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Welfare gains of inward-looking: an *ex-ante* assessment of general equilibrium impacts of protectionist tariffs on India's edible oil imports

Balaji S J[1*], Umanath M[2], and Arun G[3]

[1]ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi 110 012
[2]Madras Institute of Development Studies (MIDS), Chennai 600 020, Tamil Nadu
[3]Commission for Agricultural Costs & Prices (CACP), New Delhi 110 001

*Corresponding author: balajiniap@gmail.com

Abstract Import substitution policies are often *inward-looking* in trade deliberations. The present study is an attempt to quantify the likely benefits of protectionist tariff hikes in enhancing domestic production and improving producer prices. It takes the case of the edible oil imports of India and estimates the price gains the oilseed producers (farmers) and the processing industries may receive; likely increase in domestic oilseeds and edible oil production, and the role the technology in attaining oilseeds/edible oil self-sufficiency. A three-sector open-economy Computable General Equilibrium (CGE) model is calibrated to a 2017-18 SAM developed for this purpose. Tariff hikes are assumed in different protectionist scenarios and their impacts on production and prices are simulated. Total Factor Productivity (TFP) estimates are derived for the oilseeds (2005-18) and the edible oil (2014-18) sectors to understand the technological penetration there. The price gains vary between 2.4% and 6% to the oilseeds producers and between 1.2% and 2.9% to the edible oil industries. The oilseeds production may enhance by 1.8% at maximum, and the edible oil production by 2.9%. The existing TFP growth is inadequate to move towards oilseeds/ edible oil self-sufficiency. This demands a shift in production technology.

Keywords Import substitution, oilseeds, edible oil, SAM, CGE, India

JEL Codes E16, E17, F14, F17, O53

India's intellectual and policy communities are often noted to embrace *self-reliance* or in other words, the *atmanirbhar* strategy, abandoning export orientation and disfavoring liberalizing trade (Chatterjee and Subramanian 2020) in manufactured goods. Even in the case of agriculture, the country's stance is observed to be static, noting the region levying the highest tariffs on its imports of most of the agricultural products (Beckman and Scott 2021). Such policies are claimed to be instrumented to protect and benefit the domestic industries and farm communities by the proponents, which, in turn, is perceived by the opponents as an *inward-looking* strategy that shall demote the nation's growth and welfare. The pursuit of *cereal self-sufficiency* policy it succeeded remains hard to replicate in enhancing oilseeds production. The country meets to date around 60% of its domestic edible oil demand through imports (GoI 2021a).

Much of these imports emerge from very few countries. India imports around 54% of palm oil from Indonesia and 37% from Malaysia[1]. Such heavy dependency costs over the long run not just on the public exchequer but may turn the domestic consumer market vulnerable to the international price shocks. Persisting imports also signal limited response in the domestic production

[1]In value (nominal) terms; estimated based on imports in the years 2019-20 & 2020-21.

system to the demand. For instance, while edible oil imports grew by about 6.8% a year[2] during 2001-11, domestic edible oil production grew by just 2.2%. To this end, the states of Andhra Pradesh and Telangana show prospects for augmenting domestic contributions. These two states together produced around 97% of the crude palm oil production in the TE 2019-20 (GoI 2021b). The state of Andhra Pradesh produced as much as 84% of the total crude palm oil.

At the policy front, initiatives focusing on self-sufficiency in oilseeds and edible oil production date back to the 1980s. The Government of India launched Technology Mission on Oilseeds (TMO) in May 1986 to enhance oilseeds production and productivity, hence increasing the domestic edible oil production. In the year 1992-93, oil palm was brought into the ambit of the Mission. The Oilseeds Production Programme (OPP) and the Oil Palm Development Programme (OPDP) were brought under the Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) that came into operation in April 2004. In the year 2014, the ISOPOM together with the Integrated Development of Tree Borne Oilseeds and Oil Palm Area Expansion (OPAE) were under the National Mission on Oilseeds and Oil Palm (NMOOP). To boost the efforts further, in August 2021, the Union Cabinet approved the launch of a new scheme named National Mission on Edible Oils – Oil Palm (NMEO-OP).

These policies helped to enhance both oilseeds and edible oil production but were not on par with the rise in demand. During the period 2004-14, both oilseeds and edible oil production grew around 4% a year. But the domestic demand has been much stronger, resulting in edible oil imports growing by 9.6% a year. On the other side, notably in the case of oil palm, while the statistics show the crop is cultivated in about 0.35 million hectares, the potential exists to bring as high as 2.8 million hectares of additional land under cultivation (GoI 2021b). The policies that encourage oilseeds and edible oil production in the country shall help to reduce the drain on import bills and help to generate income and employment.

Tariffs shall be an effective instrument to make imports expensive. Tariff hikes curb imports in a competitive economy, triggering domestic firms and farms to expand their production. While the non-tariff barriers act similarly, the former has been the common instrument in India to regulate domestic prices and imports in the case of oilseeds/edible oils in India. In the present study, we construct a hypothetical economy that attempts to raise tariffs for the edible oils it imports to encourage domestic oilseeds and edible oil production. We then estimate potential economy-wide impacts of this hike calibrating a 3-sector Computable General Equilibrium (CGE) model to a Social Accounting Matrix (SAM) representing the Indian economy, focusing on the production and price gains to the farmers and the domestic edible oil industries. We estimate then the Total Factor Productivity (TFP) growth in both sectors to observe the potential role technology can play in rising production. The results indicate that both the farmers and the edible oil industries enhance their production and receive better prices when tariffs are hiked, hence raising their welfare. But the TFP growth estimates suggest the present rate of technology growth may barely be sufficient to bridge the gap in production caused by these hikes, calling for the need to enhance the technology in both the oilseeds and the edible producing sectors that shall enhance the outputs rapidly.

Materials and methods

Data

Data on oilseeds production and costs and returns are gathered from statistics published by the Department of Agriculture, Cooperation and Farmers Welfare (Ministry of Agriculture & Farmers Welfare). The domestic edible oil production, imports, and tariff rates are collected from the Department of Food and Public Administration (Ministry of Consumer Affairs, Food and Public Distribution) for the aggregate level. The details of import statistics at the commodity level are obtained from the Department of Commerce (Ministry of Commerce and Industry). For estimating TFP growth in oilseeds, the information contained in the Cost of Cultivation (CoC) is used covering the period 2004-05 to 2017-18. The TFP growth in the edible oil industry is estimated for the period 2013-14 to 2017-18 using the statistics published in the reports of the Annual Survey of Industries (Ministry of Statistics and Programme Implementation). The nominal values are deflated using GVA, GCF, and CPI (Urban) indices

[2]CAGR, estimated with a 3-year moving average series

respectively in the case of the edible oil industry with the 2011-12 base[3]. Physical quantities are used in estimating TFP in oilseeds, and GVA (Agriculture and allied sector) deflators with 2011-12 base are used to derive the irrigation and insecticide expenses in real terms.

A Social Accounting Matrix (SAM) is developed to assess the economy-wide impacts when tariff-hikes are imposed. The IFPRI's Social Accounting Matrix for India for the year 2017-18 (Pal et al. 2020) is used as the base. This matrix differentiates economic *activities* and *commodities* under 112 categories. To focus on the present objective, at stage-1, this *standard* version is collapsed to form a 3-sector version accommodating oilseeds, edible oils, and all others. The oilseeds covered groundnut, rapeseed and mustard, and all others. Further, the 13-factor components in the original version are clubbed to form two basic factors namely labour and capital; and households and firms are differentiated into just farmers and all others. In stage-2, this collapsed version is further simplified to follow Lofgren (2003). The panel of SAM constructed for the present study is outlined in Table A1 (in the appendix). A three-sector open-economy CGE model is calibrated following the author mentioned above, the details of which are discussed under the methodology section.

The Computable General Equilibrium (CGE) model

The costs of protection vary with the type of inquiry one adopts to estimate. One follows either a Partial Equilibrium (PE) or a Computable/Applied/ General Equilibrium (CGE/AGE/GE) model. The former allows one to observe impacts at a finer level but within a sector or among a group of classes within a sector. The CGE models are effective in capturing both direct and indirect repercussions within and outside the sector intervened, like the impacts on production and X-efficiency, prices, employment, and income, among others. A CGE model comprises a set of nonlinear equations, to describe mathematically. As the present study explores cross-sectoral effects, the CGE based approach is followed. The study adopts the models and equation sets discussed in Lofgren (2003). The equations solved are listed in Table A2 (in the appendix). As the author states, this system reflects a critical minimum of real-world features laying a foundation for country-specific detailed policy analysis.

Oilseeds and edible oils are specified as non-exported commodities and the former as non-imported commodities. Labour employed in respective activities is estimated from the Periodic Labour Force Survey 2017-18 (GoI 2019), together with the crop production estimates of 2019-20 (GoI 2021b). Farmers and other nonfarm households earn their incomes by offering labour and capital services and spending on food and non-food commodities. The oilseeds and the edible oil production technologies follow the Cobb-Douglas form. Imperfect substitutability is presumed among the domestic and the imported commodities and is captured by the Constant Elasticity of Substitution (CES) aggregation function. Trade elasticities are adopted from Imbs and Mejean (2010). Investment drives savings; capital is activity-specific and fully employed; labour is mobile and receives fixed wages; flexible exchange rate clears current account.

Malmquist Productivity Index (MPI) and Data Envelopment Analysis (DEA)

The Malmquist Productivity Indices (MPI) are estimated to observe the TFP growth in both oilseeds and the edible oil sectors. These TFP growth rates shall provide an idea of technology growth one might expect in these sectors in the coming years and hence their contribution to oilseed and edible oil production. Introduced by Malmquist (1953), the approach has undergone improvements (Caves et al. 1982 a&b; Färe et al. 1994; Bjurek 1996; Lovell 2003) and is widely applied (Fulginiti and Perrin 1998). These indices are estimated using the Data Envelopment Analysis (DEA), a nonparametric piecewise linear frontier. It allows for technical inefficiencies, unlike the parametric approach that assumes outputs are technically efficient. Advantage also lies in its constructability in the absence of prices of inputs and outputs. The indices are deterministic and avoid specification bias. The index identifies TFP growth concerning two time periods through a quantitative ratio of distance functions. We follow the output-based Malmquist index of productivity change to estimate the growth of TFP as it estimates the maximum level of outputs that can be produced using a given input vector and a production

[3] 2012=100 for CPI(Urban)

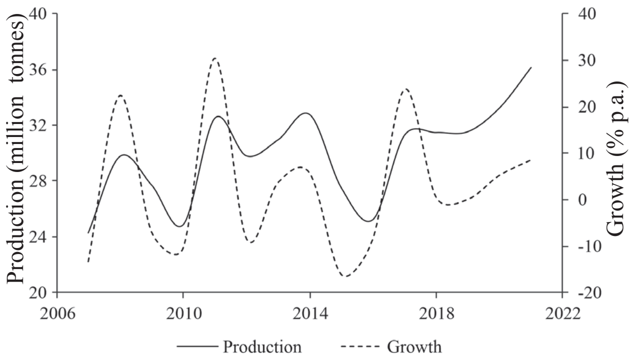

Figure 1 Production and growth in oilseeds (All-India, 2007-2021)
Source Ministry of Agriculture & Farmers Welfare
Note Growth estimates are in the secondary axis

technology relative to the observed level of outputs (Coelli et al. 2005). It estimates the radial distance of the observed output vectors in periods *t* and *t+1* relative to a reference technology. A detailed discussion is made in Method A1 (in the appendix).

Results and discussion

Performance in oilseeds production

The oilseeds production has increased gradually, from 28 million tonnes in 2005-06 to 33 million tonnes in 2013-14. Since the NMOOP was introduced, production has grown faster reaching 36 million tonnes in 2020-21. Still, production has remained highly volatile, not subduing over years (Figure 1). For instance, growth was as high as 31% in 2010-11 but was -16% in 2015-16. While such volatility has remained over years, which determines the level of edible oil production by the domestic industries, demand for edible oils at the consumer market has witnessed a stable growth with rising income and population, necessitating imports.

While the performance at the sectoral level shows positive growth, the growth in different oilseed commodities produced, especially since TE 2014-15, shows that the positive growth is limited to a few but major commodities (Table 1). Soybean, rapeseed and mustard, and groundnut together contribute around 92% to the total oilseeds produced, and these were the only crops to grow at a positive rate since TE 2014-15. The soybean production, which contributes over 37% of total oilseeds produced, has grown by 1.8%. This has been about 5.2% and 3.1% in rapeseed and mustard and groundnut, whose contributions are about 28% and over 26%, respectively. On the other side, the safflower production has declined over 15%, the sunflower over 12%, and the niger seed over 11%. Castor seed, sesamum, and linseed are the other oilseeds to witness negative production growth.

The oilseeds production has undergone a notable change since the NMOOP was introduced. The negative production growth shifted to a positive rate in the case of groundnut in the period TE 2015-21 when comparing the period TE 2008-14. While growth was -1% a year during the former period, it was over 3% in the latter. Similar is the case in rapeseed and mustard production. The production growth of 1.6% a year in the former period rose to 5.2% in the latter. The sunflower production, which was declining at the rate of over 16% also moderated to over 12% a year since TE 2014-15. Thus, performance has shifted to a positive side since the scheme came into operation. But the opposite was the case in other commodities. The soybean production has declined from over 6% to around 2%; castor seed production from around 15% to -3.2%; sesamum production from 2.7% to -1.7%; niger seed production from -2.5% to -11.6%; linseed production

Table 1 Growth in oilseeds production (All India, 2008-2021)

Oilseeds	Season	Growth* (% p.a.)	
		TE 2008-14	TE 2015-21
Groundnut	Kharif	-1.2	3.9
	Rabi	-0.1	0.1
	Total	-1.0	3.1
Castor seed	Kharif	14.9	-3.2
Sesamum	Kharif	2.7	-1.7
Niger seed	Kharif	-2.5	-11.6
Soybean	Kharif	6.1	1.8
Sunflower	Kharif	-16.6	-9.8
	Rabi	-16.6	-14.5
	Total	-16.6	-12.8
Rapeseed & mustard	Rabi	1.6	5.2
Linseed	Rabi	-2.4	-3.7
Safflower	Rabi	-10.5	-15.5

Source Authors' estimates based on Ministry of Agriculture & Farmers Welfare
Note *CAGR estimates based on 3-year moving averages

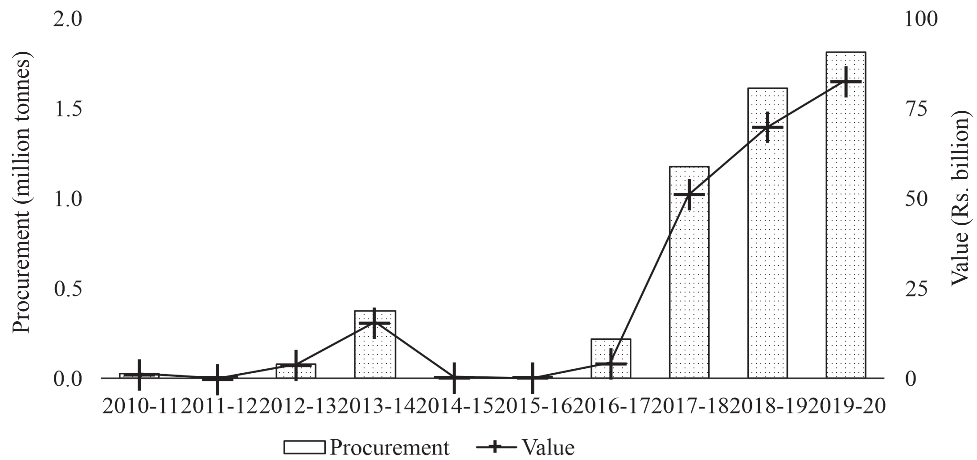

Figure 2 Oilseeds procurement under Price Support Scheme (PSS)
Source National Agricultural Cooperative Marketing Federation
Note Values are in the secondary axis

from -2.4% to -3.7%; and safflower production from -10.5% to -15.5%. Thus, the production growth of groundnut and rapeseed, and mustard has been at the cost of fall of production in the rest of the commodities.

Part of the reason for expansion in oilseeds production in recent years is the rise in oilseeds procurement by the Government. Observing the procurement trend since 2010–11, one shall point out it was only since 2017–18 the oilseeds procurement crossed more than a million tons (Figure 2). Leaving the years 2013-14 and 2016–17, none of the years witnessed substantial procurement. In the past three years, the government has procured about 4.6 million tonnes of oilseeds costing over Rs. 200 billion.

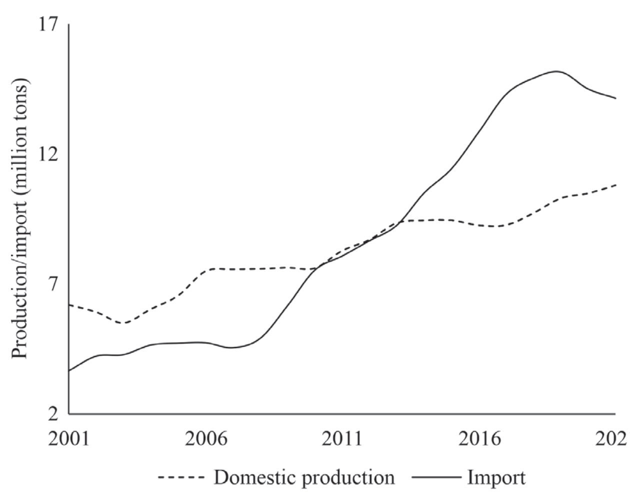

Figure 3 Domestic production and imports of edible oil in India
Source Ministry of Consumer Affairs, Food & Public Distribution
Note Trend lines are based on 3-year moving averages

Edible oils sector: domestic capacity and import dependency

All these efforts to raise the oilseeds production have helped rising domestic edible oil production but not to the rate of expansion in demand. With a rise in oilseeds production, domestic edible oil production has increased from 6.2 million tonnes in the year TE 2001 to 10.8 million tonnes in TE 2021 (Figure 3), growing at a rate of 3.2% a year. To the other end, the domestic demand has grown by 5.7% a year, demanding the edible oil imports to grow by 8.3% a year. The country imported about 14.2 million tonnes of edible oil in TE 2021, which was about 3.7 million tonnes in TE 2001.

Import basket mostly consists of crude and refined palm oils, soybean, and sunflower oils (Table 2). The former two categories make the major pie. Around 79% of the imported oils were crude and refined palm oils in the year 2009–10. More than half of all edible oils imported to date is crude palm oil, refined by the domestic industries. To date, this has remained to be the largest edible oil item imported. While the share of the refined has remained more or less stable, the share of crude palm oil has consistently declined with a rise in soybean and sunflower oil imports. For instance, the share of crude palm oil has declined from 62.6% in the year 2009–10 to 55.4% in 2020–21. During the same time, the import of soybean oil has risen from 13.7% to

Table 2 Share of major edible oils in total imports (%)

Year	Crude Palm Oil	Refined Palm Oil	Soybean Oil	Sunflower Oil	Others	Total
2009-10	62.6	16.3	13.7	6.5	0.9	100.0
2010-11	61.9	12.6	16.4	8.9	0.2	100.0
2011-12	63.2	16.1	10.6	9.2	0.8	100.0
2012-13	65.6	12.9	10.2	10.3	1.0	100.0
2013-14	51.5	24.4	12.8	10.3	1.0	100.0
2014-15	56.3	9.4	18.2	13.5	2.7	100.0
2015-16	46.6	16.5	25.3	9.5	2.1	100.0
2016-17	38.6	21.0	24.7	12.3	3.3	100.0
2017-18	44.7	18.1	20.5	14.6	2.2	100.0
2018-19	43.6	16.8	21.2	17.2	1.2	100.0
2019-20	43.2	16.5	22.6	17.1	0.6	100.0
2020-21	55.4	1.0	26.9	16.1	0.5	100.0

Source Authors' estimates based on Ministry of Commerce and Industry

26.9%, and the sunflower oil has more than doubled from 6.5% to 16.1%, respectively. A decline in the rate of soybean production in the country – as noted earlier, and a consistent fall in sunflower production could be the major reason behind such change.

Tariff hikes: scenarios, simulations, and impacts

The present rates of duties for edible oil imports are shown in Table 3. In general, crude forms attract lower tariffs when compared with the refined oil categories. One shall observe the difference is fixed at 11% between the crude and refined forms. This helps domestic processing companies enhance their outputs and profits and acts as a means for generating and maintaining employment in these industries. Crude palm oil attracts the lowest tariff at present among all edible oil categories. Having the largest import share backed by strong domestic demand, it's not uncommon to observe the Government maintaining this tariff highly flexible to adjust to the oilseeds production and consumer edible oil prices in the country. It is also common to observe a co-movement in tariff hikes in both the crude and the refined forms simultaneously in most cases. Higher tariffs are maintained in recent years, possibly to enhance the domestic production capacity - especially since late 2017 when compared with the previous years. One shall correlate these hikes with higher oilseeds production and procurement discussed earlier.

Table 3 Import duties on edible oils (%, w.e.f. 30th June 2021)

Products	Rate	Agri Cess	Social Welfare Cess	Effective Duty
Crude palm oil	10.00	17.50	10.00	30.25
RBD palmolein	37.50	-	10.00	41.25
RBD palm oil	37.50	-	10.00	41.25
Crude soybean oil	15.00	20.00	10.00	38.50
Crude sunflower oil	15.00	20.00	10.00	38.50
Crude rapeseed oil	35.00	-	10.00	38.50
Refined soybean oil	45.00	-	10.00	49.50
Refined sunflower oil	45.00	-	10.00	49.50
Refined rapeseed oil	45.00	-	10.00	49.50

Source Solvent Extractors' Association of India

Table 4. Tariffs assumed under different scenarios

Item	Tariff rate (%)						
	Base	S-1	S-2	S-3	S-4	S-5	S-6
Crude palm oil	30.25	48.40	37.81	45.38	48.40	37.81	45.38
RBD palmolein	41.25	59.40	51.56	61.88	59.40	51.56	61.88
RBD palm oil	41.25	59.40	51.56	61.88	59.40	51.56	61.88
Crude soybean oil	38.50	38.50	48.13	57.75	38.50	48.13	57.75
Crude sunflower oil	38.50	38.50	48.13	57.75	38.50	38.50	38.50
Crude rapeseed oil	38.50	38.50	48.13	57.75	38.50	48.13	57.75
Refined soybean oil	49.50	49.50	61.88	74.25	49.50	61.88	74.25
Refined sunflower oil	49.50	49.50	61.88	74.25	49.50	49.50	49.50
Refined rapeseed oil	49.50	49.50	61.88	74.25	49.50	61.88	74.25

Source Authors (rates in scenario-1 are based on the Ministry of Consumer Affairs, Food & Public Distribution)
Note Base rates are the present tariff rates; S-1 through S-6 refer to the scenarios

The present study attempts to simulate an economy that attempts to encourage its domestic production capacity. As an *ex-ante* measure, different scenarios are assumed. In scenario-1, the country is presumed to impose the highest tariffs it levied in past on different edible oil items, expecting to increase its domestic production and processing capacities. One shall note that leaving palm oil, the tariff rates at present are equivalent to the highest rates in past. This protectionist approach is presumed to intensify in scenarios 2 and 3 where an additional 25% and 50% tariff hikes are presumed over the existing rates. The latter three scenarios follow the former, the exception being an absence of a hike in crude and refined sunflower oils as its seed production trend has sharply declined for more than a decade. Tariff rates presumed in different scenarios are displayed in Table 4. One shall note the tariff rates are similar in scenarios 1 and 4 as the base rates are equivalent to the highest tariff in past for the crude and refined sunflower oil category. Net tariff rates are derived for the edible oil sector using nominal import values of different items during 2019-20 as weights[4] and were used in the simulation.

The aggregate tariff hikes over the base rates derived under different scenarios and their probable impacts on selected attributes are displayed in Table 5. In all the scenarios, a tariff hike raises import prices and hence reduces the edible oil imports as common to expect, with the volume of reduction varying with the level of tariff hikes. For instance, in scenario-3, which levies the highest tariff, the results indicate that the edible oil import shall decline by over 20%. The rate varies to over 16% in scenario-6; around 12% in scenarios-1&4 that replicates the highest tariffs levied in past; and lesser in other cases. Note that the rate of decline responds together with the import substitution elasticity, which is held constant in different scenarios. This reduction in import boosts both the domestic oilseeds and edible oil production – but marginally. In scenario-3, which levies the highest tariff, oilseeds production rises just around 2%, and edible oil production increases by around 3% in response to the decline in import by over 20%. One shall observe similar effects in other scenarios as well in varying rates.

These tariff hikes and subsequent rise in oilseeds production still bring higher prices to the farmers and the edible oil industries, primarily due to the persisting gap between the domestic demand and the supply after the hike. Results show this price gain shall vary from 2.4% to 6% depending upon the tariff imposed. The scenario-5, which excludes sunflower oil from tariff imposition, generates lower price gains at an aggregate level, whereas scenario-3 brings the highest gain, among others. Price gains to the processing industries are relatively less when compared with the oilseed

[4]Item-1 also included *crude palm kernel oil*; item-3 included *RBD palm stearin* and *other refined palm oil*; and item-6 included '*rape oil*' while estimating net tariff.

Table 5 Simulation results: impact of tariff hikes

Impacts	Scenarios					
	1	2	3	4	5	6
Tariff hike (% over the base rate)	27.54	25.00	50.00	27.54	19.71	39.42
Price effects						
The domestic price of domestic output						
a. Oilseeds	3.3	3.0	6.0	3.3	2.4	4.7
b. Edible oil	1.6	1.5	2.9	1.6	1.2	2.4
Import price						
a. Oilseeds	-	-	-	-	-	-
b. Edible oil	4.7	4.3	8.5	4.7	3.4	6.7
Composite commodity price						
a. Oilseeds	3.4	3.0	6.0	3.4	2.5	4.8
b. Edible oil	2.4	2.1	4.1	2.4	1.6	3.3
Producer price						
a. Oilseeds	3.3	3.0	6.0	3.3	2.4	4.7
b. Edible oil	1.6	1.5	2.9	1.6	1.2	2.4
Production effects						
Quantity of domestic output						
a. Oilseeds	1.0	0.9	1.8	1.0	0.8	1.5
b. Edible oil	1.7	1.5	2.9	1.7	1.2	2.3
Quantity of imports						
a. Oilseeds	-	-	-	-	-	-
b. Edible oil	-11.9	-10.8	-20.4	-11.9	-8.7	-16.5

Note $\sigma_{md} = 4.874$; $\Omega_{ed} = 2.771$

producers, ranging between 1.2% and 2.9%. Overall, the results suggest tariff hikes signal moderate but positive impacts on domestic oilseeds and edible oil production but considerable price gains – especially to the farmers.

Technological potential

The positive impact on production and prices discussed above shall help to enhance both oilseeds and edible oil production in the country. But the observed rate of increase in production is considerably low when compared to the domestic demand. Enhancing production and processing technology shall be a viable option to produce more per unit of land with existing rates of inputs used in the oilseeds sector, and to process more with the level of labour and capital employed in the edible oil sector. The pattern of change over the years in the oilseeds producing sector indicates a lower rate of yield growth in most of the commodities (Table A3 in the appendix). Except for soybean, average yield levels have increased in several edible oil commodities across states. While the use of labour has been substituted increasingly with machine power and a higher rate of fertilizers and pesticides are applied, the decline in irrigation expenses in most cases raises concerns about sustaining the existing yield growth in the long run. Similar is the case of the edible oil industries. While a substantial rise in the capital is an encouraging feature (Table A4 in the appendix), this has been at the cost of stagnant labour intake. With falling labour and other inputs use, the income and profit gains have been moderate in recent years.

The TFP growth estimates show considerable variations when compared with the past. The estimates of Chand et al. (2012) show a positive but less than unitary growth during 1975-05 in major oilseeds like soybean, groundnut, rapeseed and mustard (0.71%, 0.77%, and 0.79% respectively). Chandel et al. (2007) report a negative growth in the case of soybean (-0.06%), positive but lower growth in groundnut (0.39%), and

Table 6 Total Factor Productivity (TFP) growth in oilseeds and edible oil industry

Sector/Commodity/State	TFP Growth (% p.a.)
Oilseeds (2004-05 to 2017-18)	
Groundnut	4.58
Sesamum	-0.95
Soybean	-0.93
Rapeseed & mustard	0.06
Sunflower	4.58
Total oilseeds	1.47
Edible oils (2013-14 to 2017-18)	
Andhra Pradesh	-36.5
Assam	-2.1
Bihar	5.1
Gujarat	-3.3
Haryana	1.5
Himachal Pradesh	15.8
Jammu & Kashmir	-0.2
Jharkhand	-3.6
Karnataka	-9.1
Kerala	10.3
Madhya Pradesh	-15.2
Maharashtra	-41.5
Odisha	7.8
Punjab	4.5
Rajasthan	6.9
Tamil Nadu	-0.4
Uttar Pradesh	2.3
Uttarakhand	-13.6
West Bengal	2.6
All states	-3.52

a more than unitary growth in rapeseed and mustard (2.41%) while studying the period 1981-00. Kumar et al. (2008) observe an improvement in TFP growth from 0.14% during 1971-86 to 0.33% during 1986-2000. The present study, which extends the period of analysis to 2005-18, obtains a lower but positive TFP growth in rapeseed and mustard (0.06%), higher growth in the case of groundnut (4.6%), and negative growth in soybean (-0.93%) (Table 6). The sunflower, despite a persistent fall in production, observes a higher TFP growth while the sesamum has negative growth.

The higher TFP growth in groundnut is a reason why the production shifted towards a higher growth trajectory in the recent past *i.e.* groundnut production growth shifted from a negative annual rate of -1% during TE 2008-14 to 3.1% during TE 2015-21. The case of sunflower needs further probe. Turning our attention to the negative TFP growth in the edible oil industries both at the national level and across some major states, a persistent fall in capacity utilization in the industry shall in part be taken for validation. The capacity utilization averages just to 46%, falling from 65% five years earlier, often explained by the stagnant oilseed production trend. Despite the differences in numerical TFP growth estimates in both oilseeds and edible oil industries, one shall observe the existing rate of technology growth may barely help to expand the domestic production of these commodities.

Conclusions

Tariffs shall be an effective instrument to make imports expensive. The present study attempted to quantify the likely benefits of protectionist tariff hikes in enhancing domestic production and improving producer prices. Taking the case of the edible oil imports in India, it estimated the price gains the oilseed producers (farmers) and the edible oil industries shall receive; likely increase in domestic oilseeds and edible oil production, and the role the technology in attaining oilseeds/edible oil self-sufficiency. To quantify the impacts of tariff hikes, it calibrated a three-sector open-economy Computable General Equilibrium (CGE) model calibrated to a 2017-18 SAM developed for this purpose. Tariff hikes were assumed in different protectionist scenarios and their impacts on production and prices were simulated. In scenario-1, the country was presumed to impose the highest tariffs it levied in past on different edible oil items, expecting to increase its domestic production and processing capacities. This protectionist approach was presumed to intensify further in scenarios 2 and 3, where an additional 25% and 50% tariff hikes were presumed over the existing rates. The latter three scenarios followed the former, the exception being an absence of a hike in crude and refined sunflower oils as its seed production trend has sharply declined for more than a decade. Total Factor Productivity (TFP) estimates were derived for the oilseeds (2005-18) and the edible oil (2014-18) sectors to observe the existing rate of technology growth.

Results showed a tariff hike raises import prices in all scenarios and hence reduces the edible oil imports, with the volume of reduction in imports varying with the level of tariff hikes. This reduction in import boosts both the domestic oilseeds and edible oil production – but marginally. These tariff hikes and subsequent rise in oilseeds production still bring higher prices to the farmers and the edible oil industries, primarily due to the persisting gap between the domestic demand and the supply after the hike. The price gains were predicted to vary between 2.4% and 6% to the oilseeds producers (farmers) and between 1.2% and 2.9% to the edible oil industries. The oilseeds production was predicted to enhance by 1.8%, and the edible oil production by 2.9% at maximum. The existing rates of TFP growth were low, hence inadequate to meet self-sufficiency in oilseeds hence in edible oils, demanding a shift in production technology. With a huge share of land under oilseeds operated by the marginal and smallholders in resource-poor environments, policies that incentivize to bring more area under oilseeds and invest more for better yield shall help to enhance production in the medium and long run.

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Table A1 Outline of SAM (2017-18) constructed for the study

		ACT			COM			FAC		HHD		GOV	S-I	YTX	STX	TAR	ROW	TOT
		OSD	OIL	OTH	OSD	OIL	OTH	LAB	CAP	FAR	OTH							
ACT	OSD					X												
	OIL																	
	OTH																	
COM	OSD		X							X		X	X				X	
	OIL																	
	OTH																	
FAC	LAB		X															
	CAP																	
HHD	FAR							X				X					X	
	OTH																	
GOV															X		X	
S-I										X		X					X	
YTX																		
STX							X											
TAR																		
ROW																		
TOT																		

Note ACT=activities; COM=commodities; FAC=factors; HHD=households; GOV=government; S-I=savings/investment; YTX=income tax; STX=sales tax; TAR=tariff; ROW=rest of the world; OSD=oilseeds; OIL=edible oils; LAB=labor; CAP=capital; FAR=farmers; OTH=others; TOT=total

Table A2 Equations solved in the CGE model

Import price

$$PM_c = (1 + tm_c).EXR\, pwm_c \qquad c \in CM$$

$$\begin{bmatrix} import \\ price \\ (dom.\ cur.) \end{bmatrix} = \begin{bmatrix} tariff \\ adjust- \\ ment \end{bmatrix} . \begin{bmatrix} exchange\ rate \\ (dom.cur.per \\ unit\ of\ \ for.cur.) \end{bmatrix} . \begin{bmatrix} import \\ price \\ (for.cur.) \end{bmatrix}$$

Export price

$$PE_c = (1 - te_c).EXR.pwm_c \qquad c \in CE$$

$$\begin{bmatrix} export \\ price \\ (dom.\ cur.) \end{bmatrix} = \begin{bmatrix} tariff \\ adjust- \\ ment \end{bmatrix} . \begin{bmatrix} exchange\ rate \\ (dom.cur.per \\ unit\ of\ \ for.cur.) \end{bmatrix} . \begin{bmatrix} export \\ price \\ (for.cur.) \end{bmatrix}$$

Absorption

$$PQ_c.QQ = \left[PD_c.QD_c + (PM_c.QM_c)_{|c \in CM|} \right].(1 + tq_c) \qquad c \in C$$

$$[absorption] = \left(\begin{bmatrix} domestic\ sales\ price \\ times \\ domestic\ sales\ quantity \end{bmatrix} + \begin{bmatrix} import\ price \\ times \\ import\ quantity \end{bmatrix} \right) . \begin{bmatrix} sales\ tax \\ adjustment \end{bmatrix}$$

Domestic output value

$$PX_c.QX_c = PD_c.QD_c + (PE_c.QE_c)_{|c \in CE} \qquad c \in C$$

$$\begin{bmatrix} producer \\ price \\ times \\ domestic \\ output\ quantity \end{bmatrix} = \begin{bmatrix} domestic \\ sales\ price \\ times \\ domestic \\ sales\ quantity \end{bmatrix} + \begin{bmatrix} export \\ price \\ times \\ export \\ quantity \end{bmatrix}$$

Activity price

$$PA_a = \sum_{c \in C} PX_c.\theta_{ac} \qquad a \in A$$

$$\begin{bmatrix} activity \\ price \end{bmatrix} = \begin{bmatrix} producer\ prices \\ times\ yields \end{bmatrix}$$

Value-added prices

$$PVA_a = PA_a - \sum_{c \in C} PQ_c\,.\, ica_{ca} \qquad a \in A$$

$$\begin{bmatrix} value \\ added \\ price \end{bmatrix} = \begin{bmatrix} activity \\ price \end{bmatrix} = \begin{bmatrix} input\ cost \\ per\ activity \\ unit \end{bmatrix}$$

Activity production function

$$QA_a = ad_a \cdot \prod_{f \in F} QF_{fa}^{\alpha_{fa}} \qquad a \in A$$

$$\begin{bmatrix} activity \\ level \end{bmatrix} = f \begin{bmatrix} factor \\ inputs \end{bmatrix}$$

Factor demand

$$WF_f \,.\, WFDIST_{fa} = \frac{a_{fa} \,.\, PVA_a \,.\, QA_a}{QF_{fa}} \qquad f \in F, a \in A$$

$$\begin{bmatrix} marginal\ cost \\ of\ factor\ f \\ in\ activity\ a \end{bmatrix} = \begin{bmatrix} marginal\ revenue \\ product\ of\ factor \\ f\ in\ activity\ a \end{bmatrix}$$

Intermediate demand

$$QINT_{ca} = ica_{ca} \,.\, QA_a \qquad c \in C,\ a \in A$$

$$\begin{bmatrix} inter- \\ mediate \\ demand \end{bmatrix} = f \begin{bmatrix} activity \\ level \end{bmatrix}$$

Output function

$$QX_c = \sum \theta_{ac} \,.\, QA_a \qquad c \in C$$

$$\begin{bmatrix} domestic \\ output \end{bmatrix} = f \begin{bmatrix} activity \\ level \end{bmatrix}$$

Composite Supply (Armington) Function

$$QQ_c = aq_c \,.\, \left(\delta_c^q \,.\, QM_c^{-\rho_c^q} + (1-\delta_c^q) \,.\, QD_c^{-\rho_c^q}\right)^{\frac{-1}{\rho_c^q}} \qquad c \in CM$$

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = f \begin{bmatrix} import\ quantity,\ domestic \\ use\ of\ domestic\ output \end{bmatrix}$$

Import domestic demand ration

$$\frac{QM_c}{QD_c} = \left(\frac{PD_c}{PM_c} \,.\, \frac{\delta_c^q}{1-\delta_c^q}\right)^{\frac{1}{1-\rho_c^q}} \qquad c \in CM$$

$$\begin{bmatrix} import- \\ domestic \\ demand\ ratio \end{bmatrix} = f \begin{bmatrix} domestic- \\ import \\ price\ ratio \end{bmatrix}$$

Composite supply for non-imported commodities

$$QQ_c = QD_c \qquad c \in CNM$$

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} domestic\ use\ of \\ domestic\ supply \end{bmatrix}$$

Output Transformation (CET) function

$$QX_c = at_c \cdot \left(\delta_c^t . QE_c^{\rho_c^t} + (1-\delta_c^t) . QD_c^{\rho_c^t} \right) \rho_c^{1/t} \qquad c \in CE$$

$$\begin{bmatrix} composite \\ output \end{bmatrix} = f \begin{bmatrix} export\ quantity,\ domestic \\ use\ of\ domestic\ output \end{bmatrix}$$

Export Domestic Supply Ratio

$$\frac{QE_c}{QD_c} = at_c \cdot \left(\frac{PE_c}{PD_c} . \frac{1-\delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \qquad c \in CE$$

$$\begin{bmatrix} export \\ domestic \\ supply\ ratio \end{bmatrix} = f \begin{bmatrix} export \\ domestic \\ supply\ ratio \end{bmatrix}$$

Output Transformation for Non-Exported Commodities

$$QX_c = QD_c \qquad c \in CNE$$

$$\begin{bmatrix} domestic \\ output \end{bmatrix} = \begin{bmatrix} domestic\ sales\ of \\ domestic\ output \end{bmatrix}$$

Factor Income

$$YF_{hf} = shry_{hf} \cdot \sum_{a \in A} WF_f . WFDIST_{fa} . QF_{fa} \qquad h \in H, f \in F$$

$$\begin{bmatrix} household \\ factor \\ income \end{bmatrix} = \begin{bmatrix} income \\ share\ to \\ household\ h \end{bmatrix} . \begin{bmatrix} factor \\ income \end{bmatrix}$$

Household Income

$$YF_h = \sum_{f \in F} YF_{hf} + tr_{h,gov} + EXR . tr_{h,gov} \qquad h \in H$$

$$\begin{bmatrix} household \\ income \end{bmatrix} = \begin{bmatrix} factor \\ incomes \end{bmatrix} + \begin{bmatrix} transfers\ from \\ governmnets\ \& \\ rest\ of\ world \end{bmatrix}$$

Household Consumption Demand

$$QH_{ch} = \frac{\beta_{ch} . (1-mps_h) . (1-ty_h) . YH}{PQ_c} \qquad c \in C, h \in H$$

$$\begin{bmatrix} household \\ demand\ for \\ commodity\ c \end{bmatrix} = f \begin{bmatrix} household\ income, \\ composite\ price \end{bmatrix}$$

Investment Demand

$$QINV_c = \overline{qinv_c}\ .IADJ \qquad c \in C$$

$$\begin{bmatrix} investment \\ demand\ \ for \\ commodity\ c \end{bmatrix} = \begin{bmatrix} base-year\ investment \\ times \\ adjustment\ \ factor \end{bmatrix}$$

Government Revenue

$$YG = \sum_{h \in H} ty_h\ .\ YH_h + EXR\ .\ tr_{gov,row} + \sum_{c \in C} tq_c.(PD_c.QD_c + (PM_c.QM_c)_{|c \in CM})$$
$$+ \sum_{c \in CM} ty_c\ .\ EXR.\,pwm_c.QM_c + \sum_{c \in CE} te_c.EXR.\,pwe_c.QE_c$$

$$\begin{bmatrix} govern- \\ ment \\ revenue \end{bmatrix} = \begin{bmatrix} direct \\ taxes \end{bmatrix} + \begin{bmatrix} transfer \\ from \\ RoW \end{bmatrix} + \begin{bmatrix} sales \\ tax \end{bmatrix} + \begin{bmatrix} import \\ tariffs \end{bmatrix} + \begin{bmatrix} export \\ taxes \end{bmatrix}$$

Government Expenditure

$$EG = \sum_{h \in H} tr_{h,gov} + \sum_{c \in C} PQ_c.qg_c$$

$$\begin{bmatrix} government \\ spending \end{bmatrix} = \begin{bmatrix} household \\ transfers \end{bmatrix} = \begin{bmatrix} government \\ consumption \end{bmatrix}$$

Factor Markets

$$\sum_{a \in A} QF_{fa} = QFS_f \qquad f \in F$$

$$\begin{bmatrix} demand \\ for \\ factor\ f \end{bmatrix} = \begin{bmatrix} supply\ of \\ factor\ \ f \end{bmatrix}$$

Composite commodity market

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + qg_c + QINV_c \qquad c \in C$$

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} composite\ demand; \\ sum\ \ of\ \ intermediate, \\ household,\ government, \\ \&\, investent\ \ demand \end{bmatrix}$$

Current Account Balance for Rest of the World (in Foreign Currency)

$$\sum pwe_c.QE_c + \sum_{i \in I} tr_{i,row} + FSAV = \sum_{c \in CM} pwm_c.QM_c$$

$$\begin{bmatrix} export \\ revenue \end{bmatrix} = \begin{bmatrix} transfers \\ from \\ RoW \\ to\ households \\ \&\ government \end{bmatrix} = \begin{bmatrix} foreign \\ savings \end{bmatrix} = \begin{bmatrix} import \\ spending \end{bmatrix}$$

Saving – Investment Balance

$$\sum_{h \in H} mps_h \,.\, (1 - ty_h) \,.\, YH_h + (YG - EG) + EXR \,.\, FSAV$$
$$= \sum_{c \in C} PQ_c \,.\, QINV_c + WALRAS$$

$$\begin{bmatrix} household \\ savings \end{bmatrix} + \begin{bmatrix} government \\ savings \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix} = \begin{bmatrix} investment \\ spending \end{bmatrix} + \begin{bmatrix} WALRAS \\ dummy \\ variable \end{bmatrix}$$

Price Normalization

$$\sum_{c \in C} PQ_c \,.\, cwts_c = cpi$$

$$\begin{bmatrix} price\ times \\ weights \end{bmatrix} = [CPI]$$

Source Lofgren (2003)

Method A1: Estimating TFP growth using Malmquist Productivity Change Index (MPI)

The output-oriented Malmquist productivity change index based on period t and t+1 technology are respectively defined as:

$$M_t = \frac{D_t(x_{t+1}, y_{t+1})}{D_t(x_t, y_t)} \quad \ldots\ldots\ldots (1)$$

$$M_{t+1} = \frac{D_{t+1}(x_{t+1}, y_{t+1})}{D_{t+1}(x_t, y_t)} \quad \ldots\ldots\ldots (2)$$

Malmquist TFP index measures the change in TFP between two data points by computing the ratio of the distances of each data point relative to constant returns to scale (a common technology) Färe et al. (1994). Equation (3) presents the output-orientated Malmquist TFP change index. In the equation, technology in period t is used as reference technology in the first term while the technology of period t+1 is used as reference technology in the second term inside the bracket. A value of index more than one will indicate progress in TFP from period t to period 1 + t while a value less than one indicates a TFP regress.

$$M = [\frac{D_{t+1}(x_{t+1}, y_{t+1})}{D_{t+1}(x_t, y_t)} X \frac{D_{t+1}(x_{t+1}, y_{t+1})}{D_{t+1}(x_t, y_t)}]^{1/2} \quad \ldots\ldots\ldots (3)$$

The output-oriented Malmquist productivity is a measure of productivity growth (Caves et al., 1982). The above Malmquist equation is decomposed into two components namely efficiency change which captures the performance relative to the best practice in the sample and can be interpreted as the catching-up effect and the technical change which measures the shift in the frontier over time. The decomposition of the above equation is given in equation (4)

$$M = \frac{D_{t+1}(x_{t+1}, y_{t+1})}{D_t(x_t, y_t)} [\frac{D_t(x_{t+1}, y_{t+1})}{D_{t+1}(x_{t+1}, y_{t+1})} X \frac{D_t(x_t, y_t)}{D_{t+1}(x_t, y_t)}]^{1/2} \quad \ldots\ldots\ldots (4)$$

From the equation above, the ratio outside the square brackets measures the change in technical efficiency in period t+1 relative to period t, The efficiency change part tries to compare the distances of two observations (x_t, y_t) and (x_{t+1}, y_{t+1}) to the corresponding production frontiers. It gives information on whether production is catching up with or falling behind the production frontier with the assumption that the component captures diffusion of technology related to differences in innovation and institutional setting. The part inside the bracket (the geometric mean of the two ratios inside the square brackets) captures the shift in technology between the two periods, evaluated at (x_i, y_i) and (x_{i+1}, y_{i+1}).

The distance functions components in equation (4) can be calculated using two techniques known as parametric and non-parametric techniques. In this paper, a non-parametric technique to construct the Malmquist TFP index is utilized. Given the panel data set, we calculate the required distance measures for the Malmquist TFP index using DEA-like linear programs. For each state, four (4) distance functions must be calculated to measure the productivity change between two periods, t and t+1. This requires the solving of four linear programming (LP) problems assuming constant returns to scale (CRS) technology:

$$\begin{aligned}
&[D_t(x_t, y_t)]^{-1}) = Max_{\phi,\gamma}\varphi \\
&\textit{subject to} \\
&Y_t >= \theta\, y_{it} \\
&x_{it} >= \theta\, X_t \lambda \\
&\lambda >= 0
\end{aligned} \quad \ldots\ldots\ldots (5)$$

$$\begin{aligned}
&[D_{t+1}(x_{t+1}, y_{t+1})]^{-1}) = Max_{\phi,\gamma}\varphi \\
&\textit{subject to} \\
&Y_{t+1} >= \theta\, y_{it+1} \\
&x_{it+1} >= \theta\, X_{t+1} \lambda \\
&\lambda >= 0
\end{aligned} \quad \ldots\ldots\ldots (6)$$

$$
\begin{aligned}
&[D_t(x_{t+1}, y_{t+1})]^{-1}) = Max_{\phi,\gamma}\varphi \\
&\textit{subject to} \\
&Y_t >= \theta\, y_{it+1} \\
&x_{it+1} >= \theta\, X_t \hat{\lambda} \\
&\hat{\lambda} >= 0
\end{aligned}
\qquad \ldots\ldots\ldots (7)
$$

$$
\begin{aligned}
&[D_{t+1}(x_t, y_t)]^{-1}) = Max_{\phi,\gamma}\varphi \\
&\textit{subject to} \\
&Y_{t+1} >= \theta\, y_{it} \\
&x_{it} >= \theta\, X_{t+1} \hat{\lambda} \\
&\hat{\lambda} >= 0
\end{aligned}
\qquad \ldots\ldots\ldots (8)
$$

where is a vector of output quantity for the i^{th} entity given as *M x 1*; is a vector of input quantities for the i^{th} entity denoted as *K x 1*; *Y* is a matrix of output quantities for all *N* countries written as *N x M*; *X* is a matrix of input quantities for all *N* countries given as *N x K*; λ is an $N\times 1$ vector of weights, and φ is a scalar. The analysis involved the application of a non-parametric approach which includes both the multi-stage and Malmquist DEA Models to determine the efficiency and productivity change of each entity.

Table A3 Yield and input growth in oilseeds (All-India, 2004-05 –*vs*- 2017-18)

Output/inputs	Groundnut		Sesamum		Soybean		Rapeseed & Mustard		Sunflower	
	2004-05	2017-18	2004-05	2017-18	2004-05	2017-18	2004-05	2017-18	2004-05	2017-18
Yield (qtl/ha)	10.80	13.90	3.23	4.88	11.71	10.96	10.54	14.06	6.51	7.69
Seed (kg/ha)	101.83	116.75	5.69	5.74	97.94	90.11	6.29	6.38	6.62	8.64
Fertilizer (kg/ha)	68.52	118.40	19.08	47.73	53.99	70.38	78.92	115.34	66.93	57.49
Manure (qtl/ha)	22.96	12.35	4.12	6.84	2.42	2.68	6.47	1.56	1.44	0.22
Human labor (man-hrs/ha)	733.67	603.46	353.33	392.82	442.01	237.51	383.87	335.30	345.42	310.24
Animal labor (pair-hrs/ha)	53.03	28.42	36.40	8.65	63.04	14.79	56.32	10.34	65.53	27.90
Machine power (Rs/ha)	2043.99	3913.55	1321.22	2489.68	2104.84	4432.20	2736.22	3479.36	1042.91	2116.31
Insecticides (Rs/ha)	282.2	683.0	66.6	278.8	66.6	1136.1	96.0	204.8	52.2	116.5
Irrigation charges (Rs/ha)	1029.45	917.09	274.99	749.78	274.99	52.60	1901.74	1611.35	1170.75	71.46

Source Cost of Cultivation data
Note Estimates are the states' averages reported in the cost-of-cultivation data; expenditures are in real terms (constant 2011-12 prices)

Table A4 Selected characteristics in edible oil processing sector (2013-14 –vs- 2017-18)

	2013-14	2017-18	Growth (% p.a.)
Gross Value Added (Rs. billion)	63.34	64.62	0.50
Gross capital formation (Rs. billion)	25.81	47.38	20.89
Wages and salaries (Rs. billion)	13.02	16.66	7.00
Persons employed (million)	0.11	0.11	-0.60
Inputs consumed (Rs. billion)	1354.38	1280.71	-1.36
Income (Rs. billion)	40.69	44.87	2.57
Profit (Rs. billion)	26.21	29.53	3.16

Source Annual Survey of Industries