JAE Journal of Agricultural Economics

Journal of Agricultural Economics
doi: 10.1111/1477-9552.12305

Measuring Distortions to Agricultural Incentives for Value Chain Analysis: Evidence from Indian Value Chains

Simla Tokgoz and Fahd Majeed[1]

(Original submitted January 2018, revision received May 2018, accepted July 2018.)

Abstract

We extend the nominal rate of protection (NRP) methodology to a value chain framework. We develop our methodology for three types of value chains: a new value chain created by policy, a value chain in which a by-product is created in the processing of a commodity, and a value chain in which processing of a commodity generates new product(s). We consider two cases of value chains: when the commodity is tradable and when it is non-tradable. The proposed indicator, value chain NRP, allows policy-makers to see an aggregate measure of all policy impacts on all the commodities and products in the value chain, normalised at the farm level. We apply the methodology to selected value chains in India. Our results indicate that farmers are subsidised, but at different rates. Both sugarcane producers and sugar producers are protected, but sugar producers are protected at higher rates. Producers of downstream products such as ethanol and molasses are taxed, whereas the crushing industry is subsidised. We observe that there is increasing protection along the value chain from commodity to product for the oilseeds sector, whereas the picture is less clear for the sugarcane value chain.

Keywords: *Nominal rates of protection (NRP)*; *value chain NRP*; *India*; *oilseeds*; *sugar*.

JEL classifications: *L1, Q11, Q18.*

[1]Simla Tokgoz is with the International Food Policy Research Institute (IFPRI), Washington, DC, USA. E-mail: s.tokgoz@cgiar.org for correspondence. Fahd Majeed is in the Department of Agriculture and Consumer Economics, University of Illinois Urbana-Champaign, Illinois, USA. We thank two anonymous referees for their helpful comments on an earlier draft, as well as Maximo Torero, Will Martin, David Laborde and Sara Gustafson for their helpful comments in improving the paper. This work was undertaken as part of, and funded by, the CGIAR Research Programme on Policies, Institutions, and Markets (PIM) led by the International Food Policy Research Institute (IFPRI). PIM is in turn supported by these donors (http://pim.cgiar.org/donors/). The opinions expressed here belong to the authors, and do not necessarily reflect those of PIM, IFPRI or CGIAR.

1. Introduction

Complex global value chains (supply chains) have emerged on a wider scale than ever before reflecting multiple factors including lower transaction and transportation costs in international trade, increasing speed of globalisation, and a surge of regional trade agreements. Value chains are defined as the full range of activities by firms to bring a product to market from origin to final use, including design, production, marketing, logistics and distribution in these activities (OECD, 2013).

These global value chains are mostly in the industrial and services sector, but agricultural value chains are also expanding. The global agricultural sector is undergoing a transformation, with a rapid expansion of trade in processed agricultural commodities. With this transformation comes expanded interest in how agricultural value chains can aid rural development. Through development of new downstream value chains and expansion of markets for their products, jobs are created at different nodes of the value chain. These new value chains also increase demand for agricultural commodities benefiting farmers. Development of value chains leads to efficiency gains from economies of scale and scope, reflecting and encouraging a division of tasks between different nodes in the value chain.

Analysis of distortions to agricultural incentives needs to include both individual commodities and their value chains, and these distortions can affect various value chain actors in different ways. Measuring and understanding how distortions to agricultural incentives impact the value chain is necessary to form a complete picture and to design effective policies to minimise unintended consequences for value chain actors.

We propose a methodology to extend the nominal rate of protection (NRP) approach to a value chain framework and apply this new methodology to selected downstream value chains in India. While the earlier literature on NRPs has evaluated policy-induced distortions at the commodity level (Krueger *et al.*, 1988; Anderson *et al.*, 2008), we analyse the distortionary effect of policies on the products in their downstream value chain. First, we compute the relative price of the downstream value chain products (processed goods and by-products) in agricultural commodity equivalent; then we measure distortions to agricultural incentives within the value chain framework to compute NRP for the value chain. Rather than computing NRPs for an agricultural commodity and its downstream products individually, we incorporate their respective relationships to compute a value chain NRP (VCNRP). Although we have a value chain focus, our methodology differs from effective rate of protection (ERP) methodology since we do not compute value added through each node of the value chain.

With a growing population, increasing GDP, and an uneven income distribution, achieving food security is a critical goal for the Government of India (GOI); to meet these goals, the GOI implements a wide variety of policies with often overlapping and counteracting outcomes. This policy environment affects producers, processors and consumers across the value chain, with vital implications for farmers and others.

We focus on two oilseed value chains (rapeseed and groundnut), and the biofuels value chain (ethanol-molasses-sugar-sugarcane).[2] Policies in India as elsewhere, often

[2]Table A1 in online Appendix A provides value of production by agricultural sector, and value of production by value chains in this paper, to show the relative importance of the selected value chains.

display contrasting policy goals which require a careful analysis of net impacts on the value chain and on the economic agents along those value chains. We utilise state-level price data from the 2008–2009 marketing year to the 2011–2012 marketing year.

We proceed as follows. The next section summarises the existing literature. We then present a summary of Indian agricultural policies relating to our value chains. We follow with a description of our methodology, explanation of our contribution to the literature, and the dataset used. We then present results and conclude.

2. Literature Review

There is an extensive literature and multiple institutional databases that measure distortions to agricultural incentives, either calculating indirect measurement of incidence or direct measurement of policies (or a combination of both methods). NRP estimates by Krueger *et al.* (1988) follow the indirect measurement of incidence approach and are the first major attempt to estimate the impact of direct sector-specific and indirect economy-wide policies on agricultural incentives. Their study measures the effect of policies by the proportional difference between the domestic producer price P_i and the border price P_i', adjusted for distribution, storage, transport and other marketing costs to make the two price series comparable. The authors define *direct* NRP (NRP_d) as follows:

$$\mathrm{NRP}_d = \frac{P_i}{P_i'} - 1. \qquad (1)$$

Anderson *et al.* (2008) expands this analysis and measures NRAs for agricultural commodities in a large set of countries, outlining many methodological issues (output and input NRAs, transmission of prices along the value chain). The authors differentiate between NRA-to-farm output conferred by border price support and NRA conferred by domestic price supports. They also calculate NRA to inputs, which is then added to the NRA on outputs to get the total NRA. The authors also analyse transmission of prices along the value chain, paying attention to where prices are adjusted. This includes factoring in both international and domestic trading costs, domestic processing costs, and intermediary margins through wholesale and retail. This database is later updated by the World Bank (Anderson and Nelgen, 2013) and is widely used in applied agricultural economic analysis (Anderson *et al.*, 2016).

ERP, discussed by Corden (1966) and Balassa (1965), is also used to identify the impacts of tariff structure and resource allocation effects. ERP is the percentage increase in domestic value added per unit in an economic activity due to current tariff structure relative to a situation in absence of tariffs (Corden, 1966). Corden (1966) diverges from Balassa (1965) by arguing that non-traded inputs can be treated as primary factors in computation of ERP for tradables, where non-traded inputs do not have infinitely elastic supply, and their prices change with higher demand. Balassa (1965) proposes treating them like tradable inputs in computation of ERP, with zero tariff/tax rates since their prices do not change if they have infinitely elastic supply. Schweinberger (1975) argues that Corden's methodology does not include resource allocation effects, whereas Balassa's methodology will give information on resource movements between final outputs, and between final output and non-traded products.

Alonso and Swinnen (2016) develop a methodology to compute NRA for multiple agents along the value chain and apply it to Pakistan's wheat and wheat flour value chains. They compute NRA to output, NRA_o^i, measuring the extent of distortions to output prices expressed as a percentage of the undistorted domestic output price and the NRA to input, NRA_I^i, measuring the total extent of distortions to input prices for all inputs used to produce output, expressed as a percentage of the undistorted output price. The total NRA^i to agent i is the sum of both.

The OECD Producer and Consumer Support Estimates (PSE) database focuses on direct measurement of policies, but also publishes the Nominal Protection Coefficient (NPC), which includes budgetary outlays (OECD, 2015). FAO-MAFAP (Monitoring and Analyzing Food and Agricultural Policies) (2016) reports the NRP at two points in the value chain: farm-gate and point of competition for the African agricultural sector.

For studies focusing on India, Mullen *et al.* (2005) estimate market price support (MPS) for 11 crops, and product-specific and total PSEs for the period 1985–2002. The estimates suggest that sugar was highly protected from 1997 to 2002, although large fluctuations in MPS estimates are reported. For groundnuts, the general pattern of percentage MPS shows fluctuations between protection and no protection since the mid-1990s (–23.6% in 2001 and 38.7% in 2002). For rapeseed, there is a similar pattern, but results show negative NRAs in later years (–8.2% in 2001 and –10.8% in 2002).

Pursell *et al.* (2009) compute NRAs relying on Anderson *et al.* (2008), covering 12 agricultural products for the period 1965–2005. For the 2000–2004 average, they find positive NRAs for sugar (39.3%), groundnut (12.9%), and rapeseed/mustard seed (64.8%). Their results show that the Indian policy framework subsidised the farmers producing these crops. However, Pursell *et al.* (2009) do not include commodities in downstream value chains, such as meal and oil, and do not include sugarcane NRAs, but only its product sugar.

This was updated by Saini and Gulati (2017), who note that trade volume for some agricultural commodities is low, making international prices an unreliable indicator for border prices. Thus, the study compares domestic wholesale prices (not farm-gate) with estimated reference prices. They compute two NPCs: under both importable and exportable hypotheses. The trade status of each commodity is decided based on NPC value in that year. Then the final reported NPCs are trade-adjusted NPCs. The NRPs (NRP = NPC − 1 in percentage terms) at wholesale level show taxation for oilseeds and protection for sugar. Groundnut NRP averaged over the period 2008–2011 is –38%, rapeseed NRP averaged over the period 2008–2011 is –15%, sugar NRP averaged over the period 2008–2011 is 3%.

3. India's Agricultural Policy Environment

The Indian agricultural sector is regulated at both the federal and the state levels. The GOI intervenes in the agricultural sector to promote food-self-sufficiency and to protect farmers from volatility in international markets. Simultaneously, the GOI aims to protect poor consumers and has constructed a large public distribution system (PDS) for food grains. The consequence is a large number of policies to protect various groups across many markets, resulting in overlapping impacts whose net effects are hard to identify. We focus on India's agricultural policy framework for the specific crops we examine here. For an overview of India's agricultural policies' and its goals, see Brink *et al*. (2013).

A Minimum Support Price (MSP) is used to support farmers' incomes and to reduce food supply volatility. This price is announced annually by the GOI before planting. Farmers have the option to sell their produce either to the government or on the open market. The crops covered include cereals, pulses, cotton, rapeseed/mustard seed and groundnut. For those not covered by the MSP, there exists a Minimum Intervention Price (MIP).

Specifically, for sugarcane, there is the policy of the Fair and Remunerative Price (FRP), which is the price sugarcane millers must pay farmers for sugarcane. There is no procurement system available through the government for sugarcane. In addition, some individual states issue minimum prices for sugarcane that they recommend mills pay to farmers which are higher than the FRP. An additional policy requires mills to purchase all sugarcane delivered to them from within a catchment area.

GOI dictates the proportion of molasses, one of the by-products of sugar production, that may be used for the production of alcohol versus alternative products (feed and ethanol). The current policy allocates 70% of molasses to alcohol production, although this ratio has differed in the past. In our study period, the share of molasses used in ethanol increases from 52% in 2008–2009 to 80% in 2011–2012 (GAIN [Global Agricultural Information Network], 2018). Sugar mills are also required to supply a certain percentage of their output (10% in 2002–2012) to the government at a set low price. This levy sugar is then distributed to consumers through the public distribution system to those who are below the poverty line at a uniform price set by the government. The rest of the sugar is free to be sold on the open market. Obligatory supply of sugar as levy on the mills was removed for sugar produced after September 2012. The requirements for the PDS are currently procured through the open market.

There have also been bans on the direct production of ethanol from sugarcane or sugarcane juice to prevent direct competition between sugar and ethanol production. This policy was revoked in 2007 and reinstated in 2013. However, during our study period – when there was no ban on ethanol from sugarcane juice – commercial production of ethanol from sugarcane juice was negligible (GAIN 2018); most ethanol was produced using molasses. Ethanol is also subject to a procurement price, which specifies the price that factories can charge blenders. This uniform purchase price for ex-factory ethanol was rupees 21.5/litre from 2006 to 2009. The price was increased to rupees 27/litre in 2010. This then transitioned in 2013 into a procurement price to be decided by oil marketing companies and ethanol suppliers.

Ethanol demand is driven by the ethanol blend mandate, which began in 2003 and has gone through multiple iterations. In 2003, the mandate required that nine major sugarcane-growing states and four union territories use a 5% ethanol blend in gasoline. While the blend mandate was repealed in 2004 due to a sugarcane shortage and rising alcohol and ethanol prices, in 2006 it was again enforced throughout most of India. In 2007, 10% blending was made optional until October 2008 and mandatory thereafter. In 2010, it was recommended that the blend percentage in states and union territories be capped at 10%. In December 2012, 5% blending became mandatory across India although compliance was not fully reached. Currently, only 13 states sell ethanol-blended petrol with a blending level of 2% versus the mandatory 5%. Ethanol blended with gasoline is also subject to a federal central excise duty, a value-added tax levied by states, a denaturation fee, entry tax and other fees.

The National Agricultural Cooperative Marketing Federation of India also procures oilseeds under its Price Support Scheme for soybeans, groundnut, safflower seed, mustard seed, sunflower seed, copra, toria and sesamum in multiple states. During our study period, the actual physical procurement amount by the government was minimal or zero for groundnuts: 40 metric tonnes in Uttar Pradesh in 2008–0909 and zero otherwise. The support price for groundnuts ranged between 2,100 and 2,700 rupees per 100 kg in our study period. The actual procurement was zero for mustard seed, although support prices were announced between 1,830 and 2,500 rupees per 100 kg in our period of study (GOI Agricultural Statistics, 2015). The low or nil procurement of oilseeds is due to open market prices of most oilseeds being higher than the GOI's minimum support price (GAIN (Global Agricultural Information Network), 2018). Under the Integrated Oilseeds, Oil Palm, Pulses and Maize Development program (ISOPOM), oilseed growers receive additional support from GOI, such as input subsidies and extension services in multiple states (GAIN (Global Agricultural Information Network), 2018). There is also subsidized distribution of edible oils through state government PDS (GAIN (Global Agricultural Information Network), 2018).

4. Methodology

We first compute the NRPs of agricultural commodities and then compute the relative price of the downstream value chain products (processed goods and by-products) in agricultural commodity equivalents, with respect to the reference price of this agricultural commodity (RPO); we finally integrate these to obtain the NRP of the products of the downstream value chain and the NRP of the value chain, normalised at the level of the farmer.

We formulate this methodology for two value chains: (1) when the commodity is tradable, and (2) when the commodity is non-tradable. Our focus is on commodities that cannot be traded due to physical and technological constraints rather than due to policy intervention. In this study, we use a 'commodity (com)' label for agricultural commodities that are inputs to downstream value chain products, where they are processed. Inputs into agricultural production, such as fertiliser, are not included in this paper.

Our methodology can be applied to three types of value chain i) a new value chain created through policy, ii) a value chain in which a by-product is created through the processing of the commodity, and iii) a value chain in which a commodity is processed into new product(s).

The sugar and sugarcane complex allows us to test our methodology for case (1) in which the agricultural commodity (sugarcane) is non-tradable and the transformed product (sugar) is tradable. The oilseed complexes allow us to apply our methodology for case (2) in which the agricultural commodity (seed/nut) is tradable. The ethanol-molasses value chain is an example of a new value chain (ethanol) created based on legislation (blend targets; type i). Looking at the molasses-sugar value chain allows us to examine an example of a by-product (molasses) created in the production of a product (sugar) through processing of a commodity (sugarcane) (type ii). Looking at meal and oil value chains and the ethanol-molasses value chain allows us to analyse a value chain in which a commodity is processed into a new product (type iii).

We use three concepts from the previous literature on which to base our analysis.[3] *Location of Measurement:* We compare prices received by producers and reference prices (prices free of influence from domestic policies and markets) for a given agricultural commodity at a given location. We use three locations of measurement: (1) border; (2) point of competition; and (3) farm-gate. *Non-Distortionary Price Wedges:* Prices need to refer to goods that are comparable in terms of quality, processing and location. The reference price at each location is the border price evaluated at the official nominal exchange rate adjusted for transport, storage, distribution, processing and quality differences. Between each location point, we make three adjustments: quantity conversion, quality conversion and marketing costs. *Input-Output Coefficients: IO* coefficients for commodity and products from processing of that commodity in a value chain are used to generate commodity equivalency for the product price of the processed good. For a by-product, Quantity Adjustment (QA) is used to generate commodity equivalency for the product price.

4.1. Commodity (com)-level NRPs

For the commodity that will be processed or transformed we use a border price (an undistorted benchmark price) as the reference price ($\mathrm{RP}_{\mathrm{com}}^{\mathrm{border}}$) evaluated at the official nominal exchange rate. We use the net trade status of the commodity to select the appropriate border price – the FOB price for net exporters and the CIF price for net importers.

The Point of Competition (POC) price ($\mathrm{RP}_{\mathrm{com}}^{\mathrm{POC}}$) is computed making the quantity and quality adjustments to equate the border commodity price to its internal equivalent. For an imported commodity, $\mathrm{RP}_{\mathrm{com}}^{\mathrm{border}}$ is made comparable to $\mathrm{RP}_{\mathrm{com}}^{\mathrm{POC}}$ by adding the marketing costs between the border and the POC. For an exported commodity, we subtract the marketing costs.

The final location in our value chain is the farm-gate (FG). The reference price at the farm-gate ($\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}$) follows the previous methodology, but marketing costs are subtracted between the POC and the FG to allow for all the costs incurred by farmers to bring the commodity from the farm to the POC; this results in $\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}$.

We collect data for producer prices at the FG, labeled as $\mathrm{PP}_{\mathrm{com}}^{\mathrm{FG}}$ and defined as the price received by the farmer from the purchaser. NRP at the FG is:

$$\mathrm{NRP} = \frac{\mathrm{PP}_{\mathrm{com}}^{\mathrm{FG}}}{\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}} - 1. \tag{2}$$

To add the *second* dimension of value chain, we need to ensure that price units for products are the same as price units for the commodity. Thus, we convert product prices into their commodity equivalent units.

4.2. Domestic prices for products

4.2.1. Commodity equivalency for processed goods

We define a Domestic Price (DP) for the downstream products (processed goods (pg) or by-products (bp)). The DP starts at POC ($\mathrm{DP}_{\mathrm{prod}}^{\mathrm{pg,\,POC}}$); next we adjust

[3]Figure A1 in online Appendix A presents the methodology for NRP based on Krueger *et al.* (1988).

$DP_{prod}^{pg,\,POC}$ to make it comparable to prices at the farm-gate and obtain $DP_{prod}^{pg,\,FG}$. Finally, we compute the reference price for the processed good at its equivalent in unprocessed good (commodity-equivalent level), which we label as $DP_{com\ eqv}^{pg,\,FG}$ as follows:

$$DP_{com\ eqv}^{pg,\,FG} = IO \times \left(DP_{prod}^{pg,\,FG} \right) \tag{3}$$

where IO coefficient $= \frac{Q_{prod}}{Q_{com}}$.

4.2.2. Commodity equivalency for By-products

We follow the same methodology for by-products. $DP_{prod}^{bp,\,FG}$ is computed by adjusting $DP_{prod}^{bp,\,POC}$ for quality differences and marketing costs. Next, we compute the reference price for the by-product at its commodity-equivalent level, which we label as $DP_{com\ eqv}^{pg,\,FG}$ as follows, using $QA = \frac{Q_{bp}}{Q_{prod}}$:

$$DP_{com\ eqv}^{bp,\,FG} = QA \times \left(DP_{prod}^{bp,\,FG} \right). \tag{4}$$

4.3. International prices for products

To compute distortions to agricultural incentives for a value chain, we also need to apply the NRP methodology for processed goods and by-products. Since these are internationally traded, we need international reference prices (IP). IP comes from the border price, and two steps of transformation (border to POC and POC to FG) make it equivalent to the farm-gate level. If no policy-induced distortions occur, IP would equal DP for products.

The methodology for *Commodity Equivalency for Processed Goods* generates:

$$IP_{com\ eqv}^{pg,FG} = IO \cdot \left(IP_{prod}^{pg,\,FG} \right). \tag{5}$$

The methodology for *Commodity Equivalency for By-products* generates:

$$IP_{com\ eqv}^{bp,FG} = QA \times \left(IP_{prod}^{bp,\,FG} \right). \tag{6}$$

4.4. NRP calculations

4.4.1. Case 1: Commodity is tradable

For the commodity-level NRP, we follow equation (2). To incorporate the *second* dimension of the value chain, we differentiate between adding the *second* dimension through DP at the farm-gate location and adding the *second* dimension through IP at the farm-gate location to take into consideration distortions caused by policies for these downstream value chain products.

4.4.1.1. Case 1a: No policy intervention on downstream value chain: We use DP to compute a reference price for downstream value chain products (RPO) which is defined to be consistent with the NRP of the commodity in terms of units of measurement, i.e. DP of products are in commodity-equivalent units:

$$\mathrm{RPO}_{\mathrm{prod}}^{\mathrm{domestic}} = \sum\nolimits_{\mathrm{BP}} \mathrm{RPO}_{\mathrm{bp}}^{\mathrm{FG}} + \sum\nolimits_{\mathrm{PG}} \mathrm{RPO}_{\mathrm{pg}}^{\mathrm{FG}} = \frac{\sum_{\mathrm{BP}} \mathrm{DP}_{\mathrm{com\ eqv}}^{\mathrm{BP,\,FG}}}{\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}} + \frac{\sum_{\mathrm{PG}} s^{\mathrm{pg}} \times \mathrm{DP}_{\mathrm{com\ eqv}}^{\mathrm{pg,\,FG}}}{\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}}. \tag{7}$$

BP is the set of by-products and bp is each by-product. PG is the set of processed goods and pg is each processed good. s^{pg} is the share of produced commodity used in production of a processed good. This share is added to account for cases where not all of a commodity is used to produce a processed good.[4]

4.4.1.2. Case 1b: Policy intervention on downstream value chain: Here, we consider policy intervention in the downstream value chain of the commodity and use IP as it now differs from DP.

$$\mathrm{RPO}_{\mathrm{prod}}^{\mathrm{international}} = \sum_{\mathrm{BP}} \mathrm{RPO}_{\mathrm{bp}}^{\mathrm{FG}} + \sum_{\mathrm{PG}} \mathrm{RPO}_{\mathrm{pg}}^{\mathrm{FG}} = \frac{\sum_{\mathrm{BP}} \mathrm{IP}_{\mathrm{com\ eqv}}^{\mathrm{bp,\,FG}}}{\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}} + \frac{\sum_{\mathrm{PG}} s^{\mathrm{pg}} \cdot \mathrm{IP}_{\mathrm{com\ eqv}}^{\mathrm{pg,\,FG}}}{\mathrm{RP}_{\mathrm{com}}^{\mathrm{FG}}} \tag{8}$$

4.4.1.3. Value chain NRP: Combining the above RPOs for the downstream parts of the value chain leads to:

$$\mathrm{VCNRP}_{\mathrm{prod}}^{\mathrm{FG}} = \mathrm{RPO}_{\mathrm{prod}}^{\mathrm{domestic}} - \mathrm{RPO}_{\mathrm{prod}}^{\mathrm{international}} \tag{9}$$

NRP for the value chain is defined as:

$$\mathrm{VCNRP}^{\mathrm{FG}} = \mathrm{NRP}_{\mathrm{com}}^{\mathrm{FG}} + \mathrm{VCNRP}_{\mathrm{prod}}^{\mathrm{FG}}. \tag{10}$$

These $\mathrm{VCNRP}_{\mathrm{prod}}^{\mathrm{FG}}$ and $\mathrm{VCNRP}^{\mathrm{FG}}$ are normalised at the level of the farmer and can be directly compared to $\mathrm{NRP}_{\mathrm{com}}^{\mathrm{FG}}$. The $\mathrm{VCNRP}^{\mathrm{FG}}$ accounts for all the economic agents within the value chain. The difference from previous literature is that VCNRP is computed for the value chain, including commodity, processed goods and by-products, to take into consideration the impact of domestic policies that are geared towards downstream parts of the value chain and towards the commodity.

4.4.2. Case 2: Commodity is non-tradable, transformed product is tradable
We revise equation (3) for transformed product (tfprod):

$$\mathrm{NRP}_{\mathrm{tfprod}}^{\mathrm{FG}} = \frac{\mathrm{PP}_{\mathrm{tfprod}}^{\mathrm{FG}}}{\mathrm{RP}_{\mathrm{tfprod}}^{\mathrm{FG}}} - 1. \tag{11}$$

In this case, by-products or processed goods are produced when or after the commodity is transformed into another product. The previous methodology is followed to compute:

[4]In value chains where by-products and processed goods co-exist (such as ethanol production from molasses), the formula needs to be adjusted so as not to double count commodity volume used for multiple purposes.

$$DP^{bp,\,FG}_{tfprod\;eqv}, DP^{pg,\,FG}_{tfprod\;eqv}, IP^{bp,\,FG}_{tfprod\;eqv}, \text{and } IP^{pg,\,FG}_{tfprod\;eqv}$$

4.4.2.1. Case 2a: No policy intervention on downstream value chain:

$$\begin{aligned} RPO^{domestic}_{tfprod} &= \sum_{BP} RPO^{FG}_{bp} + \sum_{PG} RPO^{FG}_{pg} \\ &= \frac{\sum_{BP} DP^{bp,\,FG}_{tfprod\;eqv}}{RP^{FG}_{tfprod}} + \frac{\sum_{PG} s^{pg} \cdot DP^{pg,\,FG}_{tfprod\;eqv}}{RP^{FG}_{tfprod}} \end{aligned} \tag{12}$$

4.4.2.2. Case 2b: Policy intervention on downstream value chain:

$$\begin{aligned} RPO^{international}_{tfprod} &= \sum_{BP} RPO^{FG}_{bp} + \sum_{PG} RPO^{FG}_{pg} \\ &= \frac{\sum_{BP} IP^{bp,\,FG}_{tfprod\;eqv}}{RP^{FG}_{tfprod}} + \frac{\sum_{PG} s^{pg} \cdot IP^{pg,\,FG}_{tfprod\;eqv}}{RP^{FG}_{tfprod}} \end{aligned} \tag{13}$$

4.4.2.3. Value chain NRP:

$$VCNRP^{FG}_{tfprod} = RPO^{domestic}_{tfprod} - RVA^{international}_{tfprod} \tag{14}$$

$$VCNRP^{FG} = NRP^{FG}_{tfprod} + VCNRP^{FG}_{tfprod} \tag{15}$$

In our methodology, we assume a Leontief technology, i.e. the physical *Input-Output Coefficients* (IO) for commodity and products from processing of that commodity, and the *Quantity Adjustment* (QA) used for by-products are fixed. We do not account for substitution among factors of production at different levels of the value chain which is beyond the scope of this paper.

The specific formulae used for the Indian downstream value chains (ethanol-molasses-sugar-sugarcane value chain, rapeseed-rape meal-rape oil value chain, and groundnut-groundnut meal-groundnut oil value chain) are presented in online Appendix A.

4.5. Effective rate of protection calculations

In order to compare the results from our new methodology with ERP, we also compute ERP for ethanol production where input is molasses, and ERP for meal and oil production where input is oilseed (for groundnut and rapeseed complexes).

Following Corden (1966), Balassa (1965), Schweinberger (1975) and Valdes and Foster (2011), observed value added in an industry is VA defined as gross revenue minus costs of tradable inputs. VA^H is the hypothetical value added without protection of output and inputs, where:

$$\mathrm{VA} = \mathrm{IP}_{\mathrm{output}} \times \left(1 + t_{\mathrm{output}}\right) \times \left(1 + s_{\mathrm{output}}\right) \times \mathrm{output} - \sum\nolimits_{\mathrm{input} \in 1} \mathrm{IP}_{\mathrm{input}} \times \left(1 + t_{\mathrm{input}}\right) \times \mathrm{input} \quad (16)$$

$(1 + t_{output})$ is the ad valorem equivalent of domestic protection. $(1 + s_{output})$ is subsidies per unit of output. $(1 + t_{input})$ includes formal applied tariffs on inputs and ad valorem equivalents due to non-trade barriers (NTBs).

ERP in an industry is:

$$\mathrm{ERP} = \frac{\mathrm{VA}}{\mathrm{VA}^{\mathrm{H}}} - 1 \quad (17)$$

Since molasses is a by-product of sugar production from sugarcane and is tradable, the application of ERP to ethanol is straightforward. However, sugarcane which is an input to molasses and sugar production is non-tradable and we do not have an observed international price for sugarcane. Thus, our application of ERP in downstream value chains of sugarcane does not include ERP for molasses. Next, we compute ERP for meal and oil production activity where input is oilseed (for groundnut and rapeseed complexes) and we have two products (meal and oil) from the same activity. Following Corden (1966), we do not include inputs into farmers' production of sugarcane, groundnut, and rapeseed in our computation of ERP for ethanol, meal and oil.

5. Data

Price data from various sources (international and national) are collected for the rapeseed complex (seed, meal and oil), groundnut complex (seed, meal and oil), and biofuels complex (ethanol, molasses, sugar and sugarcane) for different market locations (border, retail, wholesale and farm-gate). These data are used to generate quality adjustments and marketing costs along the value chain. All domestic price data are at the state level and all international price data are based on the country which best represents the international price of that commodity. Analysis is done for 2008–2009, 2009–2010, 2010–2011 and 2011–2012, which correspond to the crop years in the GOI Agricultural Statistics (2015). Detailed data documentation is given in online Appendix C.

The net trade status of the agricultural commodities is computed using the Production, Supply and Distribution (PS&D) Online database (USDA, 2015a). State-level production for commodities, conversion rates between commodities, and *IO* coefficients' data are taken from the GOI Agricultural Statistics (2015).

International prices are from sources such as the USDA ERS (USDA, 2015b,c) and GAIN Reports (2018). International prices are converted to Indian rupees using World Development Indicators (WDI) exchange rates (2016). Retail prices and farm-gate prices are from the GOI Agricultural Statistics (2015). Wholesale prices are from IndiaStat (2016).

For quality adjustments and marketing costs, we are limited by data availability. We apply quality adjustments and marketing costs between the point of competition and the farm-gate. For quality adjustment, we use price data for sugar and gur at the retail market. Since these prices are at the same location, we use the difference between these prices to compute the quality adjustment for sugar between the point of competition and the farm-gate. This method is also applied to sugarcane using relevant conversion rates.

For marketing cost data, we have a wider range of sources, such as wholesale prices and retail prices for all the commodities at the state level. We have data for most states and utilise these to compute the marketing costs to be applied between the point of competition and the farm-gate.

For ERP computation, we use tariff rates for outputs and inputs from World Integrated Trade Solution (WITS) from World Bank, specifically the UNCTAD Trade Analysis Information System (TRAINS) database. We use total tariffs including ad valorem equivalent with estimation method as UNCTAD. The WITS dataset we used included total tariffs, but there was no TRAINS-Historical Non-Tariff Measures (NTM) dataset for India for the commodities covered in this study within the time period of the study. Thus, we confine our analysis to total applied tariff rates.

6. Results

Tables 1 and 2 present VCNRP results for India as averages of state-level VCNRPs. Average computation is done using major producing states over four marketing years (2008–2009 to 2011–2012). We provide RPOs using international prices and domestic prices for India average in Tables B1, Table B2, Table B6 and Table B7 in the online Appendix B. Table 3 presents ERPs for India averaged over four marketing years (2008–2009 to 2011–2012) for comparison purposes.

Table 1 shows the commodity NRP values, followed by the Molasses and Ethanol + Molasses downstream value chain NRPs, and then the full VCNRP.

Table 1
India Value Chain NRPs for the ethanol-molasses-sugar-sugarcane value chain

			Product value chain NRP		Value chain NRP	
Commodity	States	Commodity NRP	Molasses value chain NRP	Ethanol + Molasses value chain NRP	Molasses + Commodity value chain NRP	Ethanol + Molasses + Commodity value chain NRP
Sugar	Andhra Pradesh, Bihar, Gujarat, Haryana, Tamil Nadu, Uttar Pradesh	260%	−12%	−6%	248%	254%
Sugarcane	Karnataka, Maharashtra, Uttar Pradesh	176%	−11%	−5%	165%	171%

Notes: NRPs are calculated across marketing years, and averages of 2008–2009, 2009–2010, 2010–2011 and 2011–2012 values.
Source: Authors' computations.

Table 2
India value chain NRPs for oilseeds value chain

Commodity	States	Commodity NRP	Product value chain NRP Meal + Oil value chain NRP	Value chain NRP Meal + Oil + Seed value chain NRP
Groundnut	Andhra Pradesh, Gujarat, Tamil Nadu	11%	10%	21%
Rapeseed	Uttar Pradesh, West Bengal	9%	32%	40%

Notes: NRPs are calculated across marketing years, and averages of 2008–2009, 2009–2010, 2010–2011 and 2011–2012 values.
Source: Authors' computations.

Table 3
India ERPs

Activity	ERP
Ethanol	–10%
Groundnut meal and oil	–301%
Rapeseed meal and oil	–181%

Notes: ERPs are calculated across marketing years, and averages of 2008–2009, 2009–2010, 2010–2011 and 2011–2012 values.
Source: Authors' computations.

The commodity NRPs for sugar and sugarcane indicate that the sugar sector is subsidised, assisting not only sugarcane farmers, but also sugar mills. The difference between the sugar and sugarcane NRPs shows that gains are not evenly distributed among value chain agents – sugar processors are protected at higher levels than sugarcane farmers. Molasses value chain NRP results indicate that the molasses sector is on average taxed. The molasses value chain NRP is negative due to much lower domestic molasses prices than international molasses prices. This reflects the by-product nature and the lack of development of the domestic molasses market, and efforts to keep domestic molasses prices low to assist ethanol producers, who are the major users of molasses. Ethanol + Molasses NRP is also negative, but remains higher than the molasses NRP. This result shows that both the molasses and the ethanol markets are disincentivised in India, but that taxation is lower for ethanol than for molasses. The ethanol price is fixed by legislation below international prices, benefiting ethanol sector consumers (refiners/blenders) which dominates the support effect of the mandate, resulting in a negative Ethanol + Molasses NRP.

Next, we add commodity NRPs to product value chain NRPs since they are in the same unit, and present VCNRP for Molasses + commodity and VCNRP for Ethanol + Molasses + commodity at high positive values. These results show that the net subsidisation of the overall Ethanol + Molasses + commodity value chain is due to much higher subsidisation of sugar and sugarcane producers, exceeding the taxation of the two products in the value chain.

Table 2 presents results for groundnut and rapeseed value chains. Both commodity NRPs show that oilseeds producers have been subsidised by the government. The product NRPs for Oils + Meals for groundnut and rapeseed value chains are positive as well. These results indicate that the oilseed crushing industry is subsidised enough by domestic agricultural policy that even though they buy seeds and nuts at higher prices, the net impact is positive. Adding commodity NRP to product value chain NRP, we obtain value chain NRP (last column) at high positive levels, showing subsidisation. The net positive subsidisation of the overall value chain is due to the subsidisation of all components along the value chain. We also observe that protection in the rapeseed value chain is more geared toward the processing side compared to groundnut value chain.

Table 3 presents ERPs for three sectors. ERP for ethanol is negative due to the slightly higher tariff rates for molasses relative to the import tariffs for ethanol. It is not possible to directly compare ERP for ethanol to VCNRP for ethanol and molasses, since ERP is for ethanol only. However, we can observe that both indicators show that the ethanol markets are disincentivised in India through both trade policy and domestic agricultural policy.

ERP for groundnut meal and oil is negative due to lower import tariffs for groundnut oil relative to import tariffs for groundnuts. This result differs from the positive VCNRP for groundnut meal and oil in Table 2. The negative ERP shows that the trade policy aims to help consumers by keeping groundnut oil import prices low and aid farmers by keeping groundnut import prices high. Thus, the crushing industry is taxed by the trade policy. VCNRPs for groundnut meal and oil show the impact of domestic agricultural policy as positive. Thus, there is some discrepancy between trade and domestic agricultural policy objectives towards the crushing industry.

ERP for rapeseed meal and oil is negative, due to much lower import tariffs for rapeseed oil relative to import tariffs for rapeseed showing that the crushing industry is taxed by trade policy. The ERP and the trade policy reflects that the aim of policy space is to help final consumers by keeping rapeseed oil import price low and aid farmers by keeping rapeseed import price high. VCNRP for rapeseed meal and oil is positive showing positive impact of domestic policy on crushing industry for rapeseed. We can observe that trade and domestic agricultural policy frameworks are inconsistent for the rapeseed complex too.

To sum up, our results show that farmers are being protected and assisted in India. Producers of ethanol and molasses (manufacturers) are being taxed, whereas consumers of these two commodities are being subsidised. Producers of meal and oil are being subsidised by domestic agricultural policy to aid the development of the domestic crushing industry. When we analyse producers along the value chain, with producers and processors, we find that producers along the value chain experience different impacts from the GOI's policies – some positive and some negative.

We present the state-level NRP and RPO computations in Table B3, Table B4, Table B5, Table B8, Table B9 and Table B10 in online Appendix B. The results illustrate the impact of state-level policies on farmers and value chains. The observed heterogeneity among state-level commodity and value chain NRP values demonstrates that states differ widely in their policies. This leads to redistribution from one state to another, posing significant challenges to establishing an integrated market in India.

7. Conclusions

We compute distortions of agricultural incentives for economic agents along the value chain of an agricultural commodity, extending the nominal rate of protection (NRP) methodology to a value chain framework. Our methodology can be applied to three types of value chain i) a new value chain created by government policy, ii) a value chain in which a by-product is created in the processing of the commodity, and iii) a value chain in which a commodity is processed to generate a new product(s). We also develop the methodology for two cases of value chains: (1) when the commodity is tradable, and (2) when the commodity is non-tradable.

The proposed methodology incorporates the respective relationship between a commodity and its downstream value chain products. To do this, we use a reference price for the processed commodities and by-products in the downstream value chain (RPO) which is defined in the same units as the raw commodity and then integrate these RPOs to the NRP of Krueger *et al.* (1988). This allows us to compute NRPs for the downstream products of the value chain that are comparable to the NRP of the raw commodity since they are normalised at the farmer level. The final indicator, value chain NRP (VCNRP) integrates the NRP of the raw commodity with the NRP of the downstream products, allowing policy-makers and analysts to see an aggregate measure of all policy impacts on the commodities in the value chain, normalised at the farmer level. VCNRP identifies protection/taxation of multiple commodities along the value chain. This makes it possible to compare and contrast the impacts of policy on different economic agents along the value chain in a consistent manner since NRPs are normalised at the farmer level. One caveat when interpreting results from our methodology is that although we can interpret the downstream value chain producers as consumers of the raw materials (sugarcane, rapeseed, groundnut), our interpretation is strictly from a producer's point of view.

We apply the methodology to selected downstream value chains (oilseeds, meals and oils, and sugarcane, sugar, molasses and ethanol) in India. Our results indicate that along these value chains, farmers are subsidised, but at different rates. For example, both sugarcane producers and sugar producers are protected, but sugar producers are protected at higher rates. Similarly, producers of ethanol and molasses are taxed, whereas the crushing industry, which produces meal and oil, is subsidised. When comparing NRPs across these value chains, we observe that there is increasing protection along the value chain from commodity to product for the oilseeds sector (i.e. higher NRPs for meal and oils relative to NRPs for seeds and nuts). The picture is less clear for the sugarcane value chain. Sugar NRP is higher than sugarcane NRP, but the molasses and ethanol value chain NRP is negative. Thus, the segment of the value chain that the GOI protects (farmers or processors) varies based on the type of value chain.

One caveat is that our methodology does not account for the impact of a new value chain and the protection/taxation of products along the value chain on the price of the agricultural commodity. Although there may be impact from the policy intervention in downstream value chain products' markets on farmers, not all profits from downstream value chain products go to farmers. The price transmission from downstream value chain products' markets to farmers' profit margins depends on value chain characteristics, and it can be estimated empirically using simulation models (by running counterfactual scenarios) or utilising econometric techniques to estimate coefficients of price transmission.

Our methodology differs from ERP since we do not compute a value added through each node of the value chain thus do not subtract cost of agricultural commodities. Another distinction is that while ERP measures protection of an activity producing a finished good, our methodology considers protection of all goods along the value chain for a comprehensive analysis of policy space on a value chain. Our aim and methodology differ from Alonso and Swinnen's (2016) approach since we incorporate the various by-products and processed goods in a value chain to compute a single value chain NRP and use undistorted commodity price in the denominator.

To sum up, VCNRP enables a comprehensive analysis of policies targeting different nodes of a value chain, allowing policy-makers and analysts to identify the overall impact. The methodology can also be used to show policy-makers where to focus interventions, either by re-evaluating the existing policy framework or by focusing on other sources of inefficiencies and distortions along the value chain. It should be noted that policy-makers need to consider that new value chain development requires stable policy framework and that legislation alone is not enough to generate new value chains.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table A1. Indian agricultural sector.

Figure A1. Price transmission across different locations of measurement.

Table B1. India NRPs and RPOs using international prices for ethanol-molasses-sugar-sugarcane value chain.

Table B2. India NRPs and RPOs using domestic prices for ethanol-molasses-sugar-sugarcane value chain.

Table B3. State-level RPOs using international prices for ethanol-molasses-sugar-sugarcane value chain.

Table B4. State-level RPOs using domestic prices for ethanol-molasses-sugar-sugarcane value chain.

Table B5. State-level value chain NRPs for ethanol-molasses-sugar-sugarcane value chain.

Table B6. India NRPs and RPOs using international prices for oilseeds value chain.

Table B7. India NRPs and RPOs using domestic prices for oilseeds value chain.

Table B8. State-level RPOs using international prices for oilseeds value chain.

Table B9. State-level RPOs using domestic prices for oilseeds value chain.

Table B10. State-level value chain NRPs for oilseeds value chain.

Table C1. Tariff lines and values used in ERP computation.

Figure D1. Price transmission for seed along the groundnut complex value chain.

Figure D2. Price transmission for oil along the groundnut complex value chain.

Figure D3. Price transmission for meal along the groundnut complex value chain.

Figure D4. Price transmission for seed along the rapeseed complex value chain.

Figure D5. Price transmission for oil along the rapeseed complex value chain.

Figure D6. Price transmission for meal along the rapeseed complex value chain.

Figure D7. Price transmission for ethanol along the ethanol-molasses-sugar value chain.

Figure D8. Price transmission for molasses along the ethanol-molasses-sugar value chain.

Figure D9. Price transmission for sugar along the ethanol-molasses-sugar value chain.

Figure D10. Price transmission for sugarcane along the ethanol-molasses-sugar-sugarcane value chain.

Figure D11. Oilseeds Value Chain.

Figure D12. Ethanol-molasses-sugar-sugarcane value chain.

References

Alonso, E. B. and Swinnen, J. 'Who are the producers and consumers? Value chains and food policy effects in the wheat sector in Pakistan', *Food Policy*, Vol. 61, (2016) pp. 40–58.

Anderson, K. and Nelgen, S. *Updated National and Global Estimates of Distortions to Agricultural Incentives, 1955 to 2012* (Washington, DC: World Bank, 2013). Available at: www.worldbank.org/agdistortions (last accessed 2 May 2017).

Anderson, K., Kurzweil, M., Martin, W., Sandri, D. and Valenzuela, E. 'Measuring distortions to agricultural incentives, revisited', *World Trade Review*, Vol. 7(4), (2008) pp. 675–704. Also circulated as World Bank Policy Research Working Paper 4612, Washington DC, April 2008.

Anderson, K., Jensen, H. G., Nelgen, S. and Strutt, A. 'What is the appropriate counterfactual when estimating effects of multilateral trade policy reform?', *Journal of Agricultural Economics*, Vol. 67, (2016) pp. 764–778.

Balassa, B. 'Tariff protection in industrial countries: an evaluation', *Journal of Political Economy*, Vol. 73, (1965) pp. 573–594.

Brink, L., Orden, D. and Datz, G. 'BRIC agricultural policies Through a WTO lens', *Journal of Agricultural Economics*, Vol. 64, (2013) pp. 197–216.

Corden, W. M. 'The structure of a tariff system and the effective protective rate', *Journal of Political Economy*, Vol. 74(3), (1966) pp. 221–237.

FAO. *Monitoring and Analysing Food and Agricultural Policies* (Rome: FAO, 2016). Available at: http://www.fao.org/in-action/mafap/home/en/ (last accessed 22 May 2017).

GAIN (Global Agricultural Information Network). Various GAIN Reports, 2018. Available at: gain.fas.usda.gov/Pages/Default.aspx (last accessed 23 May 2018).

GOI Agricultural Statistics. *Public Database* (Directorate of Economics and Statistics, Department of Agriculture, Government of India, New Delhi, 2015). Available at: http://eands.dacnet.nic.in/latest_2006.htm (last accessed 2 May 2016).

IndiaStat. *Public Database* (IndiaStat: New Delhi, India, 2016). Available at: http://www.indiastat.com (last accessed 2 May 2016).

Krueger, A. O., Schiff, M. and Valdes, A. 'Agricultural incentives in developing countries: Measuring the effect of sectoral and economywide policies', *The World Bank Economic Review*, Vol. 2(3), (1988) pp. 255–271.

Mullen, K., Orden, D. and Gulati, A. *Agricultural Policies in India*, Discussion Paper No. 82 (International Food Policy Research Institute, Washington, DC, 2005). Available at: http://www.ifpri.org/publication/agricultural-policies-india (last accessed 2 May 2016).

OECD (Organization for Economic Co-operation and Development). *Interconnected Economies: Benefiting from Global Value Chains, Synthesis Report 54* (OECD: Paris, 2013). Available at: http://www.oecd.org/sti/ind/interconnected-economies-GVCs-synthesis.pdf (last accessed 2 May 2016).

OECD (Organization for Economic Co-operation and Development). Agricultural Policy Monitoring and Evaluation. 2015. 298 pp. Available at: https://doi.org/10.1787/agr_pol-2015-en (last accessed 2 May 2016).

Pursell, G., Gulati, A. and Gupta, K. 'India', Chapter 10 in K. Anderson and W. Martin (eds.), *Distortions to Agricultural Incentives in Asia* (World Bank Publications: Washington, DC, 2009). Available as a free e-book at: www.worldbank.org/agdistortions.

Saini, S. and Gulati, A. *Price Distortions in Indian Agriculture*. World Bank Report (The World Bank: Washington, DC, 2017). Available at: http://icrier.org/pdf/Price_Distortions_in_Indian_Agriculture_2017.pdf (last accessed 27 November 2017).

Schweinberger, A. G. 'Nontraded intermediate products and the measurement of protection', *Oxford Economic Papers, New Series*, Vol. 27(2), (1975) pp. 215–231.

US Department of Agriculture. *Production, Supply, and Distribution Database* (USDA: Washington, DC, 2015a). Available at: www.fas.usda.gov/psdonline/psdHome.aspx (last accessed 2 May 2016).

US Department of Agriculture. *Economic Research Service Oil Crops Yearbook* (Washington, DC: USDA, 2015b). Available at: http://www.ers.usda.gov/data-products/oil-crops-yearbook.aspx (last accessed 2 May 2016).

US Department of Agriculture. *Economic Research Service Sugar and Sweeteners Yearbook Tables* (Washington, DC: USDA, 2015c). Available at: http://www.ers.usda.gov/data-products/sugar-and-sweeteners-yearbook-tables.aspx (last accessed 2 May 2016).

Valdes, A. and Foster, W. *A profile of border protection in Egypt: An Effective Rate of Protection approach adjusting for energy subsidies*. (Washington, DC: World Bank, 2011). Available at: http://documents.worldbank.org/curated/en/391841468234323094/pdf/WPS5685.pdf (last accessed 16 May 2018).

World Bank. *World Development Indicators* (The World Bank: Washington, DC, 2016). Available at: http://data.worldbank.org/indicator (last accessed 2 May 2016).