1. Introduction

One of the most commonly applied policies to improve nutrition among the poor is a food subsidy. Yet there is substantive debate about the extent to which nutrition among the poor improves with lower food prices (Ecker and Qaim 2011; Behrman, Deolalikar, and Wolfe 1988; Guo et al. 1999; Shimokawa 2010). Indeed, the evidence on the link between food prices and nutrition has been mixed (see Jensen and Miller 2011). Among resource-constrained poor, conventional wisdom suggests that lower prices can address the problem of undernourishment especially when the food that supplies scarce nutrients is dear.

The existing (mixed) evidence on the impact of food price subsidies on nutrition moreover faces the concern that price variations are often not exogenous. The households that seek and receive a food subsidy are usually poorer to begin with and hence have relatively lower levels of food consumption and nutrition. Measuring an association between the food subsidy and consumption/nutrition improvements thus would likely provide biased estimates of the causal link between movements in prices and outcomes at the household level (Kaushal and Muchomba 2015). Moreover, unobserved factors such as tastes and preferences could lead to systematic differences between those who avail themselves of the food subsidy and those who do not. Faced with identification problems, Jensen and Miller (2011) use a randomized controlled trial to address the issue of endogeneity of price variation across households.

In this paper, we study the case of pulse subsidies in select Indian states and their impact on consumption and ultimately nutrition (in terms of protein intake) by exploiting an exogenous variation in prices. As a natural experiment, we use the introduction of pulses into India’s Public Distribution System (PDS) to identify the causal effects of the food price subsidy. The variations in prices that we exploit were brought about by the inclusion of pulses in the PDS in some states and not in others.

The case of a consumption subsidy in pulses is quite important in India, which is home to the largest number of malnourished people in the world. A large percentage of the Indian population is poor and faces nutritional challenges, including that of protein deficiency. With a high incidence of vegetarianism, pulses occupy a unique place in India, being long considered as the poor man's meat.

Pulses complement cereals in the diet with protein, essential amino acids, vitamins, and minerals. They contain 22 to 24 percent protein by weight—almost twice the protein in wheat and thrice that in rice (Gowda et al. 2013).[1] Pulses in fact constitute the most common source of protein (the frequency of pulse consumption is higher than of any other source of protein) among Indian consumers. As the cheapest source of protein, they are consumed by both rich and poor. Around 89 percent of consumers in India have pulses at least once a week, while the corresponding number for fish or chicken/meat is only 35.4 percent (IIPS and ORC Macro 2007).

In investigating the impact of a subsidy on consumption of and protein intake from pulses, we exploit the cross-sectional and over-time variation in the introduction of the subsidy. Given the unique setting, where only a few states have introduced pulses in the PDS (as opposed to food grains—rice and wheat—which all states in the country have in the portfolio), and that there is sufficient pre- and postintervention data from a nationally representative survey, without the benefit of a controlled experiment, a difference-in-differences (DID) estimation emerges as a natural choice. The significant parallel trends in consumption of pulses across treatment and

[1] Pulses also provide other nutritional benefits for weight control, slow digestible carbohydrates, high fiber content, and moderate energy density when compared to other protein-rich sources like meat and meat products.

control states prior to the state-specific introduction of pulses into the PDS lends confidence to our estimates as being causal.

Our DID estimates show that the induced change in the consumption of pulses because of inclusion in the PDS though statistically significant is of a small order. The effective changes are not large enough to bring about any sizable difference in the consumption of pulses and by extension protein intake. Moreover, differences exist across states.

We do not see a significant price effect (expense per kilogram) of the pulse subsidy through the PDS in Punjab and Andhra Pradesh. In Tamil Nadu, we see a large price effect of the arhar subsidy, on the order of 14 rupees per kilogram, and a small effect of the subsidy on urd dal of 4 rupees per kilogram. In Himachal Pradesh, we see comparatively large effects of the subsidy on chana and urd dal, but not of the moong subsidy (given only to households with five or more members who were eligible, accounting for 43 percent of all households). In response to the subsidy, beneficiaries could make adjustments on both the intensive (more or less consumption of the pulse itself) as well as the extensive margin (changes in consumption of non-PDS pulses or items other than pulses).

With the impacts that we estimate, we go a step further to try to delineate the channels behind the results. We cannot attempt the exercise using consumer expenditure survey data from the National Sample Survey Office because those data do not separate out the source of consumption, that is, the open market or the PDS. We employ an alternative dataset from the Village Dynamics in South Asia (VDSA) of ICRISAT to help us pin down the mechanics behind the changes in overall pulse consumption following the subsidy. If the increased consumption of cheaper pulses bought through the PDS were to be offset by reduced consumption from open market sources, then we should not expect sizable changes in the intake of pulses.

The VDSA collected data on the quantity of pulses purchased by households from different sources, including the PDS. These disaggregated data allow us to see how the inclusion of subsidized pulses in the PDS changed the amount of pulses bought from the open market and the fair price shops where subsidized grains are sold. That the VDSA data cover multiple states is useful as it allows for both with-and-without and before-and-after scenarios that facilitate replication of a DID estimation strategy.

Note that for the DID technique all we need is that the comparison group accurately represents the change in outcomes that would have been experienced by the treatment group in the absence of treatment. To apply DID we need to measure outcomes in the group that got PDS pulses and the group that did not both before and after the program. DID does not require specifying the rules by which the treatment is assigned. We can examine two states, one with and one without pulses in the PDS, without specifying the reasons behind the adoption of such a policy.

Taking the case of Andhra Pradesh (where pulses were included in the PDS) and Maharashtra (where pulses were not included in the PDS) and using the VDSA data, we do find that on average, the household response to the price subsidy in pulses was to almost retain the level of preexisting consumption. In doing so, households were reallocating across sources of purchase—reducing market purchases and making up for that with uptake from the PDS. The net effect is near the status quo in consumption, which goes against the spur of the program for the proponents—that is, to expand consumption of pulses and thereby mitigate protein deficiency among the poor. At the same time, if the objective were to protect the existing consumption of pulses, the program would appear to be successful in doing so.

The estimated impacts of the price subsidy scheme are quite important from a policy perspective. Because of the high incidence of undernourishment, these programs have enjoyed political and public support despite widespread evidence of corruption and poor targeting (Kaushal and Muchomba 2015). An existing scheme that provides for cereals in the PDS already accounts for nearly 2 percent of India's gross domestic product (GDP) (Tarozzi 2005). Expanding the portfolio with new items could be desirable if it brought about a significant consumption effect leading to nutrition benefits. But if it does not increase consumption of the subsidized item, one would question the efficacy of the program unless its objective were to maintain the status quo in consumption under persistent price increases, as has been the case with pulses.

The proponents of including pulses in the PDS, however, have advocated such a policy based on larger objectives mainly comprising nutrition improvement. For example, Pravin Dongre, chairman of the India Pulses and Grains Association, articulated the industry's stand on the issue when he said, "We support the Government's initiative of [the] Food Security Bill. We need to look at not only food but nutrition security too. We urge the Government to include pulses in the proposed Bill" ("Include Pulses in Food Security Scheme" 2013)[2].

Similarly, representing the stand of the influential Right to Food Campaign in India, Biraj Pattnaik, principal adviser to the Supreme Court commissioners on the right to food, stated, "It's time for the PDS to diversify in a basket of foods. We are giving cereals but we should also look at distributing millets, pulses, oils, and possibly even fruits, eggs and milk in order to provide

[2] http://articles.economictimes.indiatimes.com/2013-08-07/news/41167871_1_india-pulses-grains-association-record-pulses-production

wholesome nutrition" (Mohan 2015)[3]. Findings from the present study could provide a counterargument by showing that only limited changes in consumption might take place postsubsidy since consumers adjust their consumption levels on both the extensive and intensive margins. The final effect is net of the two channels. To what extent a program like this can be expected to address the nutrition problem would likely depend on the context. In the case of pulses, we show that the effects on consumption are small, and hence nutrition effects might not be of the first order.

This is not to say that the decline in dietary diversity is not an important issue in itself in India and deserving of policy attention. Jha et al. (2013), for example, find an increasing concentration for food expenditure across various food groups using a concentration index. Desai and Vanneman (2014) find a reduction in dietary diversity among PDS users, which seems to be skewing consumption toward cereals and away from food that would provide important nutrients like protein and micronutrients. What our results show is that, notwithstanding the importance of the issue, inclusion of nutrient-rich food in the PDS might not be the way forward. With a subsidy, channels such as substitution and wealth effects come into play that could lead to end results different from what were primarily expected.

This paper contributes to an extensive body of literature on India's food price subsidy programs. Given the subject's size, spatial differences, and dynamic nature, it has been studied from different perspectives. Kochar (2005) finds that India's food subsidies (on wheat and rice) have a limited impact on calorie intake mainly due to low take-up and little induced changes in the buying of subsidized food. Tarozzi (2005) finds limited effects on children's weights. Other

[3] http://www.catchnews.com/india-news/biraj-patnaik-it-s-time-to-diversify-pds-we-should-start-giving-pulses-oil-fruits-eggs-1442145985.html

studies look at the direct impacts on nutrition of price changes, and the evidence seems mixed (see Behrman and Deolalikar 1988; Behrman, Deolalikar, and Wolfe 1988; and Guo et al. 1999).

Further, this study on the impacts of the introduction of pulses into the PDS takes place against the backdrop of PDS evaluation studies that focus on distribution of rice and wheat (see Khera 2011; Umali-Deininger, Sur, and Deininger 2005). The evidence from those studies is clearly mixed in terms of take-up and thereby nutritional effects. Jensen and Miller (2011) clearly show that food subsidies have different offsetting effects that can result in ambiguous impacts on consumption and nutrition. In particular, they highlight the wealth effects from reduced food prices under subsidy.

Including pulses in the PDS can certainly increase demand for pulses, but by releasing money, it can also increase consumption of other items such as rice and wheat, high-value food items, and nonfood items. With these effects, Jensen and Miller (2011) argue and later show with their experimental data that an increase in income resulting from the subsidy may have a negligible or even negative effect on nutrition. Our findings, although in a different context, are qualitatively similar to those of Jensen and Miller from that perspective.

To the best of our knowledge, no studies exist that evaluate the impacts of introducing a noncereal food into the food subsidy scheme in India. Notwithstanding the importance of the PDS in development debates in India, research on diversification of the PDS portfolio aimed at addressing the issues of diet diversity and nutrition is missing. Pulses are unique not only in terms of being an important source of protein but also in terms of their persistently high market price in recent years. Having faced a spiral of high prices, the price differential between the PDS and the open market has been comparatively high vis-à-vis cereals.

Pulses moreover are complementary to the consumption of food grains as they are combined with cereals in consumption. Hence, rice or wheat or both cannot be substituted away by pulses. Thus, consumers relying on the PDS for grains would likely continue to do so even after the introduction of pulses. The impact on households would be incremental to the ones from the subsidy on food grains.

The paper is organized as follows. The next section presents the data and some motivating descriptive statistics. The following section looks at the implementation details of the pulse subsidy scheme. This is followed by a section outlining the empirical methods. The results are presented next, with results of the estimated impacts of the subsidy including all states followed by state-specific impacts. We also present results based on analysis of the VDSA data, which illuminates pathways leading to the impacts. Derived impacts on protein intake are presented in the results section as well. The final section concludes and presents some policy implications.

2. Data and Descriptive Statistics

Data are drawn from the national sample survey's (NSS's) thick rounds, administered by the National Sample Survey Organization every five years with a larger sample size than the annual thin rounds. These are nationally representative consumer expenditure surveys in India covering between 100,000 and 125,000 households in each round. The sample is representative at the state level and uses the same sampling strategy and interview schedule format across different rounds. The NSS thick round collects data on expenditure on and quantity consumed of different commodities including pulses.

Overall, the NSS gives information on quantity and value of more than 142 food items with a reference period of the last 30 days for state/union territories, for the country as a whole, and also separately for rural and urban areas. Household monthly consumption of food items has been converted into per capita terms by dividing by household size. Since the income data tend to be noisier, it is customary to use monthly per capita expenditure as a proxy for income.

Pulses were added to the PDS between the 61st and 66th rounds of the NSS in four states. We use data from earlier rounds (50th and 55th) to test for parallel trends. An important limitation of the NSS data from the perspective of this paper is that the survey does not collect data separately on consumption by source—that is, PDS versus non-PDS origin of consumption. What we see in the data is simply the total consumption of pulses, and in terms of prices we observe only a weighted average price of PDS and market purchases.

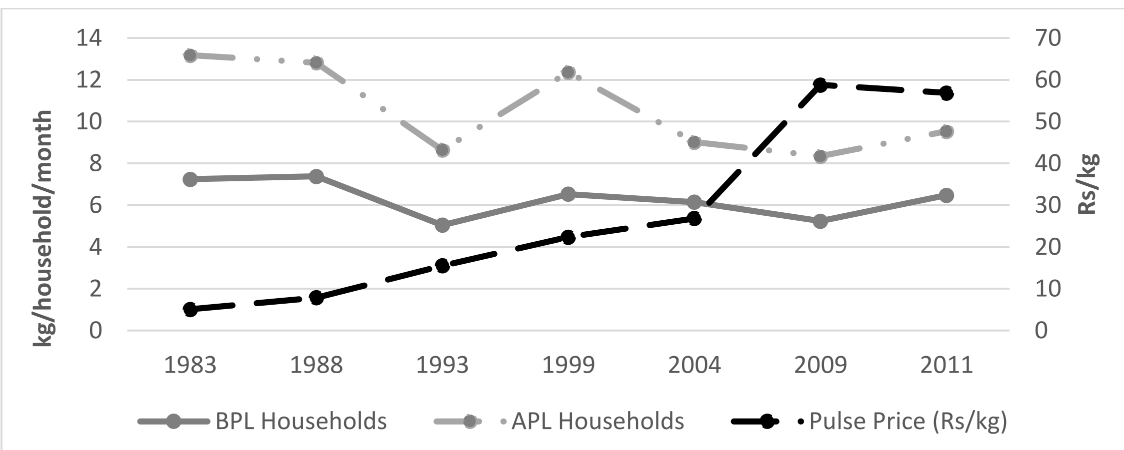
Following Deaton (1997), the prices of food commodities are computed from the NSS household data by dividing the value by the quantity of each item. Further, detailed data on food consumption are converted into nutrient intake of protein using conversion factors from the NSS. The NSSs do provide information on quantities of wheat and rice purchased, and the value thereof, from the PDS and from the open market, but for noncereal food like pulses such details are not available.

Table A.1 in the appendix summarizes characteristics of households located in both treatment and control states in the periods before and after pulses were introduced into the PDS.

To analyze the pathways for the impacts of food subsidy, we use the longitudinal village-level studies of ICRISAT that collected data on social and economic changes in the village and household economies in the semiarid tropics of Asia and Africa. In India, the VDSA (earlier known as Village level studies or VLS) initiated data collection in 1975 (Walker and Ryan, 1990). The VDSA is a comprehensive survey at a monthly frequency that has been used extensively in the literature (Mazzocco and Saini 2012 is a recent example).

VDSA surveys, in particular, provide data on purchases from the PDS of both the principal cereals (rice and wheat) as well as other items such as pulses in states where they are offered through the PDS. Further, the surveys provide information on prices paid by beneficiaries and total expenses incurred. Hence, VDSA data help us assess the relative importance of the PDS in the consumption portfolio since information exists on both PDS as well as non-PDS purchases of food items. In the case of PDS items, data exist on purchases from fair price shops, from home production, as well as from any other source.

Figure 2.1 Pulse prices and consumption (all India level, 1983–2011)



Source National Sample Survey Office consumption expenditure data.

Note: BPL = below poverty line; APL = above poverty line. The little spike in consumption in 1999-00 is probably because of a change in recall period which led to increased estimates of consumption expenditure in this round (Deaton, 2003)

Based on NSS data, Figure 2.1 plots per capita consumption of pulses over time. There is a distinct downward trend in pulse consumption that is uniform across income classes. Both poor households (below poverty line) and nonpoor households (above poverty line) have experienced the long-term fall. The latest survey round shows recovery in per capita consumption, but the level still remains below the Indian Council of Medical Research norms. Table 2.1 shows changes in per capita consumption by location (rural and urban).

Table 2.1 Pulse consumption across rural and urban households, by national sample survey round

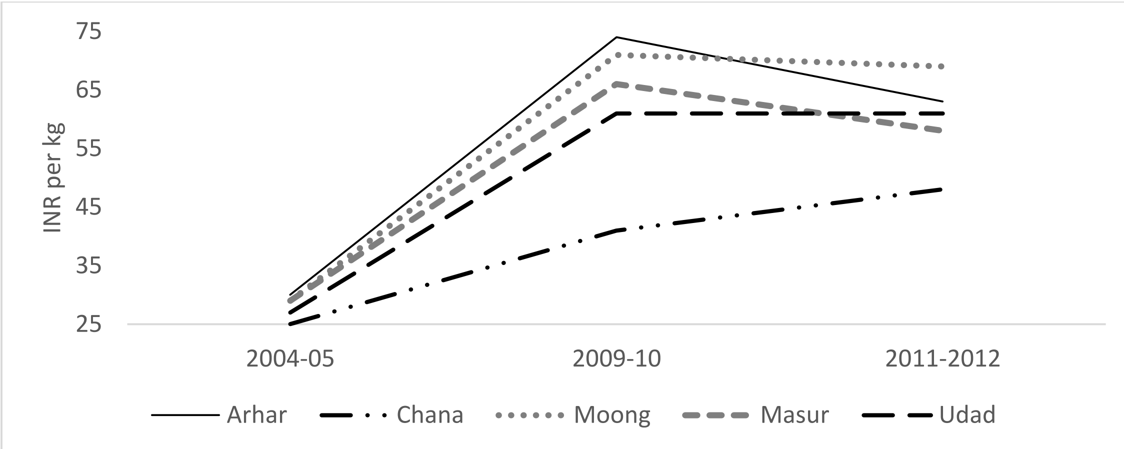
	Pulse consumption (kg/person/month)	
Year	*Rural*	*Urban*
2004/2005	0.76	0.74
2009/2010	0.68	0.67
2011/2012	0.78	0.75

Source National Sample Survey Office consumption expenditure data corresponding to years 2004/2005, 2009/2010, and 2011/2012 (NSSO surveys start in July 2004 and end in June 2005. That is why we list them as 2004/05).

Note: Per capita consumption of pulses in rural areas is actually lower than in urban areas. The household size is larger in rural areas.

Several studies (for example, Birthal et al. 2013) document diversification in consumption in India away from staples (such as cereals and pulses) toward high-value items (fruits, vegetables, animal source food, and processed items). As for pulses in particular, apart from shifting preferences, price dynamics would also play a role in declining consumption given that pulse prices have been consistently high. Figure 2.2 shows that prices for pulses as a group and for individual varieties have been high. The portion of the decline due to high prices could be mitigated through a subsidy such as through inclusion in the PDS. Pulses are almost universally consumed by households in India: in the 61st, 66th, and 68th rounds of the NSS, only around 3 percent of households reported no consumption of pulses in the last 30 days.

Figure 2.2 Prices of different pulses (average all India level) over time



Source National Sample Survey Office consumption expenditure data corresponding to years 2004/2005, 2009/2010, and 2011/2012.

3. Implementation Mechanisms for the Pulse Price Subsidy Scheme

The PDS is jointly operated by the central and state governments. That joint operation provides some flexibility to the state governments regarding within-state allocation as well as choosing the product mix. Traditionally, India's PDS provides subsidized rice and wheat (along with kerosene and sugar in some places) through a nationwide network of fair price shops.

To address issues related to targeting and leakages in the system, the central government replaced the PDS, a universal program, with the targeted PDS (TPDS) in 1997 (Kishore and Chakrabarty, 2015). The TPDS restricted the sale of subsidized food grains to families with incomes below the 1993/1994 poverty threshold fixed by the federal government (below-poverty-line households) (Kaushal and Muchomba 2015). Over time the allocation of rice and wheat under the TPDS has increased from an initial level of 10 kilograms per household to 20 kilograms in 2000 and finally to 35 kilograms in 2002.

The recent National Food Security Act of 2013 made 25 kilograms of grains available to two-thirds of households in India at highly subsidized prices of 2 rupees per kilogram for wheat and 3 rupees per kilogram for rice. Further, a system of highly subsidized grains called the Antyodaya Anna Yojana (AAY) was introduced for the poorest households. The inclusion of pulses in the PDS does not have such detailed allocation rules (see Table 3.2).

When a commodity is included in the PDS, different aspects related to implementation become important. Specifically, with regard to pulses, they form a group with different types and varieties. Moreover, there is heterogeneity in preferences across Indian states. Only specific types of pulses are consumed in each region, with little substitution among them. States that have included pulses in the PDS have tended to keep the state's most preferred pulses in the subsidy plan.

Table 3.1 shows the significant price increases (measured in terms of unit values from the NSS data) in pulses over time in the open market between the pretreatment and the posttreatment periods. Clearly, those price increases have been significant, and one would expect a consumption subsidy to be important with such price dynamics.

Table 3.1 Pulse prices, pretreatment and posttreatment

	2004/2005	**2009/2010**	
Pulse variety	*Price (Rs./kg)*		*Percentage increase in price*
Arhar	30.11	74.38	147.03
Chana dal	24.93	40.6	62.86
Moong	28.54	70.58	147.3
Masur	28.78	65.69	128.25
Urd dal	26.87	60.91	126.68
Peas	20.22	33.35	64.94
Khesari	16.55	36.22	118.85
Other pulses	26.13	51.6	97.47
All	27.63	58.97	113.43

Source: National Sample Survey Office consumption expenditure data corresponding to years 2004/2005 and 2009/2010.

Table 3.2 lists states that at some time have included specific pulses in the PDS. Inclusion of pulses has to specify some allocation and assignment rules as with rice and wheat. The rule can be individual based (quantity per member of household) or it can be specified at the household level with its affiliated price. As evident in Table 3.2, states have different arrangements with regard to inclusion of pulses in the PDS. While Andhra Pradesh and Tamil Nadu exclusively include pigeon pea in their PDS, Himachal Pradesh and Punjab have introduced a mix of pulses in the subsidy system.

Table 3.2 Pulse subsidization scheme in different states

State	Pulse subsidized	Details	Year of Introduction of Pulses in the PDS
Andhra Pradesh	Arhar dal	1 kg at Rs. 50/kg	2008
Himachal Pradesh	Moong whole	1 kg per ration card having 5 and above family members per month at Rs. 49.99/kg	2007
Himachal Pradesh	Urd Dal	1 kg per ration card per month to all ration card holders at Rs. 34.99/kg	2007
Himachal Pradesh	Chana Dal	1 kg per ration card having 3 and above family members per month at Rs. 25/kg	2007
Punjab	Pulses	0.5 kg per member to a max. of 2.5 kg per family at Rs. 20/kg	2007
Tamil Nadu	Arhar dal	1 kg at Rs. 30/kg	2007
Tamil Nadu	Urad dal	1 kg at Rs. 30/kg	2007

Source: Department of Food and Civil Supplies, Government of India (2014).

In terms of timing, Andhra Pradesh, Himachal Pradesh, Punjab, and Tamil Nadu began including pulses in their PDS sometime between 2004/2005 and 2009/2010. As discussed above, all four states have subsidized the most commonly eaten pulse. This includes urd dal and chana dal in Himachal Pradesh, arhar in Andhra Pradesh, chana dal in Punjab, and arhar and urd dal in Tamil Nadu. Table 3.3 shows that the price of the specific pulse (the one included in the PDS) relative to the price of that pulse in the rest of India did come down substantially (measured as unit values). On average, pulses were 20 to 50 percent cheaper in the included-in-PDS (IIP) states relative to the open-market prices.

Table 3.3 Prices paid by consumers for pulses in "included-in-PDS" states vis-à-vis other states in 2009/2010

Pulse	Andhra Pradesh	Himachal	Punjab	Tamil Nadu	Rest of India
Arhar	74.5			60.8	74.4
Urd dal		33.4	60.9	56.6	60.9
Chana dal		28.8	40.7		50.6
Moong		70.0	76.0		70.6

Source National Sample Survey Office consumption expenditure data.

4. Empirical Methods

Our objective is to identify the average effect of introducing pulses into the PDS on consumption and by extension on protein intake. Specifically, we are interested in comparing consumption of subsidized pulses to the counterfactual at the same point in time. Since the counterfactual is never observed, we must estimate it. In principle, as the best option, we would like to randomly assign access to pulses at different prices and compare the average outcomes of the groups availing themselves of PDS prices for pulses and those paying non-PDS prices. This is the approach Jensen and Miller (2011) adopted to deal with a similar research question.

In the absence of a randomized controlled trial, we must turn to nonexperimental methods that try to mimic the randomized allocation setting under reasonable conditions. A major concern is that states that have chosen to include pulses in the PDS could be different from the states that have opted otherwise and that those differences may be correlated with specific pulse consumption. For example, poorer states in which comparatively expensive pulse consumption was lower may have been the ones that brought pulses into the PDS. Also, it is possible that states with better or worse governance of the PDS system selectively include pulses in the PDS leading to selection issues.

In this case, the correlation between pulse consumption and inclusion in the PDS could be confounded with other effects. In principle, many of the unobservable characteristics that may confound identification are those that vary across states but are fixed over time. A common method of controlling for time-invariant unobserved heterogeneity is to use panel data and estimate DID models (Galiani, Gertler, and Schargrodsky 2005).

In estimating the effect of the program of including pulses in the PDS, the potential problem of selection arises at two levels: first, from the targeted rollout of the program, and second, from self-selection of households into accessing and utilizing the PDS system, including for pulses when included. This can raise potential econometric issues. If poorer, more liquidity-constrained households—with worse access to pulses to begin with—self-select themselves into the scheme, then simple ordinary least squares regression estimates would likely be downward biased. In contrast, if the better-off households in terms of consuming pulses take advantage of the scheme first, then estimates without fixed effects might be biased upward in measuring the impacts of the scheme.

The difference in timing of inclusion of pulses across states creates a near "natural experiment" setting. We exploit this mode of inclusion of pulses in the PDS to implement our DID strategy. With DID, we control for observed and unobserved time-invariant state-level characteristics that might be correlated with the decision to introduce pulses into the PDS as well as with citizens' levels of pulse consumption. The change in the control group is an estimate of the true counterfactual, that is, what would have happened to the treatment group if there had been no intervention. As Galiani, Gertler, and Schargrodsky (2005) point out, another way to state this is that the change in outcomes in treatment areas controls for fixed characteristics and the change in outcomes in the control areas controls for time-varying factors that are common to both control and treatment areas.

Formally, the DID model can be specified as a two-way fixed-effect linear regression model. We use the following DID model to identify the impact of inclusion of pulses in the PDS on household-level consumption:

$$C_{ist} = \sum_s \beta_s D_{t_k} + \gamma_{DID} W_{st} + \mu_s + \delta * X_{ist} + \varepsilon_{ist}. \quad (1)$$

The dependent variable C_{ist} represents the outcome of interest, that is, pulse consumption for household i in state s at time t (time corresponding to different rounds of NSS data). The variable D_{t_k}, where k corresponds to the different rounds of NSS, is the common time effect across all states. The main variable of interest is W_{st}, which is the interaction of the treatment group dummy with the time indicator. Let T_s denote the treatment state indicator for inclusion of pulses in the PDS, which takes a value equal to 1 if the state has included pulses in the PDS and equals 0 otherwise. W_{st} is the interaction of T_s with the time dummy. W_{st} is the indicator variable that equals 1 if $state\ s$ has provided a pulse subsidy at time t and equals 0 otherwise. μ_s is a state fixed effect for state s.

X_{ist} is a matrix comprising household-specific and state- and/or time-specific characteristics of household i. These variables, for example, include indicators for social group identity of the household, household size, education level of the household head, and age of the household head among the characteristics. Note that the NSS data constitute a repeated cross-section, and hence while we have controlled for state, type of pulse, and time-specific fixed effects, household fixed effects cannot be included in the estimation. The variable ε_{ist} is meant to capture the influence of unobserved factors that vary at the household, state, and time level.

The coefficient of W_{st}, that is, γ_{DID}, estimates the average difference in the change in pulse consumption between the treatment and control states in the posttreatment state relative to the baseline (where in both the treatment as well as the control state, pulses were excluded from the PDS). Since we have no way of capturing compliance with the treatment state and control state policies, the estimates that we have capture the intent to treat rather than the average treatment effect.

With the fixed effects that are included in the estimation equation, we can address some of the concerns related to possible omitted-variable bias. The fixed effects included in equation 1 can neutralize additive linear effects of other unobserved heterogeneity in terms of disadvantages or advantages associated with location in a particular state, food practices, values, norms, habits, and also time-invariant state-specific governance factors. The time fixed effects capture common effects across states such as global prices of pulses.

Apart from the omitted-variable bias concern at the household level, there is potential for concern at the geographic level—that is, the state in our case. It is possible that states with better unobservable attributes (like governance or access to markets) may have better outcomes of interest and also extent of uptake of pulses in PDS program coverage. For example, in the case of elite capture in the PDS, local conditions can determine who ultimately gets pulses from the PDS. The standard errors are clustered at the state level to control for intrastate correlations. Clustering is done at the state level because policy and program exposure both vary at the state level.

Further, it is possible that even in the absence of such supply-side factors, take-up of pulses under the program could be driven by demand for pulses that may be picking up the existing nutritional status of the households—for example, in terms of protein sufficiency and household's awareness about the program. Some of these concerns are addressed by employing VDSA data to delineate the channels explaining our estimated effects of pulses in the PDS. Whether the program of pulses in the PDS is typically driven by the supply of or demand for pulses is not clear. The households themselves had not mobilized to demand pulses in the PDS, and hence it is unlikely that the availability of the program is picking up propensity to consume or actual prior consumption of pulses.

Although there is agreement that pulses as a group are inflationary and have a high price elasticity, estimates of the impact of including pulses in the PDS can differ widely across varieties by a number of factors, such as the extent of price rise, duration of exposure to the treatment, and the degree of substitutability by cheaper varieties. Thus, in order to find heterogeneous impact, we further estimate equation 1 separately for different pulses individually given that their inclusion in the program varies by state.

Issue of Parallel Trends

One key assumption of DID estimation is that the trends in outcomes of interest would have been the same in both the treatment and the control groups—that is, consumption of pulses for households that included pulses in the PDS and those that did not. This so-called parallel trends assumption is a necessary condition for the DID methodology for identifying causal impacts. The basic assumption is that the very inclusion of pulses in the PDS induced a deviation from the common trend.

Recall, γ_{DID} in equation 1 is the DID estimate of the average effect of inclusion of pulses in the PDS on consumption of pulses. The main identifying assumption for this interpretation is that the change in pulse consumption in control states is an unbiased estimate of the counterfactual. As Galiani, Gertler, and Schargrodsky (2005) point out, while we cannot directly test this assumption, we can test whether the secular time trends in the control and treatment groups were the same in the preintervention periods. If the secular trends in household pulse consumption were the same in the preintervention periods, then it is likely that they would have been the same in the postintervention period if the treated states had not introduced pulses into the PDS.

Given the nature of the problem, it is not possible to discern whether outcomes of states with pulses in the PDS and those without would have moved in parallel in the absence of the program (the basic problem of impact evaluation). However, the test of parallel trends by checking for relative movement before the program was put in place in treatment states can lend confidence to the estimated impacts. With parallel trends we investigate whether outcomes would have continued to move in tandem in the postintervention period (without inclusion of pulses in the PDS).

To test the assumption of parallel trends we perform an additional DID estimation. As already noted, a key assumption of DID estimation is that the trends in outcomes of interest would have been the same in both groups (pulses in PDS and pulses not in PDS states) in the absence of the IIP that induced a deviation from the common trend. We test that the preintervention time trends for the control and treatment groups are not different by estimating a slightly modified version of equation 1. We use only the observations of the control and the treatment states in the pretreatment period. In particular we use the data from earlier rounds—that is, the 50th and 55th—to test for parallel trends.

We modify equation 1 by excluding the IIP dummy and including separate time dummies for (eventual) treatments and controls. In this model, we cannot statistically reject the hypothesis that the preintervention time dummies are the same for both the control and treatment states at conventional levels of statistical significance. Table 4.1 presents the results of the parametric test for parallel trends that is necessary before delving into DID estimation. The results are presented separately for each of the different types of pulse.

Table 4.1 Test for parallel trends

	(1) Pulses	(2) Arhar	(3) Chana Dal	(4) Moong	(5) Masur	(6) Urd Dal	(7) Other pulses
Trend	-0.118*	-0.029**	-0.007*	-0.017*	-0.031*	-0.012*	-0.003
	(-2.4)	(-3.1)	(-2.7)	(-2.4)	(-2.2)	(-2.2)	(-0.9)
Subsidy states	-0.659	0.021	0.147	-0.039	-0.689*	0.399*	0.021
	(-1.0)	(0.0)	(0.9)	(-0.2)	(-2.6)	(2.2)	(0.2)
Parallel trends	**0.077**	**0.017**	**-0.001**	**0.004**	**0.023**	**0.001**	**0.004**
	(1.5)	(1.7)	(-0.4)	(0.4)	(1.6)	(0.2)	(0.7)
Constant	4.775***	1.258***	0.352***	0.643***	0.974***	0.443***	0.243***
	(8.7)	(4.8)	(6.2)	(6.7)	(4.7)	(4.2)	(4.3)
N	360,307	360,307	360,307	360,307	360,307	360,307	360,307

Source: National Sample Survey Office consumption expenditure data corresponding to years 1993/1994, 1999/2000, and 2004/2005.
Notes: *t* statistics in parentheses. Standard errors are corrected for clustering at the state level.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The test for parallel trends that we report in Table 4.1 is essentially a falsification test using a *fake* treatment. Thus, we use data from earlier rounds of the NSS to estimate DID using the same treatment and comparison group states. The only exception is that there was no inclusion of pulses for all the households.

5. Results

We present the estimation results of equation 1 for pulse consumption from introduction in the PDS in Table 5.1. Column 1 reports the results for a model using the whole sample (combining all states) and including no covariates except for the different fixed effects including year dummies. We find that introducing a pulse subsidy into the PDS in the selected states is associated with about a 300-gram increase in consumption, which amounts to about a 7.4 percent increase from the baseline level (assuming a family size of five and average consumption as in Table 2.1).

Table 5.1 Impact of subsidizing pulses through the PDS—national impact

	(1) OLS 2009/2010 without controls	(2) OLS 2009/2010 with controls
Posttreatment year 2009/2010	-0.381***	-0.521***
	(-5.1)	(-7.7)
States that provided pulse subsidy through PDS	0.109	0.087
	(0.3)	(0.3)
Difference-in-differences estimator for 2009/2010	**0.296***	**0.214***
	(2.6)	**(2.7)**
Constant	3.596***	2.325***
	(14.3)	(8.6)
R^2	0.003	0.067
N	225,499	225,499

Source: National Sample Survey Office consumption expenditure data corresponding to years 2004/2005 and 2009/2010.
Notes: *t* statistics in parentheses. Standard errors are corrected for clustering at the state level. OLS = ordinary least squares.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

One concern in these estimates is the possible existence of household-level characteristics that vary across time and space and that are correlated with both consumption of pulses as well as the price differential between the PDS and open-market pulse price. For example, perhaps the areas that included pulses in their food subsidy program were also hit by economic shocks, or perhaps improvements were made in the delivery systems of subsidized food at the time pulses were included in the PDS. Therefore, we directly control for a number of observed time-varying characteristics in the model, and those results are reported in column 2 in Table 5.1. The controls include per capita monthly consumption expenditure of the household (as a proxy for household income levels), location of the household (rural or urban), the main occupation of the family, the family size and sex, age, religion, caste group, education level of the head of household, and whether that head is a salaried employee.

We investigate whether shocks to the state (reflected in the situation of the households in states that included pulses in the PDS) might have caused a change in pulse consumption, including controls like average GDP per capita (captured in state fixed effects), and those results are reported in column 2. The state fixed effects also control for the possibility that the impact of including pulses in the PDS could come about from correlated improvements in the PDS governance or other changes that affect disposable income and/or information sets of consumers regarding nutrition. Since each state introduced a different pulse in the subsidy program, we next assess the state-specific impact of introduction of pulses in the PDS.

State-Specific Impacts of Inclusion of Pulses in the PDS

Replicating the DID estimation for each state separately, the results in Table 5.2 show the variation across different pulses as states subsidized different pulses. The largest impact of a pulse subsidy is obtained in the case of Tamil Nadu, equaling 450 grams. Hence, our estimates indicate that provision of 1 kilogram of subsidized pulse leads to an increase in household pulse consumption of about 135 to 450 grams. A question that arises then is: What happens to the rest of the 550 to 865 grams of pulse? As discussed earlier, that question cannot be addressed using NSS data. Below we use the VDSA data to try and understand the changes in pulse consumption because of the subsidy.

Table 5.2 Impact of subsidizing pulses through the PDS by state—individual state impact

	(1) OLS 2009/2010 without controls	(2) OLS 2009/2010 with controls
Posttreatment year 2009/2010	-0.381*** (-5.1)	-0.517*** (-7.7)

Himachal Pradesh	1.966***	1.800***
	(7.8)	(9.5)
Punjab	0.869**	0.652**
	(3.5)	(3.2)
Andhra Pradesh	-0.486+	-0.447*
	(-1.9)	(-2.4)
Tamil Nadu	-0.249	-0.187
	(-1.0)	(-1.0)
Himachal Pradesh DID estimator for 2009/2010	*0.396****	*0.339****
	(5.3)	*(3.7)*
Punjab DID estimator for 2009/2010	*0.064*	*0.058*
	(0.9)	*(0.8)*
Andhra Pradesh DID estimator for 2009/2010	*0.245***	*0.266****
	(3.3)	*(3.6)*
Tamil Nadu DID estimator for 2009/2010	*0.475****	*0.277***
	(6.3)	*(3.3)*
Constant	3.596***	2.000***
	(14.3)	(8.0)
R^2	0.014	0.074
N	225,499	225,499

Source : National Sample Survey Office consumption expenditure data corresponding to years 2004/2005 and 2009/2010.
Notes: *t* statistics in parentheses. Standard errors are corrected for clustering at the state level. OLS = ordinary least squares.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The large impact obtained for Tamil Nadu could be because of coverage. Coverage is the widest in that state—two main pulses have been subsidized (urd and arhar) and they are provided at prices that are less than half the market price. Yet the adjustments on both the margins show that slack remains as less than 1 kilogram is taken up. Since both urd and arhar have subsidy on 1 kilogram each, the net effect on consumption is just 27 percent of the total allocation.

Impact on Consumption of Pulses: Results Using per Rupee Subsidy as Treatment

Until now, we have considered the pulse subsidy as a binary treatment—that is, whether or not a subsidy exists is the policy intervention. In reality, depending on how much the PDS price differs from the market price, the level of subsidy varies across states, implying that the treatment could be heterogeneous across states by the variety of pulses subsidized. Table 5.3 presents the impact per rupee of subsidy entitlement.

The four states (Andhra Pradesh, Himachal Pradesh, Punjab, and Tamil Nadu) subsidize different pulses, and the PDS price of subsidized pulses (*dals*) is also different across the four states. Further, the total monthly quota of subsidized pulses also differs by state. The interstate differences in PDS prices, quantities, and types of pulse give us additional variation that we exploit to estimate the impact of subsidy on household consumption of pulses. We estimate the value of the pulse subsidy entitlement by taking the market price of each *dal* as the average price of that *dal* in all major *mandis* (wholesale markets) of the respective state in the National Sample Survey Office survey period (June–May).

According to the estimates in Table 5.3, a subsidy of 1 rupee would lead to an increase in consumption of pulses by 0.01 kilogram. The estimate is significant at the 1 percent level. In other words, averaged across states and different types of pulses, a rupee of subsidy buys a 0.01 kilogram increase in pulse consumption. On *arhar dal* (the one with the highest open market price in general), this amounts to a subsidy of about 45 rupees per kilogram in treatment states.

Hence, 45 rupees spent by the government of the respective state would bring about a 0.67 kilogram increase in consumption, which is higher than 300 grams per kilogram of subsidy that is averaged across pulses where the level of subsidy is much lower. Hence, in *chana dal* in Punjab the subsidy amounts to only 10 rupees per kilogram, and indeed the impact is much lower. In fact in the state-specific estimate, the impact of the pulse subsidy in Punjab is actually insignificant. Overall, with the level of subsidy estimation, we get significant results for continuous treatment. The results are robust to the inclusion of the type of pulse fixed effects. An additional subsidy of 1 rupee results in an increase in total pulse consumption of 18.47 grams/family/month (in a specification with type of pulse fixed effects).

Table 5.3 Impact on pulse consumption: estimates from continuous treatment

Variable	Pulses (household/kg/month)
Posttreatment dummy	-0.436***

	(0.0661)
Impact per rupee of subsidy entitlement	0.0153***
	(0.00185)
Constant	3.580***
	(0.249)
Observations	225,233
R squared	0.28

Source National Sample Survey Office consumption expenditure data corresponding to years 2004/2005 and 2009/2010.
Notes: *t* statistics in parentheses. Standard errors are corrected for clustering at the state level.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Pathways for the Changes in Pulse Consumption Postsubsidy

There are three possible reasons for the results that we obtain regarding the changes in pulse consumption:

- Only some households buy the PDS pulse while our estimate is an average over all households—compliers and noncompliers.
- Households reduce their market purchases of pulses when they become available from the PDS.
- Some of the PDS pulse is diverted to the black market.

As discussed earlier, we cannot use NSS data to check for the roles of these mechanisms. VDSA data, on the other hand, can help us answer some of these questions since it contains monthly data on household consumption of different food items—by source. The VDSA contains pulse purchase data by 600 households from four villages in Maharashtra and two villages of Andhra Pradesh for the years 2006 and 2008. Note that the VDSA has the data on quantity of *arhar dal* purchased from the PDS. Given the time period, note that none of the households in either state received subsidized pulses in 2006, while Andhra Pradesh/Telengana had introduced into the

PDS by 2008 while Maharashtra had not.[4] On average, a household in Andhra Pradesh got 10 kilograms of subsidized *arhar dal* in 2008.

Table 5.4 Difference-in-difference estimation using VDSA data

	Total ***arhar*** purchased PDS + market		***Arhar*** purchased from market only		Total household consumption of pulses other than ***arhar***		Total household consumption of all ***dals***	
	Kg/household/year							
	AP	Mah	AP	Mah	Mah	AP	Mah	AP
2006	11.59	10.59	11.59	…..	14.58	2.58	39.42	20.89
2008	17.34	12.33	7.35	……	22.87	7.37	49.32	30.49
2008–2006	5.75	1.74	-4.24	……	8.29	4.79	9.90	9.60
Diff-in-diff	5.75 - 1.74 = 4.01		-4.24	…….	4.79 - 8.29 = -3.5		9.60 - 9.90 = 0.30	

	Total ***arhar*** purchased PDS + market	***Arhar*** purchased from market only	Total household consumption of pulses other than ***Arhar***	Total household consumption of all ***dals***
Interaction	6.222*** (0.731)	-3.841*** (0.748)	-2.370*** (0.677)	2.904*** (1.030)
Constant	11.73*** (0.254)	11.73*** (0.260)	10.61*** (0.235)	33.94*** (0.358)
Observations	1,266	1,266	1,266	1,266
R squared	0.150	0.087	0.391	0.289
Number of households	685	685	685	685

Source: Authors' estimates based on VDSA data
Notes: VDSA = Village Dynamics in South Asia; AP = Andhra Pradesh; Mah = Maharashtra; PDS = Public Distribution System.

Impact on Protein Consumption of Pulse Subsidization through the PDS

The food subsidy program holds food grains as the key to food security. The PDS's traditional focus on rice and wheat goes against trends that show that there is gradual diversification in Indian diets toward several protein-rich and micronutrient-rich foods such as dairy, eggs, meats, and fruits and vegetables. Notably, one protein-rich food that has a unique place in the Indian

[4] The state of Andhra Pradesh was bifurcated in 2013, with one part becoming Telangana and the other part Andhra Pradesh.

diet because of the incidence of vegetarianism is pulse, but that food has experienced falling per capita demand over time.

Because high-value foods such as fruits and vegetables and animal source foods are often unaffordable to the poor, pulses had played an important role as a provider of protein until they became quite expensive themselves. Moreover, preferences have also shifted away from pulses as part of diet diversification. The move to include pulses in the PDS, as discussed earlier, is to a large extent motivated by that food's potential to address the issue of protein deficiency, especially among the poor. Because of the adjustments on both the extensive as well as intensive margins, the overall effect on protein consumption would be due to changes in pulse intake as well as from consumption of other sources of protein.

Table 5.5 presents the impact on protein consumption from pulses per se and from all sources combined. Assuming 300 grams per family per month, as found by our earlier DID estimate, this translates into 0.12 gram of protein per person per day as the impact of subsidization of pulses in consumption. In fact, for most cases in Table 5.5, the changes in protein consumption are not even significant. One question that arises is whether the outcome related to consumption and hence protein intake could be significant if the subsidy were applied to larger amounts (greater than 1 kilogram). Although the level of consumption could be higher, the essential feature of pulses—declining or stagnant demand—can largely not be altered with a price subsidy scheme. Even if larger amounts were subsidized, consumption and protein intake might not rise to the level envisaged since only a part of the declining consumption of pulses is price determined.

Other factors like preferences and relative prices also play a role in determining how much pulse is consumed. The takeaway seems to be that a price subsidy will have a smallerthan-expected effect on nutrient intake if countervailing forces toward restricting consumption growth are at work. Jensen and Miller (2011) look specifically at the income effects of the price subsidy as one countervailing factor. In the present study, in addition to the income effects of the pulse subsidy, we find that prior to the subsidy consumption was already falling because of changing tastes. Ultimately the results show that the subsidy engineered no significant change in protein consumption, which was a prime goal of inclusion of pulses in the PDS.

Table 5.5 Impact on protein consumption of pulse subsidization through the PDS

	(1) Total protein consumed in 2009/2010	(2) Protein from pulses consumed in 2009/2010
Posttreatment year 2009/2010	-44.751^{***}	-98.181^{***}
	(-7.8)	(-5.7)
States that provided pulse subsidy through PDS	-44.185^{*}	6.383
	(-2.2)	(0.1)
Difference-in-differences estimator for 2009/2010	**10.410**	**50.086***
	(0.7)	**(2.1)**
Constant	87.894^{***}	74.776
	(4.8)	(1.4)
R^2	0.433	0.202
N	225,499	225,499

Source: National Sample Survey Office consumption expenditure data corresponding to years 2004/2005 and 2009/2010.
Notes: *t* statistics in parentheses. Standard errors are corrected for clustering at the state level.
Coefficients are grams of protein consumed per household per day.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6. Conclusions

Overall, we find no evidence that the consumer price subsidy in pulses introduced in different states resulted in improved nutrition in terms of household protein intake. This result is despite the fact that the households in our sample are poor and pulses have been subject to significant price rises—a situation often blamed for the falling or stagnant consumption of pulses. India remains a country where malnourishment is widespread, including protein deficiency, for which consumption of pulses could be a mitigating factor. As we have discussed, this state of affairs was the principal motivation for inclusion of pulses in India's PDS in the first place.

Whereas the subsidies do appear to have affected pulse consumption in a statistically significant way, the size of the effect is not large enough to make much difference. The increase in consumption is less than 30 percent of the incrementally subsidized amount. Essentially it seems that subsidies have induced substitution away from pulses to other food and even nonfood items that results show do not address the protein needs of the population. Similar to Jensen and Miller (2011), our analysis focused on nutrition, as changes in nutritional status are perhaps more easily measured than changes in other outcomes that occur over the long run, such as, for example, health. In the case of pulses, the direct linkage with protein intake is quite helpful. In terms of health outcomes, such as muscle wasting, the effects of protein insufficiency are hard to measure and often occur over the long run.

Given that NSS data provide consumption-to-nutrient conversion ratios, we can easily measure protein intake with the survey data, whereas health outcomes have to be measured with primary data involving proper scientific techniques. Yet to the extent protein as a nutrient is important for short-run as well as long-run effects, the estimates of this nutrient intake provide valuable information on possible health effects. Our estimates show that application of a subsidy to a commodity the preference for which is declining is unlikely to affect several of the outcomes that matter. At the same time, it is possible that even though consumption and nutrition were not positively and significantly affected by the subsidy, there were welfare gains as the subsidy on pulses expands the budget set. At the end of the day, the choices made by the consumer depend on his or her information set. If consumers have a lower valuation of nutrition a priori, no dose of subsidy can bring about nutrition gains, and the income effects would work toward increasing other food consumption and purchase of nonfood items.

Finally, an issue the current analysis cannot address is related to the choice of instrument for helping the poor and bringing about nutrition improvements. In India, there has been much discussion on cash transfer in lieu of the in-kind transfer that the PDS uses. Several studies document leakages and corruption in India's PDS (see Khera 2011 for a review; Ramaswami 2005). It is not yet clear whether incorporating pulses in the price subsidy scheme is likely to be more successful than a cash transfer to preserve or augment consumption of pulses by the poor. In the same context, Kishore and Chakrabarti (2015) suggest that in the Indian state of Chhattisgarh, a portion of money saved through the cereal subsidy was spent on pulses. It is possible that savings from the cereal subsidy gets spent elsewhere, including on pulses, but when it comes to a pulse subsidy itself, the same effect could exist, whereby savings are spent on items other than pulses.

As for advocating for subsidies to improve nutrition, the nationally representative data and a panel that accounts for individual unobserved heterogeneity do not validate such an argument. If the counterfactual would have been greater reduction in consumption of pulses, then policymakers should be satisfied, but improved nutrition seems farfetched in the case of a commodity that is losing favor with consumers.

Our results showing little nutritional effects from the consumption subsidy have been established in studies other than that of Jensen and Miller (2011) for different nutrients in India (see Kochar 2005; Tarozzi 2005; Behrman and Deolalikar 1988). Those studies look at commodities that were offered uniformly across the whole country. In contrast, the introduction of pulses into the Indian PDS offered a variation, as only some Indian states have participated. It is not clear from the analysis what the effects would be if larger quantities of pulses were subsidized or better targeting schemes were employed across income groups. The scope remains to use experimental data to look at these issues for the purpose of policy recommendations related to program design in terms of the size of the subsidy and its targeting.

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Appendix: Supplementary Table

Table A.1 Characteristics of households in states with and without subsidized pulses through the Public Distribution System

	2004/2005 States without subsidized pulses in PDS	2004/2005 States with subsidized pulses in PDS	2009/2010 States without subsidized pulses in PDS	2009/2010 States with subsidized pulses in PDS
Monthly per capita consumption expenditure (current rupees)	754.4	852.7	1,299.1	1,496.3
Urban population as percentage of total population	26.5	31.5	28.0	35.8
Hindus (%)	83.0	84.8	83.2	83.6
Muslims (%)	12.7	4.9	12.8	5.7
Christians (%)	2.3	3.1	2.2	4.1
Scheduled tribes (%)	9.9	4.1	10.1	3.1
Scheduled castes (%)	19.1	22.2	19.8	21.2
Other backward castes (%)	37.4	51.7	37.6	55.1
Households with gas stoves (%)	20.3	28.6	24.9	38.8
Households with electricity (%)	59.6	88.9	68.6	95.8
Households that purchase subsidized rice from PDS (%)	13.9	52.1	25.5	66.7
Households that purchase subsidized wheat from PDS (%)	10.7	4.7	24.3	26.4
Households that purchase subsidized sugar from PDS (%)	8.3	41.4	17.0	57.4
Households that purchase subsidized kerosene from PDS (%)	64.4	50.9	69.7	57.1
Observations	101,086	23,558	82,169	18,686

Source: Authors' estimates from the national sample survey of the National Sample Survey Office—consumer expenditure data from rounds 61 and 66.
Note: PDS = Public Distribution System.