Trading suspensions and food price inflation

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Abstract

Since the global food price inflation of 2008-09, concerns regarding futures market speculation and its impact on food prices have grown. Conflicting results from existing studies highlight the limitation of the research design (Cheng and Xiong, 2014). We apply the synthetic control methodology to examine if futures trading suspensions bring down food prices. Analysing three recent agri-futures trading suspensions events from India, we find no empirical evidence that such suspensions impact food prices. The counterfactual for each episode indicates that even in the absence of such suspensions, food prices would have followed a similar trend. Our findings inform the policy debate on agricultural market interventions related to derivatives trading.

Keywords: food price inflation, agricultural derivatives, trading suspensions, synthetic control, India

JEL Classification Codes: Q13, Q18, G1, G18

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1 Introduction

Food price inflation is a global concern. High prices have implications on food security, overall inflation, and can cause social unrest (Bellemare, 2015). Thus, countries across the world intervene in their food markets to ensure price stability. These interventions typically take the form of import relaxations, export curbs, release of reserve stocks etc (see Abbott (2012); Demeke *et al.* (2012); Jones and Kwieciński (2010) among others) to ensure adequate food supply in domestic markets.

Since the global food price inflation of 2007-08, an added concern has been regarding excessive speculation in the derivatives market and its impact on food prices. Between 2003 and 2008, it was estimated that about USD 200 billion of institutional investment flows were to various commodity futures indices (CFTC, September 2008). This growing financialization of commodity markets and the concurrent increase in food prices raised concerns amongst policymakers and academics that futures market speculation was distorting food prices (Cheng and Xiong, 2014). Calls for more regulation in these markets thus strengthened (Masters, M., 2008).

Similar concerns were raised in India where national commodity derivatives exchanges were set up as recently as 2003 to aid efficient price discovery and effective risk management.[1] However, amidst the fear that excessive speculation on commodity futures market exacerbated food price inflation and volatility, in 2007-08, India suspended derivatives trading in eight agricultural commodities traded on its national commodity futures exchanges. As prices cooled down, the ban on some of these commodities was lifted but continued on other 'sensitive'[2] commodities. Since then, lack of empirical evidence on the impact of agricultural derivatives on food inflation has prompted the regulators to suspend agricultural derivatives trading as and when there is a large surge in food prices in India.[3]

While several studies in the global context have examined the impact of financialization of commodity markets on food prices, the evidence is mixed and conflicting. Studies including Gilbert (2010) and Singleton (2014) argue that non-information based institutional investor flows impacted commodity prices during the 2008-09 boom. Others such as Brunetti and Buyuksahin (2009), Stoll and Whaley (2010), Hamilton and Wu (2015) and Chari and Christiano (2017) find little evidence to support the claim. As argued by Cheng and Xiong (2014), the conflicting results from these studies may be due to the limitation of the empirical design.[4] Lack of clear identification strategies could lead to erroneous inferences that modern causal inference methods in the spirit of Angrist

[1] This was however not the first time that commodity futures began trading in India. The first organized futures market was established in 1875 under the name of Bombay Cotton Trade Association to trade in cotton derivatives (Bhattacharya, 2007).

[2] These included wheat, rice, sugar and some pulses including tur and urad.

[3] The latest episode was in December 2021 when the regulator suspended seven commodities from derivatives trading amidst high food prices. The suspension was extended by one more year in December 2022. See Appendix Table A.1 for a list of agricultural derivatives suspensions announced since the launch of national commodity derivatives exchanges.

[4] Studies that rely on contemporaneous correlations, cross-sectional tests or tests of Granger causality may lack power to identify the impacts. Tests of changes in index traders' positions and food prices suffer from simultaneity bias as these tests assume index traders' position changes to be exogenous which is unlikely to be the case (Cheng *et al.*, 2014).

and Pischke (2010) can significantly improve upon. It is in this context that we revisit the question of whether derivatives trading exacerbates food price inflation.

Specifically, we ask: does derivatives trading suspension rein in food price inflation? Can we construct a counterfactual to determine the price trajectory in the absence of such suspensions? To answer these questions, we use the improved methodological toolkit from the recent advances in the policy evaluation literature (Athey and Imbens, 2017). In particular, we use the synthetic control methodology developed by Abadie *et al.* (2010), Abadie *et al.* (2015) and Abadie and Gardeazabal (2003) to identify the impact of agricultural derivatives trading suspensions on food prices. The methodology enables us to construct the counterfactual (called the synthetic control) based on a linear combination of unaffected comparison units. This counterfactual helps us answer whether the observed price path would have been any different if derivatives trading were not suspended. We assess the effect of derivatives suspension by comparing the observed price behaviour vis-a-vis that of the synthetic control.

The synthetic control methodology offers several advantages over the traditional regression approach (Abadie *et al.*, 2015; Abadie, 2021) which is not well suited for case studies when an intervention is implemented at an aggregate level affecting a small number of large units (e.g regions, countries) or a single unit such as the case discussed in this paper. Regression analysis typically requires large samples and several instances of the event, and is thus ill-suited to estimate the effects of infrequent events such as suspension episodes (Abadie, 2021). Further, unlike a regression, the methodology explicitly provides weights attributed to each comparison unit and avoids the risks of extrapolation.

The episodes that we study in this paper are the most recent agricultural derivatives trading suspension events in India that were implemented to contain the price rise: the August 2021 Gram / Bengal Gram (*chana*) derivatives suspension in the pulses category and the October 2021 mustard seed derivatives suspension in the oilseeds category. In addition, we also analyse the *chana* derivatives suspension of June 2016. Both *chana* and mustard seed contracts are heavily traded agri-derivatives commodities in India and therefore serve as a useful case study to analyse if derivatives suspension rein in food price inflation. Besides, in contrast to all other such suspensions, the episodes that we study were standalone suspension events that would enable us to identify the impacts, if any.

Using data on prices as well as predictor variables including international prices, global production shocks, domestic production, net imports and *mandi* arrivals, we construct a synthetic control for each suspension episode to analyse if derivatives suspension did contain food price inflation. Our results show no empirical evidence that derivatives suspension did have any impact on food prices. The analysis shows that prices of both the commodities, *chana* and mustard oil, would have had a similar trend even without the suspension. The presence of the same trend amongst both treated and the synthetic control series indicate that even in the absence of derivatives suspension, prices would have shown the same behaviour as observed with derivatives suspension, thus providing evidence that the suspension had no impact on prices of these commodities. 'In-space' and 'in-time' placebos further confirm our findings. Our results are robust to sensitivity tests based on alternative choices of predictor variables as well as leave one out distribution of the synthetic control.

To explain our findings, we analyse derivative trading volumes of both the commodities prior to the suspension and its association with food prices. We do not find any evidence that changes in derivatives trading volumes were leading spot price changes in that period. We also find that price trends in the two sample commodities both before and after the suspensions were similar to other commodities in the same commodity group (oilseeds and pulses respectively), irrespective of the trading status of their derivatives. It suggests that price increase in both commodities was driven by factors other than derivatives trading. Structural break tests on domestic mustard oil prices as well its international benchmark, canola futures prices, also reveal that domestic prices were following the international price trends, adding to the finding that the observed price trends both before and after the suspension were not due to derivatives trading.

Our findings have important policy implications. A well functioning agricultural derivatives market enables efficient price discovery, facilitates price risk mitigation, as well as assists farmers in their production and marketing decisions, such as storage and price negotiation. Its presence becomes particularly critical during times of high price volatility. Lack of empirical evidence so far on the effects of agricutural derivatives suspension on prices has resulted in frequent imposition of such bans. Our study fills this gap and informs the policy debate on interventions related to agricutural derivatives trading.

The paper contributes to the literature related to financialization of commodity markets. The methodology overcomes the identification issues cited in the existing literature that examines if derivatives trading distorts food prices. To the best of our knowledge, ours is the first paper that uses the synthetic control methodology to examine causal evidence of derivatives trading suspension on price behaviour.

More broadly, the study also contributes to the growing literature that examines the impact of government interventions on food prices. Studies such as Baylis *et al.* (2014), Saini and Gulati (2017), Narayanan and Tomar (2023) and Saroj *et al.* (2021) explore the impact of trade and marketing restrictions in India and find that such interventions lead to inefficiencies in functioning of markets. Saini and Gulati (2017) find evidence of price distortion in Indian agriculture due to trade policies and argue that such policies have been subservient to the overall goal of ensuring food security to poor consumers. Baylis *et al.* (2014) find that India's export ban of wheat and rice in 2007 resulted in domestic markets becoming disconnected from the world market and reduced market integration between producing and consuming regions within the country. Narayanan and Tomar (2023) find that the price deficiency payments implemented in Madhya Pradesh, one of the major states in India, led to a general tendency to depress agricultural prices that may result in a temporary supply glut in the market. Our study adds to this body of literature through the analysis of yet another commonly used agricultural markets intervention by the government, that is the derivatives suspension.

The rest of the paper is organized as follows: Section 2 provides a brief background on agricultural commodity derivatives in India along with detailed description of the two commodities analysed in this study. Section 3 discusses the data and the empirical strategy. Section 4 presents the results followed by a discussion in Section 5. Section 6 tests the sensitivity of our main findings using various robustness tests. Section 7 concludes the paper.

2 Background

2.1 Agricultural commodity derivatives market in India

The first futures trade in India was recorded in 1875 in cotton with the setting up of the Bombay Cotton Trade Association Ltd. (Bhattacharya, 2007). Subsequently, several exchanges came up in different parts of the country for futures trade in various commodities (Sahadevan, 2002). However, frequent restrictions and suspensions by authorities resulted in low depth and poor liquidity in these markets. The first major boost to the development of commodity derivatives market came in 2000 when the government announced liberalisation of these markets under the 'National Agricultural Policy'. The new policy led to the setting up of a regulated organized national commodities derivatives exchanges that allowed participants to manage price risk and facilitate price discovery using futures contracts.

At present, there are five national exchanges in India that trade agriculture commodity derivative contracts. These are: Multi Commodity Exchange Limited (MCX), National Commodity & Derivative Exchange Limited (NCDEX), Bombay Stock Exchange Limited (BSE), National Stock Exchange Limited (NSE) and Indian Commodity Exchange Limited (ICEX).[5] Of these, the MCX has a dominant share in trading of non-agricultural commodities such as crude oil, gold and metals, while the NCDEX has a dominant share in trading of agricultural commodities.

However, despite the National Agricultural Policy that recommended development of active futures trading, commodity derivatives market in India continues to be subjected to frequent restrictions and commodity suspensions (Gulati *et al*, 2017). These restrictions usually take the form of imposition of additional margins and ultimately followed by suspension of the commodity from futures market trading. As an example, to curb excessive speculation, margins on potato futures contract were raised from 5 percent to 30 percent in June 2014. This was followed by a suspension.[6] Table A.1 reports derivatives suspensions announced since the 2000s. As can be seen from the table, some of the commodities have been suspended more than once in the last two decades. Others like *tur* and *urad* have been suspended for more than a decade now.

In this paper we analyse the derivatives suspension of two major commodities: *chana* (gram / Bengal gram / chickpea)[7] in the pulses category, and mustard seed in the oilseeds category. We

[5]Both NSE and BSE introduced commodity derivatives trading in 2018.

[6]See: FMC restricts futures trading in potato to check prices, The Economic Times, June 19, 2014.

[7]There are two types of *chana*: *desi* chickpea (brown) or Bengal gram, and *kabuli chana* or Garbanzo beans / white chickpea. The one that is traded on the derivatives platform is the *desi* variety. For more details, see `https://ncdex.com/products/CHANA`.

select these commodities as both have large share[8] in agricultural commodity derivatives market volumes, and the suspensions being standalone would enable us to identify the impacts, if any.[9] Below, we provide a brief background of these two commodities along with a discussion of the events that followed up to the suspension.

2.1.1 *Chana* derivatives suspension

The *chana* derivatives contract[10] was introduced by the NCDEX in April 2004, along with two other pulses, black gram (*urad*) and pigeon pea (*tur*) in July 2004 and April 2005, respectively. However, out of concerns around price rise and political pressure, derivatives trading on all three pulses was suspended in 2007 / 2008. Subsequently, while the suspension of derivatives trading on *chana* was revoked in December 2008, the derivatives ban on black gram and pigeon pea remains in place till date. Amongst other pulses, derivatives trading on green gram (*moong*) was launched in July 2019. The contract on *moong* was however, also banned in December 2021, against the backdrop of high food prices.

India is the world's largest producer and consumer of pulses, with *chana* having a dominant share of more than 40 percent in total domestic pulses production (Roy and Chandra, 2017). The domestic production of chickpea contributes to more than 60 percent of the total global production. The other major pulses in India are: pigeon pea (*tur*), green gram (*moong*), black gram (*urad*), red lentil (*masur*). Together, these pulses have 80 percent share in India's total pulses production. The other legumes that constitute the remaining 20 percent of production include cowpea (*lobia*), horsegram (*kulthi*) as well as *moath* bean.[11] In terms of domestic consumption, *chana* is second only to *tur*. Most of the demand for *chana* is met through domestic production, although about 4-5 percent of net availability is met through imports.[12] *Chana* is a *rabi* crop which grows during the cool / dry season, as is red lentil (*masur*), while pigeon pea, black gram, green gram and cowpea are grown during the warmer, rainy *kharif* season (Roy and Chandra, 2017).[13]

Exports of the four major pulses including pigeon pea, chickpea, black gram and lentils were prohibited in June 2006. The restriction was lifted on chickpea, but continued on the other three pulses. Over the years, *chana's* domestic production surged from 5.72 Million Tonnes (MT) in

[8] Shares in 2020-21 for *chana* and mustard seed were 9.4 percent and 9.6 percent, respectively of the overall agricultural derivative trade in India.

[9] This was unlike the suspensions in early 2007 and 2008, when four to five commodities were suspended together, as well as in Decemeber 2021, when six commodities were suspended at once (Table A.1).

[10] Specifically, futures contract was launched on *chana* in 2004. Options contract on agricultural commodities were allowed to trade in September 2016 by the market regulator. See `https://www.sebi.gov.in/legal/circulars/sep-2016/introduction-of-options-in-commodity-derivatives-market_33358.html`.

[11] All of these three are arid legumes.

[12] Over the years, the imports of *chana* have declined from 24 percent in total imports in 2001 to about 4 percent in 2010. This came amidst a rise in domestic production with increasing yield, and declining consumption (Roy and Chandra, 2017).

[13] There are two major agricultural seasons in India: *Kharif* which involves sowing in June while the harvest is ranges from October to January; and *Rabi* for which sowing is typically done from October onwards, while the harvest starts from March onwards.

2003-04[14] to 9.53 MT in 2013-14. However, on account of weak monsoon, the advance production estimates data on *chana* indicated lower production (7.59 MT and 7.17 MT, respectively) than the target production (9.30 MT) for the crop year 2014-15.[15] The resulting demand-supply mismatch caused the prices to rise sharply. The wholesale market prices rose from Rs. 3500 per quintal in the beginning of April 2015 to Rs. 4400 per quintal by June 2015. So was the case with retail prices, where prices went up from Rs. 49.90 per kg in April 2015 to Rs. 60 by June 2015.[16] Amidst this sharp rise in prices, the government intervened. In September / October 2015, stock limits on pulses under the Essential Commodities Act (ECA), 1955 were imposed on warehouses, wholesalers, millers, retailers as well as importers for a year.[17]

Weak monsoon continued in the following year, 2015-16, resulting in even lower production based on advance estimates. However this time, prices saw an even larger increase than the previous year. With the overall objective of improving domestic availability and price stabilization, in March 2016, the Government of India decided to create a buffer stock of 0.15 MT of pulses through domestic procurement and imports. This was followed by another 12,500 tonnes of imports in June 2016 for buffer stocks. However, prices continued to increase. From Rs. 4500 per quintal in April 2016, the wholesale prices of *chana* rose to Rs. 7000 per quintal by mid-June 2016. Similar increase was seen in retail prices (Rs. 64 in April '16 to Rs. 84.72 in June '16). The derivatives market regulator as a measure for "abundant" caution, announced the suspension of *chana* derivatives contract in June 2016.[18] However prices continued to rise. In July 2016, the wholesale prices of *chana* ranged from Rs. 8000 to Rs. 8900 per quintal, and rose to Rs. 12000 by October 2016. Figure B.1 in the appendix shows wholesale and retail prices for major pulses prior to the derivatives trading suspension.

With bumper production and lower prices, derivatives suspension on *chana* was revoked after about a year, in July 2017. The following year (2017-18) saw a record *chana* production, after which the government raised import duty to protect domestic growers.[19] Further, quantitative restrictions were also placed on imports during this period. It was only in June 2019 that some of these restrictions were removed.

The second and most recent suspension on *chana* derivatives that we analyse is the August 2021 suspension. Between 2017-18 and 2020-21, in three out of four years, *chana* production was at an all-time high with over 11 MT produced annually.[20] This was aided by higher minimum

[14] The agricultural crop year is from July to June.

[15] Source: https://eands.dacnet.nic.in/Advance_Estimate/3rd_Adv2014-15Eng.pdf and https://eands.dacnet.nic.in/Advance_Estimate/4th_Adv2014-15Eng.pdf.

[16] 100 kilogram (kg) equals 1 quintal.

[17] The ECA regulates the movement and storage of agricultural produce. The objective is to prevent hoarding and black marketing and ensure access to 'essential commodities' by consumers at affordable prices. The central and state governments impose ECA restrictions in the event of price volatility or shortage in food supply.

[18] See https://www.sebi.gov.in/media/press-releases/jun-2016/trading-in-chana-futures-on-commodity-derivative-exch 32650.html

[19] Import duty on *chana* was raised from 30 percent to 40 percent in February 2018, then to 60 percent in March 2018 and to 70 percent in June 2018. Exports incentives were also given from March 2018 till September 2018.

[20] Except in 2018-19 when domestic production was high at 9.94 MT but lower than the remaining three years.

support price (MSP) and procurement by the government under the price support scheme (PSS).[21] However, despite significant production and large buffer stocks, *chana* prices saw a sharp rise in the retail as well as wholesale market (Figure B.2). The surge in prices was seen across all major pulses, particularly since March 2020, and can potentially be attributed to COVID-19[22] induced supply chain disruptions (Figure B.2). From June 2020, retail prices of *chana* rose from Rs. 65 per kg to Rs. 75 per kg by November 2020. The government relaxed import restrictions on other pulses during this period (2020-21) to ensure greater domestic availability. Buffer stocks were also released in open market at lower prices in December 2020 / January 2021 in an attempt to ease supply constraints. While to some extent, the price rise was contained from December 2020, retail prices went further up when the second lockdown was imposed in April-2021, amidst the harsh Delta wave of COVID-19 in the country. It was only from mid-June onwards that retail prices started showing some decline.

Despite the declining retail prices, on July 2, 2021, the central government imposed stock limits on all pulses except green gram (*moong*) to rein in any potential future price rise owing to the gradual opening up of the country as well as the upcoming festival season. News reports from that time indicate the officials were worried that pulses demand from hotels, restaurants and catering units would increase once the commercial sector opened up.[23] In the following month, on August 16, 2021, *chana* derivatives were also suspended by the market regulator. Unlike the 2016 suspension, no rationale was provided behind the first such commodity derivatives suspension in that year. However, it is likely that just like stock limits, *chana* derivatives were also suspended in anticipation of potential price rise. Prices however continued to increase (Figure B.2). The suspension on *chana* derivatives contract was subsequently extended by one year in December 2021 and another year in December 2022.

2.1.2 Mustard seed derivatives suspension

Unlike *chana*, since its launch in 2003, mustard seed derivatives contracts were suspended for the first time in October 2021. Besides mustard seed, the only other oilseed traded on the derivatives market is soybean. However, derivatives contracts on soybean were also suspended in December 2021, against the backdrop of increasing prices. In addition to the two oilseeds, crude palm oil and refined soy oil are traded on derivatives platform. However, like soybean and mustard seed, both these contracts were also suspended in December 2021.

In terms of oilseeds production, India ranks fourth in the world. It accounts for about 15-20 percent of global oilseeds area, and 6-7 percent of vegetable oils production, and 9-10 percent of

[21]See `https://pib.gov.in/PressReleasePage.aspx?PRID=1855678` and `https://www.financialexpress.com/market/commodities/nafed-invites-bids-for-sale-of-chana-from-govts-surplus-stocks/2648799/`.

[22]India imposed a strict countrywide lockdown on March 24, 2020 until May 30, 2020. During this period, supply of only essential items was permitted. Other services were allowed to resume in a phased manner from June 8, 2020 onwards.

[23]See `https://theprint.in/india/modi-govt-imposes-stock-limit-on-pulses-to-rein-in-surging-prices/689154/`.

total edible oils consumption.[24] There are seven major edible oilseeds that are grown in India, of which soybean (34 percent), rapeseed-mustard (27 percent) and groundnut (27 percent) accounted for about 88 percent of domestic oilseeds production in 2018-19. Sunflower, sesame, safflower and niger are the remaining four major edible oilseeds. Besides, small quantities of coconut, oil palm, cottonseed and rice bran oil also contribute to total production. Amongst the oilseeds, rapeseed-mustard and safflower are *rabi* crops, while soybean, nigerseed and sesame are grown during the *kharif* season. Groundnut and sunflower are grown during both the seasons, though most of the groundnut is grown during the *kharif* season.

While the production of oilseeds has grown steadily since 2016-17,[25] India has not been able to keep up with its growing demand for vegetable oils. Hence over 60 percent of the domestic consumption of vegetable oils is met through imports (Government of India, 2021-22).[26] India's vegetable oil market primarily comprises palm oil (38 percent), soybean oil (24 percent), mustard oil (16 percent) and sunflower oil (7 percent). The remaining oils that are consumed in the country are cottonseed oil (6 percent) and groundnut oil (5 percent).

Of the four major oils, India meets almost all of its palm oil demand through imports from Indonesia and Malaysia,[27] while over 60 percent of soyoil demand is met through imports, primarily from Argentina and Brazil. Over 90 percent of sunflower oil supply in the country is made available through imports from Ukraine. The demand for mustard oil is, however, met through domestic production. Despite self-sufficiency in mustard, given the huge dependence on imports for other vegetable oils, soaring international prices of any one vegetable oil would spill over to other oils as well, both internationally as well as domestically, as consumers switch from a more expensive to a relatively less expensive oil type.[28]

India's rapeseed-mustard production, like all other oilseeds, has grown steadily over the years, from 7.9 MT in 2016-17 to 10.2 MT in 2020-21. To encourage domestic production and ensure remunerative price to farmers, the government often intervenes using import policy restrictions,[29] higher MSPs as well as public procurement under the PSS whenever the market price falls below the MSP. With concerns over falling demand amidst the COVID-19 pandemic, international prices of all vegetable oils fell across the board (B.3). However in early May 2020, the prices began to rise internationally amidst strong demand as COVID-19 restrictions began to ease worldwide. Tighter global supplies due to adverse growing conditions in major producing countries had also

[24]See: `https://www.nabard.org/auth/writereaddata/tender/2106212557Ruralpercent20Pulsepercent20Issuepercent20XXXIVp` `.pdf`

[25]The oilseed production grew by 43 percent from 2015-16 to 2020-21.

[26]India is the world's second largest consumer and largest importer of vegetable oils (15 percent). See: `https://www.indiabudget.gov.in/economicsurvey/ebook_es2022/files/basic-html/page265.html`

[27]Since 2018, in view of the persistently high imports, the government is promoting the production and productivity of oilseeds under the National Food Security Mission: Oilseeds (NFSM-oilseeds) Scheme. For more details, see (Government of India, 2021-22) and `https://www.nfsm.gov.in/StatusPaper/NMOOP2018.pdf`

[28]See: `https://theprint.in/india/as-cooking-oil-prices-rise-indian-households-spend-more-look-for-cheaper-alterna` `912563/`

[29]As an example, in June 2018, the government increased import duty on refined soyoil, crude soybean oil, crude sunflower oil and crude rapeseed oil. Import duty on RBD Palmeolin was also increased in September 2019, and that on CPO was increased to 44 percent in February 2020.

put pressure on the prices of oilseeds.[30] Further, in August 2021, reports of significantly lower rapeseed production in Canada due to adverse climate conditions impacted prices of all oilseeds. A USDA report on oilseed markets released on August 12, 2021 estimated that with lower production and lower stocks from previous year, rapeseed supplies from Canada were forecasted to decline by more than 20 percent, the lowest level in a decade (USDA, 2021).[31]

During periods of high edible oil prices, the Indian government has often intervened via both trade policy and by imposing stock limits domestically under the Essential Commodities Act. From April 2008 to September 2017, the central government often imposed stock limits on oilseeds and edible oils.[32] While these limits were removed in June 2018, in lieu of higher prices, stock limits were once again imposed in October 2021. This was followed by an order from the derivatives market regulator which suspended mustard seed derivatives trading on October 8, 2021.[33] Like *chana*, this suspension was extended by one year in December 2021 and again for one more year in December 2022.

3 Data and Empirical Strategy

3.1 Data

Our analysis is primarily concerned with data on oilseeds as well as pulses. For this purpose, we rely on multiple data sources. Our main variable of interest is domestic prices, for which we gather data at wholesale as well as retail level. We obtain the wholesale price data from the Government of India *Agmarknet* portal on agricultural marketing. The portal is a centralized database and collects data from all wholesale markets across the country. These wholesale markets are regulated markets or *mandis* and are the dominant marketing channel for sale of agricultural produce in India (Aggarwal and Narayanan, 2023). At the end of each trading day, every *mandi* uploads three pieces of information on the centralized portal: minimum price, maximum price and modal price. In addition, information on total arrivals to a *mandi* for that day is also reported.[34] In total, there are about 3000 such *mandis* in the country that trade over 200 agricultural commodities. For our purposes, we collect daily data on all oilseeds[35] as well as pulses[36] for the analysis from July 2014 to December 2021 which constitutes our main sample period.

To arrive at a national level wholesale price for each crop, we compute the arrivals weighted average of the modal price for major *mandis*. We consider only those *mandis* whose median annual

[30] See USDA December 2020 report on oilseeds. Also see, https://www.bloomberg.com/news/articles/2021-06-14/palm-oil-output-at-risk-as-virus-lockdown-worsens-labor-shortage

[31] Canada represented more than 60 percent of global trade in rapeseed in the previous four years.

[32] Based on NCDEX file "government interventions time series record.docx", last table. But do cross-check.

[33] See: https://www.sebi.gov.in/media/press-releases/oct-2021/sebi-issues-directions-to-ncdex-regarding-trading-in 53182.html

[34] Arrivals refers to the quantity of produce that comes to a *mandi* for sale each day. For more details, see (Aggarwal and Narayanan, 2023).

[35] These include cottonseed, groundnut seed, soybean, mustard seed, coconut seed, sunflower, niger seed and linseed.

[36] These include pigeonpea (*tur* / *arhar*), Bengal gram (*chana*), black gram (*urad*), cowpea (*lobia*), green gram (*moong*), chickpea (*kabulichana*), horse gram (*kulthi*) and red lentils (*masur*).

market share is in the top 20 percentile over the sample period. We also exclude *mandis* that do not regularly report their data. Thus, in selecting the major *mandis*, we only consider those markets whose median reported number of days for prices and arrivals data is in the top 20 percentile.

To determine the accuracy of our national level wholesale price series,[37] we compare the price series from another benchmark, the polled price collected by the NCDEX. The polled price is the average of the prices quoted by empanelled polling participants representing value chain participants including traders, processors, and importers / exporters) in the major producing centers of a commodity.[38] However, these prices are not collected for all commodities. The exchange collects this information for only those commodities that are traded on its derivatives platform, and their close substitutes. We compare the polled prices of these 'select' commodities with our national level wholesale price series derived from the data based on the *Agmarknet* portal.

While the *Agmarknet* data and NCDEX polled price data provide data for oilseeds and whole pulses, we obtain data on wholesale prices for vegetable oils from the Solvent Extractors Association (SEA).[39]

We source retail price data from another government data portal, the price monitoring division of the Department of Consumer Affairs, Government of India.[40] The division collects data on retail prices at a daily frequency from 184 market centers spread across the country for twenty two major commodities that include five pulses and six vegetable oils. We scrape daily data for all these eleven commodities for our sample period. For our analysis, we compute an average retail prices across all these 184 centers to arrive at a national daily retail price for the relevant commodities.[41] To eliminate noise, for all the commodities in our analysis we compute a weekly average of the national daily price.

We further require data on factors that affect price behaviour. For this purpose, we collect data on annual production, area under production and yields from 2014-2022 crop years from the website of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. We also obtain annual and monthly exports and imports data from the Ministry of Commerce and Industry web portal. We collate minimum support prices (MSP) data from the Farmers' portal of the Government of India.[42] For oilseeds, we obtain global and domestic oil and oilseeds supply and demand data from the monthly oilseeds report published by the United States Department of Agriculture.[43] We obtain monthly international prices for major vegetable oils from the FAO price

[37]In India, there is no other mechanism that provides wholesale market spot price information of agricultural commodities.

[38]In computing the average, the polling agency trims the data to remove extreme observations. For more details, see NCDEX Spot Price Polling Process, 2018.

[39]The SEA is the primary association of vegetable oil processors in India. For more details, see `https://seaofindia.com/`.

[40]See `https://consumeraffairs.nic.in/en/price-monitoring-cell/price-monitoring-cell`.

[41]These are five pulses: pigeon pea, green gram, Bengal gram, black gram, red lentil; and six vegetable oils: groundnut oil, sunflower oil, mustard oil, soya oil, palm oil, and *vanaspati*.

[42]The data are available at `https://farmer.gov.in/mspstatements.aspx`.

[43]Data are available at `https://www.fas.usda.gov/data/oilseeds-world-markets-and-trade`.

database, GIEWS.[44] For the oilseeds and pulses that trade on the derivatives platform, we obtain open interest, trading volumes and near month futures price data from NCDEX.

3.2 Empirical strategy

To examine the impact of derivatives suspension, we use the synthetic control method, an approach first introduced by Abadie and Gardeazabal (2003), and further developed by Abadie *et al.* (2010) and Abadie *et al.* (2015). As opposed to traditional regression based techniques that require large samples and several instances of the intervention of interest (Abadie, 2021), the synthetic control method is well suited for case studies wherein an intervention is implemented at an aggregate level affecting a small number of large units (e.g regions, countries) or a single unit such as the case discussed in this paper. The method has gained significant popularity in recent years with applications spanning across disciplines including economics, political sciences, biomedical disciplines and so on (Abadie, 2021). The methodology provides a data-driven systematic approach to detect the effects of a policy intervention on a treated unit by constructing a counterfactual based on a combination of comparison units *unaffected* by the intervention. The idea is to compare the behaviour of the outcome variable for the treated unit with the behaviour of the outcome variable of the counterfactual i.e. a 'synthetic control' created from a set of comparison units which were not affected by the intervention. The selection of comparison units and the associated weights on these units are based on a data driven procedure, the key advantage of the synthetic control method. Using *chana* as an example, we discuss the methodology and the implementation of the technique in detail below.

3.2.1 Constructing the synthetic control for *chana*

We consider data on all $J+1$ pulses including *chana* indexed by $j = 1, 2 \ldots, J+1$ and denote the treated unit, i.e. the unit affected by derivatives suspension, *chana* as $j = 1$. All other pulses with $j = 2, 3, \ldots, J+1$ constitute the 'donor pool', or the set of comparison units not affected by the suspension. These are a group of eight pulses that include cowpea, horsegram, *kabulichana*, *masur*, *moath*, *moong*, *tur*, *urad*. As suggested in Abadie *et al.* (2015), Abadie (2021), we restrict our attention only to pulses and do not consider commodities from other commodity groups such as cereals, spices, oilseeds etc in our control basket to ensure that the donor pool units display characteristics similar to the affected unit, *chana*. Further due to lack of data on production, we had to drop two more comparison group units out of the group of eight pulses, cowpea and *kabulichana* when we include production in the list of predictor variables.

For the June 16, 2016 *chana* derivatives suspension, we analyse the period from July 2014 to June 2017[45] which gives us 105 weekly price observations in the pre-intervention period and 54

[44]In particular, we collect data on Rape oil (Dutch, f.o.b. ex-mill), Groundnut oil (Any origin, c.i.f. Rotterdam), Palm oil (Crude, c.i.f. Rotterdam), Soybean oil (Dutch, f.o.b. ex-mill), Sunflower oil (f.o.b. North West European Ports). The data are available at `https://fpma.apps.fao.org/giews/food-prices/tool/public/#/dataset/international`.

[45]The ban was revoked in July 2017.

weekly price observations in the post intervention period. In the case of second intervention on August 11, 2021, we analyse the period from July 2019 to December 2021[46], which gives us 112 and 19 observations in pre- and post-intervention periods, respectively.

With the weights on comparison unit restricted to be non-negative (Abadie and Gardeazabal, 2003; Abadie *et al.*, 2010, 2015), the technique relies on the convex hull condition since the methodology is predicated on the idea that a combination of unaffected units can be used to approximate the synthetic control for the treated unit. However if the treated unit is "extreme" in value for a particular variable, more so, for the outcome variable of interest, the convex hull condition will not be satisfied. A potential way to mitigate this issue as suggested by Abadie (2021) is by considering the differenced series for the outcome variable with deviations from the pre-intervention means. In such a case, we use both the methods, i.e. the raw weekly price series and the differenced weekly price series.[47]

We next describe the predictor variables in our analysis. For each unit j, the predictor variables are denoted by $X_{1j}, \ldots, X_{kj}$, a vector of dimension $k \times 1$. Each element of this vector represents the values of the pre-intervention characteristics for the j^{th} unit that we aim to match as closely as possible for the treated unit and its synthetic control. That is, the synthetic control is selected based on W^* such that the difference given by $X_1 - X_0W^*$ is minimized. W^* is the $J \times 1$ vector of optimal weights on each unit in the donor pool. X_1 represents a $k \times 1$ vector containing the pre-intervention characteristics of the treated unit, while X_0 is a $k \times J$ matrix with values of same variables for the units in the donor pool (Abadie *et al.*, 2015). In essence, for each of the m^{th} variables, W^* is the set of weights that minimizes:

$$\Sigma_{m=1}^{k} \nu_m (X_{1m} - X_{0m}W)^2$$

where ν_m is a weight that reflects the relative importance of the m^{th} variable when we measure the discrepancy between X_1 and X_0W (Abadie *et al.*, 2015). Thus, under this optimization, variables with large predictive power for the outcome variable get a higher weight which ensures that the synthetic control resembles the key factors driving the outcome of interest. The choice of ν_m thus plays an important role in determining the optimal weights. We also a keep validation period to determine the fit of the resulting synthetic control with that of the outcome variable in the pre-intervention sample as in Abadie *et al.* (2015). In that, we divide the pre-intervention period into training and validation periods. We leave three to four months before the intervention as the validation period.[48]

For our analysis, the vector of pre-intervention characteristics or predictor variables consists of a range of variables including yearly production, average net imports, average prices and *mandi* arrivals for three periods in the pre-intervention period. These variables are critical in determining

[46] A second ban was imposed on several other commodities on December 20 2021, including a donor pool commodity, *moong*. To remove the potential impacts of the December 20 2021, we thus analyse the period only until December 19, 2021.

[47] This is true of *chana* 2021 analysis.

[48] This gives 11 and 15 observations for the 2016 and 2021 suspension episodes respectively.

the demand and supply of the underlying agricultural commodity and hence its prices. For our robustness checks, we try alternative specifications by dropping one predictor variable at a time. Once we obtain W^*, we estimate the counterfactual of prices of *chana* in the absence of the intervention as the weighted average of prices of units in the donor pool. To determine the effect of derivatives suspension on prices of *chana*, we analyse the difference between the prices of *chana* (P_{1t}) and its counterfactual in the post intervention period:

$$P_{1t} - \Sigma_{j=2}^{j+1} w_j^* P_{jt}$$

where P_{jt} represents the weekly prices of the j^{th} unit in the donor pool.

3.2.2 Constructing the synthetic control for mustard

We follow the same strategy for constructing the synthetic control for mustard as we do for *chana*. Since the key objective of derivatives suspension on mustard seed was to rein in the price increase in mustard oil, we analyse the prices of mustard oil after suspension.

Like *chana*, we use the domestic prices of other oils to form our donor pool: crude palm oil (cpo), refined soy oil, groundnut oil, sunflower oil, and cottonseed oil. Additionally, we also use data on international prices of oils (for which data are available) as additional units in the donor pool. Separately, we also use these international oil prices as predictor variables and while doing so, we do not use these international prices as donor pool units.

The oils for which we are able to obtain reliable data on international prices are: mustard oil, groundnut oil, soybean oil, palm oil and sunflower oil. Given the small size of oil and oilseeds derivatives market in India, the international prices of mustard oil are not expected to have any impact due to derivatives suspension in India. However, we believe that the correlation between the international and domestic prices will help us improve the fit of the synthetic control in the pre-intervention period.

In contrast to *chana* which saw a derivatives suspension in 2016 that was revoked in 2017 due to which we had to limit the period of analysis from 2019 to 2021, for mustard oil we are able to take a slightly longer period for analysis. Our estimation window includes data on weekly prices of mustard oil from July 2017 to April 2021 (256 observations). We keep May 2021 to October 6, 2021 (22 observations) as the validation period. Finally, the period from October 16, 2021 to December 19, 2021 is our post-intervention window (11 observations).

As predictor variables, we include the pre-intervention values of average prices, domestic production (total domestic supply), global production shock measured as year-on-year percentage change in world production and total *mandi* arrivals for each of the units for which data are available.

3.3 Inference

For inference, we rely on the methodology proposed by Abadie *et al.* (2010) which is based on permutations. We conduct "in-space" placebos where we reassign the intervention to each member of the donor pool (potential control unit) and estimate the impacts. A permutation distribution will thus be obtained by iteratively reassigning the treatment to units in the donor pool and estimating "placebo effects" for each iteration against which we can evaluate the effect estimated for the true treated unit. The effect of the treatment on the unit affected by the intervention is deemed significant when its magnitude is extreme relative to the placebo effects (Abadie, 2021).

While we use this technique for inference, we also recognize the limitation arising out of a small number of units in the donor pool in our sample. We thus also re-run the model using "in-time placebos" (Abadie *et al.*, 2015) wherein we use a few dates from the pre-intervention period as faux dates and estimate the placebo effects to test the predictive power of the synthetic control. As in "in-space placebos", a good overlap or at least a similar trend between the synthetic control and observed data would be a validation of the methodology.

4 Results

We begin by discussing our findings for the more recent interventions on mustard and *chana* in October 2021 and August 2021, respectively, followed by the findings for the derivatives suspension episode of *chana* in June 2016.[49]

4.1 Effect of 2021 derivatives suspension on mustard prices

As discussed earlier, to construct the synthetic control of mustard, we use a range of predictor variables. These include pre-intervention domestic prices, domestic and global production, total domestic supply[50], international prices as well as *mandi* arrivals. Besides we also use change in global supply to incorporate the effect of changes in total availability from one year to another on vegetable oil prices. The importance of these predictor variables in tracking the path of the outcome variable (domestic mustard oil prices) is captured in the ν_m vector of weights (Section 3.2.2). We try different combinations of these predictor variables, and analyse the ones which give us a good fit (close overlap between the resulting pre-intervention synthetic control and the true price series in the test / cross-validation period). The specification that gives us the closest fit is the one with the following predictor variables: pre-intervention prices, corresponding international prices, total domestic supply, global production and year on year change in global production. Global production and total domestic supply data are particularly important, as are international prices since a large percentage of domestic demand of vegetable oils is fulfilled through imports (Section 2.1.2). Even though mustard oil is not imported, its substitutability with other vegetable oils results in high correlation between the prices of mustard and other vegetable oils.

Figure 1 shows the weights obtained for each unit in the donor pool, along with the weights on predictor variables. The most important predictors in this specification turn out to be total domestic supply averaged over October 2019 to September 2020, followed by the weekly prices

[49] For implementation of the methodology, we use the R package *tidysynth* (Dunford, 2021).

[50] includes year-end stocks, net imports along with production

Figure 1 Weights on donor pool and predictor variables for *mustard oil*

Notes: The graphs show the weights on units in the donor pool and the predictor variables for the first specification. Table A.2 provides the definitions of the predictor variables.

averaged over July 2020 to April 2021 and average weekly prices from July 2017 to June 2019. The two other variables that get a high weight are the total domestic supply averaged over October 2020 to September 2021 and prices between July 2019 and March 2020. International prices and global production changes carry a low weight amongst predictor variables.

We next discuss the weights obtained for each unit in the donor pool. We observe from Figure 1 that the key donor pool units which carry a high weight in the synthetic control for mustard oil under this specification are refined soy oil (∼50%) and groundnut oil (∼30%). Cottonseed oil gets a weight of less than 15% while sunflower oil gets a weight of less than 5%. We next report the balance table with the pre-intervention characteristics of *mustard oil* and synthetic *mustard oil* and the donor pool average in Table 1. In comparison to the donor pool average reported in the last column of the table, we observe a lower divergence between the pre-intervention characteristics of *mustard oil* and synthetic *mustard oil*, particularly for the predictor variables that obtain high weight.

We next examine the effect of the suspension based on the difference between the weekly prices of *mustard oil* and its synthetic control, as derived from the weights shown in Figure 1. Figure 2 shows the two time series. The grey dotted vertical line in the figure is the end of the estimation period and beginning of the test / validation period. We first assess the fit of the synthetic control with the observed series in the pre-intervention period. In the estimation period (prior the grey dotted line), while we do not observe a perfect overlap between the prices of *mustard oil* and its synthetic control, broadly the two series seem to be tracking each other. The magnitude of the difference between the two series is small and stable over time. In the test / validation period, we observe that the gap between the two series in the first half is small, but the gap sharpens in

Table 1 Pre-intervention characteristics balance table for *mustard*

This table shows the balance table with pre-intervention characteristics of *mustard oil* and synthetic *mustard oil* and the donor pool average. All variables are averaged over the period specified in the parentheses.

Variable	*Mustard oil*	Synthetic *Mustard oil*	Donor sample average
Weekly prices (Jul '17 to Jun '19)	79.08	77.96	72.44
Weekly prices (Jun '19 to Mar '20)	85.67	90.17	84.17
Weekly prices (Jun '20 to Apr '21)	117.24	115.98	113.07
International prices (Jun '20 to Apr '21)	107.36	129.89	122.00
Total domestic supply (Oct '19 to Sep '20)	7.99	8.01	8.07
Total domestic supply (Oct '20 to Sep '21)	8.03	8.00	8.03
ΔYoY global production (Oct '19 to Sep '20)	1.10	4.94	4.02
ΔYoY global production (Oct '20 to Sep '21)	3.83	0.27	-2.25
Global production (Oct '19 to Sep '20)	10.24	9.95	9.88
Global production (Oct '20 to Sep '19)	10.28	9.95	9.86

the second half of the validation period around August 2021. This is because of a global shock in mustard production in response to the news that production in Canada was to be lower than expected (Section 2.1.2). This resulted in a large increase in domestic mustard prices and resulted in the series displaying a behaviour different from the past trend (USDA, 2021).

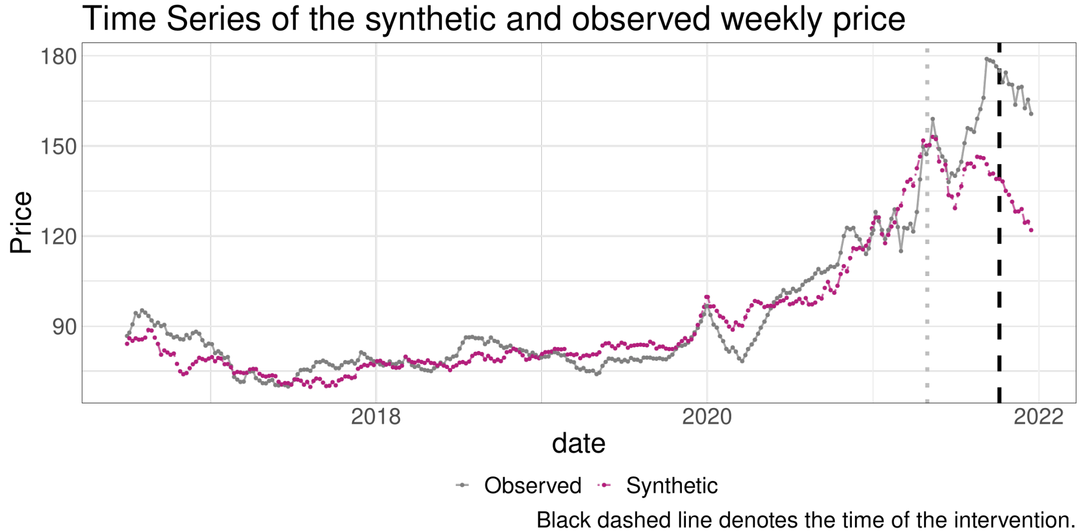
We next examine the prices of mustard oil and its synthetic control in the post-intervention period. Since mustard oil prices just prior to the intervention had gone up owing to the global production shock in August 2021, prices after the suspension continue to show wide divergence between the synthetic control and the observed series. However, we also observe that the prices for both the series show a decline in the post-intervention period. In the absence of a synthetic control analysis, one would have mistakenly attributed the observed fall in mustard oil prices to derivatives suspension. However, the synthetic control shows the same declining trend as the observed mustard oil price. The observed decline in the prices of synthetic control in the post intervention period goes against the conjecture that derivatives suspension brought down the prices of mustard oil.

If derivatives suspension did indeed impact the prices, we would have observed an increase in the prices of the synthetic control. The absence of an increase in the prices of synthetic control and the presence of same trend amongst both the series indicate that even without derivatives suspension, the prices of mustard oil would have shown the same behaviour as observed with derivatives suspension, thus suggesting that the suspension had no impact on mustard oil prices.

For inference, we conduct the "in-space" and "in-time" placebos as described in Section 3.3. If the magnitude of the difference between the placebo estimates is unusually different than the difference between the one estimated with true treated unit (in-space) and true intervention date (in-time), then one can attribute the differences to the intervention. Figure 3 shows the differences in weekly prices between each unit in the donor pool with its synthetic control along with the difference in weekly prices of *mustard oil* with its synthetic control.

We observe that the price differences of *mustard oil* with its synthetic control are within the

Figure 2 Weekly price trends in *mustard oil* and its synthetic control for the October 2021 suspension

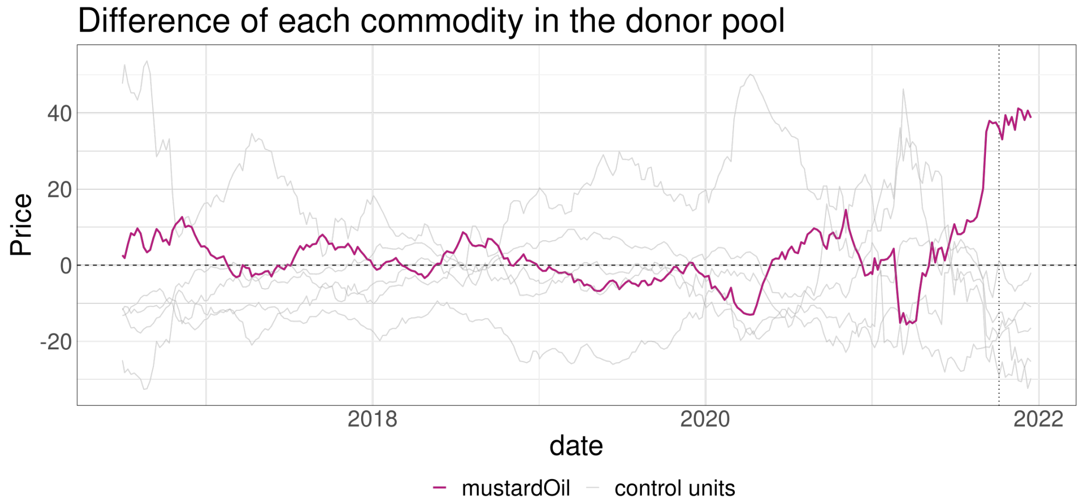


Notes: The graphs show the weekly price trend on *mustard oil* and its synthetic control for the entire sample period. The grey dotted vertical line in the figure is the end of the estimation period (April 2021) and beginning of the test / validation period. The second vertical line (dashed) is the week in October 2021 when derivatives on *mustard oil* were suspended.

range of price differences of placebos i.e when the treatment is assigned randomly to units in the donor pool. This is particularly true of the pre-intervention period. However, the price difference for mustard and its synthetic control widens just prior to the intervention, which as we mentioned earlier is attributable to the mustard oil global production shock. The effect of this shock persisted even during the post-intervention period which is evident from the size of the difference that does not change even after the suspension. However, if one eliminates the price rise in August 2021, the effect on price difference after the suspension mimicks the price differences for in-space placebos. Based on this test, we infer that the price difference of mustard oil mimicks that of the donor pool units price differences and hence the observed prices do not indicate any impact of derivatives suspension.

Further, we conduct an in-time placebo wherein we reassign the intervention to the middle of the pre-treatment period in October 2019. We use the same set of predictor controls as that of the specification described above (pre-intervention prices, international prices, global production and production shock). The pre-intervention period is set from July 2017 to September 2019 with one month of validation period. Panel A in the Appendix Figure B.5 shows the result. We observe that both the time series closely track each other which provides confidence in the predictive power of the synthetic control.

Figure 3 Weekly price differences based on placebo tests and the treated unit, *mustard oil* for the October 2021 suspension



Notes: The grey lines in the graph show the differences in weekly prices based on placebo tests by iteratively applying the method on each unit in the donor pool. The superimposed dark pink line shows the difference between the price trend of *mustard oil* and its synthetic control. The black dashed vertical line (dashed) is the week in October 2021 when derivatives on *mustard oil* were suspended.

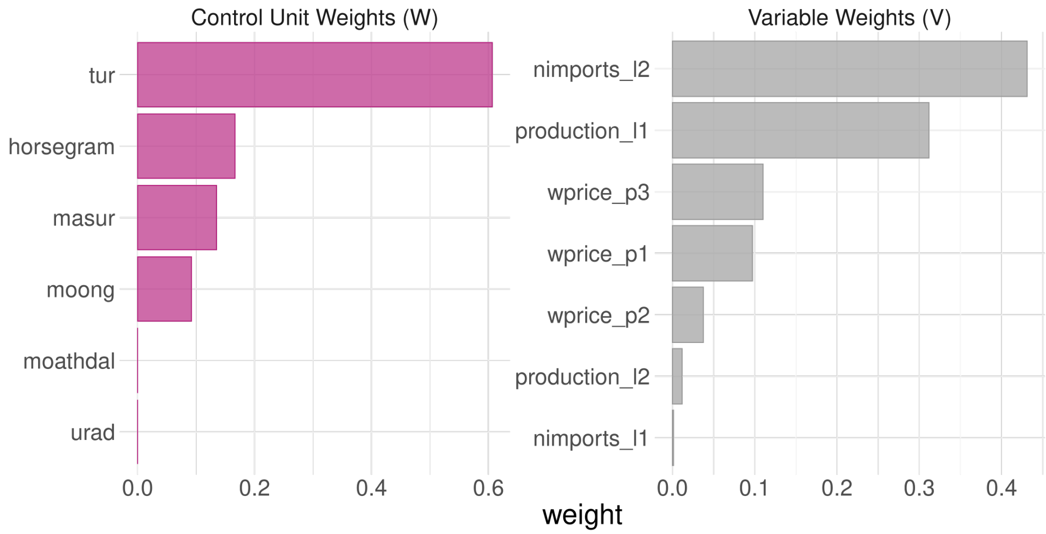
4.2 Effect of 2021 derivatives suspension on *chana* prices

The synthetic control of *chana* is constructed based on the weights (ν_m) selected on the predictor variables as described in Section 3.2.1. We try different combinations of predictor variables, and get a good fit (close overlap between the resulting pre-intervention synthetic control and the true price series in the test / cross-validation period) based on two specifications. Both the specifications include production, pre-intervention prices, and net imports. Besides the three variables, the second specification also includes *mandi* arrivals which gives a good overall fit. We also note that we report the results of the 2021 intervention for *chana* based on differenced series for which the fit of the synthetic control was better as compared to the level series.[51] Since both the specifications provide similar results, we discuss the results based on the first specification. The results from the second specification are in the robustness tests where we also discuss results with other alternatives specifications.

For the first specification, the weights for each unit in the donor pool, along with the weights on predictor variables are shown in Figure 4. The most important predictors turn out to be the average monthly net imports data from April to July 2021; production in the crop year 2019-20; demeaned weekly prices from January 2021 to April 2021 and demeaned weekly prices from July 2019 to March 2020 (Figure 4). The figure shows that the synthetic price of *chana* is a weighted average of prices of *tur*, *horsegram*, *masur* and *moong*. Both *tur* and *masur* have higher weights

[51]The results for the level series are reported in the appendix (Figure B.4). However, the validation period shows a poor overlap between *chana* and its synthetic control and hence we do not use the level series results for this episode.

Figure 4 Weights on donor pool and predictor variables for *chana*



Notes: The graphs show the weights on units in the donor pool and the predictor variables for the first specification. Table A.3 describes the predictor variables.

than the other two pulses. The weights on *moath* and *urad* turn out to be zero. We also report the balance table with pre-intervention characteristics of *chana* and the synthetic *chana* and the donor pool average in Table 2. In comparison to the donor pool average reported in the last column of the table, we observe a lower divergence between the pre-intervention characteristics of *chana* with that of synthetic *chana*.

We next examine the effect of the suspension based on the difference between the weekly prices of *chana* and its synthetic control, as derived from the weights shown in Figure 4. Figure 5 shows the two time series. The grey dotted vertical line in the figure is the end of the estimation period and beginning of the test / validation period. In the estimation period (prior the grey dotted line), we observe that though the price of *chana* and its synthetic control do not exactly overlap, the trend of both the series is similar. The magnitude of the difference between the two series is small and stable. In the test / validation period, we observe that the gap between the two series closes significantly. This close fit in the test period gives us confidence in the validity of synthetic control based on the weights arrived at using the set of predictor variables described earlier.

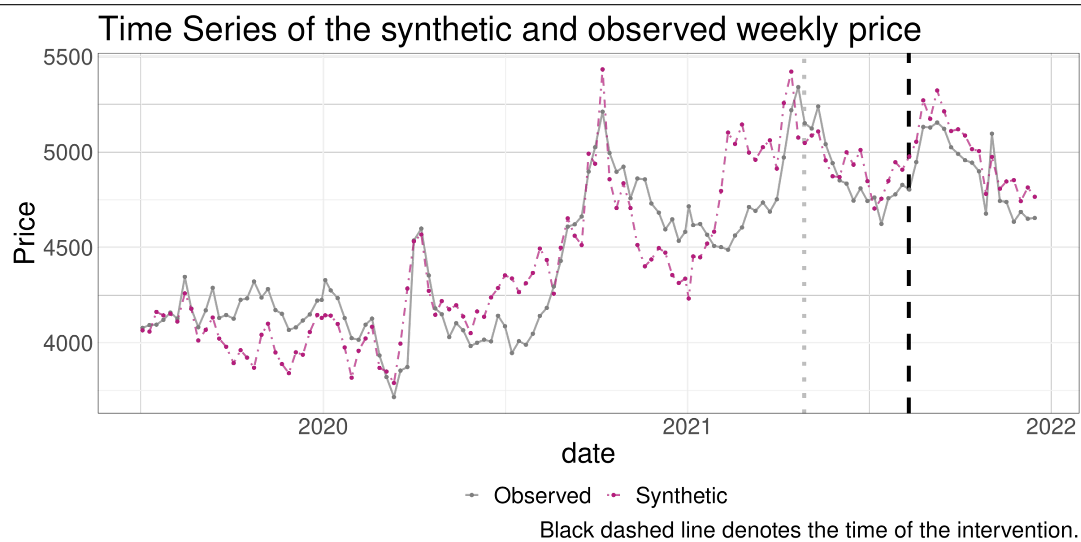
We next examine the behaviour of the two series in the post-suspension period. We find that both the series closely mimick each other suggesting that the price of *chana* was not impacted by derivatives suspension. Instead, the graph indicates that the price behaviour of *chana* would have been exactly the same even if derivatives trading were not suspended. If instead derivative trading did contribute to price rise, we would have expected a rise in the synthetic control *chana* prices in the absence of the suspension. However, the findings do not indicate so. The result once again shows that futures market trading did not *cause* price rise in the 2021 derivatives suspension.

Table 2 Pre-intervention characteristics balance table for *chana*

This table shows the balance table with pre-intervention characteristics of *chana* and synthetic *chana* and the donor pool average. Except for annual production variables, the average value of each variable is obtained for the period specified in the parentheses. Demeaned prices imply the differenced price wherein the pre-intervention mean is subtracted from weekly prices.

Variable	*Chana*	Synthetic *chana*	Donor sample average
Demeaned Price (Jul '19 to Mar '20)	-250.11	-385.31	-447.25
Demeaned Price (Jun '20 to Dec '20)	346.35	109.21	17.97
Demeaned Price (Jan '21 to Apr '21)	563.22	493.80	440.87
Annual Production (Jul '19 to Jun '20)	9.31	7.63	7.03
Annual Production (Jul '20 to Jun '21	9.39	7.74	7.15
Monthly Net Imports (Apr '20 to Mar '21)	0.10	0.52	0.32
Monthly Net Imports (Apr '21 to Jul '21)	-0.05	0.08	0.08

Figure 5 Weekly price trends in *chana* and its synthetic control for the August 2021 suspension

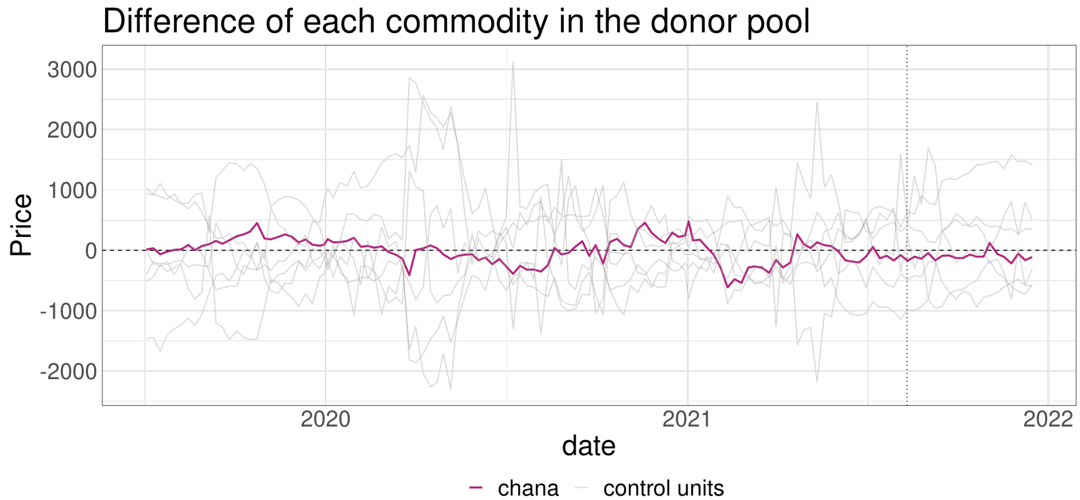


Notes: The graphs show the weekly price trend on *chana* and its synthetic control for the entire sample period. The grey dotted vertical line in the figure is the end of the estimation period and beginning of the test / validation period. The second vertical line (dashed) is the week in August 2021 when derivatives on *chana* were suspended.

The most probable causes of the price rise was the underlying supply issues due to the COVID-19 lockdown. We discuss this in detail in Section 5

To make inferences, Figure 6 shows the differences in weekly prices between each unit in the donor pool with its synthetic control along with the difference in weekly prices of *chana* with its synthetic control.

Figure 6 Weekly price differences based on placebo tests and the treated unit, *chana* for the August 2021 suspension



Notes: The grey lines in the graph show the differences in weekly prices based on placebo tests by iteratively applying the method on each unit in the donor pool. The superimposed dark pink line shows the difference between price trend in *chana* and its synthetic control. The black dashed vertical line (dashed) is the week in August 2021 when derivatives on *chana* were suspended.

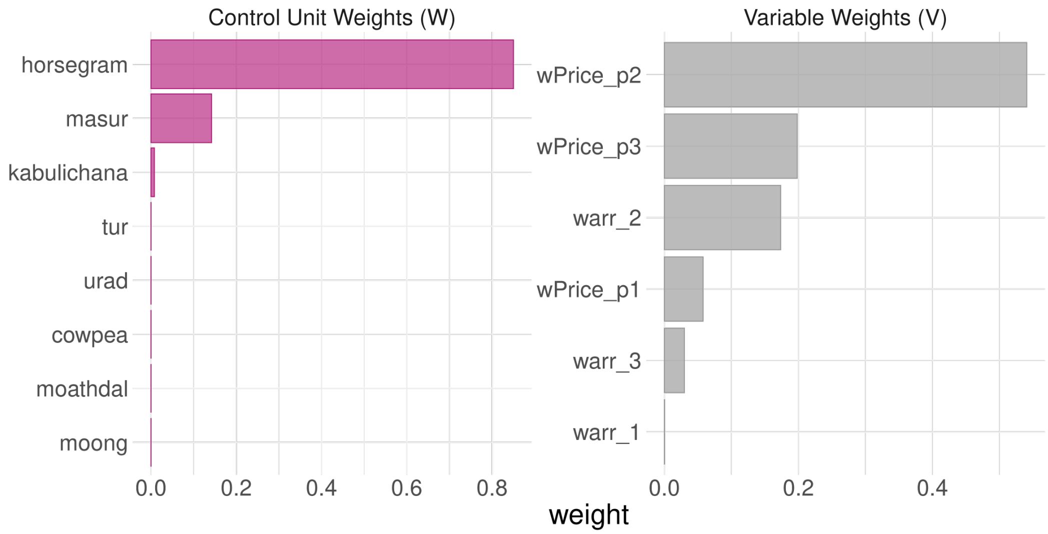
We observe that the price differences of *chana* with its synthetic control are much smaller than the price differences seen for any of the units in the donor pool. We also observe that the fit of the synthetic control of *chana* is much better than any of the units in the donor pool. Overall, the "in-space" placebos also indicate that derivatives suspension did not have any impact on weekly prices of *chana*.

As for mustard, we also conduct the "in-time" placebo for *chana* by reassigning the intervention date to one year prior to the true date, July 2020. All other predictor variables remain the same. The second graph in the Appendix Figure B.5 shows a close fit between the observed *chana* weekly price series and its synthetic control, reaffirming the predictive power of the synthetic control based on the variables used in our main specification.

4.3 Effect of 2016 derivatives suspension on *chana* prices

To construct the synthetic control of *chana* for the June 2016 suspension, we follow the same set of predictor variables used in the August 2021 episode. The specification that gives us the closest overall fit turns out to be the one with predictor variables on pre-intervention prices and

Figure 7 Weights on donor pool and predictor variables for *chana* derivatives suspension in June 2016



Notes: The graphs show the weights on units in the donor pool and the predictor variables for the first specification. Table A.3 describes the predictor variables.

mandi arrivals (Figure 7). The predictor variables that turn out to be critical are weekly prices averaged from April to June 2015, followed by weekly prices averaged across July 2015 and March 2016. Besides, *mandi* arrivals summed over April to June 2015 also turns out to be an important predictor variable (Figure 7).

In terms of weights on donor pool units, the figure shows that the synthetic price of *chana* turns out to be a weighted average of prices of *horsegram* carrying a weight of over 80%, and the remaining on *masur* and to a small extent *kabulichana*. The weights on the remaining donor pool units turn out to be zero. We also report the balance table with pre-intervention characteristics of *chana* and synthetic *chana* and the donor pool average in Table 3. We are able to obtain a lower divergence particularly on prices but not so much on arrivals.

The pre-intervention weekly prices of *chana* and its synthetic control indicate a close overlap (Figure 8). This holds even during the test period (from April to June 2016, prior to the suspension). Examining the behaviour of weekly prices in the post intervention period, we find that the prices of synthetic control are lower than the observed price series of *chana*. The trend in both the series is broadly similar, that of a decline. By March 2017, we see the two series closely moving together once again. In terms of the effect of derivatives suspension, the evidence once again points to absence of impact on prices, and the observed price changes seem to be completely external to the factors that we could capture using the data that is publicly available.

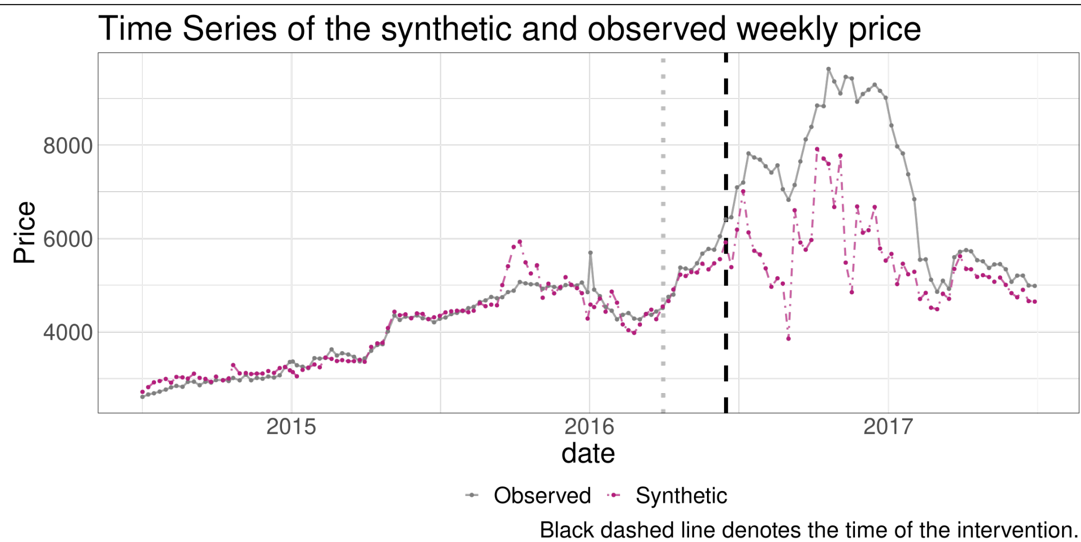
Lastly, we discuss the placebo tests. Figure 9 shows the differences in weekly prices for the "in-space" placebo. The differences for the true unit (*chana*) are not beyond the range observed for the estimated effects with a randomly selected donor pool unit, giving us confidence in drawing the inference that *chana* prices were not impacted after derivatives suspension even in the 2016

Table 3 Pre-intervention characteristics balance table for *chana* derivatives suspension in June 2016

This table provides the balance table with pre-intervention characteristics of *chana* and synthetic *chana* and the donor pool average. Mean weekly prices are averaged over the period mentioned in the parentheses. In addition, sum of arrivals during the corresponding period (as indicated in the parentheses) is taken as a proxy for market supply.

Variable	*Chana*	Synthetic *chana*	Donor sample average
Weekly prices (Jul ‘14 to Mar ‘15)	3157.39	3149.69	4848.15
Weekly prices (Apr ‘15 to Jun ‘15)	4026.93	4088.52	5831.77
Weekly prices (Jul ‘15 to Mar ‘16)	4832.71	4968.10	6738.87
Log arrivals (Jul ‘14 to Mar ‘15)	106.73	88.75	86.58
Log arrivals (Apr ‘15 to Jun ‘15)	31.93	27.66	24.37
Log arrivals (Jul ‘15 to Mar ‘16)	82.61	68.01	71.45

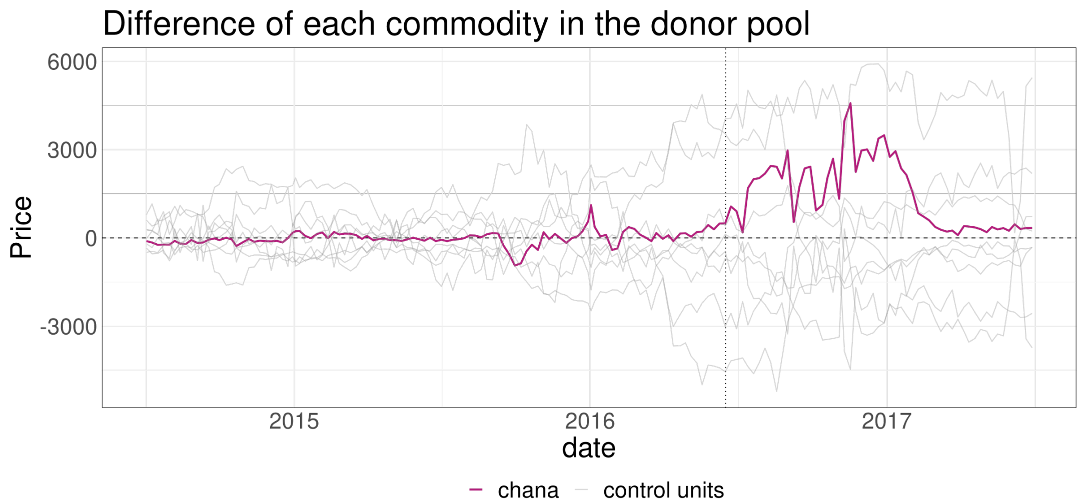
Figure 8 Weekly price trends in *chana* and its synthetic control for the June 2016 suspension



Notes: The graphs show the weekly price trend on *chana* and its synthetic control for the entire sample period. The grey dotted vertical line in the figure is the end of the estimation period and beginning of the test / validation period. The second vertical line (dashed) is the week in June 2016 when derivatives on *chana* were suspended.

episode. The results for the “in-time” placebo for this episode with the re-assigned intervention date as June 2015 is shown in the third graph in Appendix Figure B.5. The graph shows the weekly price trends between *chana* and the synthetic control. We find a close fit in the pre- as well as post-intervention period, thus validating our methodology in predicting the price trend for this episode.

Figure 9 Weekly price differences based on placebo tests and the treated unit, *chana* for the June 2016 suspension



Notes: The grey lines in the graph show the differences in weekly prices based on placebo tests by iteratively applying the method on each unit in the donor pool. The superimposed dark pink line shows the difference between price trend in*chana* and its synthetic control. The black dashed vertical line (dashed) is the week in June 2016 when derivatives on *chana* were suspended.

5 Discussion

What explains the findings in the previous section? To understand the results, we start by examining derivatives traded volumes for each suspended contract. The degree of association between derivatives volumes and spot prices offers a few insights.

Figure B.8 plots daily derivatives traded for each of the three commodities prior the suspension along with their spot prices. A visual inspection of the three graphs does not indicate a direct association between derivatives traded volumes and spot prices. This is particularly true for mustard derivatives suspension in 2021 and *chana* derivatives suspension in 2016. For these two episodes, we in fact observe that just prior to the suspension, derivatives traded volumes for these two episodes do not show any significant increase. In case of *chana* 2021 suspension episode, the derivatives traded volumes display a trend similar to spot prices. Hence we statistically examine whether derivatives traded volume were indeed leading spot price changes using the Granger causality test (Appendix Table A.4). In all three episodes, we do not find any evidence that past values of changes in trading volumes contained information to forecast future spot price changes.[52] The absence of any statistically significant lead lag relation between traded volumes and spot prices explain why the suspension of trading activity did not impact spot prices in all the three episodes.

A natural question that emerges is: what explains the observed spot price rise of the three commodities? While a thorough analysis of the reasons behind the price rise is beyond the scope of this paper, a discussion around these factors is warranted. The supply chain disruptions due to the mobility restrictions during the COVID-19 lockdowns and the strong recovery in food demand in the later half of 2020 potentially explain the surge in food prices (Vos *et al.*, 2022). Production shortfalls around this period aggravated the surge in food prices, as was evident from the sharp rise in mustard oil price as Canada announced a fall in Canola production in July-August 2021 (Section 2.1.2). Mustard prices in India were following the trends in world prices, as is also confirmed from the structural break tests. Table A.5 shows the break dates from structural break test on domestic and international mustard prices. The break dates on domestic prices are close to those for international prices, indicating that domestic prices were moving in line with the international prices of the commodity.

Further, as discussed in Section 2.1.1, production shortfall in *chana* on account of poor monsoons in 2014-15 and 2015-16 resulted in excess demand and thus high prices. As high prices prevailed for two continuous years, the *kharif* planting season of June-July 2016 saw a sharp increase in pulses acreage (Subramaniam, 2016). In anticipation of a positive supply shock, the scarcity seen in the last two years thus transformed from near-famine to near-feast (Subramaniam, 2016). Thus, prices of pulses[53] started plummeting in early July 2016. The price trends observed during this period thus seem to be primarily responding to the demand-supply mismatches rather than derivatives market operations.

6 Sensitivity tests

In this section, we run a range of robustness checks to test the sensitivity of our main results. We describe the tests below.

6.1 Donor pool: Leave one out

In this test, we iteratively re-estimate our baseline model to construct the synthetic control for each of the three episodes by dropping one control unit from the donor pool at a time. This test ensures that the results are not driven by any one particular donor pool control unit. Figure B.6 shows the results for all three suspension episodes. The graph shows the results from the main specification, that is the trajectory of the observed series (solid black line) along with its synthetic control (blue line). In addition, it shows weekly prices from the synthetic controls in the post-intervention period

[52] We conduct this test only to examine lead-lag relation between the two variables, traded volumes and spot prices. Even the rejection of the Granger causality test would not imply that increase in traded volumes was leading to increase in prices, as both may have been rising because of a third factor (endogeneity).

[53] With a greater impact on *kharif* pulses including *moong*, *tur* and *urad*.

based on leave-one-out estimates (grey lines). In all the three graphs, we observe a similar behaviour of the leave-one-out synthetic control as that of the baseline model's synthetic control discussed in the main text. We do not observe any series displaying a significantly divergent behaviour in terms of price trends, thus indicating that the results are not sensitive to any particular donor pool unit.

6.2 Alternative specifications

We next analyse the distribution of synthetic controls in the post intervention period by incorporating different specifications in the model based on variations in predictor variables. The test examines the sensitivity of the results based on changes in predictor variables. Figure B.7 shows the plot for all three suspension episodes. The black line shows the true price series, while the blue line shows the synthetic control in the post-intervention period for the main specification. The grey lines show the synthetic controls based on alternative specifications. Once again, we do not find a significantly different behaviour of the synthetic control series compared to our main specification, reassuring that the results are not sensitive to alternative specifications of predictor variables.

7 Conclusion

Recent surge in food prices has revived the interest on the need and effectiveness of policy measures to tame inflation. As in earlier instances of food price rise in India, derivatives suspension is one of the several policy tools used by policymakers in response to food price inflation. This paper examines the impact of these trading suspension in combating food price inflation. Using publicly available data and modern causal inference methods that aid better identification, we ask if derivatives trading suspensions bring down food price inflation.

We study the three most recent standalone episodes of derivative market suspension in India: *chana* in 2016 and 2021 and mustard in 2021. Across the three episodes, we do not find any evidence that derivatives trading suspension had any impact on food prices. The analysis shows that prices of both the commodities, *chana* and mustard, would have had a similar trend even without the suspension. Placebo and sensitivity tests re-affirm our findings.

While the factors driving the observed price trends is beyond the scope of this paper, we find suggestive evidence that mustard oil prices in India were mimicking the international price trends. COVID-19 lockdowns and the gradual opening of the economies worldwide disrupted the supply chains and impacted food prices globally (Vos *et al.*, 2022). Production shortfall and the resulting supply demand mismatch caused the prices to rise in *chana* and other pulses in 2015-16 (Subramaniam, 2016). Graphical evidence and the Granger causality tests do not show any strong linkages between trading volumes and spot prices for the episodes analysed in this study, further explaining the absence of any impact of trading suspensions on prices.

The advantages of derivatives market in aiding price discovery and risk management have been highlighted in several studies including Cheng and Xiong (2014). Abrupt suspensions adversely affect value chain participants and discourage the development of a liquid derivatives market.

Recent news articles and reports suggest that several farmer producer organizations benefit by locking-in prices in derivatives markets (NCDEX, July 2022). Efficient functioning of these markets can bring stability in agricultural markets and also shield farmers from a crash in spot prices in the peak season.[54] These observations along with the findings of this study emphasise the development of a well-functioning agricultural derivatives market, and suggests avoidance of abrupt measures such as trading suspensions during periods of high food inflation that discourage the growth of these markets.

[54] "Futures And Derivatives: Can Farmer Producer Organisations Take Some of the Risk out of Farming?", Siraj Hussain, April 2021, The Wire.

References

Abadie A (2021). "Using Synthetic Controls: Feasibility, Data Requirements, and Methodological Aspects." *Journal of Economic Literature*, **59**(2), 391–425. doi:10.1257/jel.20191450. URL https://www.aeaweb.org/articles?id=10.1257/jel.20191450.

Abadie A, Diamond A, Hainmueller J (2010). "Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program." *Journal of the American Statistical Association*, **105**(490), 493–505.

Abadie A, Diamond A, Hainmueller J (2015). "Comparative Politics and the Synthetic Control Method." *American Journal of Political Science*, **59**(2), 495–510.

Abadie A, Gardeazabal J (2003). "The economic costs of conflict: A case study of the Basque Country." *The American Economic Review*, **93**(1), 113–132.

Abbott PC (2012). "Export restrictions as stabilization responses to food crisis." *American Journal of Agricultural Economics*, **94**(2), 428–434.

Aggarwal N, Narayanan S (2023). "The impact of India's demonetization on domestic agricultural trade." *American Journal of Agricultural Economics*, **105**(1). doi:https://doi.org/10.1111/ajae.12317.

Angrist JD, Pischke JS (2010). "The Credibility Revolution in Empirical Economics: How Better Research Design Is Taking the Con out of Econometrics." *Journal of Economic Perspectives*, **24**(2), 3–30. doi:10.1257/jep.24.2.3. URL https://www.aeaweb.org/articles?id=10.1257/jep.24.2.3.

Athey S, Imbens GW (2017). "The State of Applied Econometrics: Causality and Policy Evaluation." *Journal of Economic Perspectives*, **31**(2), 3–32. doi:10.1257/jep.31.2.3. URL https://www.aeaweb.org/articles?id=10.1257/jep.31.2.3.

Baylis K, Jolejole-Foreman MC, Mallory M (2014). "Effects of export restrictions on domestic market efficiency: The case of India's rice and wheat export ban." URL https://works.bepress.com/kathy_baylis/54/.

Bellemare MF (2015). "Rising Food Prices, Food Price Volatility, and Social Unrest." *American Journal of Agricultural Economics*, **97**(1), 1–21. doi:https://doi.org/10.1093/ajae/aau038. https://onlinelibrary.wiley.com/doi/pdf/10.1093/ajae/aau038, URL https://onlinelibrary.wiley.com/doi/abs/10.1093/ajae/aau038.

Bhattacharya H (2007). "Commodity derivatives market in India." *Economic and Political Weekly*, **42**(13), 1151–1162.

Brunetti C, Buyuksahin B (2009). "Is Speculation Destabilizing?" CFTC, URL https://www.cftc.gov/sites/default/files/idc/groups/public/@swaps/documents/file/plstudy_03_cftc.pdf.

CFTC (September 2008). "Staff report on commodity swap dealers & index traders with commission recommendations." CFTF Press Rel. # 5542-08, URL http://www.cftc.gov/PressRoom/PressReleases/pr5542-08.

Chari V, Christiano L (2017). "Financialization in Commodity Markets." *Working Paper 23766*, National Bureau of Economic Research. doi:10.3386/w23766. URL http://www.nber.org/papers/w23766.

Cheng IH, Kirilenko A, Xiong W (2014). "Convective Risk Flows in Commodity Futures Markets*." *Review of Finance*, **19**(5), 1733–1781.

Cheng IH, Xiong W (2014). "Financialization of Commodity Markets." *Annual Review of Financial Economics*, **6**(1), 419–441. doi:10.1146/annurev-financial-110613-034432. https://doi.org/10.1146/annurev-financial-110613-034432, URL https://doi.org/10.1146/annurev-financial-110613-034432.

Demeke M, Dawe D, Tefft J, Ferede T, Bell W (2012). "Stabilizing price incentives for staple grain producers in the context of broader agricultural policies: debates and country experiences."

Dunford E (2021). *tidysynth: A Tidy Implementation of the Synthetic Control Method*. R package version 0.1.0, URL https://github.com/edunford/tidysynth.

Gilbert CL (2010). "How to Understand High Food Prices." *Journal of Agricultural Economics*, **61**(2), 398–425. doi:https://doi.org/10.1111/j.1477-9552.2010.00248.x. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1477-9552.2010.00248.x, URL https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1477-9552.2010.00248.x.

Government of India (2021-22). "Economic Survey." Ministry of Finance.

Hamilton JD, Wu JC (2015). "Effects of index-fund investing on commodity futures prices." *International Economic Review*, **56**(1), 187–205. URL http://www.jstor.org/stable/24517892.

Jones D, Kwieciński A (2010). "Policy responses in emerging economies to international agricultural commodity price surges." *OECD Food, Agriculture and Fisheries Papers*, **34**.

Masters, M (2008). "Testimony before the Committee on Homeland Security and Governmental Affairs." Tech Report, US Senate, Washington, DC, May 20th.

Narayanan A, Tomar S (2023). "Farm support and market distortion: Evidence from India." *American Journal of Agricultural Economics*, **105**(3), 966–993.

NCDEX (July 2022). "Connecting farmers to market." NCDEX, URL https://ncdex.com/downloads/fpo/reports/NCDEX%20Group,%20Connecting%20Farmers%20to%20Market,%20July%202022.pdf.

Roy Devesh; Joshi PK, Chandra R (2017). *Pulses for nutrition in India: Changing patterns from farm to fork*. International Food Policy Research Institute (IFPRI). doi:https://doi.org/10.2499/9780896292567.

Sahadevan KG (2002). "Sagging agricultural commodity exchanges: Growth constraints and revival policy options." *Economic and Political Weekly*, **37**(30).

Saini S, Gulati A (2017). "Price distortions in Indian agriculture." *Working paper*, Indian Council for Research on International Economic Relations.

Saroj S, Roy D, Kishore P, Kishore A (2021). "Impacts of Sweeping Agricultural Marketing Reforms in a Poor State of India: Evidence from Repeal of the APMC Act." *2021 Conference, August 17-31, 2021, Virtual 315092*, International Association of Agricultural Economists. doi:10.22004/ag.econ.315092. URL https://ideas.repec.org/p/ags/iaae21/315092.html.

Singleton KJ (2014). "Investor Flows and the 2008 Boom/Bust in Oil Prices." *Management Science*, **60**(2), 300–318. URL http://www.jstor.org/stable/42919535.

Stoll H, Whaley R (2010). "Commodity index investing and commodity futures prices." *Journal of Applied Finance*, **1**, 1–40.

Subramaniam A (2016). "Incentivising Pulses Production through Minimum Support Price (MSP) and Related Policies." Report of the Committee set up by the Government of India, URL https://pib.gov.in/newsite/PrintRelease.aspx?relid=149860.

USDA (2021). "Oilseeds: World Markets and Trade." USDA, URL https://downloads.usda.library.cornell.edu/usda-esmis/files/tx31qh68h/b5645q33m/h128pd28h/oilseeds.pdf.

Vos R, Glauber J, Hernandez M, Laborde D (2022). "COVID-19 and rising global food prices: what's really happening." IFPRI Blog, URL https://www.ifpri.org/blog/covid-19-and-rising-global-food-prices-whats-really-happening.

Appendix A Tables

Table A.1 Agricultural derivatives suspensions in India

Commodity	Suspension year	Commodity	Suspension year
Raw Jute	2005-	Potato	2008, 2014-
Rice	2007-	Sugar	2009-
Wheat	2007, 2021-	*Guar*	2012
Chana	2008, 2016, 2021-	Mustard seed	2021-
Tur	2007	Moong	2021-
Urad	2007-	Soybean	2021-
Soy oil	2008, 2021-	Paddy	2021-
Rubber	2008-	Crude palm oil	2021-

Table A.2 List of predictor variables used for mustard synthetic control

Mustard 2021: Predictor variables	**Name**	**Description**
Weekly prices (Jul '17 to Jun '19)	wPrice_p1	Average weekly wholesale oil prices from July 2017 to June 2019.
Weekly prices (Jun '19 to Mar '20)	wPrice_p2	Average weekly wholesale oil prices from June 2019 to March 2020.
Weekly prices (Jun '20 to Apr '21)	wPrice_p3	Average weekly wholesale oil prices from June 2020 to April 2021.
International prices (Jun '20 to Apr '21)	intl_price_p3	Average monthly international oil prices from June 2020 to April 2021 based on FAO data.
Total domestic supply (Oct '19 to Sep '20)	wtotSS_lag	Total domestic supply of all oils from October 2019 to September 2020 based on USDA data
Total domestic supply (Oct '20 to Sep '21)	wtotSS	Total domestic supply of all oils from October 2019 to September 2020 based on USDA data
ΔYoY global production (Oct '19 to Sep '20)	wGloProdShock_lag	Year-on-year change in global production for October 2019 to September 2020 based on USDA data
ΔYoY global production (Oct '20 to Sep '21)	wGloProdShock	Year-on-year change in global production for October 2020 to September 2021 based on USDA data
Global production (Oct '19 to Sep '20)	wGloProd	Yearly global production for October 2019 to September 2020 based on USDA data
Global production (Oct '20 to Sep '21)	wGloProd	Yearly global production for October 2020 to September 2021 based on USDA data

Table A.3 List of predictor variables used for *chana* synthetic controls

***Chana* (2021): Predictor variables**	**Name**	**Description**
Demeaned prices (Jul '19 to Mar '20)	wPrice_p1	Average weekly differenced price series (with deviations from the pre-intervention mean) July 2019 to March 2020.
Demeaned prices (Jun '20 to Dec '20)	wPrice_p2	Average weekly differenced price series (with deviations from the pre-intervention mean) June 2020 to December 2020.
Demeaned prices (Jun '21 to Apr '21)	wPrice_p3	Average weekly differenced price series (with deviations from the pre-intervention mean) June 2021 to April 2021.
Annual production (Jul '19 to Jun '20)	production_l1	Annual domestic production for the crop year 2019-20
Annual production (Jul '20 to Jun '21)	production_l2	Annual domestic production for the crop year 2020-21
Monthly net imports (Apr '20 to Mar '21)	nimports_l1	Average monthly net imports (difference between exports and imports) from April 2020 to March 2021
Monthly net imports (Apr '21 to Jul '21)	nimports_l2	Average monthly net imports (difference between exports and imports) from April 2021 to July 2021

***Chana* (2016): Predictor variables**	**Name**	**Description**
Weekly prices (Jul '14 to Mar '15)	wPrice_p1	Average weekly differenced price series (with deviations from the pre-intervention mean) July 2019 to March 2020.
Weekly prices (Apr '15 to Jun '15)	wPrice_p2	Average weekly differenced price series (with deviations from the pre-intervention mean) June 2020 to December 2020.
Weekly prices (Jul '15 to Mar '16)	wPrice_p3	Average weekly differenced price series (with deviations from the pre-intervention mean) June 2021 to April 2021.
Log arrivals (Jul '14 to Mar '15)	warr_1	Sum of weekly *mandi* arrivals from July 2014 to March 2015.
Log arrivals (Apr '15 to Jun '15)	warr_2	Sum of weekly *mandi* arrivals from April 2015 to June 2015.
Log arrivals (Jul '15 to Mar '16)	warr_3	Sum of weekly *mandi* arrivals from July 2015 to March 2016.

Table A.4 Granger causality test results on *chana* and mustard seed traded volumes and spot price changes prior the suspension

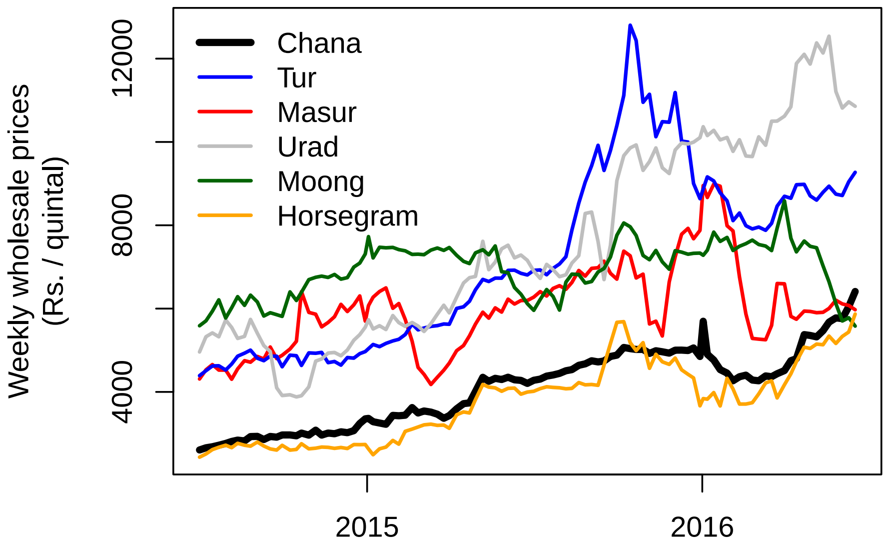
Mustard 2021 suspension		
Granger causality	Order	*p*-value
Δ Volumes $\nrightarrow$ Δ Price	1	0.35
Δ Volumes $\nrightarrow$ Δ Price	3	0.42
Δ Volumes $\nrightarrow$ Δ Price	5	0.73
Chana 2021 suspension		
Granger causality	Order	*p*-value
ΔVolumes $\nrightarrow$ Δ Price	1	0.47
ΔVolumes $\nrightarrow$ Δ Price	3	0.66
ΔVolumes $\nrightarrow$ Δ Price	5	0.55
Chana 2016 suspension		
ΔVolumes $\nrightarrow$ Δ Price	1	0.96
ΔVolumes $\nrightarrow$ Δ Price	3	0.11
ΔVolumes $\nrightarrow$ Δ Price	5	0.13

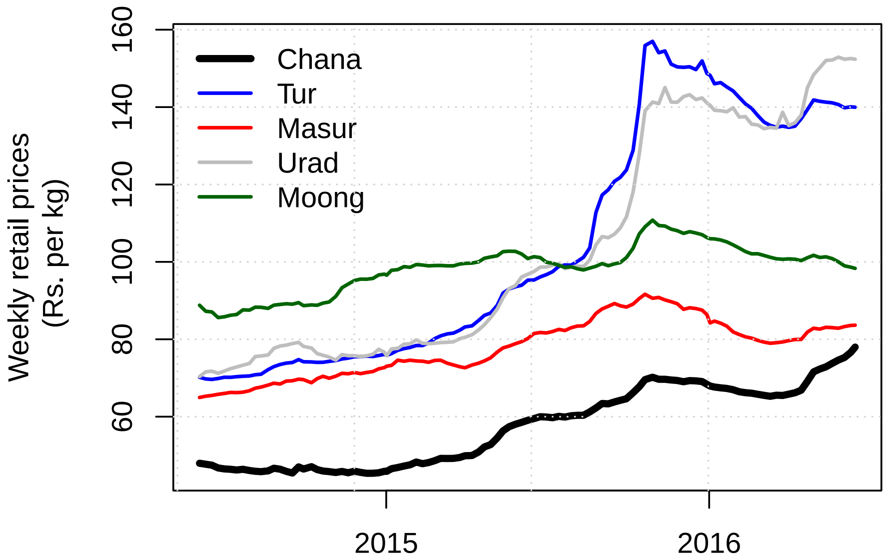
Table A.5 Structural break test on domestic and international mustard prices

Price Series	Break date 1	Break date 2	Break date 3	Break date 4
Mustard oil (retail)	2019-11-28	2020-06-11	2020-11-12	2021-04-15
Canola	2019-11-07	2020-06-15	2020-11-29	2021-04-08

Appendix B Figures

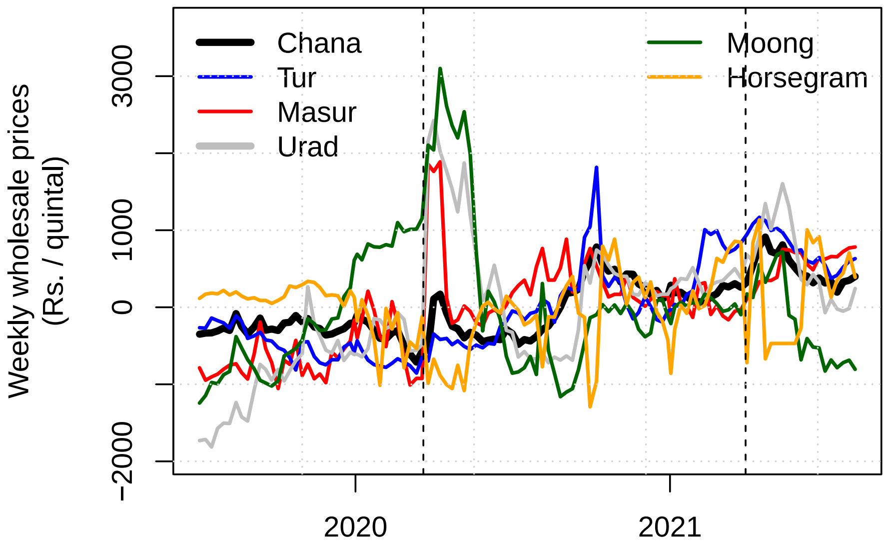
Figure B.1 Wholesale and retail prices of major pulses prior the derivatives suspension in June 2016

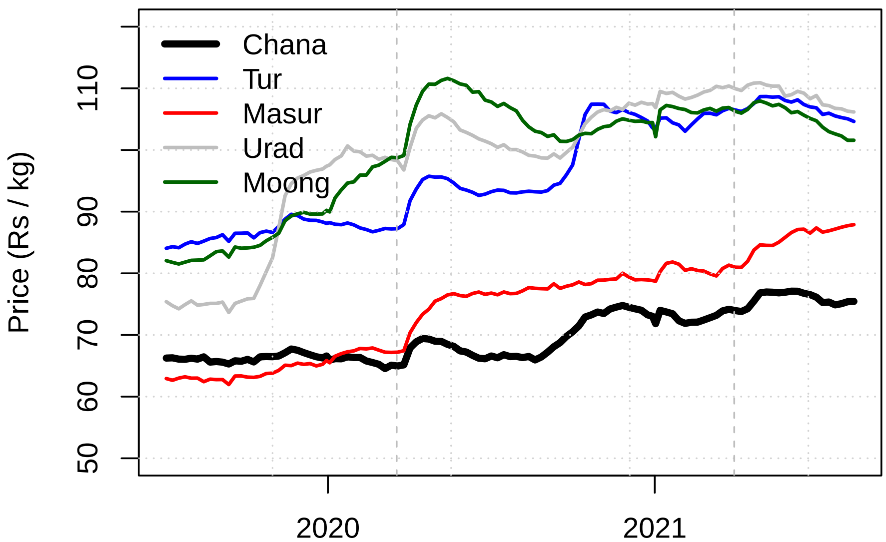




Notes: The first graph shows weekly wholesale prices for major pulses from July 2014 to June 2016 based on *mandi* data. The second graph shows weekly retail prices for the same period. Retail price data is only available for the five pulses shown in the graph.

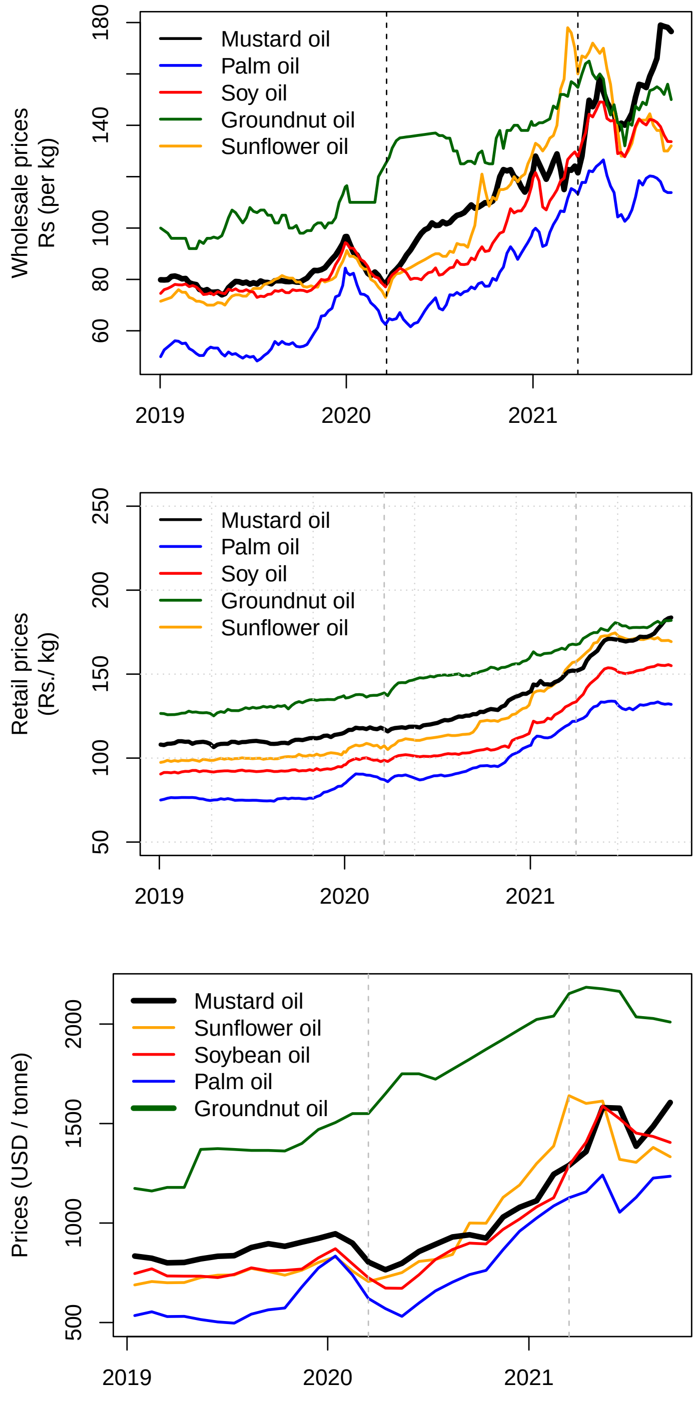
Figure B.2 Wholesale and retail prices of major pulses prior the derivatives suspension in August 2021





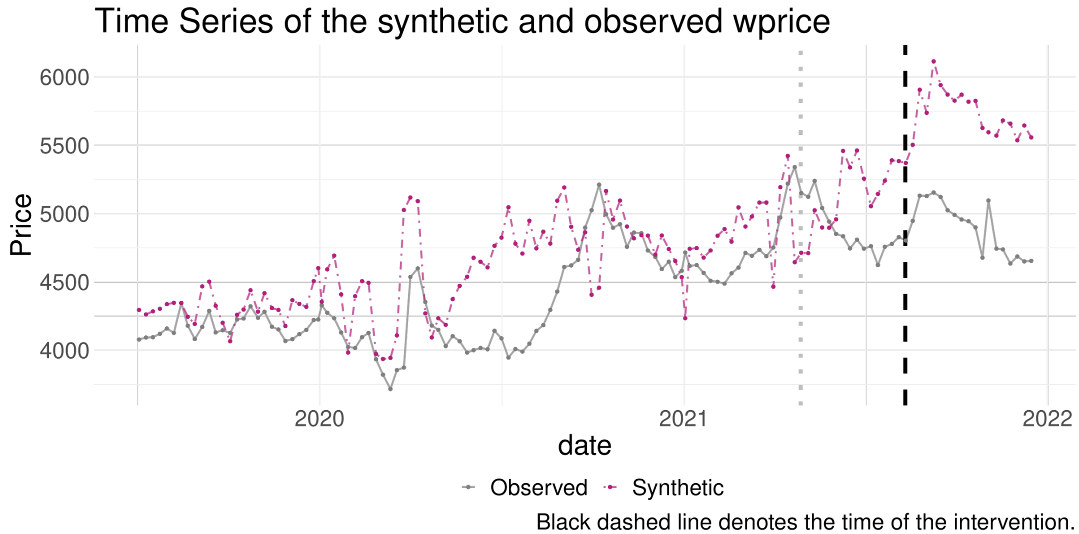
Notes: The first graph shows weekly wholesale prices for major pulses from July 2018 to August 2021. The second graph shows weekly retail prices for the same period. The first dashed grey line shows the week in March 20, 2020 when a nationwide lockdown was imposed amidst COVID-19, while the second dashed grey line marks the first week in April when the country was hit by the Delta wave of COVID-19.

Figure B.3 Prices of major oilseeds prior the derivatives suspension in October 2021



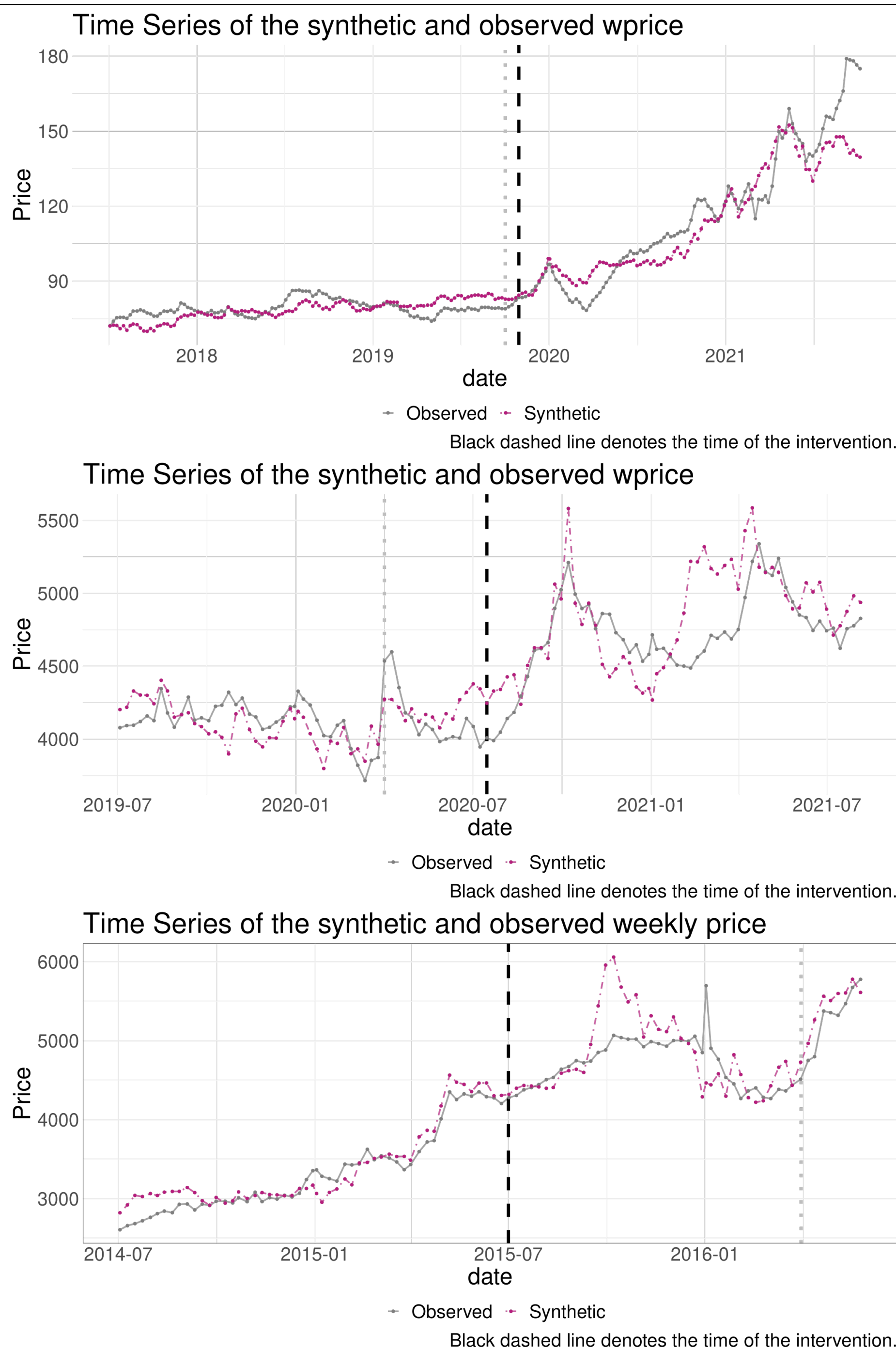
Notes: The first graph shows weekly wholesale prices for major oils from January 2019 to September 2021, while the second graph shows weekly retail prices for the same period. The third graph shows the monthly international prices of these oils. The first dashed grey line shows the week of March 20, 2020 when a nationwide lockdown was imposed amidst COVID-19, while the second dashed grey line marks the first week of April when the country was hit by the Delta wave of COVID-19.

Figure B.4 Weekly price trends in *chana* and its synthetic control for the August 2021 suspension for the level series



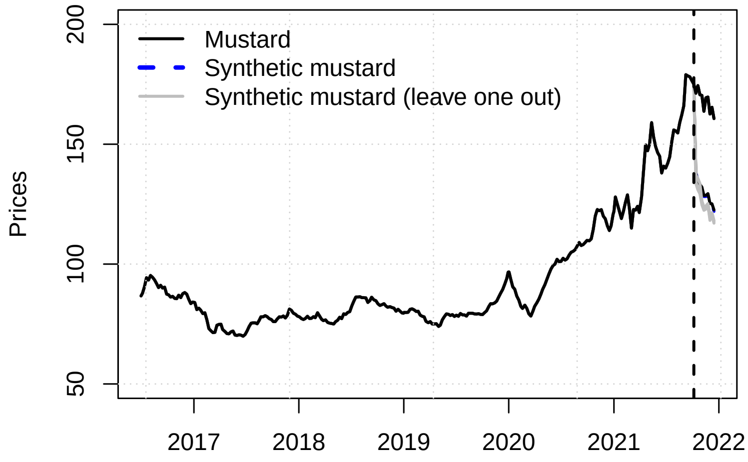
Notes: The graphs show the weekly price trend on *chana* and its synthetic control for the entire sample period based on level series. The grey dotted vertical line in the figure is the end of the estimation period and beginning of the test / validation period. The second vertical line (dashed) is the week in August 2021 when derivatives on *chana* were suspended.

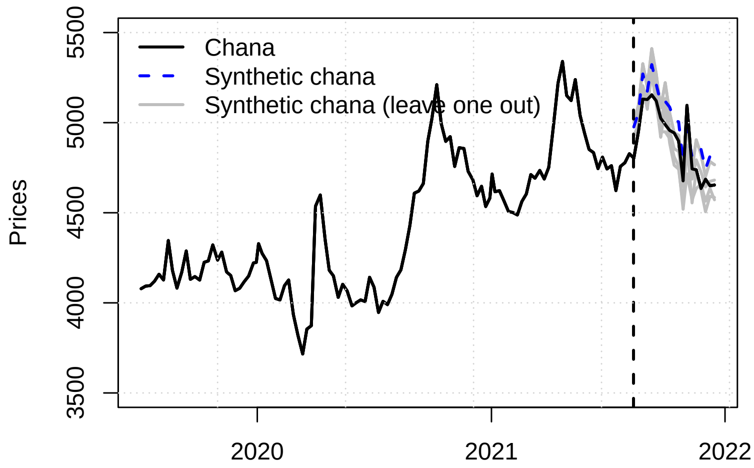
Figure B.5 In-time placebo: Weekly price trends in *chana* and *mustard* with their synthetic controls by reassigning treatment date to a faux date

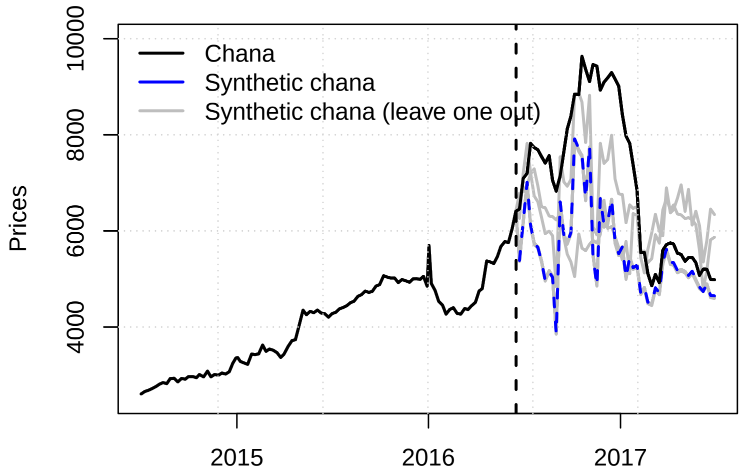


Notes: The first graph shows the in-time placebo for mustard with the re-assigned intervention date as October 2019, while the second and the third graphs show the in-time placebo for *chana* with July 2020 and June 2015 as the re-assigned intervention dates.

Figure B.6 Leave-one out distribution of the synthetic control for each episode

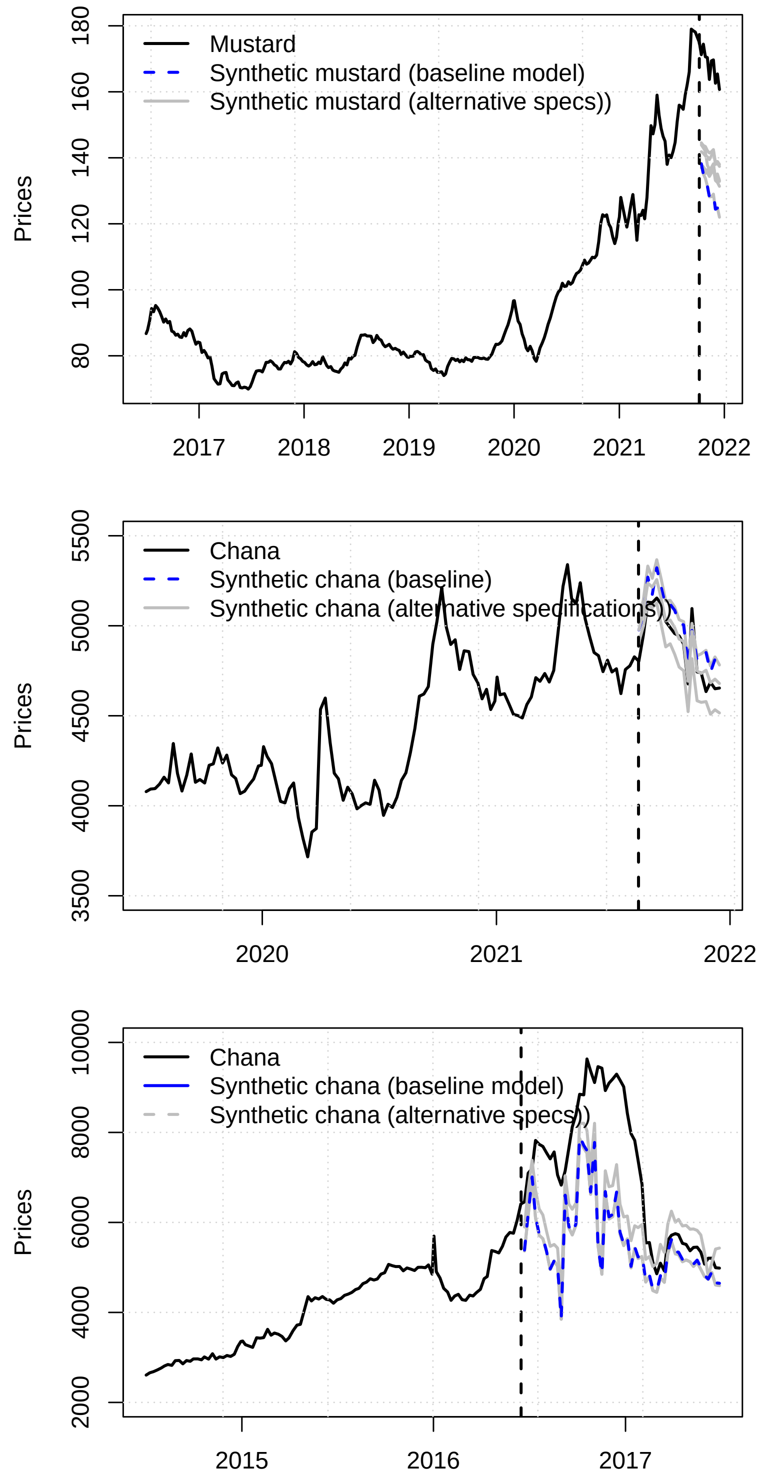






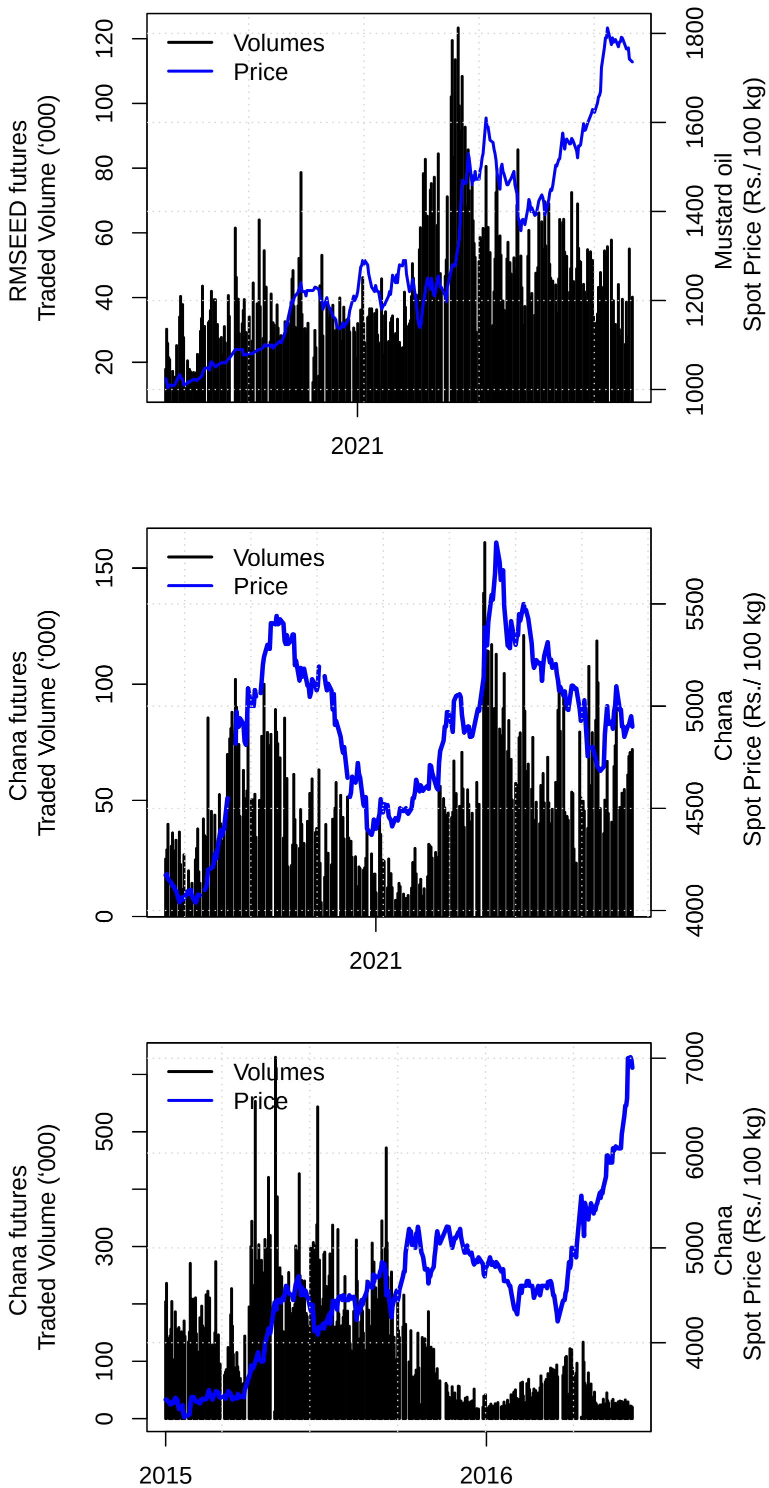
Notes: The first graph shows the leave-one-out distribution of the synthetic controls for mustard derivatives suspension of 2021, while the second and the third graphs show the derivatives suspension of *chana* in August 2021 and June 2016.

Figure B.7 Robustness test: Alternative specifications based distribution of the Synthetic control for each episode



Notes: The first graph shows the alterative specifications based distribution of the synthetic controls for mustard derivatives suspension of 2021, while the second and the third graphs show the derivatives suspension of *chana* in August 2021 and June 2016.

Figure B.8 Exchange traded volumes prior to the suspension and spot prices of mustard and *chana*



Notes: The first graph shows the exchange traded volumes on futures contract for mustard prior to its suspension in October 2021 along with spot prices. The second and third graphs show the two variables for *chana* prior to the August 2021 suspension and June 2016, respectively.