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Abstract

Food inflation has been a major concern for Indian policy makers the last decade. In an attempt to prevent domestic wheat and rice prices from rising during the food crisis the Indian government restricted export of these two key staples first by increasing minimum export prices successively followed by an outright export ban lasting from 2007-11. In this paper we ask, what was the effect of this ban on domestic prices and consequently on the welfare of the consumers? We approach this problem by applying new Bayesian techniques to estimate the price impact by calculating the entire counterfactual price development following the export ban. Our results indicate that the ban did indeed have a significant effect on domestic rice and wheat consumer prices. Domestic wheat prices increased around 40 percent less than they would have in the absence of a ban. We do not, however, find a significant relationship between international and domestic rice prices in India prior to the export ban. The effect of the export ban on domestic rice prices was to make them less responsive to changes in producer support. We conclude that welfare impact from the rice export ban was probably smaller than the literature suggests.

Keywords: Export Ban, Price transmission, Counterfactual analysis, India, Food crisis

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1 Introduction

The international food price spikes of 2007-7 and 2010-11 are believed to have pushed millions of vulnerable households into poverty with a resulting increase in global undernourishment (Anríquez et al., 2013; De Hoyos and Medvedev, 2011; Dessus et al., 2008; FAO, 2011; Ivanic and Martin, 2008; Ivanic et al., 2012; Tiwari and Zaman, 2010; Wodon and Zaman, 2010; Zezza et al., 2008). Most governments in developing countries took actions to limit the impact on domestic food prices and/or welfare (Abbott, 2010; Demeke et al., 2009; Jones and Kwiecinski, 2010; Götz et al., 2013). Importers slashed tariff rates and exporters restricted foreign trade with export taxes, export quotas and minimum export prices or even with outright export bans. The evidence on the domestic price and welfare impacts of these policies is, however, surprisingly scarce. In this paper we therefore set out to evaluate the domestic price effects of the 2007-11 Indian grain export ban.

Due to its vast number of poor consumers, the price of food is enormously important in India and therefore subject to heavy government involvement and public scrutiny. The total fiscal costs of India's food price policy, the so called food subsidy, has ballooned the last decade and with the passing of India's National Food Security Act in 2013, providing access to subsidized for two-thirds of the population, this development is unlikely to reverse (Mishra, 2013; Sinha, 2013). To make matters worse, the PDS is widely considered to be a wasteful and highly inefficient social safety net system prone to leakages and targeting errors. This helps to explain why food insecurity, despite a tremendous increase in grain production, is still widespread in India.

Domestic food price stability is a top priority for the Government of India (GoI), which therefore actively manages domestic availability of the two major staples wheat and rice through its trade policy. This became especially clear in connection with the 2007-8 and 2010-11 international food crises when import tariffs were removed and exports restricted in series of steps culminating with the outright export ban on wheat and non-basmati rice in 2007-8 lasting until September 2011. A few studies have assessed the impact of the export ban on domestic market integration and price transmission. Baylis et al. (2014), in particular, find that the ban resulted in domestic rice and wheat markets which became disconnected from the world market as well as reduced market integration between producing and consuming regions in India. These findings are consistent with those of other studies looking at different countries (e.g. Götz et al., 2013; Ihle et al., 2009).

Price transmission and market integration studies including the ones mentioned above typically use VAR models and focus on a few key parameters such as the cointegrating vector; especially how this is affected by changes in trade policy. It is much

rarer to find studies comparing actual post-intervention price development with that predicted by the model before the export restrictions kicked in. This is peculiar because, arguably, such an approach leads to a much clearer picture of the policy’s price effect relative to the conventional approach based on a discussion of the size and stability of parameter estimates. In this paper we therefore take the counterfactual approach, focusing on the important case of India’s 2007-11 wheat and rice export ban.

We use a Bayesian structural time-series model to estimate the impact of the Indian grain export ban. More specifically, we estimate the counterfactual price development with a statespace time-series model and compare it with the actual price development. The counterfactual prices are the model predictions, ignoring the export ban. These predictions are also known as a dynamic forecast in the time series literature. Essentially, we estimate the model parameters on the pre-intervention sample and use these to calculate the entire post-intervention price path. One component of the state is a linear regression on the contemporaneous predictors. The dynamic forecast is thus conditional on the pre-intervention price path as well as the pre- and post-intervention values of the predictor variables. These represent the international price of wheat/rice, producer support prices, input costs and the general price level.

Our results indicate that the export ban did indeed have a significant effect on domestic (retail) rice and wheat prices. The simulated wheat model suggests that domestic wheat price would have increased around 40 percent more than they actually did at the time of the 2008 peak in international wheat prices, had there not been an export ban. Results from the simulated rice model, on the other hand, suggest that there was a very weak link between the international and domestic rice prices, prior to the ban. The international rice price spike in May 2008 would therefore not have a significant impact on Indian retail rice prices even in the absence of an export ban, according to the model. What the rice export restrictions did seem to have an effect on was the producer support-retail price relationship. In particular, according to the model, retail rice prices reacted much less to increases in the level of producer support during the export ban, than they did prior to the ban.

In the conclusion we discuss the welfare impact of the export ban in light of its effect on domestic rice and wheat prices. Only a couple of studies have quantified the welfare effects of domestic price changes occurring during the 2007-8 food crisis, namely De Janvry and Sadoulet (2009) and Groom and Tak (2015). However, these studies take the international price increases as the counterfactual which, according to our results, is not an appropriate assumption for the domestic retail price of rice in India. That is, our counterfactual analysis shows that it is not reasonable to assume that domestic rice prices in India would have increased as much as the international ones, in the absence of a ban. Our analysis of India’s 2007-11 grain export ban therefore

contributes to both the poverty impact and the price transmission literature and to the wider policy discussion on global food security and the domestic welfare effect of grain export restrictions.

The paper now proceeds as follows. Section 2 provides some background information on the Indian agricultural and food policy. Section 3 describes the methodology and data. Section 4 summarizes the results from the counterfactual analysis and, finally, section 5 concludes.

2 Background

In this section we provide some background information on the Indian food policy with an emphasis on the 2007-11 wheat and rice export bans in response to the international food crisis.

2.1 Agricultural and food policy in India

Since its independence in 1947, the Government of India (GoI) has strived to reduce hunger, food insecurity, malnourishment and poverty by ensuring national food security through domestic self-sufficiency in the two major food grains, rice and wheat (Acharya, 2009; Sarma, 1978). This objective is pursued through four broad instruments; producer price support, trade policies, input subsidies and food distribution subsidies (OECD, 2014). The main government agency in charge of implementing food policy, the Food Corporation of India (FCI), is responsible for procuring grain from farmers, for distributing the grain back to the consumers (both tasks in cooperation with state agencies), as well as for managing the "central pool" of government held stocks through international and domestic market transactions.

Farmers receive support through input and output price subsidies.¹ Input market policies play an important role in India's agriculture, affecting access to seeds, fertilizers, electricity, water and farm credit (OECD, 2014). Especially fertilizer prices are heavily subsidized and fiscal fertilizer subsidy expenditures have been growing strongly the last decade or so from Rs 262 billion in 2006-07 to Rs 680 billion in 2013-14 and a budgeted Rs 730 billion in 2014-15 (Planning Commission, 2014). Not all of the subsidy reaches the farmers though. Fan et al. (2008) estimate that two thirds of the fertilizer subsidy went to the Indian farmers over the last two decades and the rest was captured by the domestic fertilizer industry.

¹India does not participate in the OECD agricultural policy review process. Consequently, OECD estimates of agricultural support for India are not available. The World Bank's Distortions to Agricultural Incentives database does cover India, but the support estimates are unavailable for several of recent years of interest. For this reason we choose to disregard them in the present paper.

To eliminate some of the price uncertainty farmers face, fixed Minimum Support Prices (MSPs) are announced at the beginning of the sowing season every year.² FCI subsequently conducts open ended procurement of rice and wheat, meaning that it is obliged to buy any amount offered at the MSP, thus ensuring a floor level to farm gate prices. The government does not procure other crops but instead it intervenes in the market in other ways to defend the minimum farm-gate prices.

As shown in upper panel of figure 1, annual increments in support prices have increased following the 2007-08 international grain price spikes. In fact, average annual growth from the 2005-06 to the 2014-15 crop years in the nominal MSP of paddy, coarse grain and wheat was 9, 10 and 11 percent, respectively, compared with 4, 2 and 3 percent, respectively, in the 2000-01 to 2005-06 period.

Prior to the food crisis, real MSPs were fairly constant or even slightly decreasing (cf. the lower panel of figure 1). Since 2005-06, however, real paddy, coarse grain and wheat MSPs have increased somewhat by 12, 17 and 5 percent, respectively, corresponding to average annual rates of 1, 2 and 1 percent. In real terms, the MSP of the three grains peaked in the 2009-10 (paddy) and 2007-8 (coarse grains/wheat) crop years. Table 3 in the appendix summarizes the yearly MSP increases since 1990.

Although producer support prices have gone up considerably the last decade it is, apparently, primarily a small group of large farmers, which supply most of the grain, that have benefited from this. According to GoI (2015b), out of India's 90 million agricultural households, around 19 million reported sale of paddy during the period July-Dec 2012, but only 2.5 million households actually sold paddy to a procurement agency and these sold less than 30 percent of their rice at MSP. During the period Jan-June 2013 only 550 thousand households benefited from procurement operations, a mere 10 percent of the households reporting sale of paddy in this period. Further, these 550 thousand households sold only 14 percent of their paddy at MSP. Of the 13 million households reporting sale of wheat, only 2.1 million benefited from procurement and these sold only 35 percent of their wheat at support prices.

Until 1997 India's food distribution policies was carried out under the aegis of the Public Distribution System (PDS). At that time the PDS turned into the Targeted Public Distribution System (TPDS) following reforms which, as the name suggests, meant abandoning the universal nature of the PDS in favor of an approach which targets poor households. Recently, there has been a move back towards universalism though, with the passing of the National Food Security Act (NFSA) in September 2013

²For rice, which is the main kharif or summer crop, sowing starts with the onset of the monsoon in June and harvesting commences in October. For wheat, which is the main Rabi or winter crop, sowing begins in October and harvesting starts from April onwards. The Indian crop year runs from July-June and the marketing year runs from April-March. Rabi crops grown in crop year t are marketed in year $t + 1$.

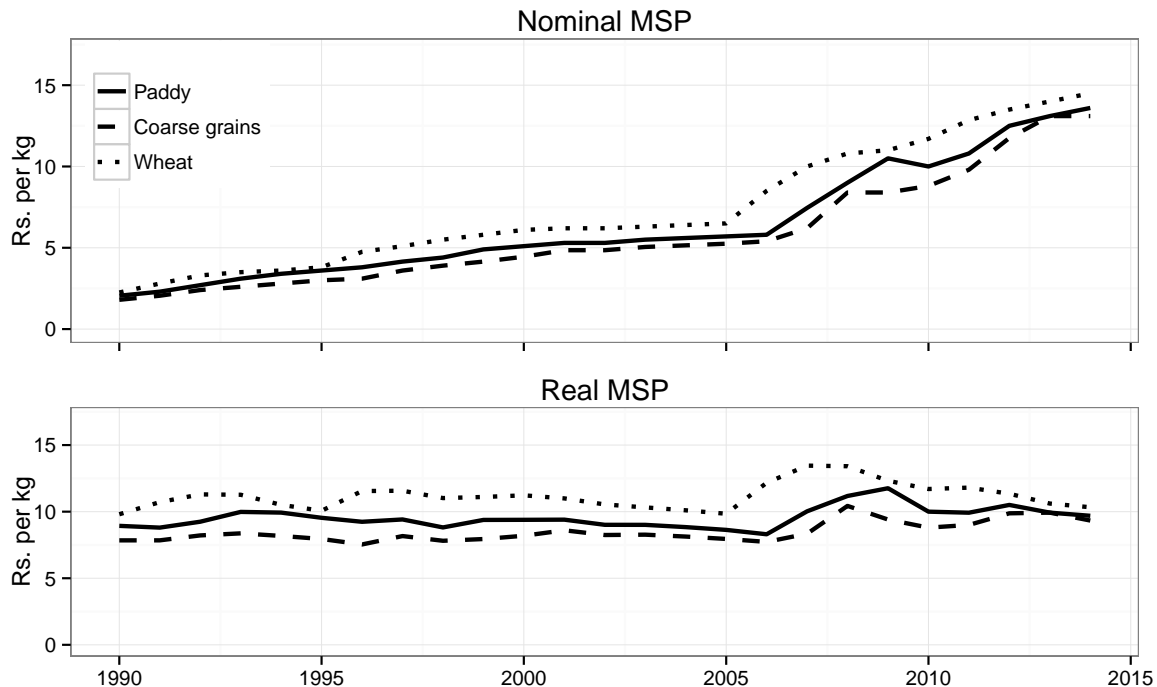


Figure 1: Minimum Support Prices for selected grains 1990-2014. Source: Federal Reserve Bank of India. Database on Indian Economy; OECD. Main Economic Indicators. Note: real MSPs have been deflated by the consumer price index which is normalized with respect to the 2010 average. For MSPs, years refer to crop years, i.e. 1990 refers to the 1990-91 crop year etc.

which expands the access to subsidized food grains to two thirds of the population.

Grain procured by the Indian Government is distributed back to the consumers through registered outlets called fair price shops. Prices in these shops are administered by the state governments which buy the grain from FCI at so called Central Issue Prices (CIPs). Under the TPDS the CIPs depended on the income status of the household, in particular whether the household was below or above the poverty line. Specifically, during the 2002 to 2013 period when CIPs remained constant, below average (BPL) households CIPs were Rs 4.15, 5.65 and 3 for a kilo of wheat, rice and coarse grain, respectively. Above poverty line (APL) household CIPs were Rs 6.10, 7.95 and 4.50, respectively, per kilo of grain and, finally, CIPs for the group of very poor called Antyodaya Anna Yojana (AAY) were Rs 2, 3 and 1.5, respectively. Real CIPs decreased by 7.5 percent on average, annually, in this period due to inflation as measured by increases in the consumer price index.

Under the old rules, each household could buy up to 35 kg of subsidized grain per month through the fair price shop, at prices not exceeding the CIP by more than a state specific retail margin. Many states were (and still are), however, selling the grain to the

consumers at prices below the CIPs.³ The new food security bill (NFSA) entitles 75 percent of the rural and 50 percent of the urban population to 5 kg of grain per month at issue prices of Rs 3, 2 and 1 per kg of rice wheat and coarse grains, respectively. With an average household size of 5 persons, these priority households will be able to purchase around 25 kg of grain per month, on average. AAY households will, in principle, be able to purchase up to 35 kg. of grain per month at these prices. Amounts above these limits must be purchased on market terms.

The widening difference between administered producer and consumer prices has caused fiscal costs of the food redistribution scheme, called the food subsidy, to increase rapidly in recent years, from Rs 240 billion in 2006-07 (around USD 5.3 billion) to Rs 920 billion in 2013-14 (around USD 15.7 billion) and a budgeted Rs 1,150 billion in 2014-15 (Planning Commission, 2014). In relative terms though, the food subsidy still corresponds to less than one percent of GDP, reflecting high rates of inflation as well as strong economic growth during this period.

What is more worrying is the evidence that the food distribution scheme is highly inefficient and subject to major ‘leakages’, although there appears to have been some progress recently. Himanshu (2013), for example, reports that as much as 40 percent of all grain distributed through the PDS did not reach its intended recipients in 2009-10 (25 percent the rice and 59 percent of the wheat, respectively).⁴ It is commonly believed that much of the TPDS is sold on the black market but the system is also plagued by inclusion and exclusion errors. That is, many households are classified incorrectly and does therefore not have access to the amounts of subsidized grain they are entitled to.

2.2 Trade, stocks and the 2007-11 grain export bans

India is the world’s second largest producer of rice after China and, according to USDA, one fourth to one fifth of all the rice produced comes from India. It is the third largest producer of wheat after China and the European Union, with around one eighth of the global wheat production coming from India. As figure 2 illustrates, the country used to import large amounts of both grains, especially wheat, but it is now self sufficient in most years and it has actually emerged as a major exporter of especially rice since the mid-1990’s with exports above 10 MMT in 2011-13. However, as can be seen, Indian grain trade in the recent period has been highly unstable. The reason is that

³According to Himanshu (2013), as of 2010, 13 Indian states had reduced the price of wheat and rice to Rs 3/kg or less. In the state of Tamil Nadu, all resident households are entitled up to 20 kg of rice per month, free of charge.

⁴See also Himanshu (2011), Khera (2011a,b), Drèze and Khera (2015), Gulati and Saini (2015) among others.

the Indian domestic agricultural and food policies are supplemented by ad-hoc trade policies through which GoI regulates the domestic supply and stocks of grain.

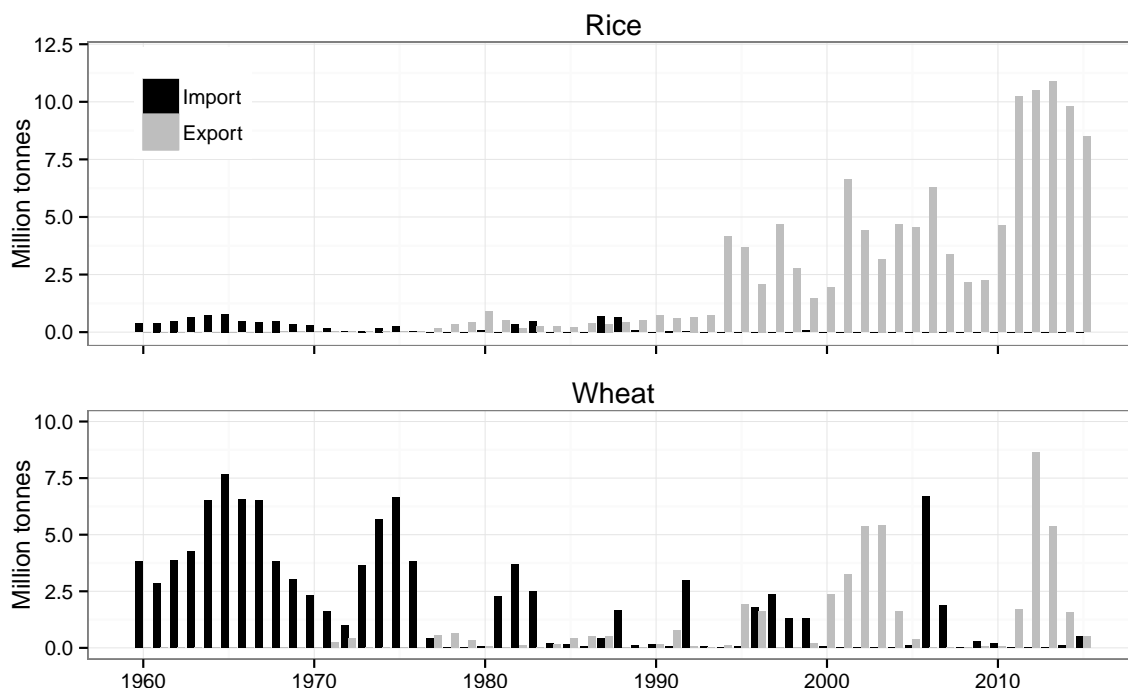


Figure 2: Wheat and rice trade 1960-2014. Source: USDA (2015).

Government stocks must be large enough to supply the TPDS and other welfare schemes and to ensure adequate supply and stable wholesale prices in years of production shortfalls e.g. due to droughts or floodings. However, stock levels have proved difficult to manage in practice and have often exceeded the norm by a large margin. Specifically, since 2008, stocks have been 90 percent higher than the mandated norm on average (Saini and Kozicka, 2014). Government stocks of wheat and rice reached a record level of 82 MMT in June 2012 (FCI, 2015), cf. figure 3. At the time, the buffer norm for rice was 11.8 MMT including the 2 MMT strategic reserve (for stabilizing prices) and the wheat buffer norm was 20.1 MMT including the 3 MMT strategic reserve.⁵ According to GoI (2015b), the storage capacity of FCI and state agencies is 72.5 MMT as per January 2015, of which 15.7 MMT is so called cover and plinth, which is a standardized system of outdoor storage of grain in bags covered by plastic. As noted by Gulati et al. (2012) and many others, overstocking is very costly and leads to wastage⁶,

⁵Indian buffer stock norms depend on the quarter of the year reflecting the cyclical pattern of grain production. Buffer norms are thus highest right after the harvest and lowest prior to the harvest. See Saini and Kozicka (2014) for a review of the Indian stocking policies

⁶GoI (2015b), for example, reports operation costs of Rs 30/kg of rice and Rs 22/kg wheat against a rice MSP of around Rs 20/kg (assuming a turn out ratio of 0.67) and a wheat MSP of Rs 14/kg in

which may force the politicians to off-load the excess stock on the international markets. This may even require export subsidies to an extent which is exacerbated by the negative impact on world market prices (Jensen and Anderson, 2014).

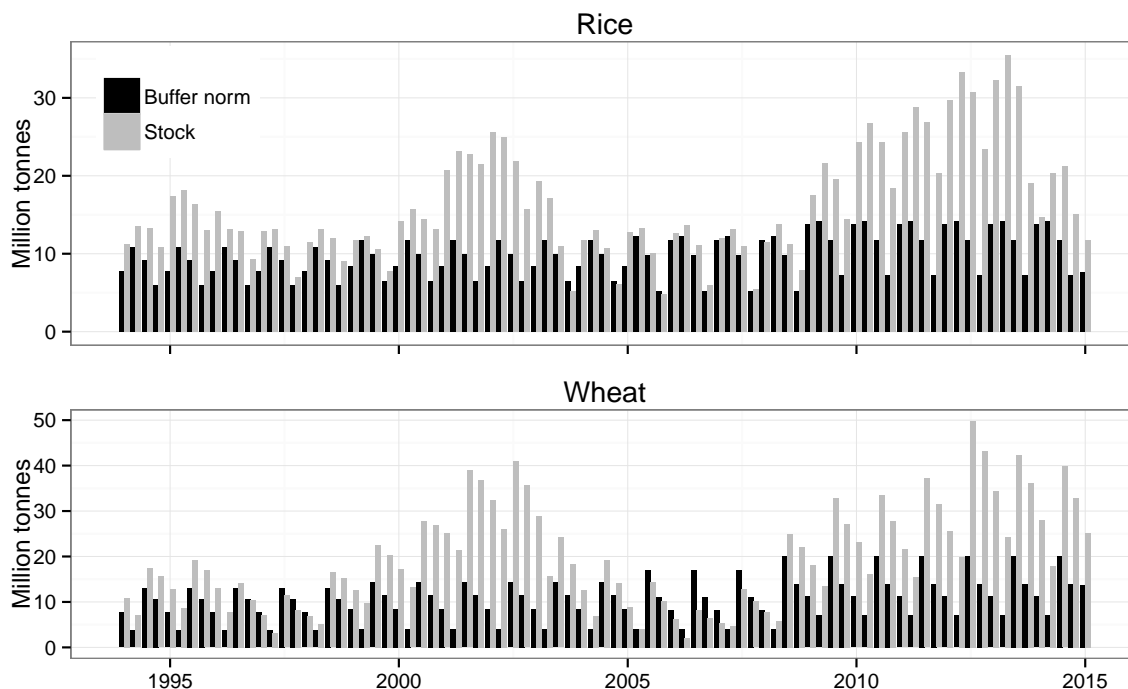


Figure 3: Stocks and buffer norms. Source: GoI (2014, 2010, 2005, 2001)

This is exactly what happened in the early 2000s. As shown in figure 2 and 3, following a period with growing stocks of both grains due to generous producer support prices, Indian wheat exports increased from 0.2 MMT in 1999 to 5.4 MMT during the peak year of 2003. In the following years wheat exports declined back to 0. Rice exports grew from 1.4 MMT in 1999 to an average of 4.2 MMT during the 2001-2006 period prior to the ban. Given the relatively high domestic prices caused by high MSPs, the increase in exports was a direct result of GoI providing budgetary subsidies to support exports of surplus grain (Kubo, 2011; Jha et al., 2007). In 2005 GoI decided to cancel its export subsidies but it was too late; in June 2006 wheat stocks were reduced to 8.2 MMT, around half of the buffer norm. To replenish stocks and increase domestic supply, GoI increased procurement and distribution through the PDS and slashed import tariffs on wheat to zero. This resulted in a wheat import of 6.7 MMT in 2006 and 1.9 MMT in 2007. The rice tariff remained at 70 percent; a level which prohibits import.

Export of wheat and rice was banned from 2007-11. However, as figure 2 shows, this did not prevent rice from leaving the country. This is mainly because the ban only

applied to ordinary rice, which is the type mainly consumed domestically, not basmati which is mainly exported to the Middle Eastern countries, Saudi Arabia, in particular (Kubo, 2011). As shown in figure 4, exports of basmati rice have grown steadily since 2000 and have been above 1 MMT p.a. since 2004-05. The large fluctuations in total rice exports since the mid-1990's noticeable from figure 2 is thus a result of fluctuation in the level of basmati exports.

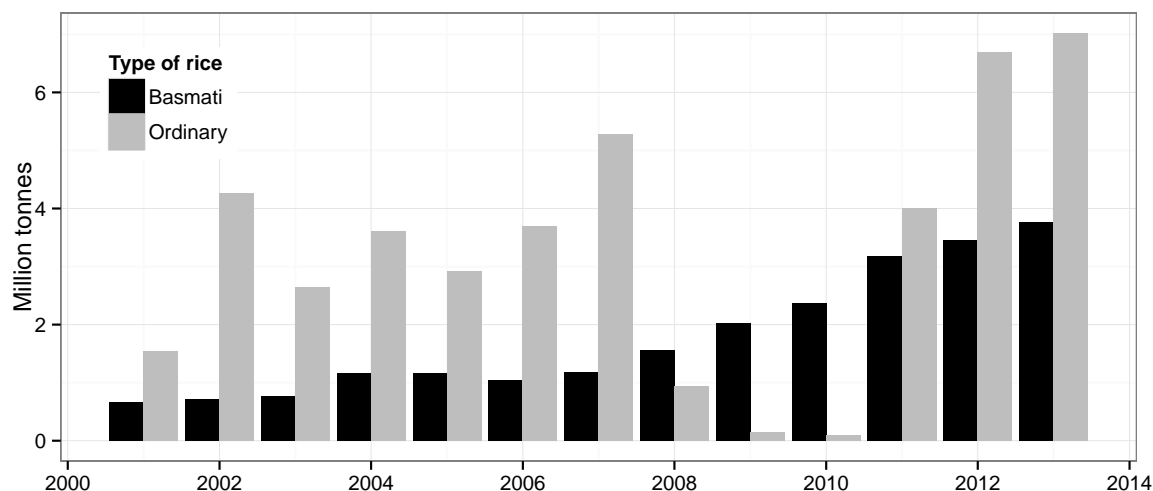


Figure 4: Indian export of ordinary and basmati rice 2001-14. Source: GoI (2015a, 2011, 2008). Note: years refer to fiscal years (April-March). 2001 therefore refers to April 2001-March 2002 etc.

India became a major exporter of ordinary rice in 1995-96. This was a result of export liberalizations in 1993, replacing quantitative restrictions on non-basmati exports with minimum export prices which were subsequently abolished in 1994. At the time of the new millennium non-basmati rice exports had become uncompetitive due to increases in the MSP and low world market prices causing stocks to grow. The following years exports picked up again, initially due to budget subsidies and later due to rising world market prices. But when FCI failed to procure its wheat targets in 2006 and again in 2007 necessitating large imports in those years, the government became anxious to secure domestic availability of grain (Kubo, 2011).

Faced with a wheat procurement failure two years in a row and stocks well below the norm, the GoI placed a ban on export of wheat in February 2007 and actively began to import wheat. Prior to that, the import tariff was reduced to zero in September 2006. In anticipation of a rice procurement failure as well, the GoI placed a ban on export of non-basmati rice on October 9, 2007 (Sharma, 2011). Export demand for Indian non-basmati rice was so great at this point that there were reports of rice meant for the

PDS being diverted for exports and millers shirking their levy obligations in order to export the rice instead (Sarma, 2007). The ban naturally led to protests from growers of premium non-basmati varieties meant for export (Kubo, 2011). The rice export ban was therefore replaced with a minimum export price (MEP) of \$425/tonne on October 31 which was supposed to prevent the cheaper varieties from flowing out of the country. so called incentive bonuses of Rs 1000/tonne were also added to the MSP of wheat and common paddy in 2007. To the surprise of GoI and most others the international price of rice kept increasing and exports of common rice kept flowing. GoI therefore raised the non-basmati MEP to \$ 500/tonne in December 2007 and subsequently to \$650/tonne in early March 2008 and to \$1000/tonne later same month. Also in early March 2008 a separate basmati MEP of \$900/tonne was introduced which was raised to \$1000/tonne later same month. Finally, on April 1, 2008 an export ban was reimposed on non-basmati rice and the basmati MEP was raised to \$1200/tonne (Kubo, 2011).

The wheat MSP increased by two thirds from RS 6500/tonne for the crop year of 2005-06 (marketed in 2006-07) to Rs 10800/tonne for the 2008-09 crop year (marketed in 2009-10). Similarly, the common paddy MSP went from Rs 5800/tonne for the 2006-07 crop year (marketed in 2006-07) to Rs 10500/ tonne in 2009-10, an increase of more than four fifths. In combination with the export ban, this caused the stocks to grow substantially as discussed above. The export ban on wheat and rice was lifted on July 19, 2011.

As figure 4 shows, Indian exports of non-basmati rice were not zero in the ban period. Some export did take place, mainly in the form of government-government deals concerning food aid to other developing countries. In particular, in 2008 GoI agreed to sell 450 thousand tonnes at a price of \$400/tonne to Bangladesh which had been badly hit by the cyclone Sidr in November the previous year (Kubo, 2011). Table 4 in the appendix, which is reproduced from Baylis et al. (2014), provides a timeline of the policies associated with the rice and wheat export bans.

3 Methodology and data

This section presents the frameworks used to estimate the price impact of the 2007-11 Indian grain export ban. We first present the data based on which we analyse the Indian export ban and its consequences. Then we introduce the general approach to estimating causal impacts of interventions used in this paper.

3.1 Data

We model separately the domestic wholesale and retail price of rice and wheat. A number of sources provide data on Indian (food) prices (see Patnaik et al., 2011). First, regarding individual commodity prices, the Indian Ministry of Agriculture and Directorate of Economics and Statistics keep databases of wholesale and retail prices of a large number of food goods and markets. But the time series are littered with missing values and outliers and/or it is only possible to retrieve data for one month at a time. Centre for Monitoring Indian Economy (CMIE) writes on its website that it has a large database of agricultural commodity prices but one needs a subscription to access the data. For these reasons we choose not to use any these data sources. The FAO price database, GIEWS, supplies retail price data on several food items, including rice and wheat from 4 important producing and consuming areas going back to January 2000. This data, which represents actual market prices, is easily accessed and complete and our rice and wheat price analysis is therefore based on this data.

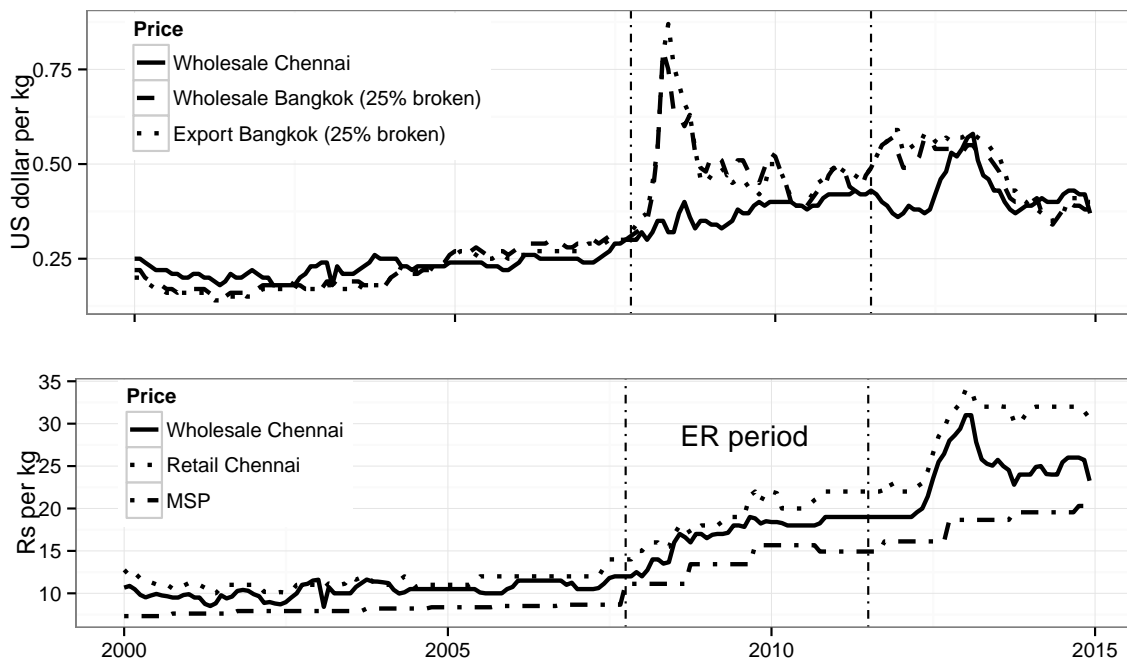


Figure 5: Wholesale, retail, export and producer support prices of rice 2000:1-2014:12. Source: FAO/GIEWS; Federal Reserve Bank of India. Note: The Paddy MSP, which is measured in Rs/100 kg has been divided by 67 to make it comparable to the Rs/kilo rice prices (assuming a conversion rate of 0.67).

Figure 5 illustrates the development in rice prices between January 2000 and December 2014. The top panel compares the wholesale price of rice in Chennai, the state

capital of Tamil Nadu which is an important rice producing area in the south of India, with the (very similar) Bangkok wholesale and export prices of 25% broken. As can be seen, Indian wholesale prices clearly avoided the spike which hit the international benchmark prices and domestic prices in many other countries. Also note that the starting date of the rice export ban, more precisely the second rice export ban starting from April 1, 2008, was just prior to the peak in international rice prices in May. The lower panel compares the Chennai wholesale and retail prices and MSP of paddy, where the latter has been converted to milled basis (see figure note). Price margins appear to be fairly constant up to the spike in early 2013, after which they diverge.

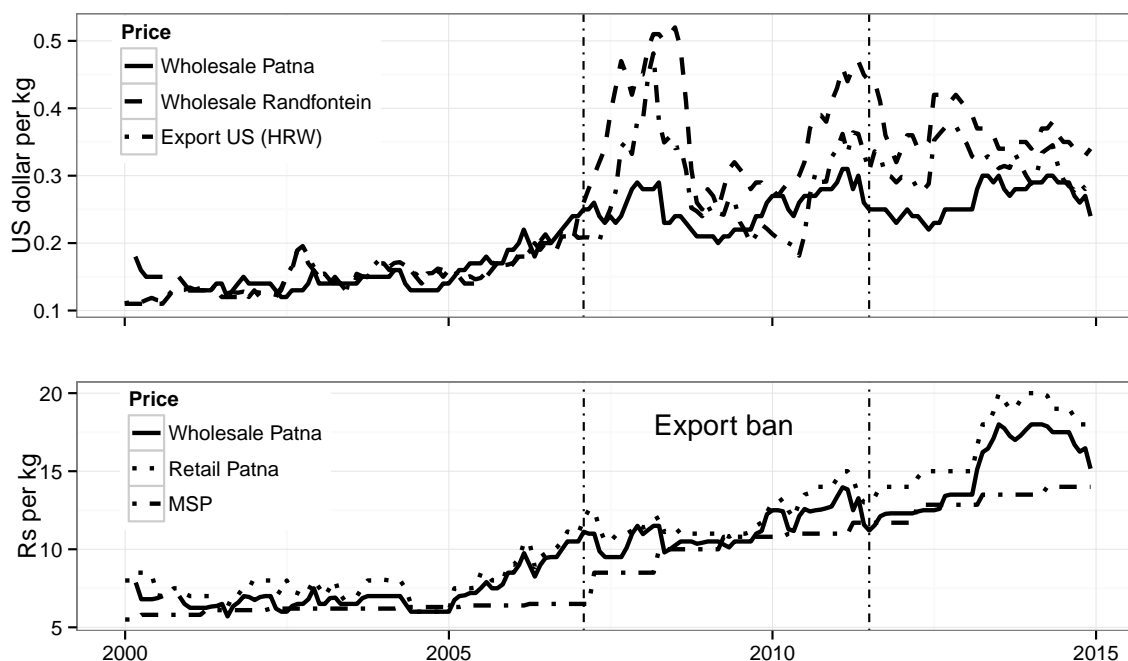


Figure 6: Wholesale, retail, export and producer support prices of wheat 2000:1-2014:12. Source: FAO/GIEWS; Federal Reserve Bank of India.

The top panel of figure 6 compares the wholesale price of wheat in Patna, the state capital of Bihar, an important wheat (and rice) producing area in the north of India, with the Randfontein wholesale price and the US gulf export price of hard red winter. Again we see that the Indian wholesale prices did not increase the same spikes as did the prices in less interventionist countries such as South Africa or the world market price. From 2000 and up until the start of ban, Indian, US and South African wheat prices followed each other quite closely. Since then, they appear to have become detached until recently. Indian market margins appear to be fairly constant in the entire period, as shown in the lower panel of figure 6.

Apart from actual market price data, there are also Indian price *indexes* covering wheat and rice. As it happens, there are currently four separate consumer price indexes (CPIs) as well as a wholesale price index (WPI) in use in India. The WPI, which is the index that has traditionally been used to monitor Indian inflation, is by far the most detailed and it includes wheat and rice sub-indexes. The downside is that it neither represents prices faced by consumers nor producers but rather transactions at the first point of bulk sale which, for agricultural commodities, may be farm harvest prices, prices at the village mandi/market of the Agricultural Marketing Produce Committee or support prices (OEA, 2008). The WPI, therefore, is an average of market prices and administered prices such as MSPs. For this reason we do not base our analysis of domestic price increases on the wheat and rice components of the WPI.

We do, however, use WPI data related to input prices and the general price level, more specifically the WPI of fertilizer, pesticides, fuel, non-food and manufactured goods. In addition we control for the domestic price of other common food Indian items such as chickpeas, onions, potatoes and sugar. In the rice model we also control for the domestic price of wheat and, of course, the world market price of rice. In the wheat model we control for the domestic price of rice and the world market price of wheat.

3.2 Conceptual model

Our conceptual models relates the domestic price of grain $g = (rice, wheat)$ to the world market price of g as well as to other relevant prices. It is written

$$p_{g,d} = f(p_i, p_{np}, p_{g,w}, u),$$

where p_i , p_{np} , p_{fp} and $p_{g,w}$ denote the price of inputs (fertilizer, pesticides, fuel price indexes), other non-food prices (the non-food and manufactures price indexes) and international grain prices, respectively. Finally, u denotes a vector of other unmodeled price shifters and seasonal effects. We could also have included the domestic price of other important Indian food staples such as chickpeas, onions, potatoes, etc. but these are presumable not exogenous to the price of wheat/rice prices. Likewise, one could argue that the international price of wheat and rice depends on the domestic price of these grains in India but in this paper we consider the international prices to be exogenous to the domestic ones.

In contrast to Baylis et al. (2014) and many others we our model is not based on the Law of One Price (LOP) framework. Instead we take a more general approach encompassing the LOP. The LOP framework which relates a domestic price to its in-

ternational counterpart is very popular in time series analyses because its parsimony. However, its assumptions are often not realistic. Even when it comes to something as basic as agricultural commodities there are important differences related to quality, varieties and blends. This means that there other factors determining price differences other than transport costs.

3.3 Estimating the price impact of the grain export ban

We use a Bayesian structural time-series model to estimate the impact of the Indian grain export ban. More specifically, we estimate the counterfactual domestic rice, wheat and food price development with a statespace time-series model and compare it with the actual price development. The counterfactual prices are the model predictions, ignoring the export ban. These predictions are also known as a dynamic forecast in the time series literature. Essentially, we estimate the model parameters on the pre-intervention sample and to use these to calculate the entire post-intervention price path. One component of the state is a linear regression on the contemporaneous predictors. The dynamic forecast is thus conditional on the pre-intervention price path as well as the pre- and post-intervention values of the predictor variables. This approach to intervention analysis was popularized by Harvey and Durbin (1986) and has recently been reconsidered by Scott and Varian (2014) and Brodersen et al. (2014).

We follow Durbin and Koopman (2012) and write the general Gaussian state space model as

$$y_t = Z_t \alpha_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, H_t) \quad (1)$$

$$\alpha_{t+1} = T_t \alpha_t + R_t \eta_t, \quad \eta_t \sim N(0, Q_t), \quad t = 1, \dots, n, \quad (2)$$

where y_t is a $p \times 1$ observation vector and α_t is an unobserved $m \times 1$ vector called the state vector. Equation (2), governing the evolution of the system's latent state, is called the state equation whereas the equation (1), linking the observed outcomes to the underlying latent state of the system, is called the observation equation. ε_t is a vector of observation errors with covariance matrix H_t and η_t is a system error vector with state-diffusion matrix Q_t , where $q < d$. Finally, Z_t and T_t are parameter matrices with dimensions $p \times m$ and $m \times m$, respectively. The benefit of writing the error structure of equation (2) as $R_t \eta_t$ is that it makes it possible to incorporate state components of less than full rank where a seasonal component is the leading example.

A large class of time series models, including ARIMA models, can be written on state space form which makes it a very flexible framework. Another advantage of structural models is that they are modular, meaning that the state vector and system parameter

matrices can be specified to include component sub-models capturing various features of the data such as trends, seasonality and cycle dynamics. The specific model we work with in this paper is given by

$$y_t = \gamma_t + x_t\beta_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_\varepsilon), \quad (3)$$

where y_t is a scalar and γ_t is a seasonal component evolving according to

$$\gamma_{t+1} = - \sum_{s=0}^{S-2} \gamma_{t-s} + \zeta_t, \quad \zeta_t \sim N(0, \sigma_\zeta). \quad (4)$$

The random shock, ζ_t ensures that the seasonal patterns changes over time. S is the number of seasons such that γ_t includes the $S - 1$ most recent seasonal effects. Note the implied parameter restriction $\sum_{j=1}^S \gamma_j = 0$ since ζ_t have expectation zero. That is, the total (average) seasonal effect summed over all S seasons is zero.

The second and crucial component of the model is a set of contemporaneous covariates, x_t , with assumed constant coefficients, β . The covariates, x_t , are a number of control time series which respond to some of the same unobserved (non-seasonal) effects as y_t but they receive no treatment. Their linear combination represents a single ‘synthetic control’ and it is this regression component of the model, $x_t\beta$, which allows us to obtain counterfactual predictions following the intervention.

We bring our specific model (3)-(4) on state space form by defining the state and system errors as

$$\alpha_t = (\gamma_t, \gamma_{t-1}, \dots, \gamma_{t-S+2}, \beta_t')', \quad \eta_t = \zeta_t$$

and the system matrices as

$$Z_t = (Z_\gamma, x_t), \quad T_t = \text{diag}(T_\gamma, 1)$$

$$R_t = (1, 0, \dots, 0), \quad Q_t = \sigma_\zeta,$$

where

$$Z_\gamma = (1, 0, \dots, 0), \quad T_\gamma = \begin{bmatrix} -1 & -1 & \cdots & -1 & -1 \\ 1 & 0 & & 0 & 0 \\ 0 & 1 & & 0 & 0 \\ & & \ddots & & \\ 0 & 0 & & 1 & 0 \end{bmatrix}.$$

There are at least three things worth noting here. First, the formulation implies constant regression component parameters, $\beta_{t+1} = \beta_t$. Secondly, the rank of the diffusion matrix $Q_t = \sigma_\zeta$ is obviously unity reflecting the fact that there is a single state innovation

process $\{\zeta\}_{t=1}^n$ driving the latent state of the system. Thirdly, neither the state nor the observation error variances have time indexes implying stationary forcing processes. Each of these assumptions can be relaxed within this framework.

3.4 Priors and Inference

Let θ denote the set of model parameters and $\alpha = (\alpha_1, \dots, \alpha_n)$ the full sequence of states. By specifying a prior distribution $p(\theta)$ on the model parameters, θ , and a conditional distribution, $p(\alpha_0|\theta)$, on the initial state, α , we can sample from the joint distribution of states and parameters, $p(\alpha, \theta|\mathbf{y})$, using a Markov Chain Monte Carlo (MCMC) algorithm. The prior distribution for the variance of the state errors is traditionally chosen to be an inverse Gamma. For the regression coefficients we use a mixture prior with a spike component concentrating its mass close to zero and a slab component with a mass spread out over a wide range of values. Such so called spike-and-slab priors are used extensively for model selection within the Bayesian approach to regression analysis (see George and McCulloch (1993); Scott and Varian (2014); Brodersen et al. (2014)).

Model inference involves three steps. First we simulate draws from the joint distribution of model parameters and states given the pre-intervention observed data. Next we use these draws to simulate the posterior predictive distribution of the counterfactual. Finally, we compute the pointwise impacts of the intervention by subtracting the counterfactual draws from the target series in the intervention period in order to get the approximate posterior predictive density of the effect attributed to the intervention, i.e. the export restrictions. It is the pointwise causal impact that is of primary interest in this paper. A detailed description of the procedure can be found in Brodersen et al. (2014).⁷

4 Results

In this section we present the results from the analysis described above.

Figure 7 illustrates the development of the Chennai rice retail prices since January 2000 as well as the counterfactual estimated development and the impact of the the export restrictions (the difference between the counterfactual and the actual) based on the structural rice model discussed in section 3. Like Baylis et al. (2014) we consider the period of export restrictions (ER) starting from October 2007, rather than the ban per se, c.f. table 4 in the appendix and the discussion in section 2.

As can be seen from the top panel of figure 7, the model is not able to predict the

⁷We use the R-package CausalImpact, written by the same authors, to carry out inference of the model.

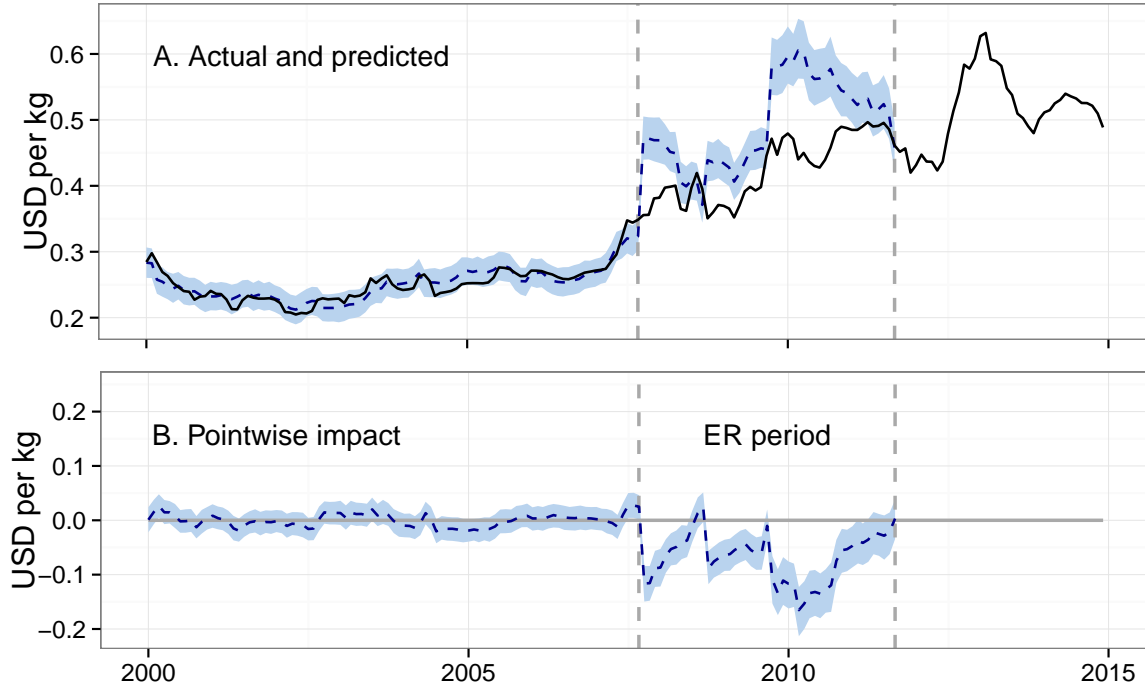


Figure 7: Predicted and actual rice prices. Note: The solid line represents the retail price of rice in Chennai, India, in USD/kg. The dashed line is the mean of the posterior 90% predictive interval (the shaded area).

domestic rice price development during the ban very accurately since the predicted price is somewhat higher than the actual price in most of the ER period. This suggests that the export restrictions did indeed have an effect on domestic retail rice prices. Domestic prices are predicted to increase sharply right after the beginning of the ER period but, in reality, they did not. The same holds for the periods around 2008 and 2009-2010. Counterfactual and actual prices converge towards the end of the ban period as we would expect them to from the LOP.

The lower panel of figure 7 illustrates the pointwise impact of the policy intervention, i.e. the rice export restrictions, on domestic rice prices. The impact is defined as the actual price minus the counterfactual price. It therefore makes sense that the impact is negative, given that the purpose of the export restrictions was to insulate the domestic market and thus prevent domestic prices from rising too much. The sharp spikes in the counterfactual prices in 2007, 2008 and 2009, and the significant negative impacts, correspond to the sharp increases in the paddy MSP in these periods. Recall that paddy support prices were increased by 28, 21 and 17 percent in October 2007, 2008 and 2009, respectively, c.f. table 3. The main finding here seems to be that retail rice prices responded less than predicted to this during the ER period. On the contrary,

there is no sharp spike in the counterfactual rice price at the time of the international rice crisis in the first part of 2008, which seems to suggest a weak connection between the domestic retail price of rice in India and the international export price, even prior to the ER period.

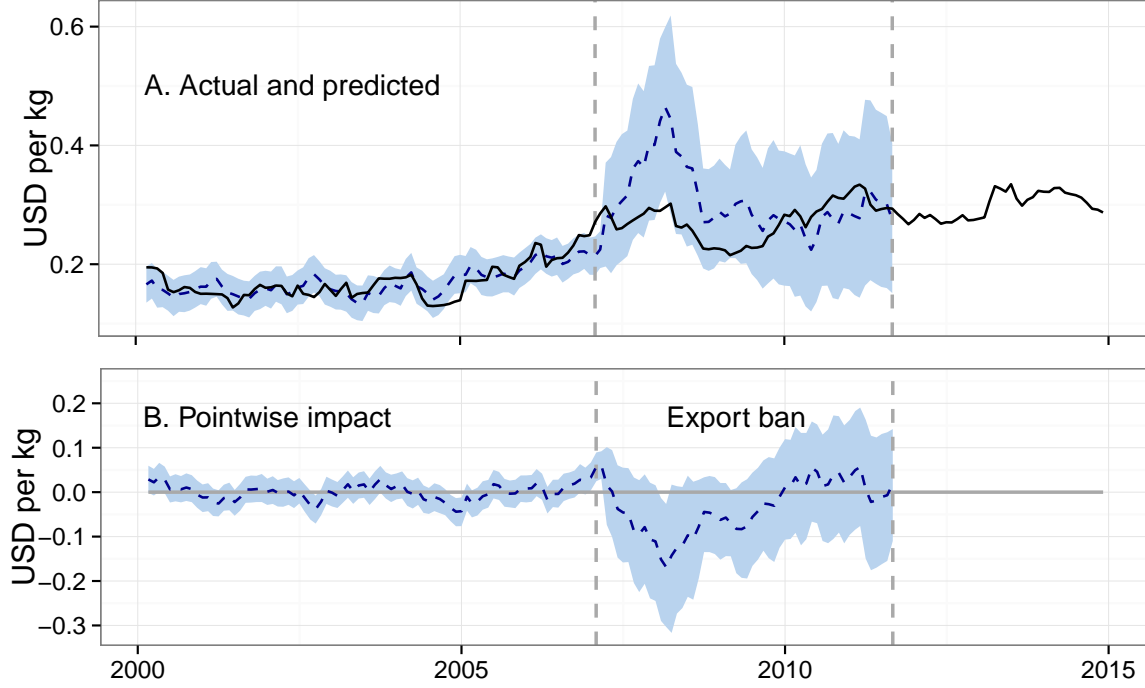


Figure 8: Predicted and actual wheat prices. Note: The solid line represents the retail price of wheat in Patna, India, in USD/kg. The dashed line is the mean of the posterior 90% predictive interval (the shaded area).

The top panel of figure 8 illustrates the evolution of domestic retail wheat prices from Patna, India, since January 2000 along with the counterfactual price path predicted by the model and the estimated causal impact of the wheat export ban. Again following Baylis et al. (2014), we predict the domestic wheat price starting from February 2007 and onwards. In this case the 2008 international price spike is clearly visible in the predicted domestic wheat price. The smaller 2010-11 spike is not noticeable. Around 2010, domestic wheat prices starts to evolve almost as one would expect, given the development in producer support and input prices and the general price level such that, at the end of the ban period, the actual and predicted prices converge as in the rice model. The lower panel shows that the causal impact of the export ban on domestic wheat prices is significant, at the 90 percent level, the time of 2008 peak. The mean impact at the time is around -0.175 meaning that domestic wheat kilo prices increased 17.5 cents or 40 percent less than predicted.

The coefficients underlying the predictions illustrated in figure 7 and 8 are summarized in table 1 and 2. The first two columns represent the mean and standard deviations from the distribution of the estimated coefficients from all simulations. Similarly, column three and four represent the mean and standard deviation of the estimated coefficients based on the simulations where the variable in question is included in the regression. Finally, the last column shows the share of simulations that the variable is included in the regression i.e. the inclusion probability. It is the spike-and-slab prior mentioned in section 3.4 which is the source of this model averaging.

	mean	sd	mean.inc	sd.inc	inc.prob
msp	1.67	0.13	1.67	0.13	1.00
Fertilizer	-0.35	0.07	-0.36	0.06	0.99
FUEL	-0.01	0.05	-0.13	0.12	0.08
MANUF	-0.01	0.05	-0.08	0.16	0.06
int_rice	-0.00	0.04	-0.02	0.17	0.06
NFOOD	0.00	0.03	0.06	0.10	0.05
Pesticide	-0.00	0.00	-0.02	0.02	0.02
(Intercept)	0.00	0.00	0.00	0.00	0.00

Table 1: Coefficients from the rice model

	mean	sd	mean.inc	sd.inc	inc.prob
NFOOD	-1.09	0.21	-1.09	0.21	1.00
int_wheat	0.94	0.21	0.94	0.21	1.00
msp	0.98	0.92	1.63	0.58	0.60
MANUF	0.38	0.43	0.76	0.29	0.50
Pesticide	-0.01	0.03	-0.10	0.05	0.06
FUEL	-0.01	0.10	-0.17	0.37	0.06
Fertilizer	-0.01	0.06	-0.11	0.23	0.05
(Intercept)	0.00	0.00	0.00	0.00	0.00

Table 2: Coefficients from the wheat model

In the rice model the MSP has a large positive effect on the retail price, as expected from figure 7, whereas the price of fertilizer and fuel have negative effects. These latter inverse price relationship are hard to make sense of and probably do not represent causal effects. Also as expected, the international price of rice does not have an effect on the domestic price of rice, according to the model. In the wheat model there are more variables that have large coefficients. The effect size of the wheat MSP is similar to the rice MSP in the rice model. But as we expected from figure 8 and unlike international rice prices in the rice model, international wheat prices have a strong effect on domestic wheat prices in the wheat model.

5 Concluding remarks

Our analysis shows that the 2007-11 Indian grain export ban had the desired effect; it caused domestic rice and wheat prices to increase less in certain periods than they would have in the absence of any export restrictions. Domestic wheat prices in particular increased around 40 percent less than they would have done otherwise in 2008, according to the model. The effect of the export ban on domestic rice prices was a bit different. It apparently caused increases in producer support prices to have a lower impact on consumer prices than they would have had otherwise. International rice prices do not seem to have had a significant impact on domestic rice prices even prior to the ban. What is the cause of these differences between the wheat and the rice market in India? At this point we can only conjecture that the occasional and recent reliance on the world market for import is the root of the tighter link between domestic and international wheat prices in India.

As mentioned in the introduction, a couple of papers have formally considered the welfare impact of the 2007-08 domestic food price increases in India, namely De Janvry and Sadoulet (2009) and Groom and Tak (2015). Both these studies calculate the welfare changes associated with the actual domestic food price changes around the time of the 2007-08 food crisis. Groom and Tak (2015) go a step further and compare these with the welfare changes resulting from counterfactual domestic price increases as large as the international ones. The difference between the two welfare impacts is the estimated impact of the export ban. It turns out that the mean welfare impact of the export ban, based on this calculation, is 7 percentage points for net consumers of rice and -23 percentage points for the net sellers of rice. More precisely, according to their calculations, net consumers would have experienced a welfare loss of 6 percent during the period April-June 2008 had domestic rice prices increased as much as an international benchmark but instead net consumers of rice experienced an welfare increase of 1 percent as a result of the actual domestic price changes. Net sellers, on the other hand, would have been 19 percent better off had the domestic rice prices increased as much as the international rice prices. This was not the case, however, and instead they ended up 5 percent worse off in this period. As we have pointed out several times in this paper, it is probably not reasonable to assume that domestic rice prices in India would have increased as much as, for example, the Thai export prices, had there been no export ban. This means that the welfare impact of the export ban is probably much lower than the Groom and Tak (2015) study suggests.

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Appendix

Crop year	MSP_p	ΔMSP_p	$\% \Delta MSP_p$	MSP_w	ΔMSP_w	$\% \Delta MSP_w$
2014-15	1360	50	3.80	1450	50	3.60
2013-14	1310	60	4.80	1400	50	3.70
2012-13	1250	170	15.70	1350	65	5.10
2011-12	1080	80	8.00	1285	115	9.80
2010-11	1000	-50	-4.80	1170	70	6.40
2009-10	1050	150	16.70	1100	20	1.90
2008-09	900	155	20.80	1080	80	8.00
2007-08	745	165	28.40	1000	150	17.60
2006-07	580	10	1.80	850	200	30.80
2005-06	570	10	1.80	650	10	1.60
2004-05	560	10	1.80	640	10	1.60
2003-04	550	20	3.80	630	10	1.60
2002-03	530	0	0.00	620	0	0.00
2001-02	530	20	3.90	620	10	1.60
2000-01	510	20	4.10	610	30	5.20
1999-00	490	50	11.40	580	30	5.50
1998-99	440	25	6.00	550	40	7.80
1997-98	415	35	9.20	510	35	7.40
1996-97	380	20	5.60	475	95	25.00
1995-96	360	20	5.90	380	20	5.60
1994-95	340	30	9.70	360	10	2.90
1993-94	310	40	14.80	350	20	6.10
1992-93	270	40	17.40	330	50	17.90
1991-92	230	25	12.20	280	55	24.40
1990-91	205	20	10.80	225	10	4.70

Table 3: Minimum support prices for paddy (MSP_p) and wheat (MSP_w) in Rs/100 kg.
Source: Reserve Bank of India. Own calculations

Non-basmati rice	April 2007- Futures trading on rice was suspended
	October 9, 2007 – Ban exports
	October 31, 2007 – Ban lifted and replaced with MEP of ME\$425/t fob
	December 2007 – MEP raised to \$US500/t
	March 5, 2008 – MEP raised to \$US650/t and import duty was reduced to zero
	March 27, 2008 – MEP to ME\$1000/t
	April 1, 2008 – Ban Exports
	September 2009 – Ban extended
	Feb 2010 – Ban continued except for 3 premium varieties with ME\$800/t MEP and quota of 150,000t for MY 2010/11
	July 2010 – Decided to continue the ban
	September 2011 – Ban lifted
Basmati rice	March 8, 2008 –MEP increased to \$US950/t at the same time import duty was reduced to zero
	March 17, 2008: basmati rice exports were restricted only to two ports, Mundra and Pipavav
	March 27, 2008 – MEP raised to \$US1100/t
	April 1, 2008 – MEP raised to ME\$1200/t
	April 29, 2009 – Export tax of Rs.8000/t (approx. ME\$200)
	January 20, 2009- Tax removed and MEP reduced to ME\$1100/t
	September 2009 – MEP reduced to ME\$900/t
Wheat	Feb 2010 – MEP of ME\$900/t
	September 2006: Import tariff reduced to zero and private sector allowed to import to increase supply in open market
	December 2006- duty free imports
	February 2007 – export ban on wheat and wheat products until end of December 2007. Also banned futures trading in wheat.
	October 2007- ban extended indefinitely
	July 3, 2009 – Export quota of 3 million tons through STEs
	July 13, 2009 – July 3 quota withdrawn and full export ban re-imposed
	May 2010- Export quota of 650,000 t for one year
	September 2011– Ban lifted

Table 4: Timeline of Export Restriction Measures for Rice and Wheat in India. Source: Reproduced from Baylis et al. (2014)