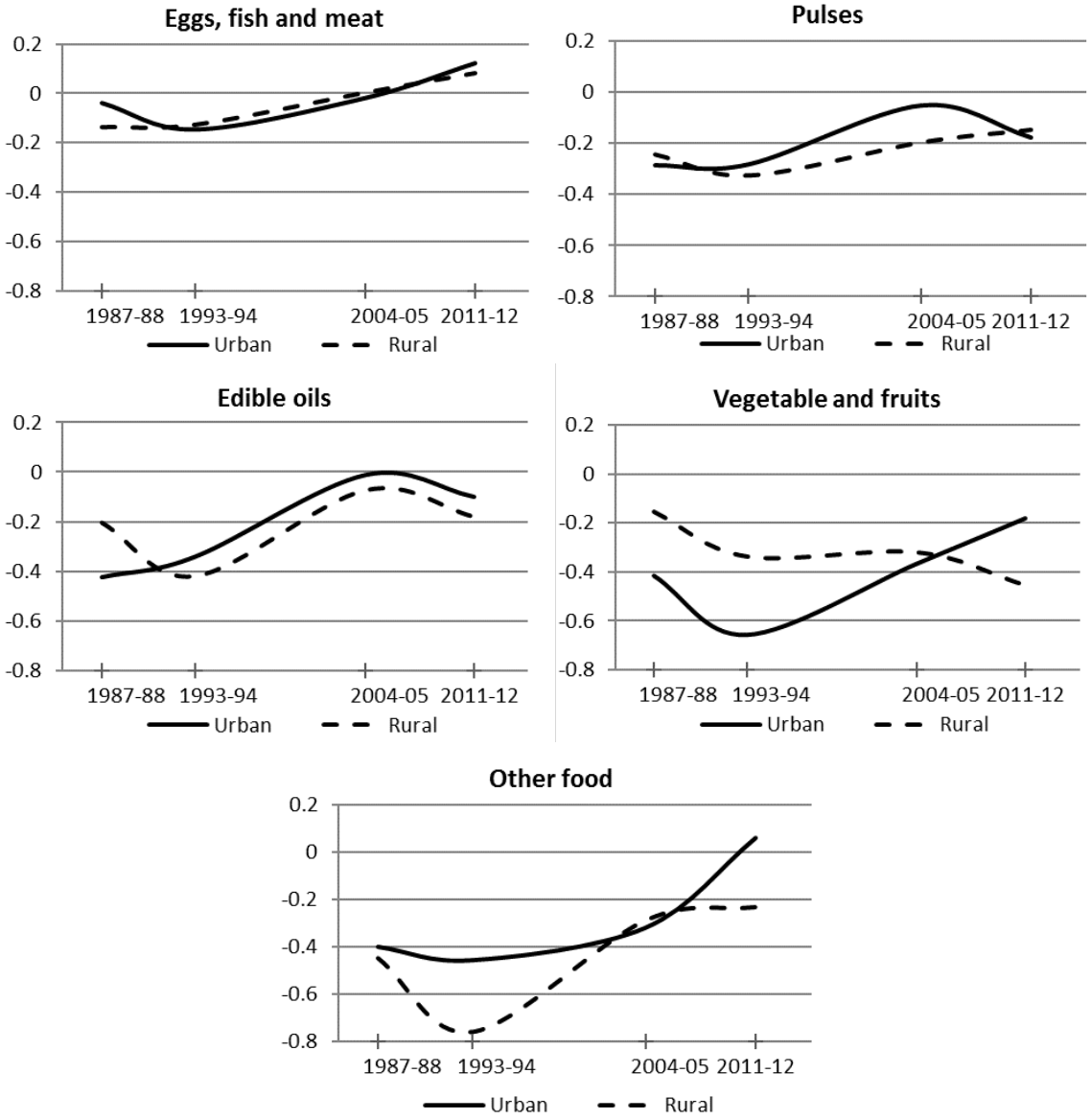
Next, we check the validity of our hypothesis on preference-induced changes in the XEDs for cereals. In columns 1 and 2 of table 3.4, the estimates of XEDs are predominately negative, suggesting that most food groups are viewed as complements to cereals by Indian households. The absolute value of the preference-based XEDs between cereals and its complements has generally decreased in absolute value over time, as shown in figure 3.2. This conforms to our prior belief that cereal demand has become less sensitive to price changes in its complements. In 2004-05 and 2011-12, the estimate of XED between cereals and animal products in urban and rural India turned positive respectively, indicating that Indian household now view them as substitutes rather than complements. Overall, the trends of preference-based XEDs reveal evidence for the shift in food preferences of Indian households away from cereals.

Standard elasticities for cereals

The standard demand elasticities reported in table 3.4 are in line with the results of Anand et al. (2016) even though the sample selection bias of zero observation is not accounted in their study. Using the same NSS data, they find that the Indian YED and PED for cereals in 2011-12 are 0.468 and -0.858 respectively.[14] In figure 3.3, we plot the standard YED and uncompensated PED for cereals, which exhibit similar trends to the preference-based elasticities. The declining YEDs reveal that both rural and urban demands for cereals have become less income elastic.

[14]In addition, our standard demand elasticities are consistent with the findings of Mittal (2010) and Kumar et al. (2011) in which the Indian demand for animal products and other food are generally more income and price elastic than other food groups. It should be noted that the elasticities reported in this paper are not directly comparable to those estimated in the above studies due to two reasons. First, their data periods are 1983, 1987-88, 1993-94 and 1999-2000, which differ from the ones used in this paper. Second, they estimate QUAIDS using a pooled dataset from the above NSS data with no attempts to account for the time trend across rounds. Their elasticities thus capture the long-term response rather the short-term changes reported in this paper.

Figure 3.4: Standard cross price demand elasticities for urban and rural India



The right panel illustrates that while the standard PED for cereals has been increasing in urban India, it is relatively stable in rural India.

The estimates of standard XEDs in columns 3 and 4 of table 3.4 show that most food groups have a complementary relationship with the demand for cereals. Figure 3.4 illustrates a general decrease in the absolute value of standard XEDs, in other words, Indian cereal demand has become less responsive to price change of its complements. Cereals have become a substitute rather than a complement to animal products in both sectors. Similar to the YEDs and PEDs, their values follow closely the preference-based elasticities. This provides evidence that changes in food preferences play an important role in driving the trends of standard demand elasticities.

Overall, the trends of standard elasticities are very much same as the ones of preference-based elasticities. This highlights that changes in utility parameters, and thus food preferences, are

crucial determinant of demand responsiveness towards income and price changes. The evolution of these estimates rejects the normal assumption of constant elasticities in demand studies. More importantly, Indian demand for cereals is found to have become less income elastic but more sensitive to changes in cereal prices. There is also evidence in support of the declining complementary relationship between cereals and other food groups. Animal products are no longer viewed as a complement to cereal but a substitute. These movements of demand elasticities confirm our hypothesis that the food preferences of Indian households have shifted away from cereals in the last few decades.

3.4.5 Robustness check

The demand elasticity estimates may be biased as the selection of Indian households is not entirely random. Due to the use of the two-stage stratification strategy, the probability of Indian households being selected varies across sample villages and urban blocks. One way to address this issue is to apply survey weights in the regression analysis. As stated by Winship and Radbill (1994), this is not necessary if sampling weights are solely a function of the observed independent variables included in the model. They argue that the use of unweighted data is preferred if the parameter estimates produced by OLS and Weighted Ordinary Least Squares (WOLS) are substantively similar as OLS estimates are more efficient and the estimated standard errors are smaller. To examine if our estimates are biased, we re-estimate the QUAIDS with the application of survey weights. The demand elasticities only differ slightly from the ones in table 3.4.[15] Therefore, the use of sampling weights is unlikely to alter the trend of preference-based demand elasticities observed above.

The food prices used in this paper may also be a source of estimation bias. As noted by Majumder et al. (2012), the quality adjustments do not completely eliminate the bias arising from using unit values as proxies for market prices. Nevertheless, if the distortions in unit values are consistent across regions and survey rounds, the impact on the patterns of demand elasticities will be minimal. Given that it is difficult to measure the magnitude of potential measurement bias, we check whether the results are robust if no quality adjustment is performed at all. To do this we re-estimated the QUAIDS with the median unit value of food groups in each region and find that the trends of demand elasticities are same as the ones discussed above.

3.5 The nutrition transition

How has this shift in food preferences contributed to the decline in dietary importance of cereals? To answer this question, we perform two simulation exercises in table 3.5 in which we estimate the cereal demand response towards income and price changes using the preference-based demand elasticities obtained from data in different periods. In both cases, we assume all other factors remain constant and take the cereal consumption in 2011-12 as base level. Recall that these preference-based elasticities are independent of changes in income, prices and demographics,

[15] We present the results of robustness check on preference-based demand elasticities in the Appendix

this implies that any difference in the predicted level of cereal consumption can only be explained by changes in the underlying utility parameters, in other words, consumer preferences towards cereals.

Table 3.5: Predicted cereal consumption (in per capita daily calories) in response to income and price changes, 2011-12

Data period of preference-based YEDs/ PEDs	Urban			Rural		
	Base level (i.e. 2011-12) (1)	Predicted change (2)	Predicted level (3)	Base level (i.e. 2011-12) (4)	Predicted change (5)	Predicted level (6)
Panel A: Income increases by 10%						
1987-88	1182	280	1463	1336	352	1688
1993-94	1182	296	1478	1336	286	1622
2004-05	1182	243	1426	1336	177	1513
2011-12	1182	274	1457	1336	222	1558
Panel B: Price increases by 10%						
1987-88	1182	-98	1085	1336	-244	1093
1993-94	1182	-161	1022	1336	-79	1257
2004-05	1182	-347	835	1336	-174	1163
2011-12	1182	-318	864	1336	-252	1084

Panel A shows the estimated changes in cereal demand in response to income growth. Assuming income increased by 10%, rural households would have increased their cereal consumption by 352 kcal if the YED did not change since 1987-88. Nevertheless, because their demand for cereals has become less income elastic over time, the rise in consumption would only be 222 kcal under the YED estimated with 2011-12 data. This difference in the predicted change in cereal consumption is less obvious in urban India due to its relatively stable YEDs.

In panel B, we consider a cereal price increase by 10%. Using the preference-based PED in 1987-88, it is predicted that cereal consumption would have decreased by 98 kcal in the urban sector and 244 kcal in the rural sector. But when the elasticities estimated with 2011-12 data are used, the predicted decrease in urban and rural India become 318 kcal and 252 kcal respectively. This illustrates that by making demand more price elastic, the decline in preferences towards cereals have increased the magnitude of the fall in cereal intake in respond to the price rise.

Combining the results from both panels, it can be seen that with equal percentage increase in income and cereal price, rural and urban households would have consumed more cereals if their preferences towards cereals did not change, in other words, if the preference-based demand elasticities remained at 1987-88 level. This is because the income-induced increase in cereal consumption is larger than the decrease triggered by price changes. However, as cereals have become less preferred over time, the rise in income and cereal price would result in a decrease in cereal intake instead. This is apparent when elasticities estimated with 2011-12 data are used for simulation. The price-induced fall in cereal intake becomes larger than the increase caused by income growth. As a result, with 10% rise in income and cereal price, rural and urban households would consume 44 kcal and 30 kcal less cereals respectively.

The above simulation exercises reveal the role played by changing food preferences in driving the nutrition transition. Weaker preferences for cereals have slowed the rate of increase in cereal consumption in response to the recent income growth in India. It has also made households

more sensitive to the increase in cereal prices and hence led to a larger fall in cereal intake. These changes have contributed to dietary shift away from cereals in India despite the various policy efforts implemented in India to deal with food insecurity and nutrition. Besides, given that animal products are now viewed as substitutes to cereals rather than complements, the fall in their relative prices may have further discouraged cereal consumption and hence given rise to the decline in dietary importance of cereals.

An additional insight from our simulation results is the potential error in demand projection arisen from the use of demand elasticities from previous years. If one were to use elasticities estimated with data of earlier years to forecast future food demand, then one would misestimate the extent of dietary change associated with income and price changes as it is implicitly assumed that there are no changes in the utility parameters of demand functions and therefore food preferences. This issue is likely to be more problematic if the analysis covers a long period of time or if the country of interest is experiencing dramatic changes. This points to the importance of using up-to-dated consumption data when estimating demand elasticities. In cases where recent survey data is not available, a closer scrutiny of factors influencing food preferences is necessary to better understand how demand responsiveness to income and price changes may have evolved over time and thus improve the accuracy of demand projection.

3.6 Limitations

While the trend of demand elasticities is robust, there are some caveats that should be kept in mind. As highlighted by Strauss and Thomas (1995), expenditure survey data does not adequately control for food wastage. Since rich households are likely to waste more food than the poor ones, their actual food consumption may be overstated. Besides, the NSS does not account for meals that are given to guests and employees and the ones that are received in kind, causing a potential upward bias on demand elasticities. Smith (2015) also raises a concern about the inadequacy of NSS in capturing consumption of meals consumed away from home, which leads to an underestimation of actual cereal consumption. This downward bias would be greater if the meals consumed away from home contained relatively more cereals than those eaten at home. Nonetheless, these measurement errors are likely to be mitigated with the inclusion of demographics in our model estimation since the likelihood of food wastage and the patterns of giving and receiving meals and eating out are correlated with household characteristics. Furthermore, given that these errors tend to be consistent over time, their impact on the trends of demand elasticities is expected to be minimal.

Another issue is the simultaneous bias in estimating food demand. In this paper, we have taken the view that income determines the level of food consumption and have neglected the efficiency-wage hypothesis which argues that households with better food intakes are likely to have higher work productivity and hence higher income earnings. This reverse causation in the relationship between income and food consumption gives rise to an endogeneity bias on the estimates of demand elasticities. However, the existing evidence for efficient wage is thin

(Strauss and Thomas 1998). In the case of India, Dawson and Tiffin (1998) examine the long-run relationship between per capita calorie intake and per capita income using aggregate data from 1961 to 1992. In their co-integration analysis, they find that calorie intake is Granger caused by income and not vice versa, suggesting that income generation is not constrained by food intake in India. Hence, the bias caused by reverse causation is unlikely to be a concern in our case.

3.7 Discussion and conclusion

This paper identifies the influence of changing preferences towards cereals and its impact on dietary patterns from 1987-88 to 2011-12. We estimate preference-based demand elasticities with the assumption that income constraints, food prices and demographics remain constant at 1987-88 levels. These elasticities only capture variations in the utility parameters of demand functions, making them a good indicator of changes in food preferences. Our results show that rural demand for cereals has become more sensitive to income changes as a result of the changes in utility parameters. The increasing trend of preference-based PEDs reflects that both urban and rural demand for cereals had become more price elastic. In terms of preference-based XED, Indian households now view animal products as a substitute for cereals rather than a complement. There is also a decrease in the XEDs between cereals and its complements. These findings are generally consistent with our prior beliefs, confirming that cereals have become less favored by Indian households over time. Through our simulations exercises, we illustrate how these changes in demand elasticities are linked to the declining dietary importance of cereals.

The decline in dietary importance of cereals may come at a nutritional cost for Indian households. As pointed out by Meenakshi (2016), although cereals are not rich in iron, they are major source of dietary iron because of the large quantity consumed. The author argues that the decreases in aggregate iron intake of Indian households over time is largely a reflection of lower cereal consumption. Indeed, as non-cereals are generally more expensive than cereals in terms of price per nutrient, the decline in cereal intake may reduce overall nutritional intake unless the real food expenditure is adjusted accordingly. However, Indian households are unlikely to increase their food budget under the rising pressure of non-food expenses, as evidenced by the estimates of demand elasticities for food in this paper and the limited changes in real food expenditure observed by Deaton and Drèze (2009). Their nutritional intake is therefore vulnerable to changes in the price or availability of non-cereals. Cereals are no longer the only key to Indian food security as they are now less favored.

Pingali (2015) "*There is a growing disconnect between agricultural policy and contemporary nutritional challenges.*"(page 583).

Nevertheless, the current Indian food security policy remains heavily biased towards staple grains. The main focus of PDS lies on the provision of subsidised sugar, rice and wheat to the poor. Besides, Indian agricultural policy has a historical bias which incentivises only rice and wheat production and discourages diversification towards nutritious crops (Pingali et al. 2017). There

is therefore a widening divergence between current food system and the newly developed food preferences. To narrow this gap, the Indian government needs to look beyond cereals and expand the basket of food covered under the current policy. In particular, it is rather ineffective to rely on subsiding traditional staples that are losing the favour of Indian households to improve nutrition outcomes. A diversified food system that enhances accessibility and availability of nutritious non-cereal food hence holds the key to the contemporary food insecurity and nutritional challenges.

Appendix

Table A2.1: Proportion of zero observations in food consumption

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
Cereals	0.05	0.05	0.03	0.02	0.03	0.03	0	0
Eggs, fish and meat	0.39	0.39	0.36	0.34	0.44	0.42	0.36	0.31
Edible oils	0.05	0.07	0.03	0.03	0.04	0.04	0.02	0.01
Pulses	0.06	0.06	0.03	0.04	0.07	0.05	0.02	0.02
Vegetables and fruits	0.01	0.01	0	0	0.01	0	0	0
Other foods	0.05	0.05	0.02	0.02	0.08	0.07	0.01	0.02

Table A2.2: Estimates of the Working-Leser model

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
Food price index	0.079***	0.030***	0.049***	0.040***	0.045***	-0.005**	0.034***	0.023***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
MPCE	-0.138***	-0.145***	-0.144***	-0.128***	-0.103***	-0.111***	-0.140***	-0.122***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Market access	-0.328***	-0.326***	-0.301***	-0.264***	-0.392***	-0.422***	-0.339***	-0.271***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.008)	(0.008)	(0.006)	(0.005)
Gender of household head	-0.012***	-0.006***	-0.000	-0.001	0.003	0.006***	0.001	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Household size	-0.004**	-0.004***	-0.004***	-0.014***	0.018***	0.006***	0.002*	-0.003***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Share of adult female	0.021***	0.023***	0.020***	0.019***	0.055***	0.041***	0.016***	0.016***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)
Share of adult male	0.048***	0.050***	0.016***	0.014***	0.043***	0.030***	0.012***	0.013***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)
Age of household head	0.041***	0.033***	0.030***	0.025***	0.008***	0.004**	0.014***	0.013***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Constant	0.948***	1.161***	1.145***	1.111***	0.937***	1.171***	1.252***	1.180***
	(0.012)	(0.012)	(0.010)	(0.009)	(0.010)	(0.010)	(0.008)	(0.009)
Observations	43,166	45,098	44,543	41,260	79,303	68,342	78,819	59,306

Note: Food price index, MPCE, household size and age of household head enter in logarithm form. Market access is measured by the percentage of meals that members of households consumed outside of home. Gender of household head is a dummy variable which takes the value of 1 for female and 0 for male. The remaining independent variables are percentages. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1

Table A2.3: QUAIDS

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
α_1	-0.834	0.172	0.053	0.304	0.244	0.000	0.187	0.332
	(-23.62)	(6.67)	(3.44)	(22.47)	(7.52)	(0.56)	(15.10)	(26.22)
α_2	-0.002	0.028	0.045	0.136	0.096	0.128	0.226	0.118
	(-0.37)	(1.39)	(5.15)	(28.45)	(6.61)	(11.85)	(20.93)	(17.50)
α_3	0.404	-0.197	0.296	0.140	-0.160	0.000	0.045	0.065
	(16.32)	(-11.24)	(17.04)	(15.06)	(-10.06)	(1.80)	(5.14)	(5.10)
α_4	0.255	0.114	0.058	0.105	-0.096	-0.134	-0.091	-0.032
	(10.39)	(6.57)	(3.63)	(16.69)	(-7.16)	(-12.60)	(-9.91)	(-3.67)
α_5	0.811	0.804	0.536	0.247	0.699	0.861	0.615	0.494
	(22.59)	(48.08)	(28.86)	(15.59)	(59.18)	(89.95)	(71.44)	(35.09)
α_6	0.262	0.034	0.000	0.093	0.174	0.105	0.084	0.035
	(11.01)	(2.89)	(0.33)	(13.46)	(9.79)	(9.39)	(6.79)	(3.58)
β_1	0.578	0.406	0.200	-0.007	0.145	0.240	0.062	-0.086
	(43.51)	(41.62)	(17.27)	(-0.76)	(9.00)	(49.78)	(6.10)	(-8.24)
β_2	0.061	0.032	0.027	0.000	0.061	0.020	-0.027	-0.002
	(28.80)	(2.43)	(5.10)	(0.13)	(7.29)	(3.55)	(-4.08)	(-0.48)
β_3	-0.140	0.054	-0.011	-0.023	0.088	-0.022	0.168	0.033
	(-14.28)	(4.35)	(-0.81)	(-2.66)	(7.65)	(-5.83)	(28.24)	(3.16)
β_4	-0.086	-0.031	0.013	0.041	0.098	0.040	0.044	0.058
	(-9.91)	(-3.19)	(1.42)	(9.33)	(11.48)	(8.70)	(7.45)	(8.02)
β_5	-0.213	-0.293	-0.160	-0.079	-0.168	-0.112	-0.079	-0.048
	(-15.52)	(-19.35)	(-10.66)	(-14.92)	(-24.19)	(-20.78)	(-22.89)	(-21.43)
β_6	-0.194	-0.153	-0.054	0.071	-0.206	-0.150	-0.186	0.047
	(-20.08)	(-17.39)	(-5.72)	(12.47)	(-26.75)	(-23.97)	(-21.82)	(5.99)
γ_{11}	-0.398	0.026	0.069	0.093	0.187	0.068	-0.024	0.007
	(-12.94)	(1.83)	(5.72)	(11.26)	(15.01)	(10.06)	(-4.28)	(1.08)
γ_{12}	-0.080	-0.020	0.023	0.056	-0.001	-0.014	0.024	0.050
	(-31.20)	(-2.13)	(7.53)	(37.67)	(-0.37)	(-4.48)	(12.56)	(27.02)
γ_{13}	0.108	-0.134	0.008	-0.030	-0.133	-0.060	0.011	-0.016
	(10.62)	(-13.47)	(1.41)	(-9.14)	(-33.32)	(-28.80)	(2.94)	(-5.18)
γ_{14}	0.027	-0.063	-0.056	-0.023	-0.102	-0.084	-0.001	-0.025
	(2.43)	(-8.00)	(-12.14)	(-8.40)	(-28.51)	(-32.43)	(-0.62)	(-7.90)
γ_{15}	0.231	0.176	-0.026	-0.095	-0.009	-0.030	-0.045	-0.056
	(11.05)	(11.60)	(-2.44)	(-15.22)	(-1.11)	(-4.53)	(-9.38)	(-13.37)
γ_{16}	0.124	-0.055	-0.025	-0.005	0.021	0.021	-0.013	0.032
	(8.91)	(-5.94)	(-3.99)	(-1.57)	(2.46)	(5.10)	(-2.85)	(10.99)
γ_{22}	-0.045	-0.016	-0.013	-0.013	-0.024	-0.005	-0.038	-0.011
	(-33.94)	(-8.62)	(-18.48)	(-26.99)	(-8.64)	(-3.81)	(-31.81)	(-22.03)
γ_{23}	0.015	-0.018	-0.011	-0.001	-0.023	-0.006	0.003	0.008
	(12.13)	(-6.94)	(-7.31)	(-1.69)	(-8.18)	(-5.84)	(1.25)	(8.94)
γ_{24}	0.010	0.009	-0.002	-0.042	-0.023	-0.011	0.006	-0.044
	(7.50)	(8.87)	(-1.92)	(-34.13)	(-8.89)	(-12.37)	(6.56)	(-31.62)
γ_{25}	0.021	0.010	0.004	-0.001	0.030	0.019	0.023	-0.004
	(10.13)	(1.19)	(2.20)	(-1.62)	(7.64)	(8.36)	(8.94)	(-2.75)
γ_{26}	0.075	0.046	-0.003	0.001	0.038	0.021	-0.018	0.001

	(34.10)	(13.40)	(-3.77)	(7.11)	(8.09)	(9.96)	(-7.96)	(2.51)
γ_{33}	-0.007	0.125	-0.033	0.034	0.038	0.058	-0.126	0.025
	(-1.45)	(25.72)	(-11.41)	(13.72)	(7.20)	(21.33)	(-26.88)	(10.81)
γ_{34}	0.010	0.007	0.004	-0.005	-0.014	0.009	-0.022	0.002
	(3.19)	(3.17)	(1.45)	(-2.02)	(-3.51)	(4.66)	(-8.49)	(0.95)
γ_{35}	-0.081	0.028	0.024	0.005	0.084	0.016	0.055	-0.012
	(-20.61)	(2.85)	(5.18)	(1.41)	(13.90)	(5.66)	(19.14)	(-4.54)
γ_{36}	-0.037	0.034	0.006	-0.009	0.050	0.004	0.059	-0.015
	(-8.31)	(8.65)	(2.78)	(-6.32)	(7.59)	(2.75)	(14.97)	(-15.99)
γ_{44}	0.027	0.050	0.025	0.056	0.041	0.091	0.036	0.070
	(8.04)	(24.04)	(9.31)	(20.72)	(9.33)	(44.70)	(13.89)	(21.15)
γ_{45}	-0.045	-0.035	0.008	0.012	0.060	0.017	0.006	0.014
	(-10.56)	(-6.10)	(2.42)	(4.42)	(13.93)	(7.85)	(3.62)	(4.55)
γ_{46}	-0.010	0.020	0.021	0.000	0.052	0.015	0.018	-0.009
	(-2.88)	(7.70)	(15.19)	(-0.34)	(10.17)	(8.49)	(7.07)	(-7.79)
γ_{55}	-0.089	-0.173	-0.026	0.040	-0.073	-0.001	-0.020	0.056
	(-7.08)	(-9.00)	(-1.90)	(5.73)	(-10.55)	(-0.22)	(-4.00)	(7.42)
γ_{56}	-0.038	-0.020	0.016	0.039	-0.089	-0.025	-0.007	0.007
	(-5.12)	(-2.34)	(3.66)	(11.37)	(-21.25)	(-6.43)	(-1.91)	(2.50)
γ_{66}	-0.106	-0.025	-0.016	-0.025	-0.061	-0.030	-0.042	-0.017
	(-13.33)	(-4.23)	(-3.09)	(-14.95)	(-7.39)	(-5.39)	(-6.57)	(-6.01)
λ_1	-0.053	-0.054	-0.044	-0.010	-0.018	-0.022	-0.011	0.019
	(-41.45)	(-24.19)	(-16.23)	(-2.53)	(-7.90)	(-26.02)	(-5.87)	(7.25)
λ_2	-0.006	-0.003	-0.005	-0.001	-0.010	-0.003	0.005	0.002
	(-23.27)	(-1.47)	(-5.63)	(-0.48)	(-7.31)	(-4.27)	(4.95)	(1.78)
λ_3	0.009	-0.018	-0.004	-0.003	-0.011	0.003	-0.028	-0.010
	(11.19)	(-8.30)	(-1.59)	(-0.91)	(-5.80)	(5.30)	(-22.85)	(-4.08)
λ_4	0.004	-0.002	-0.005	-0.020	-0.017	-0.006	-0.009	-0.012
	(5.33)	(-1.60)	(-3.10)	(-11.00)	(-12.01)	(-10.57)	(-9.04)	(-6.69)
λ_5	0.016	0.034	0.018	0.008	0.004	-0.011	-0.018	-0.008
	(11.51)	(10.50)	(5.43)	(4.66)	(2.59)	(-11.28)	(-18.16)	(-8.70)
λ_6	0.029	0.042	0.038	0.025	0.049	0.037	0.064	0.009
	(26.11)	(20.19)	(15.87)	(5.76)	(30.29)	(35.72)	(34.47)	(4.24)
ϕ_1	-0.358	-0.252	-0.207	-0.270	-0.222	-0.160	-0.212	-0.266
	(-16.91)	(-19.94)	(-19.08)	(-22.83)	(-24.62)	(-22.17)	(-22.42)	(-35.66)
ϕ_2	0.006	-0.020	0.000	-0.003	0.000	-0.001	-0.001	0.006
	(6.68)	(-6.76)	(-0.86)	(-5.95)	(-1.36)	(-3.15)	(-6.08)	(6.41)
ϕ_3	-0.033	-0.006	-0.031	-0.011	-0.007	0.001	-0.006	-0.002
	(-6.27)	(-2.90)	(-5.09)	(-4.39)	(-1.71)	(0.19)	(-3.51)	(-1.81)
ϕ_4	0.035	0.033	0.086	0.048	0.082	0.078	0.073	0.021
	(15.57)	(15.41)	(25.68)	(14.11)	(29.00)	(34.95)	(30.82)	(8.74)
ϕ_5	-0.150	-0.127	-0.060	-0.023	-0.094	-0.073	-0.053	-0.009
	(-15.90)	(-20.63)	(-5.86)	(-5.62)	(-14.31)	(-17.92)	(-18.31)	(-7.03)
ϕ_6	-0.075	-0.059	0.067	-0.018	-0.028	-0.043	0.014	-0.023
	(-9.55)	(-10.29)	(9.03)	(-6.33)	(-4.63)	(-8.70)	(8.88)	(-7.95)

Cereals								
Market access	0.121	0.042	0.004	-0.007	0.025	0.019	0.057	-0.022
	(14.00)	(7.37)	(1.33)	(-2.51)	(4.57)	(6.19)	(15.93)	(-5.87)
Age of household head	0.000	0.000	0.000	-0.002	0.005	-0.006	-0.001	-0.005
	(0.29)	(0.30)	(-0.97)	(-3.87)	(4.44)	(-6.09)	(-5.15)	(-5.93)
Gender of household head	0.001	-0.005	0.003	0.001	0.021	0.006	0.008	0.005
	(0.30)	(-6.74)	(6.62)	(0.97)	(14.79)	(4.16)	(9.26)	(8.57)
Household size	-0.021	-0.001	-0.004	-0.001	-0.028	-0.013	-0.014	0.003
	(-23.46)	(-2.58)	(-14.10)	(-6.13)	(-32.99)	(-14.89)	(-21.85)	(7.83)
Share of adult female	0.020	0.002	0.001	-0.004	0.003	0.004	-0.007	-0.006
	(6.71)	(1.48)	(0.70)	(-3.61)	(3.04)	(1.83)	(-4.92)	(-6.76)
Share of adult male	-0.011	-0.005	-0.010	-0.013	-0.033	-0.007	-0.033	-0.017
	(-3.36)	(-3.50)	(-10.74)	(-11.87)	(-17.35)	(-3.63)	(-22.82)	(-16.24)
Eggs, fish & meat								
Market access	0.000	0.007	0.000	0.000	-0.027	-0.056	-0.054	0.000
	(-0.00)	(1.53)	(0.79)	(-0.39)	(-4.61)	(-12.26)	(-10.89)	(-0.52)
Age of household head	-0.001	0.009	0.000	-0.001	0.000	0.000	0.008	0.000
	(-6.25)	(5.77)	(-1.71)	(-1.69)	(-0.87)	(-0.29)	(6.88)	(1.49)
Gender of household head	0.009	0.002	0.002	-0.003	-0.004	-0.003	-0.003	0.003
	(5.61)	(1.95)	(4.08)	(-2.48)	(-1.26)	(-1.47)	(-1.97)	(1.54)
Household size	-0.014	-0.022	-0.028	-0.020	-0.001	-0.002	-0.005	-0.006
	(-16.47)	(-21.06)	(-27.85)	(-16.14)	(-2.60)	(-1.52)	(-9.77)	(-5.31)
Share of adult female	0.039	0.037	0.010	0.000	0.003	0.002	-0.012	-0.004
	(10.78)	(15.27)	(4.58)	(-1.38)	(6.34)	(1.78)	(-9.71)	(-2.50)
Share of adult male	0.029	0.029	-0.014	-0.001	0.009	0.020	0.002	0.000
	(8.58)	(12.57)	(-6.94)	(-2.38)	(3.32)	(8.11)	(2.77)	(0.31)
Edible oils								
Market access	-0.009	-0.020	-0.029	-0.125	0.023	-0.015	0.017	-0.083
	(-0.98)	(-2.68)	(-3.89)	(-15.07)	(4.34)	(-6.04)	(3.67)	(-15.16)
Age of household head	0.001	0.008	0.000	0.006	0.001	0.000	0.000	0.008
	(2.88)	(6.99)	(-0.40)	(8.62)	(1.40)	(-1.73)	(-1.26)	(5.25)
Gender of household head	0.001	0.004	0.007	-0.001	-0.001	-0.002	0.000	0.002
	(1.36)	(2.83)	(5.28)	(-0.33)	(-1.25)	(-1.80)	(-0.77)	(1.30)
Household size	-0.016	-0.013	-0.013	-0.016	-0.013	-0.008	-0.009	-0.007
	(-19.40)	(-17.45)	(-19.26)	(-12.24)	(-18.26)	(-12.72)	(-17.52)	(-5.62)
Share of adult female	0.023	0.024	0.007	-0.023	0.010	0.005	0.002	-0.013
	(6.11)	(9.66)	(2.19)	(-8.97)	(4.41)	(3.79)	(1.29)	(-5.81)
Share of adult male	0.017	0.017	0.000	-0.001	-0.005	0.004	-0.002	-0.008
	(5.80)	(8.29)	(0.28)	(-1.06)	(-2.08)	(3.04)	(-3.05)	(-2.21)
Pulses								
Market access	0.055	0.154	0.199	0.416	0.126	0.138	0.109	0.443
	(4.46)	(10.67)	(16.49)	(26.87)	(22.20)	(36.45)	(19.84)	(34.02)
Age of household head	-0.009	-0.005	-0.019	0.000	-0.009	0.000	-0.009	-0.028
	(-10.28)	(-5.98)	(-10.23)	(-0.54)	(-8.70)	(-5.83)	(-18.24)	(-24.19)
Gender of household head	0.018	0.009	0.021	0.019	0.000	0.021	0.021	0.012
	(4.31)	(7.08)	(3.45)	(8.56)	(0.14)	(11.57)	(7.29)	(4.10)
Household size	-0.004	-0.023	-0.044	-0.043	-0.068	-0.099	-0.093	-0.051
	(-3.76)	(-15.20)	(-17.25)	(-11.08)	(-28.16)	(-40.21)	(-22.92)	(-11.77)
Share of adult female	0.072	0.077	0.078	0.053	0.120	0.096	0.087	0.034
	(13.98)	(18.36)	(14.27)	(12.54)	(21.15)	(34.95)	(23.61)	(21.34)
Share of adult male	0.051	0.039	0.000	0.002	0.077	0.006	0.018	0.001

	(9.69)	(8.43)	(2.79)	(2.09)	(15.52)	(7.07)	(14.64)	(0.93)
Vegetables & fruits								
Market access	0.209	0.081	0.032	-0.018	0.104	0.104	0.149	-0.069
	(13.72)	(6.21)	(2.24)	(-1.56)	(19.14)	(22.04)	(20.31)	(-7.89)
Age of household head	0.000	0.011	0.021	0.001	0.005	0.015	0.009	0.020
	(-0.47)	(4.73)	(11.18)	(3.28)	(4.75)	(18.08)	(6.70)	(12.20)
Gender of household head	0.007	0.000	-0.001	-0.004	-0.008	-0.026	-0.019	-0.020
	(1.94)	(0.15)	(-0.49)	(-2.39)	(-2.31)	(-5.88)	(-6.52)	(-5.11)
Household size	0.018	0.026	0.002	0.031	0.025	0.037	0.042	0.040
	(11.24)	(19.85)	(1.19)	(15.63)	(11.83)	(17.63)	(14.42)	(12.68)
Share of adult female	0.000	-0.011	-0.037	-0.002	-0.035	-0.027	-0.012	-0.003
	(-0.00)	(-2.63)	(-4.00)	(-1.44)	(-8.99)	(-7.93)	(-5.66)	(-1.87)
Share of adult male	-0.014	-0.017	-0.045	0.031	-0.017	0.025	0.002	0.048
	(-3.49)	(-4.61)	(-6.09)	(11.73)	(-4.39)	(6.83)	(4.79)	(11.85)
Other food								
Market access	0.301	0.251	0.181	-0.006	0.376	0.276	0.193	0.052
	(42.23)	(66.35)	(26.53)	(-0.37)	(48.76)	(50.31)	(24.16)	(5.96)
Age of household head	0.081	0.014	0.020	0.037	0.059	0.011	0.048	0.040
	(38.95)	(8.54)	(16.70)	(28.78)	(28.80)	(6.44)	(23.47)	(27.98)
Gender of household head	0.268	0.061	0.104	0.059	0.053	0.102	0.119	0.030
	(25.82)	(8.90)	(13.10)	(14.98)	(10.80)	(31.65)	(16.03)	(7.20)
Household size	-0.047	0.088	0.029	0.052	-0.068	-0.024	-0.076	0.032
	(-6.29)	(18.43)	(8.76)	(35.85)	(-12.63)	(-6.60)	(-13.17)	(20.37)
Share of adult female	0.710	0.754	0.767	0.688	0.842	0.332	0.691	0.789
	(34.89)	(16.56)	(16.97)	(19.28)	(44.78)	(21.75)	(30.34)	(35.56)
Share of adult male	0.081	0.071	0.101	0.108	0.113	0.130	0.123	0.156
	(27.70)	(35.47)	(26.90)	(34.87)	(45.43)	(56.22)	(23.75)	(47.19)
Observations	79303	68342	78819	59306	43166	45098	44543	41260

Note: The subscripts of parameters denote the corresponding food group (1 = cereals; 2 = eggs, fish and meat; 3 = edible oils; 4 = pulses; 5 = vegetables and fruits; 6 = other food). Food prices, MPCFE, household size and age of household head enter in logarithm form. Market access is measured by the percentage of meals that members of households consumed outside of home. Gender of household head is a dummy variable which takes the value of 1 for female and 0 for male. The remaining independent variables are percentages. Test statistics calculated from robust standard errors are reported in parentheses.

Table A2.4: Demand elasticities of other food groups

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
Panel A: Preference-based income elasticity of demand								
Eggs, fish and meat	**0.762**	**0.693**	**0.734**	**0.792**	**0.894**	**0.889**	**0.662**	**0.762**
Edible oils	**0.890**	**0.704**	**0.757**	**0.593**	**0.340**	**0.166**	**0.436**	**0.428**
Pulses	**0.755**	**0.641**	**0.630**	**0.646**	**0.275**	**0.300**	**0.499**	**-0.346**
Vegetables and fruits	**0.123**	**-0.091**	**-0.019**	**0.337**	**0.330**	**0.513**	**0.662**	**0.664**
Other food	**0.926**	**1.098**	**1.221**	**1.046**	**1.071**	**1.436**	**1.722**	**1.843**
Panel B: Preference-based uncompensated price elasticity of demand								
Eggs, fish and meat	**-1.118**	**-1.021**	**-1.280**	**-1.079**	**-1.350**	**-1.134**	**-1.099**	**-1.114**
Edible oils	**-0.526**	**-0.490**	**-1.626**	**-0.730**	**-0.635**	**0.533**	**-1.264**	**-0.572**
Pulses	**-0.197**	**0.254**	**-0.472**	-0.002	**-0.367**	**-0.249**	**-0.659**	-0.067
Vegetables and fruits	**-0.531**	0.050	**-0.293**	**-0.362**	**-0.930**	**-0.815**	**-0.725**	**-0.564**
Other food	**-0.978**	**-0.949**	**-1.011**	**-1.265**	**-1.349**	**-1.111**	**-1.389**	**-1.915**
Panel C: Standard income elasticity of demand								
Eggs, fish and meat	**0.762**	**0.687**	**0.641**	**0.650**	**0.894**	**0.939**	**0.749**	**0.720**
Edible oils	**0.890**	**0.679**	**0.960**	**0.812**	**0.340**	**0.561**	**0.514**	**0.548**
Pulses	**0.755**	**0.652**	**0.698**	**1.024**	**0.275**	**0.355**	**0.627**	**1.130**
Vegetables and fruits	**0.123**	**-0.009**	**0.130**	**0.455**	**0.330**	**0.033**	**0.390**	**0.372**
Other food	**0.926**	**1.003**	**0.904**	**0.786**	**1.071**	**0.934**	**1.145**	**0.903**
Panel D: Standard uncompensated price elasticity of demand								
Eggs, fish and meat	**-1.118**	**-1.022**	**-1.266**	**-1.057**	**-1.350**	**-1.140**	**-1.090**	**-1.079**
Edible oils	**-0.526**	**-0.413**	**-1.874**	**-0.738**	**-0.635**	**0.505**	**-1.280**	**-0.595**
Pulses	**-0.197**	**0.338**	**-0.410**	-0.018	**-0.367**	**-0.234**	**-0.621**	**-0.349**
Vegetables and fruits	**-0.531**	-0.060	**-0.438**	**-0.498**	**-0.930**	**-0.923**	**-0.743**	**-0.592**
Other food	**-0.978**	**-0.968**	**-1.063**	**-1.143**	**-1.349**	**-1.046**	**-1.258**	**-1.238**

Note: The preference-based demand elasticities are calculated using the mean data point in 1987-88 while the standard elasticities are computed based on data of current period. The estimates highlighted are statistically significant at the 99% confidence level. Like other demand literature, a few estimates of PED in this table take on a positive value, contradicting economic intuition. This may be due to the fact that the adjusted unit values are not be entirely exogenous. As remarked by Majumder et al. (2012), the corrections do not completely eliminate the distortion in unit values and produce imperfect proxies for market prices. The positive signs may also reflect a supply-demand simultaneous bias, especially for households who rely on producing and selling agricultural products for a living. Nevertheless, with the absence of market price information, these adjusted unit values remain the second best option available in capturing price changes

Table A2.5: Preference-based demand elasticities computed with survey weights and median food prices

	With survey weight		Median food price	
	Urban	Rural	Urban	Rural
	(1)	(2)	(3)	(4)
YED				
1987-88	0.850	1.109	0.866	1.025
1993-94	0.870	1.158	0.874	0.779
2004-05	0.704	0.758	0.685	0.520
2011-12	0.754	0.609	0.767	0.680
Uncompensated PED				
1987-88	-0.270	-0.793	-0.286	-0.663
1993-94	-0.228	-0.539	-0.326	-0.092
2004-05	-0.926	-0.825	-1.008	-0.434
2011-12	-0.884	-0.597	-0.953	-0.715
Compensated PED				
1987-88	-0.127	-0.484	-0.144	-0.386
1993-94	-0.082	-0.252	-0.182	0.119
2004-05	-0.808	-0.668	-0.895	-0.293
2011-12	-0.758	-0.513	-0.827	-0.531
XED to price changes in eggs, fish and meat				
1987-88	-0.027	-0.107	-0.013	-0.131
1993-94	-0.155	-0.141	-0.134	-0.065
2004-05	0.017	0.004	0.011	0.015
2011-12	0.093	0.158	0.119	0.093
XED to price changes in edible oils				
1987-88	-0.440	-0.248	-0.428	-0.252
1993-94	-0.304	-0.446	-0.346	-0.283
2004-05	-0.073	-0.105	-0.012	0.057
2011-12	-0.189	-0.154	-0.173	-0.122
XED to price changes in pulses				
1987-88	-0.291	-0.263	-0.276	-0.252
1993-94	-0.197	-0.358	-0.294	-0.283
2004-05	-0.044	-0.238	-0.064	-0.103
2011-12	-0.093	-0.153	-0.162	-0.088
XED to price changes in vegetables and fruits				
1987-88	-0.419	-0.132	-0.482	-0.149
1993-94	-0.744	-0.352	-0.763	-0.277
2004-05	-0.391	-0.344	-0.359	-0.294
2011-12	-0.333	-0.286	-0.348	-0.318
XED to price changes in other food				
1987-88	-0.505	-0.551	-0.497	-0.519
1993-94	-0.564	-0.784	-0.412	-0.662
2004-05	-0.436	-0.340	-0.241	-0.148
2011-12	-0.297	-0.283	-0.177	-0.043

Note: These demand elasticities are calculated using the mean data point in 1987-88.

Chapter 4

School feeding program and household dietary quality: Evidence from India

Abstract

Through investigating the Mid-Day School Meal Scheme in India, this paper evaluates whether school feeding schemes contribute to improvements in household dietary quality. We apply propensity score matching methods to construct a counterfactual household group for the beneficiary households and compare their diet over a vector of quality indicators. The scheme is found to have brought significant nutritional gains to the beneficiary households in terms of higher dietary diversity and daily calorie availability, providing evidence for the potential of school meal provision in enhancing food security and augmenting nutrition for families of the beneficiaries. Our results also demonstrate that some disadvantaged groups receive less nutritional gains than others, undermining the effectiveness of the scheme in reducing social disparity in nutritional development.

4.1 Introduction

School feeding programs are one of the most popular nutrition programs in both developed and developing world. Every day, over 368 million children across 169 countries receive meals at school (World Food Programme 2013). There is much evidence that these schemes have a positive influence on the nutritional and educational outcomes of targeted children (e.g.Afridi (2010); Jayaraman and Simroth (2015)). More recently, questions have been raised as to whether free school meal provision can augment the nutrition for families of the beneficiaries. Bhattacharya et al. (2006) argue that some of the positive effects of school nutrition programs might be overlooked if researchers ignore family members other than the beneficiaries. While some studies have looked into the nutritional benefits for certain individual members, such as younger siblings of the beneficiaries, limited attention has been paid on the overall nutritional benefits of free school meals to beneficiary households. By examining the Midday School Meal Scheme (MDMS) in India, this paper seeks to understand the impact of school feeding programs on dietary quality of households as a whole.

With regard to the MDMS, in 2001, the Supreme Court in India ordered all Indian states to provide free cooked meals to primary class children in public schools. Despite initial inaction to the court order, most state governments started implementation over the next five years such that by 2007, over 120 million children benefited from free cooked school meals across India (Afridi 2011). Subsequently, the MDMS is often considered to be the most successful part of the many Indian social security initiatives (Drèze and Khera 2017). Nevertheless, micronutrient malnutrition continues to persist in the country, along with the emerging problems of overweight and obesity. Indeed, food system in many developing countries has been criticised for its heavy focus on calorie sufficiency and the resulting negligence of nutrition security (Pingali et al. 2017). Through exploring the dietary impact of MDMS at household level, this study sheds light on whether school feeding scheme can be utilised to tackle the contemporary nutritional challenges in developing countries.

To undertake our analysis, we use data from two sources. First, we employ household consumption data from the 61st round of National Sample Survey (NSS), which gives comprehensive information on the composition of households'diet. It also records their MDMS beneficiary status, which this paper exploits to identify the effect of MDMS on household dietary quality. Second, we supplement the NSS data with the school feature data from the District Information System for Education (DICE) to account for the schooling situation faced by households living in different districts. These two datasets were both collected in 2004-2005 during the rolling-out period of the scheme in which not all public schools in India had provided free meals to primary school children.

In term of empirical strategy, we employ propensity score matching (PSM) methods to construct a valid counterfactual group for households who reported to have at least one member benefited from the MDMS. The impact of free cooked meals on household dietary quality is then estimated as the difference in food consumption between the two groups. This empirical strategy

accounts for the self-selection bias that arises when households send their children to schools which provide free cooked meals in anticipation of the potential dietary gains. Across a variety of dietary outcome indicators and matching algorithms, there is some evidence for a positive impact of the MDMS on households' daily calorie availability. While there is no significant difference in daily protein acquisition between the two groups, the scheme is found to provide significant nutritional benefits to beneficiary households in terms of higher dietary diversity. These results provide evidence in support of the nutritional gains from school feeding schemes to the family of beneficiaries.

From the standpoint of nutrition, the improvement in dietary diversity is a particularly important benefit of the scheme. Dietary diversity is generally found to have a close and positive correlation with nutrient adequacy and anthropometric outcomes (Ruel 2002; Zezza and Tasciotti 2010). It is also strongly linked to households' ability to access food and is therefore a promising and commonly used indicator of food security (Hoddinott and Yohannes 2002; Zezza and Tasciotti 2010).[1] As a consequence, by enhancing household diet diversification, the MDMS and school feeding schemes more generally have the potential to act as a vehicle for improved micronutrient status and food security.

Another facet of this study is that in light of the huge social inequality in nutritional status in India, we stratify the household samples to assess whether disadvantaged households from scheduled caste (SC) and scheduled tribe (ST) receive similar nutritional gains from MDMS as other households. Among all social groups, SC households are found to have benefited the most. Their diet contains significantly more calorie and protein and is more diverse, compared to SC households who did not participate in the scheme. For ST households, they only received nutritional gains in term of enhancement in dietary diversity. There is no evidence of improvement in the availability of protein and calorie in their diet. This heterogeneity in treatment effects implies that while reducing malnutrition as an issue of school age children, school meal provision may not reduce the social disparity in nutritional development as some disadvantaged households may benefit less than others. This finding highlights the need for government to carefully examine the equality of access to nutritional benefits and enhance the inclusiveness of school meal provision accordingly.

The rest of the paper is structured as follows. Section 2 explains the sources of nutritional benefits from school feeding programs as well as describing in more detail the MDMS in India. Section 3 describes our data and explains the empirical strategy employed. The estimated effects of MDMS on household dietary quality are presented in Section 4. We then investigate how these effects differ on the basis of social groups in Section 5 and discuss the policy implications of our results in Section 6. The last section concludes.

[1] According to the U.S. Agency for International Development, food security is achieved 'when all people at all times have both the physical and economic access to sufficient food to meet their dietary needs in order to lead a healthy and productive life' (USAID 1992).

4.2 Background

4.2.1 Nutritional benefits of school feeding program

A school feeding program is often designed to reduce malnutrition among school-aged children and enhance their school attendance. The extent of nutritional benefits received by targeted children from free school meals depends on how resources are reallocated within the household of the children. In a standard model of household behaviour, transfers to one child are equivalent to an increase in total household resources. If the additional food resources are redistributed to other members, the actual nutritional gains to the child could be smaller than the amount given under the scheme. The degree to which public transfer of food resources are stuck to the targeted recipient is described as an intrahousehold 'flypaper' effect by Jacoby (2002). Through examining a school meal program in the Philippines, Jacoby (2002) provides strong evidence of a positive flypaper effect, indicating that most of the additional food resources is stuck with the child rather than being reallocated away. This effect is reaffirmed by Afridi (2010) for the MDMS in India where it is shown to have increased the daily nutrient intake of targeted children by between 49% and 100% of the transfers. Similar results are also found in Guatemala where half of the calories provided in the nutrition intervention are crowded out at home and 80% of the protein sticks with the targeted children (Islam and Hoddinott 2009). These studies demonstrate school feeding schemes provide nutritional gains to the transfer recipients and thus improves their diet quality.

School meal provision may also achieve an improvement in nutrition beyond targeted individuals if the additional resources from the transfers are pooled and reallocated to enhance the quality of food that other household members consume. This reallocation depends on the household's understanding of the content of the given school meals and the corresponding adjustment at home (Kazianga et al. 2014). The 'labelling effect' proposed by Kooreman (2000) is another possible channel through which the nutritional gains may spillover to other members of the household. This effect occurs when the scheme makes the parent aware of the level of nutrient deficiency of their children and hence they adjust the composition of food provided at home. In addition, some schemes may impart nutrition education that school children could share with their family members, leading to dietary improvement and hence nutritional gains at household level.

Only a few studies have looked into the nutritional implications of school feeding programs on other household members. Bhattacharya et al. (2006) found the School Breakfast Program in the US has improved the diet quality of preschool children and adult family members. A study in Uganda shows that younger siblings of the beneficiaries of free school meals had a significant improvement in their height-for-age score (Alderman and Bundy 2012). On the other hand, in their study of the school feeding programs in Burkina Faso, Kazianga et al. (2014) find that provision of school meals does not have a significant spillover effect on the weight-for-age and height-for-age of younger siblings of the target children. However, the indirect nutritional gains of the scheme could be underestimated in the latter two studies as the impact on adult family

members is not examined. When a household experiences food shortage, children are often fed first. In this case, adults might benefit more from the reallocation of additional food resources provided by school feeding schemes.

Most literature on school meal provision tends to focus on its nutritional and educational benefits but ignores the cost of participating in the scheme, in other words, the cost of going to school. Studies have shown that school feeding schemes have encouraged greater school participation (e.g. Jayaraman and Simroth (2015)). While public school education is theoretically free in many countries, a family may still incur expenditure on books, uniforms and transportation. Furthermore, there is an opportunity cost incurred from sending children to school as they may work as a paid worker or help out in domestic work. Child time in domestic work can be an indirect source of household income either through increasing the amount of goods produced at home or allowing the adult to participate in formal labour market (Edmonds et al. 2010). Hence, if more resources are allocated to finance schooling or less resources are available due to the loss in income from child work, less resources may be available for food expenditure on other household members, due to the existence of a school feeding scheme. This implies that the scheme may have a negative impact on the dietary quality of other household members, which underscores its overall nutritional benefits to the household.

The overall nutritional gain from the scheme to households will therefore depend on the relative magnitude of the above effects to the targeted children and other household remembers. Although some papers have looked into the nutritional impact of schemes on other members, their results only provide partial picture of household nutritional gains as not all members in the household are accounted for.

4.2.2 Midday Meal Scheme in India

The MDMS, which is officially known as National Programme of Nutritional Support for Primary Education, was first initiated by the Indian government in 1995. Under the scheme, public schools in all states were mandated to provide cooked meals to every primary class student enrolled in grades 1 to 5. The cooked meals typically consist of local staples, which can either be rice or wheat, mixed with lentils or jaggery and supplemented with other foods such as vegetables, fruits, eggs and nuts occasionally. The goal of this scheme was not only to improve the nutrition of primary school children and inculcate good food habits, but also to enhance educational outcomes and promote social integration.

Most states did not respond to the mandate in the late 1990s.[2] Many primary school children were given monthly dry food grains rather than daily cooked meals. In November 2001, the Supreme Court of India announced a directive, which ordered that all primary class children in public schools should be given a midday meal containing no less than 300 calories and 8-12 grams of protein. Nevertheless, the coverage of MDMS remained limited by the initial deadline of the

[2]This excludes the states which implemented the provision of midday school meals prior to the mandate: Tamil Nadu, Kerala, Gujarat and Pondicherry (Chakraborty and Jayaraman 2016)

court order in February 2002, which in turn triggered social discontent and campaign activities to urge the national government to take action (Khera 2006). Combined with pressure from the court, most state governments started providing cooked meals to the eligible children. In 2004, the guideline for MDMS was revised to enhance financial support to state governments in putting cooking facilitates and related infrastructure in place. The scheme has now been implemented to all Indian states. But there are ample variations in the quality and ingredients of the meals across states and even across schools within the same state (Jayaraman and Simroth 2015).

The effectiveness of MDMS on improving schooling and nutritional outcomes has been evaluated in a number of papers. In her review of several field studies, Khera (2006) concludes that the scheme contributed to an increase in school enrolment and attendance particularly among disadvantaged students. These benefits of MDMS are consistent with the survey results of Garg et al. (2013) who interviewed students, households and schools in rural Rajasthan. In terms of empirical evidence, its impact on attendance is supported by the work of Afridi (2011). By comparing school participation before and after the introduction of MDMS, she shows that the scheme led to a significant improvement in average monthly attendance rate of girls. Jayaraman and Simroth (2015) confirm the positive impact of MDMS on primary school enrolment with the aid of a large panel school level dataset based upon the District Information System for Education (DICE).

There is also evidence in support of the nutrition benefits of MDMS. Utilising a randomised evaluation in Madhya Pradesh, Afridi (2010) finds that the scheme improves daily intake of calorie, protein and iron of primary school students. Singh et al. (2013) assess the impact of MDMS on two anthropometric z-scores –weight-for-age and height-for-age –of primary school children in Andhra Pradesh. They show that the scheme provides large health benefits for children whose households suffered from drought. However, these existing studies focus on the impact of MDMS on targeted children. How MDMS affects household dietary diversity in general, the key research question in this paper, remains unknown.

4.3 Data and empirical specifications

4.3.1 Data

The primary data used in this study comes from the 61st round of National Sample Survey (NSS) which recorded consumer expenditure of Indian households from July 2004 to June 2005. Each household was asked to recall how much they consumed of each of more than 100 food items over the last 30 days. The consumed food could come from various sources, including purchases, home grown stock, receipts in exchanges of good and services, gifts, borrowing and free collection. In the view that the MDMS targeted at children in grades 1 to 5 only, we exclude households which did not have children within primary school age for a more representative sample. In India, the official age for grades 1 to 5 students is in the range of 6 to 10 years. We follow Afridi (2010) to define primary school age as 5 to 12 years to allow early enrolment and grade repetition.

Of the total of 65,551 Indian households in the sample, some 19,914 households reported that at least one household member benefited from the scheme at any time during the last 365 days. They are deemed as MDMS beneficiary households, in other words, the treatment group. The rest of the households which do not have any MDMS beneficiary children are considered as the control group. It is pertinent to mention that it was unlikely for the survey respondents to not know whether the children in their household received free meals at schools because utensils were not provided in schools and children often needed to bring their own ones for cooked meals. Hence, the measurement bias from underreporting is likely to be minimal.

Under the directive in 2001, only public schools in India were required to provide midday school meals to primary class students. Households who sent their children to private schools were therefore non-MDMS beneficiary. Unfortunately, data on the types of school that household members attended were not collected in the NSS. Moreover, the quality of cooked meals also depends on the condition and adequacy of cooking and storage facilitates at schools. To account for the differences in schooling situations faced by households, we employ the district level school data collected by the District Information System for Education (DICE) in 2004-2005. This dataset provides information on a variety of school features, such as enrolment, classroom conditions and teacher qualifications across Indian districts. It is aggregated from the results of a standardised school survey given to school headmasters. The completeness, accuracy and consistency of this dataset is checked at various levels of administration (Jayaraman and Simroth 2015). We combine this dataset with NSS consumption data based on the district where households reside.

There are several reasons why a household with primary school age children may not be a MDMS beneficiary. First, the household might not send the children to school or they might send them to private schools which are not required to provide free meal under the court order. Second, there were lots of variation in the timing of MDMS implementation across states in India. For example, while Tamil Nadu and Kerala started giving the midday cooked meal to primary class children before the directive in 2001, Assam, Bihar and West Bengal only introduced the program in 2005. Third, implementation progress was not uniform across public schools within each state. For example, Madhya Pradesh started the distribution of cooked meals in July 2003. Afridi (2010) conducted a survey in the rural area of Childwara district of this state in early 2004 and found that public schools in some villages did not provide free cooked meals. Indeed, the government data showed that, by September 2005, MDMS was only partially implemented in a number of Indian states such as Haryana, Orissa, Punjab and West Bengal (Sharma 2006).

4.3.2 Empirical framework

The key relationship we are interested in, in this paper, is the impact of free school meals on the dietary quality of Indian households. To study this relationship, we first create a control group for MDMS beneficiary households based on their demographics. The effect of the meal scheme is then estimated as the difference in dietary outcome between MDMS beneficiary households and the corresponding counterfactual households. In the following, we discuss the implementation of

PSM and explain the variables used in the estimation.

Average treatment effect on treated

One way to evaluate the effectiveness of a treatment programme is to estimate the average treatment effect on treated (ATT). In the context of this paper, the ATT is the average change in dietary quality of MDMS beneficiary households after receiving free school meals. It can be expressed as:

$$ATT = E[Y_{iB} - Y_{iN}|D = 1] \tag{4.1}$$

where D is the treatment indicator which equals one if the household is a MDMS beneficiary and zero otherwise. Y_{iB} and Y_{iN} denote the potential dietary outcome of household i when they are MDMS beneficiary (B) and when they are not respectively (N). Hence, the ATT is essentially defined as the difference in outcome variable when household i receive free cooked meals and when they do not receive them, given that they are a MDMS beneficiary (i.e. treated).

The estimation of equation (4.1) would be straightforward if we knew how the treated households would have performed, had they not received free cooked meals from schools. However, this counterfactual outcome is not observed in our cross-section dataset. We address this problem by creating a counterfactual outcome using information on the dietary quality of non-MDMS beneficiary households (i.e. control) that are similar to the treated households. Equation (4.1) is thus modified as follow:

$$\begin{aligned} ATT &= E\{E[Y_{iB} - Y_{iN}|D = 1, X]\} \\ &= E\{E[Y_{iB}|D = 1, X] - E[Y_{iN}|D = 0, X]|D = 1\} \end{aligned} \tag{4.2}$$

where X denotes a vector of observable characteristics used to match the similarity of treated and control households. With a large set of relevant covariates, the matching problem is subject to the curse of dimensionality and hence computationally intensive to solve. Matched pairs may not be found at all. To reduce the dimension of vector X, Rosenbaum and Rubin (1983) proposed to summarise the information of all observed covariates with a propensity score, $p(X)$, which is derived from the following probit model:

$$p(X) = Pr[D = 1|X] = E[D|X]; \quad p(X) = F\{h(X_i)\} \tag{4.3}$$

where $F\{.\}$ denotes the normal cumulative distribution and $h(X_i)$ is a function of the relevant covariates that are used to estimate the probability of a household having one member benefited from the school feeding program. The dataset of the counterfactual group can then be constructed using the propensity score, in other words, the predicted probability of being a MDMS beneficiary. This transforms equation (4.2) into:

$$ATT = E[E\{Y_{iB}|D_i = 1, p(X)\} - E\{Y_{iN}|D_i = 0, p(X)\}|D = 1] \tag{4.4}$$

The final step of PSM estimation is to choose the best matches of counterfactual group for each treated household conditioning on their propensity scores. This can be done by using various matching algorithms, which include nearest neighbour matching, radius matching, kernel matching and local linear matching (Caliendo and Kopeinig 2008). The selection among these methods involves an inherent trade-off between the variance of the estimator and the quality of the matches. When more control households are matched to each treated household, variance will be lowered as more information is used to construct the counterfactual. However, estimation bias may rise as the extra comparison units could be a poor match with the beneficiary households.

Nearest neighbour matching is the most commonly used and straightforward matching algorithm. It compares the outcome of the treated household with an untreated household that is closest in terms of propensity score. In this study, each MDMS beneficiary household is matched with the nearest five neighbours to reduce the variance in estimation. Considering that the matching quality may decline with the use of more than one matching partner, a maximum propensity score distance (i.e. caliper) is imposed to ensure that the matched pairs are not too 'far away' or different from each other. Radius matching is a variant of caliper matching which uses all the comparable households within the caliper rather a pre-determined number of nearest neighbours. This method allows the use of information from extra control groups when good matches are available while avoiding the risk of bad matches.

Kernel and local linear matching are both nonparametric matching techniques in which all treated households are matched with a weighted average of all untreated households. The weight is determined by the choice of kernel function and the propensity score distance between the two groups. The difference between kernel and local linear matching is that the former uses only intercept in its weighted regression of counterfactual outcome while the latter one also includes a linear term. This gives local linear matching an advantage in convergence at boundary points (Fan 1992; Caliendo and Kopeinig 2008). With the use of all available information in constructing the counterfactual, these nonparametric methods exhibit lower variance but have a drawback of lower quality matches. On the ground that there is no clear guidance on how to select a specific algorithm in the literature, we estimate the impact of MDMS on household dietary diversity with a variety of matching approaches to ensure that our results are not sensitive to the choice of estimators, which are:

(1) nearest neighbour matching with caliper of 0.1;

(2) nearest neighbour matching with caliper of 0.01;

(3) radius matching with caliper of 0.01;

(4) radius matching with caliper of 0.001;

(5) kernel matching

(6) local linear matching.[3]

In all cases, we allow a control household to be used more than once as a match so as to improve the average quality of matching and further reduce the potential bias. The PSM is conducted using PSMATCH2 in STATA developed by Leuven and Sianesi (2003).

PSM conditions

There are two necessary conditions for the above ATT estimations to be valid. The first condition is that the ATT is only defined in the region of common support. It requires households to have a positive probability of being both a MDMS beneficiary and non-beneficiary given with the same X. It is fulfilled if there is overlap in the propensity score distributions of treated and control household groups. The conditional independence assumption (CIA) is the second necessary condition, which says that given a set of observed characteristics which are not affected by treatment, potential outcome is independent of treatment assignment (Caliendo and Kopeinig 2008). It implies that the selection process of MDMS participation is random after conditioning on all the covariates. The validity of this assumption can be checked by comparing the pseudo R^2 and the joint significance of regressors on the treatment status before and after matching. We use the STATA command PSTEST written by Leuven and Sianesi (2003) to evaluate the matching effectiveness of different estimators.

Dependent variables: Indicators of dietary quality

We capture dietary quality with two types of indicator. The first one is daily household nutrient availability per adult equivalent. The term 'adult equivalent' refers to the scale used to account for the difference in nutrient requirement across household members. In this paper, we use male 18-60 years old as the reference category. By normalising the calorie value of reference group into 1, we obtain the adult equivalent weight for each household member based on their age and gender. Table 4.1 lists the recommended calorie intake for Indian male and females given by the Indian Council of Medical Research (ICMR).

Table 4.1: Recommended calorie intake per day by gender and age group

	Age (in years)							
	<3	6-Mar	9-Jun	12-Sep	15-Dec	15-18	18-60	>60
Male	1200	1500	1800	2100	2500	3000	2800	1950
Female	1200	1500	1800	2100	2200	2200	2200	1800

Source: Maitra et al. (2013)

The availability of two nutrients are measured in this paper: calories and protein. Calories are the commonly used measure in the literature on Indian food consumption as it indicates the sufficiency of energy supply in the diet. Protein is an essential nutrient for growth and repair of

[3]The bandwidth used in kernel matching is 0.06. For local linear matching, it is based on the rule of thumb bandwidth specified in the STATA command LPOLY.

body cells and tissues. For consistency, the adult equivalent weights calculated from table 1 are used to compute both daily calorie and protein availability of households. We first multiply the quantity of food items with their's value of calorie and protein, which is obtained from the NSS report on nutritional intake in India published in 2007.[4] Then, we sump up the resulting multiple across of all food items and divide the total by the number of adult equivalents in the household and the number of days in the reference period.

The second type of indicator is the diversity of household diet. Dietary diversity is widely recognised by nutritionists as a key element of a high quality diet (Rashid et al. 2011). A more varied diet helps enhance intake of essential nutrients and also protects against chronic diseases (Thiele and Weiss 2003). The simplest measure of dietary diversity is the number of food items consumed by the household, which can, however, be biased as it does not account for the composition of the diet. As long as the number of food items consumed is the same for two households, a diet that is dominated by one type of food is viewed as diverse as the one with equal portion of different items. Alternatively, we measure dietary diversity using the Simpson and Shannon indexes, which have been employed by Nguyen and Winters (2011), Liu et al. (2014) and Sharma and Chandrasekhar (2016).[5] Their formulas are given as follow:

$$Simpson\ \ index = 1 - \sum_{f} s_f^2 \tag{4.5}$$

$$Shannon\ \ index = 1 - \sum_{f} s_f log(s_f) \tag{4.6}$$

In equations (4.5) and (4.6), s_f is the share of food expenditure on a food group f. Based on the survey structure, we categorise the food items recorded in NSS into 12 food groups. They are cereals; cereal substitutes; pulses; milk and milk products; edible oils; meat; egg; fish; vegetables; fresh fruits; sugar; other foods (which consists of dry fruits, nuts, spices, cooked meals and processed food). This classification is similar to that of Sharma and Chandrasekhar (2016). The value of the Simpson index lies between 0 and 1. For the Shannon index, it takes value between 0 and the value of logarithm of the highest share of food budget on a food group. For both indices, the higher the value, the more diverse is the diet. As one can see from equations (4.5) and (4.6), these two indexes have a strong and positive correlation (0.96).

Table 4.2 compares the dietary quality of the treated and control households before matching. The descriptive statistics suggest that households that benefited from MDMS tend to have a lower quality diet than their counterparts. On average, their diet is less diverse and has less calories and protein available per adult equivalent. It is important to remember that the values in table 4.2 do not imply a negative nutritional impact of MDMS as households with poorer diet initially may self-select themselves into the scheme.

[4] It is available at http://mospi.nic.in/sites/default/files/publication_reports/513_final.pdf.

[5] The findings in this paper are robust to the use of number of recorded food items as a dietary outcome. These results are available upon request.

Table 4.2: Descriptive statistics of household dietary quality

	MDMS beneficiary households	Non-MDMS beneficiary households
Daily available calorie	2385	2568
Daily available protein	63.69	71.16
Simpson Index	0.77	0.776
Shannon Index	1.779	1.793
Observations	19914	45637

Note: Both daily available calorie and protein availability are measured in adult equivalent terms.

Explanatory variables: Household characteristics and district level school features

In selecting explanatory variables for the probit model (equation (4.3)), the key rule is to include all variables that influence treatment assignment and outcome simultaneously but exclude the ones that are affected by the treatment (Smith and Todd 2005; Caliendo and Kopeinig 2008). We use a vector of household characteristics to capture the main determinants of household food consumption and the probability of being a MDMS beneficiary. The living standard of household is accounted for by the monthly per capita expenditure (MPCE) quartile which the household belongs to and their respective social group (i.e. scheduled tribe (ST), scheduled caste (SC), other backward classes and non-disadvantaged classes).[6] Dummy variables are also added to indicate whether the household is Hindu and whether the household is located in an urban area.

Household composition is another important determinant. Households with more school aged children are more likely to benefit from the free cooked meal scheme. Moreover, by taking advantage of economies of scale, a larger household may find it easier to improve their diet compared to smaller households. We capture these composition effects through the number of household members and the proportion of adults, school-age boys and girls in the household. Our explanatory variables also consist of the age and gender of household head. Dummy variables are constructed to indicate the education of household head (i.e. not formally educated, primary education, middle and secondary education and above secondary education).

As mentioned earlier, there was ample variation in the implementation of the MDMS across Indian states. Households residing in a state which only just started providing cooked meals would be far less likely to benefit from the scheme than the ones living in a state where the scheme was not fully implemented. In light of the importance of this factor, we not only include state dummies in the probit estimation, but also impose an exact matching on the states where households resided. This means that the matched pair of treated and control households must come from the same state. Furthermore, because the MDMS was an ongoing project in many states, the progress within each state might change greatly throughout the period of the interest. In regard to this, dummy variables for the four quarters of the year when the household was interviewed (i.e. sub-round of the survey) are added into the probit model.[7] These sub-round indicators also capture the impact of seasonality on the availability of food and thus the ability of households to adjust their diet as the availability of food item varies across different times of

[6] Data on household income is not collected by the NSS due to concerns over a higher rejection rates. We follow the standard practice in literature to proxy household income with MPCE.

[7] The four quarters are July-September October-December, January-March, April-June.

the year.

In addition to household characteristics, we also include several district level school features as independent variables. Considering that the likelihood of sending children to public schools is highly correlated with the household characteristics discussed above, the absence of data on the type of schools that children attended is unlikely to cause significant bias. As an additional control, we include the share of primary class students enrolled in public schools in the district where the household resided to capture the relatively availability of public schools. Moreover, the schools' capability in providing quality cooked meals may also affect the school choice of households and also the impact of the scheme on their food consumption. The percentage of school with single teacher and the average percentage of classrooms in good condition are therefore included to account for the difference in school facilities across districts.

Summary statistics of the explanatory variables are provided in table 4.3. In general, MDMS beneficiaries are poorer than non-MDMS beneficiaries as a smaller proportion of them are in the top two income quartiles. While household heads are typically male and have a similar average age across the two household groups, the ones in MDMS beneficiary households tend to be less educated. They also generally have a larger family and a higher proportion of school age children. There are relatively less Hindu, ST and SC groups among the households which did not receive free cooked meals from school.

The school situation faced by MDMS beneficiary and non-MDMS beneficiary households does not seem to differ greatly. The majority of primary class students were enrolled in public schools. On average, around 10% of the schools in a district only had one teacher and 40% of the classrooms were not in good condition. For the worst performing districts, over 60% of schools had only one teacher and less than 10% of classrooms were in good condition. This difference in school facilitates suggests that some schools could be more capable in implementing the meal scheme than others, which partly explains the variation in quality of cooked meals highlighted by Khera (2006).

4.4 Empirical results

4.4.1 Propensity score matching

The probability of becoming a MDMS beneficiary is predicted using a probit model the results of which are shown in table A3.1 in the Appendix.[8] Given that our main purpose is to compare the dietary quality of households who benefited from MDMS and who did not, we do not discuss these estimates in details. Of note, the explanatory variables are mostly statistically significant and have the expected sign. Households were more likely to be a MDMS beneficiary if they belonged to the poorest group and their household head was not formally educated.

To check the validity of common support in our case, we plot the pre-matching kernel den-

[8]The age of household head and household size are entered in logarithm form for better fit of the model.

Table 4.3: Descriptive statistics of explanatory variables

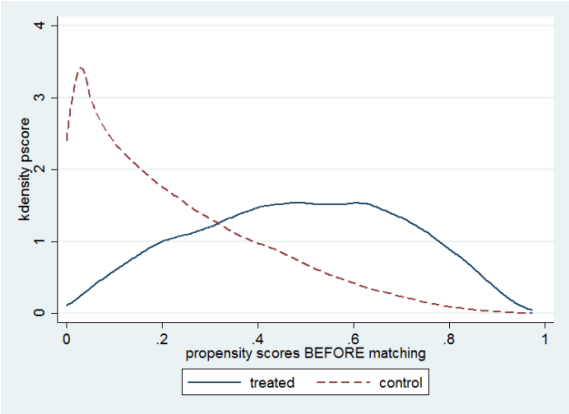
Variables	MDMS beneficiary households	Non-MDMS beneficiary households
Household level characteristics		
MPCE quartiles (%)		
First/ poorest	0.365	0.206
Second	0.320	0.247
Third	0.229	0.276
Fourth/ richest	0.086	0.271
Education of household head (%)		
Not formally educated	0.396	0.310
Primary	0.299	0.216
Middle and secondary	0.276	0.366
Above secondary	0.030	0.107
Age of household head (in years)	43.18	44.49
Gender of household head (%)		
Male	0.912	0.909
Female	0.088	0.091
Household size (in number of person)	6.073	5.873
Percent of school age girls	0.143	0.099
Percent of school age boys	0.162	0.127
Percent of adult	0.526	0.581
Religion Hindu (%)	0.803	0.726
Social group (%)		
Scheduled tribe	0.152	0.128
Scheduled caste	0.215	0.154
Other backward classes	0.396	0.369
Non-disadvantaged classes	0.237	0.349
Whether household lived in an urban area (%)	0.200	0.383
District level school characteristics		
Percent of enrollment in public school	0.762	0.772
Percent of schools with single teacher	0.107	0.117
Percent of classrooms in good condition	0.632	0.626

sity functions of the propensity scores for treated and control groups in Figure 4.1 The overlap region provides evidence that there is a subset of non-MDMS beneficiary households which are comparable to the households who received free cooked meals from schools. As their distributions are not identical, there may also be cases where no good matches are found. Hence, to ensure the accuracy of ATT, we only compare the dietary outcome of the matched pairs and drop the unmatched treatment observations. Furthermore, we impose an additional common support by excluding MDMS beneficiary households whose propensity score is higher than the maximum or lower than the minimum propensity score of the non-MDMS beneficiary households. As demonstrated in table 4.4, the number of on support treatment observations decreases with the increase in the size of caliper used. In the case where radius matching is applied with the maximum propensity score distance of 0.001, over 2,000 treated households are not supported by the control group. Based on nearest neighbour method with 0.01 caliper, the average difference in propensity score for treated and the corresponding matched households is 0.0005 with a standard error of 0.001.[9]

Table 4.4 also reports the ATT of MDMS on household dietary quality. As mentioned before,

[9]Before matching, the mean propensity scores for treated and control household groups are 0.485 (standard error of 0.217) and 0.226 (0.193) respectively.

Figure 4.1: Propensity scores for MDMS beneficiary and non-MDMS beneficiary households



the ATT estimates is the average difference in dietary quality outcomes between the matched pairs of households that were MDMS beneficiary and those that were not. There is evidence for a positive linkage between MDMS and the daily adult equivalent nutrient availability of households. The ATT estimates suggest that households receiving free school meals consume 21 to 28 more calories per adult equivalent per day. This nutritional benefit from the scheme is, however, not statistically significant when kernel bandwidth matching is used. Surprisingly, despite the legal requirement, the daily adult equivalent protein availability does not differ significantly across households received free school meals and those did not.

Table 4.4: Effects of MDMS on household dietary diversity

	Matching algorithm	Outcome	Number of on support treated	Number of treated off support	ATT	Standard error	t-values
1	Nearest neighbour matching (Caliper=0.1)	Calorie intake	19892	22	21.121*	12.73	1.66
		Protein intake	19892	22	0.249	0.488	0.51
		Simpson Index	19892	22	0.007***	0.001	6.56
		Shannon Index	19892	22	0.016***	0.003	5.2
2	Nearest neighbour matching (Caliper=0.01)	Calorie intake	19727	187	23.561*	12.633	1.86
		Protein intake	19727	187	0.331	0.482	0.69
		Simpson Index	19727	187	0.006***	0.001	5.62
		Shannon Index	19727	187	0.014***	0.003	4.44
3	Radius matching (Caliper=0.01)	Calorie intake	19727	187	24.272**	12.161	2
		Protein intake	19727	187	0.381	0.439	0.87
		Simpson Index	19727	187	0.006***	0.001	6.29
		Shannon Index	19727	187	0.014***	0.003	4.88
4	Radius matching (Caliper=0.001)	Calorie intake	17017	2897	28.408***	11.85	2.4
		Protein intake	17017	2897	0.453	0.43	1.05
		Simpson Index	17017	2897	0.005***	0.001	4.47
		Shannon Index	17017	2897	0.010***	0.003	3.54
5	Kernel bandwidth matching	Calorie intake	19891	23	18.114	11.83	1.53
		Protein intake	19891	23	0.185	0.423	0.44
		Simpson Index	19891	23	0.007***	0.001	7.23
		Shannon Index	19891	23	0.016***	0.003	5.57
6	Local linear matching	Calorie intake	19892	22	22.69**	13.127	1.73
		Protein intake	19892	22	0.338	0.555	0.61
		Simpson Index	19892	22	0.010***	0.001	7.12
		Shannon Index	19892	22	0.023***	0.004	5.8

Note: For nearest neighbour matching, each treated household is matched with five counterfactual households. In total, there are 45495 untreated households in the sample. To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of the control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

In contrast to the descriptive statistics in table 4.2, the ATT estimation results reveal that households that received free cooked meals from schools had a more diverse diet than their matched counterparts. The ATT of MDMS is statistically significant and positive regardless of the dietary diversity indicators and the matching algorithms used.[10] This is consistent with the OLS results reported in table **??**. The average difference in dietary diversity is the largest when households are matched using local linear technique. The magnitude of the ATT effect of MDMS decreases when a more restrictive caliper is imposed. It ranges from 0.005 to 0.010 and from 0.010 to 0.023 for the Simpson and Shannon Index respectively. Overall, the school feeding program in India has enabled the beneficiary households to consume a more diverse and hence a higher quality diet.

The positive MDMS effects on the Shannon and Simpson indexes also imply that households that received free cooked meals from schools are more food secure than their counterparts as they were able to consume a more diversified diet as a result of the scheme. This implication can be reconciled with the work of Singh et al. (2013). Using a longitudinal dataset from the state of Andhra Pradesh, they examine the role of MDMS in coping with large negative income shock and find that the negative effect from drought on the height-for-age and weight-for-age of targeted children is compensated by school feeding. From their results, one may deduce that households benefiting from MDMS are likely to be more food secure as their children are less likely to suffer from the decline in nutritional intake during difficult times.

4.4.2 Validity of the estimated ATT

There is a potential concern with the NSS data identified by Smith (2015). She argues that the meals consumed away from home by Indian households may be under-recorded, leading to an underestimation of the actual food consumption. Given that the pattern of eating out is largely dependent of household characteristics and the joint significance of household characteristic is rejected, the meals consumed away from home within the matched household pairs should not be considerably different. This measurement error is hence unlikely to constitute to a significant bias on the ATT estimates in this paper.

Table 4.5: Comparison of PSM quality indicators before and after matching

	Matching algorithm	Pseudo R^2	X_2	$\rho > X^2$	Mean standardised bias
	Before matching	0.227	18224	0.001	13.1
	After matching				
1	Nearest neighbour matching (Caliper=0.1)	0.001	58.52	0.166	0.5
2	Nearest neighbour matching (Caliper=0.01)	0.001	51.97	0.359	0.5
3	Radius matching (Caliper=0.01)	0.001	52.74	0.331	0.5
4	Radius matching (Caliper=0.001)	0.001	40.99	0.785	0.4
5	Kernel bandwidth matching	0.001	62.61	0.092	0.5
6	Local linear matching	0.001	53.31	0.312	0.4

Note: For nearest neighbour matching, each treated household is matched with five counterfactual households.

[10] We bootstrapped the variances of estimates based on kernel matching to check whether our results are sensitive to the uncertainty in the probit estimation. Although the bootstrapped standard errors tend to be larger than the ones reported in table 4.4, the statistical significance of the ATT estimates remains unchanged.

The above results may also be invalid if the common support and CIA are not met. The overlap region in figure 4.1 and the large number of on-support treated households in table 4.4 provides solid evidence for the fulfillment of the first condition. To check the validity of the second condition, we compare the pseudo R^2 and the Chi^2 test statistics before and after the matching in table 4.5. Prior to the matching, the value of pseudo R^2 is 0.277, indicating the covariates in the probit model are important in predicting the probability of household becoming a MDMS beneficiary. The likelihood-ratio test for the joint significance of these regressors yields a p-value that is less than 0.1. This implies that there are significant differences between the household characteristics and district level school features of treatment and control observations.

From table 4.5, it can be seen that there is no systematic difference in the distribution of covariates between both household groups after matching. The pseudo R^2 is reduced to 0.001 irrespective of the matching techniques used. The district and household level characteristics are shown to be no longer important in predicting the beneficiary status of households. With the exception of kernel bandwidth matching, the p-values of the Chi^2 test are higher than 0.1 in all cases, rejecting the joint significance of covariates in the probit model. Furthermore, as shown in the last column, the mean standardised bias of the ATT estimates, a summary indicator of the distribution of bias, is greatly reduced from 13.1 to 0.5. These quality indicators confirm that apart from kernel bandwidth, the matchings performed in table 4.4 are effective and of high quality.

In table A3.2 in the Appendix, we test the sensitivity of the results to inclusion of higher order terms for continuous variables in the probit estimation.[11] The ATT of MDMS on household dietary diversity remains positive and strongly significant. But its positive impact on daily calorie availability becomes statistically insignificant across most of matching techniques. As the joint significance test of regressors is not always rejected, the use of higher order terms is not preferable. We also check whether the results are robust to more restrictive matching by imposing exact matching at regional level, a more disaggregated geographical unit than state. As illustrated in table A3.3 in the Appendix, the resulting ATT estimates of MDMS on dietary diversity are similar to the ones reported in table 4.4 although less treated households are matched with the control group. However, there is no evidence that the daily calorie availability is higher in households that benefited from the scheme.

4.5 Heterogeneous treatment effect across social groups

While the MDMS is a universal scheme available for all primary class children in Indian public schools, there can be some heterogeneity in the magnitude of nutritional benefits received by the beneficiaries. The household response to the program can vary by household characteristics. Jacoby (2002) shows that children from poorer households receive less gains in calorie intake from the school feeding program. Afridi (2010) also finds some evidence that household size has a positive influence on the magnitude of calorie transfers to the recipients of the meal scheme.

[11] These continuous variables are household size, age of household head and district level school variables.

In this section, we extend the above studies by examining heterogeneity in household nutritional benefits across various social groups in India.

Scheduled caste (SC) and scheduled tribe (ST) are the most economically disadvantaged group in India. SC households are in the lowest caste in the traditional Hindu hierarchy and hence experience intense discrimination and deprivation. ST households tend to have limited economic and social interaction with the rest of the population as they are geographically isolated. These two social groups suffer worse nutritional status and health conditions compared to rest of the population. In Van de Poel and Speybroeck (2009)'s study of child malnutrition in India, the height-for-age score of SC/ST groups is found to be worse than the remaining population. Subramanian et al. (2006) show that adult mortality rates in the ST/SC groups are higher than the other social groups.

In order to conduct our analysis, we stratify our household samples into four social groups based on the definitions used in the NSS, which are SC, ST, other backward class and non-disadvantaged class. Other backward class is a collection of intermediate caste that have higher social status then SC. Table 4.6 summarises the dietary quality of households across these social groups. In general, the diet of non-MDMS beneficiary households in all classes contains more calories and protein than their counterparts. But it is not always more diverse. As expected, non-disadvantaged class households enjoy the highest levels of calorie and protein consumption and also the most diverse diet. While SC households have the lowest daily calorie availability , they consume slightly more protein than ST households, who, on the other hand, have the least varied diets among all groups, as reflected by the Simpson and Shannon indexes.

Table 4.6: Descriptive statistics of household dietary quality across social groups

	Daily calorie available	Daily protein available	Simpson index	Shannon index	N
Scheduled tribe (ST)					
MDMS beneficiary households	2350	61.69	0.742	1.697	3030
Non-MDMS beneficiary households	2595	71.94	0.759	1.753	5848
Scheduled caste (SC)					
MDMS beneficiary households	2338	62.65	0.764	1.757	4275
Non-MDMS beneficiary households	2428	67.58	0.765	1.75	7050
Other backward class					
MDMS beneficiary households	2359	63.35	0.778	1.797	7880
Non-MDMS beneficiary households	2560	71.01	0.775	1.787	16810
Non-disadvantaged class					
MDMS beneficiary households	2492	66.49	0.78	1.82	4729
Non-MDMS beneficiary households	2630	72.64	0.789	1.832	15929

Note: Both daily available calorie and protein availability are measured in adult equivalent term.

Using the methodology discussed in Section 4, we estimate the effect of MDMS on household dietary quality across social groups. The significance of the ATT for different household groups are consistent across matching techniques with slight variations in the magnitude of the estimates. In all cases, the condition of common support is fulfilled as there is a large number of on-support treated households. The matching quality indicators also confirms that after matching there is no systematic difference in the distribution of covariates across the treated and control household groups. For brevity, we only discuss the estimates based on radius matching with caliper set at

0.01, presented in table 4.7.[12]

There is huge difference in the nutritional benefit from MDMS across social groups. SC households are the only group that experienced a positive and significant effect of MDMS on their daily protein availability. The ATT estimate suggests that SC participating households enjoy 2.2 more grams of protein and 71.5 more calories per day in adult equivalent terms than those who did not participate the scheme. The MDMS has also enabled them to have a more varied diet. These findings are particularly encouraging considering the reports on caste discrimination in the MDMS, such as the denial of meals; separate seating for SC children; serving SC children last; not being served a sufficient quantity or quality (Khera 2006; Thorat and Sadana 2009).

Table 4.7: Effects of MDMS on household dietary quality across social groups (Radius matching with caliper = 0.01)

	Scheduled tribe (ST)	Scheduled caste (SC)	Other backward class	Non-disadvantaged class
Dietary outcome indicators				
Daily calorie available	-86.309	71.514***	13.011	49.614**
	(57.146)	(20.415)	(16.748)	(21.204)
Daily protein available	-4.469	2.131***	0.477	0.872
	(2.361)	(0.714)	(0.572)	(0.673)
Simpson index	0.014***	0.011***	0.002	0.006***
	(0.003)	(0.003)	(0.002)	(0.002)
Shannon index	0.030***	0.024***	0.002	0.017***
	(0.009)	(0.007)	(0.005)	(0.005)
Observations	8860	11289	24675	20367
Number of on support treated	2777	4001	7655	4569
Number of off support treated	253	274	225	160
Pseudo R2	0.002	0.001	0.002	0.001
	1.000	1.000	0.921	1.000
MSE	0.000	0.000	0.000	0.000

Note: To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of the control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Non-disadvantaged households are the other group experiencing a positive ATT on their daily calorie availability and dietary diversity although the magnitude of these effects is smaller than that of SC households. In the case of ST households, while the scheme does not have a positive influence on the nutrient availability in their diet, it has contributed to a significant improvement in their dietary diversity. But interestingly, there is no evidence for any nutritional benefits of the MDMS for households in other backward classes. These differences in the ATT clearly show the heterogeneity in household response to the scheme. Some disadvantaged groups may not receive as much nutritional gains as other groups.

4.6 Discussion

This paper contributes to the strand of literature on the nutritional benefits of school feeding programs. Previous studies have shown that provision of free school meals has enhanced the intake

[12]The kernel density diagram for the propensity scores across household groups and the results of probit regression and the ATT under other techniques can be found in the Appendix.

of essential nutrients of children. Our findings demonstrate that the programs can improve the dietary quality of family of the beneficiaries. It is found that Indian households benefited from the MDMS enjoyed higher calorie availability and better diet diversity, which underlines the potential of school feeding programs to act as a vehicle for improved food security and micronutrient status. It should, however, be noted that while the MDMS's impact on dietary diversity is statistically significant, the magnitude is rather small. This reflects the fact that it still has some ways to go if it were to be used as a vehicle to address the rising nutritional challenges . Indeed, the order issued by the Indian court in 2001 was designed to address calorie and protein adequacy rather than to promote a balanced diet. This limitation of MDMS is line with Pingali et al. (2017)'s concern over the nutrient insensitivity of social support programs in India. They criticise that Indian food policy does not pay sufficient attention on improving quality and diversity of diet and encouraging behavioural changes toward better nutrition.

Since 2004, several updates have been made to the MDMS to enhance school meals with greater nutritional content. For example, in 2006, the nutritional standard was revised to provide a cooked meal with a content of 450 calories and 12 grams of protein. Although the new guideline also required provision of adequate quantities of iron, folic acid and vitamin A, these micronutrients were supplied in the form of supplement tablets rather by a more nutritious school meal. Subsequently, a new food norm of school meals was announced in 2009 which set standards for the amount of grains, pulses, vegetables and oils in each school meal. Some better performing Indian states even expanded the food choice from what was recommended by the central government. For instance, Karnataka and Tamil Nadu have started to provide hot milk and eggs to school children respectively.

However, there remains limited guidelines under the MDMS in regard to the quantities of essential macro and micronutrients. The scheme needs to look beyond calorie and protein to enhance its role in reducing malnutrition in India. This can be achieved by developing predefined nutritionally balanced menus that takes into account traditional food tastes and also the availability of local food across seasons. These menus will not only provide clear guidelines for school cooks on meal preparation, but also assist procurement planning of ingredients and thus minimise the cost and delays in meal provision. Besides, by introducing students to various food combinations, these food norms may also generate a labelling effect which enhances the parents' awareness of balanced diets and encourages them to improve the nutritive value of food consumed at home.

While some state governments have already provided a suggestive menu, the implementation is far from satisfactory. In a review mission in West Bengal in 2013, egg curry was found to be provided once a week rather than twice as recommended in some school. A similar situation was also observed in the newly created state of Telangana. Even though detailed nutritional recipes were given to local officers in charge, vegetables were not being used adequately. In fact, one fifth of students in states like Bihar, Rajasthan and West Bengal reported inadequate school meals (Garg et al. 2013). What is more, there have been frequent reports of food poisoning and contamination. The most infamous incident happened in Bihar in 2013 in which 23 students died after

consuming a midday meal cooked with oil that was stored in a bottle that previously contained insecticide. Indeed, the performance of MDMS has been hindered by capacity constraints, such as inadequate infrastructure and staff, and political factors, such as delayed payments from the government and poor accountability (Pingali et al. 2017). Without tackling these setbacks in the institutional background, more nutritive sensitive menus are unlikely to have any real impact on school age children and their family. Stronger safeguard and tighter supervision, together with better support from the central government, are therefore prerequisite for the MDMS to transit from its current form to one that promotes nutrient security.

In addition, as evident in our results, some disadvantaged households in India do not receive as much nutritional gains as others, suggesting that the MDMS may not be effective in reducing social disparity in dietary quality and hence nutritional development. This heterogeneity in gains from a social support program is a common finding encountered by researchers studying social policy in India. Because of the hierarchical division of Indian society, those who are in relatively higher status groups benefit more from social development and the vice versa (Garg et al. 2013). This calls for better understanding of the constraints faced by disadvantaged groups when evaluating nutritional gains from school feeding schemes and the need to devote more resources to ensure equal access to the benefits.

4.7 Conclusion

This research investigated whether school feeding schemes improve the dietary quality of family of the beneficiaries in the context of the MDMS in India. To account for the potential selectivity bias, we applied PSM to identify the effect of free school meals on daily calorie and protein availability as well as dietary diversity. We have found that households that benefited from the scheme enjoyed a more diverse diet than non-beneficiary households who have similar characteristics and reside in the same region in India. There is less robust evidence on the positive effect of school meal provision on their daily calorie acquisition. We do not find a significant difference in daily protein availability between the two household groups. Importantly, our estimates also demonstrate disparity in nutritional gains from MDMS across social groups. While SC participating households are found to enjoy a more diverse diet with higher calorie and protein availability than those who did not participate in the scheme, there is no evidence of any nutritional benefit of the MDMS for households in other backward classes.

Considering that the MDMS in India is the largest school feeding scheme in the world, the analysis in this paper provides valuable policy lessons for other developing countries with rising malnutrition problems. First, our results provide evidence that school meal provision does augment nutrition for family of the beneficiaries. This reaffirms Bhattacharya et al. (2006)'s argument that the benefits of school feeding schemes may be underestimated if one ignores that children are often part of a larger economic unit – the family. Second, the ATT on dietary diversity points to a neglected benefit of school feeding programs on food security as a more varied diet indicates that the household has better access to food. This highlights the potential of school

feeding programs to act as a vehicle for food security. Third, in light of the growing disconnect between food policy and contemporary nutritional challenges in developing world, the design of school meals should move away from the focus of calorie sufficiency towards balanced nutrition. A more nutrient sensitive feeding scheme will not only help mitigate the situation of children malnutrition, but also contribute to diversification of household diet via income and labelling effects. Finally, the Indian experience illustrates that nutritional gains from the scheme may not reach marginalised and vulnerable groups in the society. This disparity in treatment effect may lead to wider social gap in nutritional status, which calls attention on the need to ensure the inclusiveness of school feeding schemes.

We end this paper with one caveat. Since households in the NSS are not repeatedly surveyed, we are unable to compare the nutritional outcomes before and after the receipt of free school meals. Our findings are based on the dietary difference between MDMS beneficiaries and the corresponding counterfactual households. They are hence suggestive rather than conclusive evidence on the causal relationship between school meal provision and dietary quality even though our ATT estimates are valid and robust. This shed lights on the potential advantages of future field experiment to collect food consumption data of all members in the beneficiary households. This will not only provides a more complete picture of the nutritional impact of school feeding programs but also enhance the understanding of how resources are reallocated within household in response to the scheme.

Appendix

Figure A3.1: Propensity scores for MDMS beneficiary and non-MDMS beneficiary households across social groups

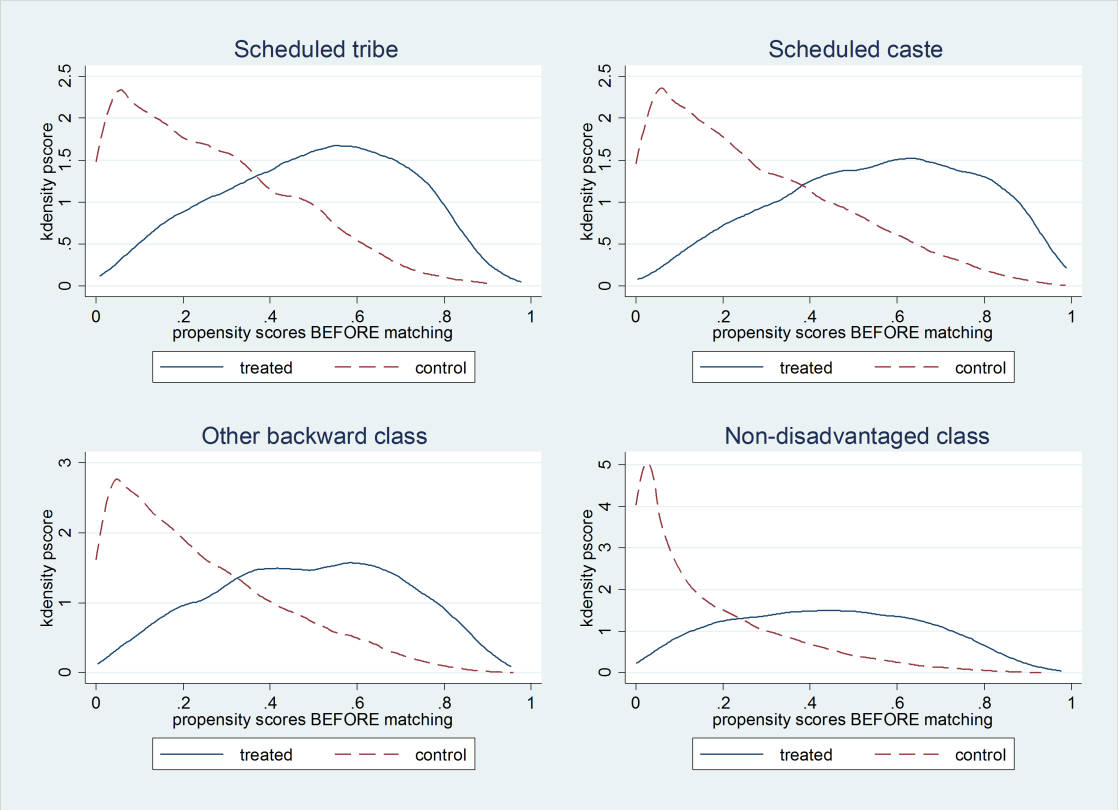


Table A3.1: Probit regression estimation for Indian households with school-age children

	Dependent variable: Household is a MDMS beneficiary	
Explanatory variables	Coefficient	Standard error
MPCE quartiles (First/ poorest)		
Second	-0.105***	(0.016)
Third	-0.301***	(0.018)
Fourth/ richest	-0.674***	(0.023)
Education of household head (not formally educated)		
Primary	-0.080***	(0.016)
Middle and secondary	-0.237***	(0.016)
Above secondary	-0.543***	(0.030)
ln(age of household head)	-0.133***	(0.029)
Gender of household haed (Male)		
Female	-0.171***	(0.022)
ln(Household size)	0.477***	(0.019)
Percent of school age girls	1.818***	(0.049)
Percent of school age boys	1.613***	(0.045)
Percent of adult	-0.805***	(0.049)
Religion (Others)		
Hindu	0.027	(0.017)
Social group (Others)		
Scheduled tribe	0.140***	(0.023)
Scheduled caste	0.243***	(0.019)
Other backward class	0.108***	(0.016)
Sub round (October-December)		
July-September	0.129***	(0.016)
January-March	0.166***	(0.016)
April-June	0.103***	(0.017)
Whether household located in an urban area	-0.546***	(0.014)
Percent of enrollment in public school	0.218***	(0.060)
Percent of schools with single teacher	-0.343***	(0.092)
Percent of classrooms in good condition	-0.560***	(0.075)
Constant	-1.878***	(0.145)
Observations	65,399	
R-Squared	0.2301	

Note: State dummy are not reported for brevity. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A3.2: Estimated effects of MDMS on household dietary diversity with higher order terms in probit model

	Matching algorithm	Outcome	Number of on support treated	Number of treated off support	ATT	Standard error	Pseudo R^2	$\rho > X^2$
1	Nearest neighbour matching (Caliper=0.1)	Calorie intake	19892	22	18.705	1.44	0.002	0.002
		Protein intake	19892	22	0.136	0.28	0.002	0.002
		Simpson Index	19892	22	0.004***	3.79	0.002	0.002
		Shannon Index	19892	22	0.008***	2.67	0.002	0.002
2	Nearest neighbour matching (Caliper=0.01)	Calorie intake	19690	224	19.181	1.49	0.001	0.015
		Protein intake	19690	224	0.128	0.26	0.001	0.015
		Simpson Index	19690	224	0.004***	3.88	0.001	0.015
		Shannon Index	19690	224	0.009***	2.82	0.001	0.015
3	Radius matching (Caliper=0.01)	Calorie intake	19690	224	20.647	1.69	0.001	0.010
		Protein intake	19690	224	0.167	0.38	0.001	0.010
		Simpson Index	19690	224	0.004***	4.52	0.001	0.010
		Shannon Index	19690	224	0.010***	3.34	0.001	0.010
4	Radius matching (Caliper=0.001)	Calorie intake	16956	2958	29.964**	2.47	0.001	0.644
		Protein intake	16956	2958	0.507	1.17	0.001	0.644
		Simpson Index	16956	2958	0.004***	4.03	0.001	0.644
		Shannon Index	16956	2958	0.009***	3.04	0.001	0.644
5	Kernel bandwidth matching	Calorie intake	19890	24	19.683	1.65	0.002	0.000
		Protein intake	19890	24	0.200	0.47	0.002	0.000
		Simpson Index	19890	24	0.005***	4.74	0.002	0.000
		Shannon Index	19890	24	0.010***	3.47	0.002	0.000
6	Local linear matching	Calorie intake	19892	22	20.671	1.47	0.002	0.000
		Protein intake	19892	22	0.225	0.41	0.002	0.000
		Simpson Index	19892	22	0.005***	3.56	0.002	0.000
		Shannon Index	19892	22	0.010***	2.67	0.002	0.000

For nearest neighbour matching, each treated household is matched with five counterfactual households. In total, there are 45495 untreated households in the sample. To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level

Table A3.3: Estimated effects of MDMS on household dietary diversity with exact matching at regional level

	Matching algorithm	Outcome	Number of on support treated	Number of treated off support	ATT	Standard error	Pseudo R^2	$\rho > X^2$
1	Nearest neighbour matching (Caliper=0.1)	Calorie intake	19884	29	13.88	1.13	0.001	1
		Protein intake	19884	29	0.179	0.39	0.001	1
		Simpson Index	19884	29	0.008***	7.36	0.001	1
		Shannon Index	19884	29	0.018***	5.87	0.001	1
2	Nearest neighbour matching (Caliper=0.01)	Calorie intake	19177	737	16.603	1.37	0.001	1
		Protein intake	19177	737	0.282	0.62	0.001	1
		Simpson Index	19177	737	0.006***	5.72	0.001	1
		Shannon Index	19177	737	0.014***	4.44	0.001	1
3	Radius matching (Caliper=0.01)	Calorie intake	19177	737	16.406	1.28	0.001	1
		Protein intake	19177	737	0.214	0.46	0.001	1
		Simpson Index	19177	737	0.006***	6.05	0.001	1
		Shannon Index	19177	737	0.014***	4.70	0.001	1
4	Radius matching (Caliper=0.001)	Calorie intake	12911	7003	18.759	1.38	0.001	1
		Protein intake	12911	7003	0.197	0.41	0.001	1
		Simpson Index	12911	7003	0.003***	3.16	0.001	1
		Shannon Index	12911	7003	0.009***	2.64	0.001	1
5	Kernel bandwidth matching	Calorie intake	19860	54	14.768	1.19	0.001	1
		Protein intake	19860	54	0.138	0.31	0.001	1
		Simpson Index	19860	54	0.008***	8.01	0.001	1
		Shannon Index	19860	54	0.018***	6.31	0.001	1
6	Local linear matching	Calorie intake	19892	23	19.309	1.26	0.001	1
		Protein intake	19892	23	0.291	0.50	0.001	1
		Simpson Index	19892	23	0.011***	7.75	0.001	1
		Shannon Index	19892	23	0.025***	6.42	0.001	1

Note: For nearest neighbour matching, each treated household is matched with five counterfactual households. In total, there are 45495 untreated households in the sample. To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of the control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A3.4: Probit regression estimation for Indian households across social groups

	Scheduled tribe		Scheduled caste		Other backward class		Non-disadvantaged class	
Explanatory variables	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
MPCE quartiles (First/ poorest)								
Second	-0.135***	(0.024)	-0.219***	(0.045)	-0.063*	(0.034)	-0.008	(0.033)
Third	-0.330***	(0.027)	-0.270***	(0.050)	-0.225***	(0.041)	-0.249***	(0.035)
Fourth/ richest	-0.788***	(0.035)	-0.517***	(0.064)	-0.671***	(0.059)	-0.536***	(0.042)
Education of household head (not formally educated)								
Primary	-0.095***	(0.024)	-0.097**	(0.042)	-0.012	(0.035)	-0.069**	(0.032)
Middle and secondary	-0.248***	(0.025)	-0.160***	(0.044)	-0.157***	(0.036)	-0.292***	(0.032)
Above secondary	-0.631***	(0.052)	-0.558***	(0.083)	-0.421***	(0.082)	-0.531***	(0.050)
ln(age of household head)	-0.217***	(0.045)	0.060	(0.075)	-0.035	(0.067)	-0.171***	(0.055)
Gender of household head (Male)								
Female	-0.137***	(0.033)	-0.116**	(0.059)	-0.218***	(0.051)	-0.242***	(0.043)
ln(Household size)	0.457***	(0.030)	0.606***	(0.052)	0.537***	(0.047)	0.406***	(0.037)
Percent of school age girls	1.799***	(0.078)	1.774***	(0.123)	2.057***	(0.111)	1.767***	(0.096)
Percent of school age boys	1.488***	(0.071)	1.906***	(0.116)	1.819***	(0.101)	1.514***	(0.089)
Percent of adult	-0.809***	(0.079)	-0.474***	(0.122)	-1.001***	(0.112)	-0.910***	(0.099)
Religion (Others)								
Hindu	0.078***	(0.029)	-0.066	(0.065)	0.167**	(0.066)	-0.031	(0.027)
Whether household located in an urban area	-0.514***	(0.022)	-0.472***	(0.045)	-0.508***	(0.033)	-0.634***	(0.027)
Percent of enrollment in public school	0.175*	(0.106)	-0.465***	(0.168)	0.285**	(0.139)	0.551***	(0.111)
Percent of schools with single teacher	-0.379***	(0.147)	-0.024	(0.229)	-0.414*	(0.213)	-0.273	(0.194)
Percent of classrooms in good condition	-0.310**	(0.125)	-0.504***	(0.171)	-0.538***	(0.178)	-0.841***	(0.146)
Constant	0.078***	(0.029)	-0.066	(0.065)	0.167**	(0.066)	-0.031	(0.027)
Observations	24,675		8,860		11,289		20,527	

Note: For dummy variable, reference groups are indicated in parathesis. State and subround dummy are not reported for brevity. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A3.5: Effects of MDMS on household dietary quality across social groups (Nearest neighbour matching with caliper = 0.01)

	Scheduled tribe (ST)	Scheduled caste (SC)	Other backward class	Non-disadvantaged class
Dietary outcome indicators				
Daily calorie available	-72.507	72.031***	10.038	45.964**
	(56.015)	(20.620)	(16.552)	(20.192)
Daily protein available	-3.863	2.168***	0.370	0.835
	(2.271)	(0.737)	(0.585)	(0.664)
Simpson index	0.014***	0.010***	0.002	0.006***
	(0.004)	(0.003)	(0.002)	(0.002)
Shannon index	0.029***	0.024***	0.003	0.018***
	(0.010)	(0.008)	(0.005)	(0.005)
Observations	8860	11289	24675	20527
Number of on support treated	2777	4001	7655	4589
Number of off support treated	253	274	255	160
Pseudo R^2	0.002	0.001	0.002	0.001
$\rho > X^2$	0.999	1	0.788	1
MSE	0	0	0	0

For nearest neighbour matching, each treated household is matched with five counterfactual households. To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of the control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A3.6: Effects of MDMS on household dietary quality across social groups (Kernel matching)

	Scheduled tribe (ST)	Scheduled caste (SC)	Other backward class	Non-disadvantaged class
Dietary outcome indicators				
Daily calorie available	-74.082	75.977***	11.562	51.256**
	(52.133)	(20.642)	(16.437)	(20.643)
Daily protein available	-3.790	2.275***	0.426	0.870
	(2.148)	(0.708)	(0.558)	(0.639)
Simpson index	0.018***	0.013***	0.003*	0.007***
	(0.003)	(0.003)	(0.002)	(0.002)
Shannon index	0.038***	0.032**	0.004	0.022***
	(0.009)	(0.007)	(0.004)	(0.005)
Observations				
Number of on support treated	8860	11289	24675	20527
Number of off support treated	3008	4251	7851	4704
	22	24	29	25
Pseudo R2	0.003	0.002	0.002	0.001
	0.993	0.997	0.921	0.999
MSE	0.000	0.000	0.000	0.000

Note: To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of the control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Table A3.7: Effects of MDMS on household dietary quality across social groups (Local Linear matching)

	Scheduled tribe (ST)	Scheduled caste (SC)	Other backward class	Non-disadvantaged class
Dietary outcome indicators				
Daily calorie available	-75.853	86.629***	16.487	54.898**
	(77.241)	(22.540)	(18.551)	(25.996)
Daily protein available	-3.801	2.570***	0.568	0.985
	(2.947)	(0.741)	(0.563)	(0.822)
Simpson index	0.019***	0.016***	0.005**	0.008***
	(0.005)	(0.003)	(0.002)	(0.002)
Shannon index	0.040***	0.039***	0.009	0.024***
	(0.013)	(0.009)	(0.006)	(0.007)
Observations	8860	11289	24675	20527
Number of on support treated	3932	4259	7871	4725
Number of off support treated	3	16	9	4
Pseudo R2	0.005	0.004	0.003	0.003
	0.466	0.609	0.022	0.798
MSE	0.000	0.000	0.000	0.000

Note: To impose a common support, treated observations with propensity score higher than the maximum or less than the minimum propensity score of the control group are dropped. ***Denotes significant at the 1% level, **at 5% level, *at 10% level.

Chapter 5

Conclusion

This thesis is motivated by the rising phenomenon of nutrition transition, which is the dietary shift from the one dominated by traditional staples to one high in animal products and processed food. This trend has complicated the nutritional challenges in many developing countries. While these countries continue to suffer from a widespread issue of undernutrition, there has also been an emerging problem of overnutrition. As a result of the rising intake of animal products and processed food, an unintended consequence of the nutrition transition has been an increase in the occurrence of obesity and other diet-related diseases. In light of its public health consequences, this thesis employed a variety of econometric methods to investigate the factors driving this dietary transition from cereals to animal products and other foods. Specifically, we used large-scale consumption data from the National Sample Survey (NSS) in India to investigate how trade liberalisation, changing food preferences and school feeding scheme affected the food consumption patterns of Indian households. In the following, we first summarise the findings of each empirical study, then discuss the policy recommendations and highlight the potential extensions of this thesis.

5.1 Summary of results

Utilising an exogeneous trade policy shift in India in 1991, we looked into how trade liberalisation may have an unintended dietary outcome and hence contributed to this nutrition transition in Chapter 2. The key research question of this study was whether the difference in consumption of cereals and animal products across rural Indian regions before and after the reforms could be attributed to their differential degree of exposure to tariff cuts. Following Topalova (2007)'s approach, the level of trade protection faced by each region was measured by the interaction term between the tariffs levied on industries and the share of region's workers employed in these industries before the onset of liberalisation. Our estimates revealed that regions experienced a larger reduction in trade protection are likely to consume relatively less cereals and more eggs, fish and meat. A series of robustness check was performed to ensure that this finding was not biased by the assignment of zero tariff, definition of food consumption, other simultaneous reforms and

the use of thin round data. This study therefore provided solid evidence for the role of trade liberalisation in facilitating diet diversification and hence driving the observed shift in dietary habit.

To further our understanding on this unintended dietary outcome of trade, Chapter 2 also investigated three possible channels, namely income, food prices and food tastes, through which trade could affect the consumption of cereals and animal products. The results indicated that Indian trade reforms discourage the cereal consumption largely by reducing the price of edible oils since they are seen as a substitute to cereals in rural India. For animal products, the positive trade effect on its regional consumption level is found to be mainly driven by the enhancement in food tastes. While earlier studies have argued that the opening of trade may influence consumer tastes through demonstration effect or improvement in consumers'access to varieties of food available, to our best knowledge, this study is the first to provide empirical evidence for the trade impact on consumer tastes. The importance of food tastes as a channel behind the trade-diet link is reaffirmed in the extension analysis in which we examined the regional trade impact on the rich and poor in rural India. For both household cohorts, food tastes are found to be the key channel through which the positive trade effect on their animal product consumption came through.

Next, we explored how food preferences have changed and led to the nutrition transition from 1987-88 to 2011-12 in Chapter 3. This study first modelled Indian food consumption with a two-stage demand budget system in which Working-Leser model and QUAIDS were estimated. It then computed time-varying income and price elasticities of demand for cereals with the assumption that household characteristics, income constraints and food prices remained constant at 1987-88 level. This assumption ensured that variations in these 'preference-based' elasticities can only be attributed to changes in the utility parameters of household demand functions, making them a good indicator of changes in food preferences. We found that the rural demand for cereals in India has become more responsive to income changes over time, indicating that households are likely to spend proportionally less on them as income increases. Our estimates also demonstrated an increasing trend of preference-based PEDs in both urban and rural sectors, which suggest that the Indian demand for cereals has become less resistant to changes in its relative prices. Moreover, the estimates of preference-based XED reflected that Indian households now view eggs, fish and meat products as a substitute for cereals rather than a complement. In line with our prior expectation, these trends indicated that cereals have become less favoured by Indian households and therefore less important to their diet over time. In addition, the evolution of these demand estimates rejects the standard assumption of constant elasticities in studies on consumer demand over a period of time.

Chapter 4 gives the final empirical study in this thesis which investigated the impact of the MDMS on the dietary diversity and nutritional intake of households. This scheme is the largest school feeding scheme in the world and is often considered as one of most successful food and nutritional policies in India. In the consideration of the potential self-selection bias, this study employed the PSM methods to compare the dietary quality of MDMS beneficiary households with that of the non-beneficiary households who shared similar characteristics and lived in the same

area. A variety of matching logarithms was employed to ensure that our ATT estimates were not sensitive to the choice of estimators. The results illustrated that the scheme brought significant nutritional gains to beneficiary households in terms of higher dietary diversity. There was also some evidence on the positive effect of school meal provision on their daily calorie acquisition. These findings demonstrated the school meal provision does augment nutrition for family of the beneficiaries, supporting Bhattacharya et al. (2006)'s argument that the benefits of school feeding programs may be underestimated if one ignores that children are often part of a larger economic unit the family. However, this study also revealed that this scheme may not be sufficient in enhancing household dietary quality. Despite the minimum protein content per school meal issued by the Court in India, there was no significance difference in the daily protein availability between the two household groups. Besides, in our examination of the heterogeneity in MDMS gains across social groups, while SC participating households were shown to have benefited the most, we found no evidence that the scheme improved the dietary quality of households in other backward class.

5.2 Policy recommendations

Nutrition transition is, undoubtedly, a phenomenon that is occurring at a fast pace in the developing world. Due to inadequacies in health promotion and health care systems, it is particularly challenging for developing countries to prevent and manage the adverse nutritional impacts from this dietary development. The widespread prevalence of under- and over-nutrition in these countries further highlights the complexity of their nutritional challenges. There is, thus, an increasing need for food and nutritional policies that can address food insecurity and hunger without adding to the prevalence of overweight and obesity within the population. Through examining the factors behind the nutrition transition in India, this thesis offers some policy insights on how to improve the quality of diets so as to eliminate malnutrition in all forms and thus achieve the goals set in the SDGs.

First, the pace of nutrition transition in developing countries are likely to accelerate with the rising importance of international trade as a growth strategy. As shown in our trade-diet analysis in Chapter 2, trade liberalisation has a negative impact on cereal consumption and a positive one on that of eggs, fish and meat. While these dietary outcomes of trade help improve the variety of micronutrient intake, the rise in intake of animal products may result in a higher incidence of obesity and other diet-related diseases, intensifying the double burden of malnutrition in developing countries. To ensure coherence between trade and nutritional targets, governments should develop complementary public policies to manage these unintended dietary outcomes of trade. Further research on the impact of global economy on nutritional and health development would provide valuable evidence for policymakers to make informed decision on these policies.

Second, cereals are no longer the only key to food security, as suggested by our demand elasticities estimated in Chapter 3. The weaker preferences for cereals, accompanied with the income and price changes in recent decades, have reduced the dietary importance of cereals and

hence contributed to the nutrition transition. The Indian experiences demonstrated that these changes in food preferences may make the nutritional intake of households vulnerable to changes in the price and availability of non-cereals, especially if real food expenditure is not adjusted to account for the fact that non-cereals are generally a more expensive source of nutrients than cereals. It is therefore unsurprising that food systems which are heavily biased towards primary staple grains fail to address the current nutritional challenges faced by developing countries. It is rather ineffective to rely on ensuring the availability of food that are losing the favour of population to improve nutritional outcome. This decline in the consumption of cereals underlines the importance of building a diversified food system in the developing world. Governments need to look beyond staple grains and ensure the availability of a wider basket of food, particularly non-cereal food that is rich in micronutrients.

Third, more emphasis should be put on measures that affect consumer tastes and preferences when formulating food and nutrition policies. In this thesis, changes in food preferences are found to have played a crucial role in driving the dietary shift away from traditional staples. This points to the use of nutritional education and other information policies in addressing the contemporary nutritional challenges since these measures are more likely to have a profound impact on food preferences and hence encourage long term behavioural changes towards healthier diets. This is particularly important in developing complementary policies for enhancing the coherence between trade and nutrition actions as food tastes are shown be the main channel through which trade enhances the consumption of animal products. Furthermore, given that food preferences are the crucial determinant of the demand responsiveness to income and price changes, as discussed in Chapter 3, a careful implementation of these measures may enhance the effectiveness of income transfer and price subsidies in promoting nutritionally balanced diets.

Fourth, the study in Chapter 4 provides evidence in support of the rising recognition for food assistance programs to move away from simply delivering dietary energy needs and instead toward commodity baskets offering a better balance of micronutrients (Lentz and Barrett 2013). As reflected by the significant treatment effect on dietary diversity, school feeding programs like the MDMS can improve beneficiary households'access to food and hence have the potential to act as a vehicle for improved food security and micronutrient status. Nonetheless, this potential is unlikely to be fully realised if there are only guidance on calorie content of school meals. Development of predefined nutritionally balanced menus would help introducing beneficiaries to various healthy food combinations. In this way, school feeding schemes will not only help reduce the occurrence of children malnutrition, but also encourage diversification of household diets via labelling effects. This exemplifies how the focus of food assistance programs can be expanded from the sufficiency of calorie to that of key macro-and micronutrients.

Lastly, the Indian experiences shed light on one important complication in solving the co-existence of over- and under-nutrition, which is the heterogeneity in the policy impact on households across social-economic classes. The analysis in Chapter 4 found no significant treatment effect from MDMS on the dietary quality of households from other backward class, revealing that nutritional gains from the scheme may not reach marginalised and disadvantaged groups in the

society. Similarly, the extension analysis of the trade-diet study illustrated a disparity in the dietary impact of trade on rich and poor households in rural India. The Indian trade reforms in 1991 are found to have enhanced the consumption of animal products of both household groups but only discouraged the intake of cereals of the rich cohort. These findings demonstrate that rather than narrowing the social gap in nutritional status, trade and food policies may in turn further complicate the nutritional challenges. It is therefore essential to account for the constraints faced by nutritionally vulnerable groups when accessing the dietary and nutritional impacts of government policies. More attention should also be put on redirecting food policy towards one that improve the availability and affordability of nutritious food for disadvantaged groups. Without a nutrient sensitive food system that is accessible for all, there is a very slim chance that the developing world could reach the ambitious SDG targets of eliminating malnutrition by 2030.

5.3 Future research

With the health impact of nutrition transition, one may deduce from the results of this thesis that trade liberalisation, changing food preferences and school feeding scheme are implicitly linked to the development of public health. While our findings are obtained through robust econometric strategies, such a linkage could not be drawn conclusively without further empirical evidence. Thus, one potential extension of this thesis is to incorporate Indian health data from the National Family Health Survey (NFHS) through which we can examine how the above factors may have affected population health in India, particularly in term of the prevalence of under- and over-nutrition.

Future research can also look into the rising consumption of processed food and beverages, another key feature of the nutrition transition. With globalisation and the rise of supermarkets and fast food outlets, these food items have become widely available and therefore commonly consumed in developing countries (Pingali and Khwaja 2004). In this thesis, we are unable to study the consumption of these food in detail as the NSSO records the expenditure on them under a few vague categories, such as 'cold beverages', 'pastry' and 'salted refreshment'. Because of the high degree of product heterogeneity within each category, the unit values obtained for various processed food and beverages are unlikely to be a reliable proxy for the market prices faced by households. This points to the benefits of collecting consumption data on processed food and beverages at a higher disaggregate level, which will enable researchers to identify food policies that can encourage behavioural changes towards consumption of these food.

Data appendix

D1 Background

India has a long tradition in collecting household level data. In 1950, the government set up the National Sample Survey Organisation (NSSO) to carry out nationwide large-scale surveys. These surveys, which are known as the National Sample Survey (NSS), use a multi-purpose framework to enable study of inter-connection between various components of the socio-economic picture of the country. To produce a national representative dataset, the NSSO adopts a two-stage stratified sampling strategy to divide the population into relatively homogeneous groups. The first stage units are rural villages and urban frame blocks within each of Indians states or union territories while households are the second stage units. There are two types of NSS round in relation to the scale of data collection. The first type is the 'thick' round, also known as full or quinquennial round. Over 100000 households are interviewed in these rounds. The other type is called the 'thin' rounds which are completed in the time interval between two quinquennial rounds and have smaller samples sizes.

The primary data used in this thesis comes from the schedule 1.0 of the NSS, which gathers data on household consumption expenditure. The NSSO conducts this schedule on a more frequent basis to generate a time-series of consumption data. For data consistency, this household consumption survey is designed in a way more or less similar to previous survey round. In each round, households are interviewed and asked to recall the consumption of a list of food and non-food items over a specified reference period. The consumption can be sourced from purchases, home-grown stock, receipts in exchange of goods and services, other receipt like gifts, charities, borrowing and free collection (NSSO 1987). It is captured by the items monetary value in Indian rupees and the corresponding physical quantitates when appropriate. A detailed item classification is used by the NSSO to minimise recall errors. It should be noted that any expenditure incurred towards the productive enterprises of the households is not counted as household consumer expenditure (NSSO 1987).

One key advantage of the NSS is its wide spectrum of socioeconomic variables. It not only provides a detailed account for household characteristics, such as education, age and gender of all household members, but also collects data on demographic particulars like their principal industry, social group, housing features and source of cooking and lighting energy. Nevertheless,

the NSS does not contain data on household income as it may increase rejection rate and result in lower quality estimates of consumption (Deaton 1997). The standard practice of literature to proxy household income with monthly per capita expenditure (MPCE). It is the sum of monetary value of all the items consumed by the household during the reference period. We follow this practice throughout this thesis and expenditure and income are hence used interchangeability thereafter.

In total, this thesis uses 12 rounds (i.e. 43^{rd}, 45^{th} to 53^{rd}, 61^{st} and 68^{th} round) of the NSS surveys over a time period from 1987-88 to 2011-12. Owing to geographical inaccessibility, three areas in the whole of India were not covered by the NSSO, which are (i) Ladakh and Kargil district of Jammu and Kashmir; (ii) interior villages of Nagaland located beyond 5 km of a bus route; (iii) villages of Andaman and Nicobar Islands. For the more recent 68^{th} round, only households locating in the latter two areas were not interviewed. In the first study on trade-diet link (Chapter 2), we develop a geographically repeated cross section dataset on regional food consumption using data from the 43^{rd}, 45^{th} to 53^{rd} NSS rounds. With the time coverage of 11 consecutive years from 1987 to 1997, these surveys enable us to compare the regional difference in food consumption periods before and after the Indian trade liberalisation in 1991 and establish the linkage between trade and diet. For the analysis on changing food preferences (Chapter 3), we exploit the large sample size of four NSS thick rounds (i.e. 43^{rd}, 50^{th}, 61^{st} and 68^{th}) to estimate the data-demanding QUAIDS. In Chapter 4, we employ the 61^{st} round NSS data, which was collected during the period 2004 -2005, to identify household nutritional gains from the school feeding scheme in India. During this period, many eligible students did not receive free school meals due to the staggered implementation of the scheme across Indian states. We take advantage of this variation in beneficiary status to construct a counterfactual group for the recipient households and compare their diet over a vector of quality indicators.

While most of the surveys used in this thesis uses a reference period of 30 days for food consumption, Indian households interviewed in the 51^{st} to 53^{rd} round were asked in to recall expenditures in either the last 30 days or the last 7 days. To align with previous survey rounds, consumption data collected using a reference period of 7 days is excluded in the study on the linkage between trade and diet (Chapter 2). For a more representative analysis, we exclude observations of households with biologically implausible calorie consumption and abnormally high food expenditure. A household is considered as outlier if its per capita calorie consumption is above 6000 kcal per day. Households with budget share of food more than one are also dropped as their records are likely to be highly biased. In addition, table D1 gives the time period and the number of rural and urban samples of each survey round.

The NSS records expenditure of Indian household on over 100 items. In case of food, household consumption during the reference period are normally recorded at a highly disaggregated level, ranging from basic staple food to various types of vegetables and fruits. Table 2 provides the complete list of items under different food categories. The food classification is largely consistent across survey rounds with some minor changes. For example, unlike earlier surveys, households are not asked to recall spending on cereal substitutes at a disaggregated level in the 61st and

Table D1: Number of households in rural and urban sector by survey round

Survey round	Time period	Number of Households	
		Rural	Urban
43rd	July 1987 June 1988	79308	43171
45th	July 1989 June 1990	14172	13682
46th	July 1990 June 1991	13336	14161
47th	July 1991 December 1991	8266	4831
48th	January 1992 December 1992	7922	4633
49th	January 1993 June 1993	18492	10737
50th	July 1993 June 1994	68351	45100
51st	July 1994 June 1995	15569	10100
52nd	July 1995 June 1996	14343	9728
53rd	January 1997 December 1997	13454	16838
61st	July 2004 June 2005	78820	44543
68th	July 2011- June 2012	59306	41260

Note: For a more representative analysis, households with abnormally high expenditure or calorie intake are not considered in this thesis.

68th rounds. Moreover, the 68th NSS uses a more detailed classification to collect information on processed food expenditure. These classification differences across NSS rounds are, however, a negligible concern as this thesis analyses diet composition changes in term of aggregated food groups rather than individual food items. Further details on the construction of dietary variables in each study can be found in the corresponding chapter.

Table D2: Food items listed in NSS data

NSSO food categories	43rd, 45th 53rd round[1]	61st round[2]	68th round
Cereals	Paddy, rice, chira, lawa, muri, other rice products, wheat, atta, maida, suji, noodles, bread (bakery), other wheat products, jowar, jowar products, bajra, bajra products, maize, maize products, barley, barley products, small millets, small millets products, ragi, ragi products	Rice, chira, lawa, muri, other rice products, wheat/atta , maida, suji, noodles, bread (bakery), other wheat products, jowar and products, bajra and products ,maize and products, barley and products, small millets and products, ragi and products, other cereals	Rice, chira, lawa, muri, other rice products, wheat/atta , maida, suji, noodles, bread (bakery), other wheat products, jowar and products, bajra and products ,maize and products, barley and products, small millets and products, ragi and products, other cereals
Cereal substitutes	Gram (full grain), gram products, tapioca dry, tapioca(green), mahua, jack fruit seed, other cereal substitutes	Cereal substitutes (no further disaggregation)	Cereal substitutes (no further disaggregation)
Milk and milk products	Milk (liquid), baby food, milk(condensed/powder), curd, ghee, butter, ice-cream, other milk products	Milk (liquid), baby food, milk(condensed/powder), curd, ghee, butter, ice-cream, other milk products	Milk (liquid), baby food, milk(condensed/powder), curd, ghee, butter, ice-cream, other milk products

[1]In 50th round, some food items under cereals, pulse, edible oils and sugar are further seperated into the amount acquired from PDS and the amount obtained from other sources.

[2]For 61st and 68th rounds, sugar, rice and wheat are further disaggregated into the amount acquired from PDS and the amount obtained from other sources

Eggs/ Fish/ Meat	Goat meat, mutton, beef, pork, buffalo meat, other meat, chicken, other bird, eggs, egg products, fish (fresh), fish (dry), fish (canned), others [3]	Eggs, fish/prawn, goat meat/mutton, beef/buffalo meat, pork, chicken, other birds/crab. etc.	Eggs, fish/prawn, goat meat/mutton, beef/buffalo meat, pork, chicken, other birds/crab. etc.
Edible oils	Vanaspati, margarine, mustard oil, groundnut oil, coconut oil, gingelly oil, linseed oil, refined oil, palm oi, rapeseed oil, oil seed, edible oil (others)	Vanaspati/margarine, mustard oil, groundnut oil, coconut oil, edible oil (others)	Vanaspati/margarine, mustard oil, groundnut oil, coconut oil, refined oil, edible oil (others)
Pulses and pulses product	Arhar (tur), gram(split gram), moong, masur, urd, khasari, peas, soyabean, other pulses, besan, other pulse products	Arhar (tur), gram(split), gram(whole), moong, masur, urd, khasari, peas, soyabean, other pulses, gram products besan, other pulse products	Arhar (tur), gram(split), gram(whole), moong, masur, urd, khasari, peas, soyabean, other pulses, gram products besan, other pulse products
Vegetables	Potato, arum, radish, carrot, turnip, beet, sweet potato, onion, other root vegetable, pumpkin, gourd, bitter gourd, cucumber, parwal, jhinga, snake gourd, other gourd, French beans and barabti, tomato, cauliflower, cabbage, brinjal, ladys finger, palak, peas, chillies, capsicum, plantain, jackfruit (green), lemon, other leafy vegetables, other vegetables	Potato, onion, radish, carrot, turnip, beet, sweet potato, arum, sweet potato, pumpkin, gourd, bitter gourd, cucumber, parwal, jhinga, snake gourd, papaya (green), cauliflower, cabbage, brinjal, ladys finger, palak/other leafy vegetables, French beans and barbate, tomato, peas, chillies, capsicum, plantain, jackfruit (green), lemon, garlic, ginger, other vegetables	Potato, onion, tomato, brinjal, radish, carrot, palak/other leafy vegetables, green chillies, ladys finger, parwal, cauliflower, cabbage, gourd/pumpkin, peas, beans and barbate, lemon, other vegetables
Fruits	Banana, jackfruit, watermelon, pineapple, coconut, guava, singara, oranges, mango, kharbooza, pears, berries, leechi, apple, grapes, other fresh fruits	Banana, jackfruit, watermelon, pineapple, coconut, guava, singara, oranges, papaya, mango, kharbooza, pears, berries, leechi, apple, grapes, other fresh fruits	Banana, jackfruit, watermelon, pineapple, coconut, green coconut, guava, singara, oranges, papaya, mango, kharbooza, pears, berries, leechi, apple, grapes, other fresh fruits

[3]Fish (canned) and others are not included in the 43rd and 45th round of NSS expenditure survey.

Dry fruits and nuts	Coconut (copra), groundnut, dates, cashew nut, walnut, other nuts, raisin/ kishmish/ monacca, other dry fruits	Coconut (copra), groundnut, dates, cashew nut, walnut, other nuts, raisin/ kishmish/ monacca, other dry fruits	Coconut (copra), groundnut, dates, cashew nut, walnut, other nuts, raisin/ kishmish/ monacca, other dry fruits
Sugar	Sugar (crystal), Khandsari, gur (cane), gur(others), sugar candy, honey, sugars (others)	Sugar, gur, candy, honey	Sugar, gur, candy, honey
Salt and spices	Sea salt, other salt, turmeric, black pepper, dry chillies, garlic, tamarind, ginger, curry powder, other spices	Salt, turmeric, black pepper, dry chillies, tamarind, curry powder, oilseeds, other spices	Ginger, garlic, jeera, dhania, turmeric, black pepper, dry chillies, tamarind, curry powder, oilseeds, other spices
Beverages, refreshment and processed food	Tea (cups), tea(leaf), coffee (cups),coffee (powder), ice, cold beverage, fruit juices and shake, coconut (green), other beverage, biscuits, salted refreshment, prepared sweets, cooked meals, cake, pastry, pickles, sauce, jam and jelly, other processed food	Tea (cups), tea(leaf), coffee (cups),coffee (powder), ice, cold beverage, fruit juices and shake, coconut (green), other beverage, biscuits, salted refreshment, prepared sweets, cooked meals, cake, pastry, pickles, sauce, jam and jelly, other processed food	Tea (cups), tea(leaf), coffee (cups),coffee (powder), ice, cold beverage, fruit juices and shake, coconut (green), other beverage, cooked meals purchased, cooked meals received free in workplace, cooked meals received as assistance, cooked snacks purchased, other served processed food, prepared sweets/cake/ pastry, biscuits, chocolates, papad/bhujia/ namkeen/mixture/ chanachur, chips, pickles, sauce/jam/jelly, other packaged processed food

D2 Concerns over the NSS data

D2.1 Recalling and measurement errors

The NSS data, like any other household survey data, is subject to concern over progressive amnesia about purchases. Respondents tend to recall less consumption with a longer recalling period, contributing to a downward bias in the reported expenditure. On the other hand, as pointed out by Deaton (1997), there is also a tendency for upward bias on expenditure from shorter recalling period due to the boundary effect, which occurs when respondents perceive the distant events to be more recent than they are. For example, given that the recalling period in the NSS is 30 days, households may report expenditures beyond 30 days as they have mistaken

that as more recent purchase. This gives rise to the tendency for households to over report their purchases. Empirical evidence has shown that the ratio of total expenditure from short to long recalling period are close to one, implying that the boundary effect is likely to cancel out the bias from recalling failure. In addition, the NSS employs a detailed food classification system to collect consumption data, which can further reduce the recalling error. Therefore, the discrepancy from recalling failure is unlikely to constitute a significant bias in the Indian food consumption data.

Apart from recalling error, the expenditure data may also be an inaccurate measure of the actual consumption due to the existence of measurement error. As pointed out by Strauss and Thomas (1995), the expenditure data does not adequately account for food wastage and leakage in which case the actual food intake will be lower than the amount recorded. This error is likely to be larger for rich households because they tend to waste more food than the poor ones. Besides, some of the food purchases made by households may have been used to make meals for guests and employees, leading to a potential upward bias on the actual food consumption. Given that income is proxied by the total expenditure in this thesis, these measurement errors will be present in both income and consumption, in other word the dependent and independent variables in the estimation of Indian food demand (Chapter 3). This gives rise to spurious correlation and hence biased estimates of demand elasticities. Besides, the coefficients of expenditure on budget shares spent on cereals and animal products in the trade-diet link study may not be accurate. In the former study, these measurement errors are likely to be mitigated with the inclusion of demographics since the likelihoods of food wastages and the patterns of giving and receiving meals are correlated with household characteristics. Given that these errors tend to be linked to the traditions and culture of the region, they are likely to be captured by the regional dummies in the latter study and hence have minimal impacts on the conclusion of the mechanism analysis.

D2.2 Absence of market prices

As in most consumption surveys, market prices of food items faced by households are not collected in the NSS. To overcome the absence of this key data, we follow the common practise to proxy them with unit values which are obtained by dividing expenditure with the quantity brought. These values, however, may be a biased proxy due the quality effect. For example, while rice is commonly consumed in India, households in richer regions may purchase rice of superior quality and hence face a higher unit value. As this difference in quality of the same food item is not distinguished in the NSS data, unit values may exaggerate the actual price differences faced by households in different regions. They may also exhibit measurement error due to the failure of households to accurately recall their expenditure and quantity consumed of food items. The price difference across markets reflected by unit values is likely to be further distorted by the fact that larger households can buy in bulk and pay a lower price for the same food item compared to their smaller counterparts. Thus, the unit value calculated from the data needs to be corrected for these potential bias before using it as the proxy for market prices (Majumder et al. 2012).

Based on Majumder et al. (2012), the initial unit values of food items for each NSS round

are adjusted with the following OLS regression:

$$v_i - (v_i^{ur})_{median} = d_{i1}D_r + d_{i2}D_u + {}_{i3}\, D_s + \theta_i food + \eta_i Z + \varepsilon_i \tag{5.1}$$

where v_i is the unit value of food group i in Indian Rupee per kilogram faced by each household. $(v_i^{ur})_{median}$ denotes median unit value of that item in sector u and region r where household resides. Regional and urban sector dummies are represented by D_r and D_u respectively.[4] As an extension of Majumder et al. (2012), we include a set of dummy variables, D_s, to denote the quarter of the year (i.e. sub-round of the survey) in which the household is interviewed. This is to capture the variation in market prices caused by the seasonal changes in supply availability of food commodities. $food$ indicates per capita household food expenditure. A vector of household characteristics, Z, is added as control variables. This includes age and gender of household head, household size, proportion of adult males and adult females in the households and share of times that meals are consumed outside by that household. The last variable is a proxy for the level of market access to food experienced by households. ε_i represents random error.

Households in the same sector of same region are assumed to face the same vector of food prices, p_i. It is obtained by summing up the median unit value (v_i^{ur}) with the median estimated residual $(\varepsilon_i^{\hat{ur}})$ from equation (5.1) of the sector in each region:[5]

$$(p_i^{ur})_{median} = (v_i^{ur})_{median} + (\varepsilon_i^{\hat{ur}})_{median} \tag{5.2}$$

Table D3: Average quality-adjusted prices of food groups

	Urban				Rural			
	1987-88	1993-94	2004-05	2011-12	1987-88	1993-94	2004-05	2011-12
Cereals	3.44	6.42	10.75	21.34	3.00	5.57	9.14	17.45
Eggs, fish and meat	24.06	41.70	62.93	113.77	20.12	35.85	57.24	109.46
Edible oils	25.67	35.14	55.23	81.99	26.13	33.82	55.63	80.37
Pulses	9.04	16.54	28.97	61.48	8.04	14.90	27.58	58.00
Vegetables and fruits	3.15	6.33	10.31	23.09	2.56	4.78	8.47	18.35
Other food	5.00	10.22	15.16	44.68	4.30	8.40	12.03	30.83

Note: Prices are in Indian Rupee per kilogram. For items which consumption is reported in numbers, they are converted into kilograms based on the following weights: 1 liter milk=1 kilogram; 1 coconut=1 kilogram; 1 egg = 0.058 kilograms; 1 lemon = 0.06 kilograms; 1 banana = 0.1 kilograms; 1 pineapple = 1.5 kilograms; 1 orange=0.015 kilograms.

The average quality and demographically adjusted unit values of food groups for selected survey rounds are presented in table D3. For both sectors, their values are consistent with the ones in Majumder et al. (2012). Urban households generally face higher food prices than their rural counterparts. Animal products are the most expensive food group, followed by edible oils. The adjusted unit value is the lowest for cereals and vegetables and fruits. In the analysis on

[4] In Majumder et al. (2012), prices are modified to the district level by adding district dummies and using median unit value in each district. However, the data on Indian districts is not available in earlier surveys. For estimation consistency, prices used in this thesis are adjusted to the regional level, which is same as the procedure taken by Cox and Wohlgenant (1986).

[5] Since other food includes a high variety of food items, the price faced by households is subject to their consumption pattern and differs greatly within sectors and regions. To eliminate the influence of extreme unit values observed and ensure positivity of the adjusted price, outliners are dropped on the basis of Cook's distance in the price adjustment regression for other food. The remaining negative regional prices of other food are replaced by the corresponding state-level minimum adjusted prices.

trade-diet link (Chapter 2), we estimate equation (5.1) and (5.2) for each year rather than each survey round so as to align with the time dimension of tariff data.

D2.3 Simultaneous bias

In this thesis, we have taken the view that income determines the level of food consumption and neglected the 'efficiency-wage hypothesis' which argues that households with better food intakes are likely to have higher work productivity and hence higher income earnings. This reverse causation in the relationship between income and food consumption may lead to a simultaneous bias for the study on changing food preferences and hence inaccurate estimates of demand elasticities. In addition, in the study of trade-diet link, we found no significant evidence in support for income as the channel of transmission between trade liberalisation and regional food consumption in rural India. This conclusion could be biased if the dietary changes triggered by trade reforms have caused changes in income.

However, as commented by Strauss and Thomas (1998), the existing evidence for efficient wage is thin. Using aggregate data for India from 1961 to 1992, Dawson and Tiffin (1998) examine the long-run relationship between per capita calorie intake and per capita income. In their co-integration analysis, they find that calorie intake is Granger caused by income and not vice versa. To reaffirm the direction of effect, we extend their study to include data until 2013 and again find no evidence of reverse causality. This suggests that income generation is not constrained by food consumption in India. Therefore, simultaneous bias caused by 'efficiency-wage hypothesis' is unlikely to be a concern.

D2.4 Credibility of the 'thin' round data

In our analysis on trade-diet link, we use the NSS data from both thick and thin rounds to obtain a dataset on regional food consumption of 11 consecutive years. There has been concern over the credibility of data from the thin survey rounds due to its relatively smaller sample size. Some researchers have raised the possibility of some little understood problems in these rounds. However, there has been no official confirmation of any such difficulty (Deaton and Kozel 2005). Besides, the NSS documents show that there are minimal changes in the design of questionnaires across rounds. Sen and Himanshu (2004) argue that there are limited reasons to believe that results from these mutually comparable rounds to be less valid than from the thick round, provided that the sample sizes of thin rounds are large enough and valid sampling strategy are used. In light of this potential data issue of thin samples, we re-estimate the main specification with only data from the thick NSS round. We also test whether the dietary impact of trade is sensitive to a particular year by excluding observations from that period in the regression. The resulting estimates are of consistent sign and similar magnitude as the main findings, reaffirming the validity of the trade-diet link established in this thesis.

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