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IMPACT OF A DROUGHT IN SOUTH INDIA ON THE INDIAN ECONOMY: AN APPLICATION WITH THE TERM-INDIA MODEL*

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Abstract

Unlike other countries, economy-wide modelling in India generally has treated the Indian nation as one entity even though one recognises that the states/regions differ significantly in respect of their resource base and factor endowments. Of course, a few models at the state level exist. However, these models do not capture the transmission channels from the rest of India since these types of models treat the rest of India as merely a balancing mechanism. A few of the existing research studies for India using a Computable General Equilibrium model use a top-down approach to analyse state-level issues. A major drawback of this approach is the lack of consideration for region-specific price effects, for which the effect of state-sponsored programmes or imperfect factor mobility or disparities across regions cannot be captured in these models. Our study is the first attempt to develop a bottom-up model--TERM (The Enormous Regional Model)-for India. The model is utilised to understand the implications of a hypothetical drought in a region (South India) and how the effect transmits to the rest of India, through a 52 commodity sector TERM model for 7 regions in India encompassing 31 states and Union Territories. Each region within the model has its own input–output database and agricultural product mix, and the simulation in this static TERM model depicts short-run effects. The study shows that despite being limited to some states in South India, the drought is likely to have a moderate impact on the Indian economy. Both GDP and employment are going to be affected at the national level, and the parameters are affected in several states in India, that are not necessarily situated in the southern region. The interconnectedness of the regions causes reduction in employment and the wage rate, leading to migration of labour and redistribution of investment.

JEL classification: C68, J21, R13

Key words: The Enormous Regional Model (TERM), bottom-up Computable General Equilibrium model, India, Drought

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1. Introduction

Economy-wide empirical models have a long history in India. In the past, they played a distinguished role both in terms of their impact on policy making and in generating better data for policy analysis. While models of various types ranging from planning models and econometric models to computable general equilibrium (CGE) models have been constructed over the years, there has been a distinct emphasis in India on econometric models.[1] However, increasingly from the late 1980s/early 1990s, one finds a distinct trend towards building CGE models for India for policy analysis. However, it must be noted that Indian CGE models that were constructed were limited in respect of sectoral disaggregation and one hardly comes across models with more than 50 sectors. By contrast, Dixon et al. (1978) constructed an ORANI model of the Australian economy in 1977 that distinguished over 100 sectors and made a notable contribution in the arena of large-scale computable general equilibrium modelling.

Of late, Indian CGE models have matured in term of sectoral details. For instance, Pal et al. (2024) uses a CGE model with 111 sectors while there are 72 sectors in the Pohit et al. (2023a) ORANI-India model. However, most of the Indian models are national, implying there are no bifurcations of the nation by region[2]. This is a serious weakness of Indian models given that there is considerable variation in terms of resource base, income base, specialisation in production across regions (states) of India. Of course, a variant of the Pohit et al. (2023a) ORANI-India model has a top-down regional module to work out the regional consequences of national economic changes; national results for quantity variables are broken down by region using techniques borrowed from input–output analysis. In this type of model, region-specific demand shocks could be simulated, but, since price variables are not given a regional dimension, there is little scope for region-specific supply shocks. On the other hand, Pohit et al. (2024) is probably the first multi-regional CGE model in the Indian context where a specific state of India, namely, Odisha, is modelled along with the rest of India and the rest of world to understand the economic implications of policy shock on a specific state of India. However, this type of modelling has a serious limitation since India has 32 states and so grouping all the states barring Odisha into the rest of India fails to capture fully the implications of region-specific policy shock.

By contrast, the Centre of Policy Studies (COPs) at Victoria University (Australia) that is at the forefront of CGE modelling work upgraded their ORANI of the Australian economy by adding two regional subscripts (source and destination) to most variables and equations. In this "bottom-up" type of multi-regional CGE model, national results are driven by (i.e., are additions of) regional results. Liew (1984), Madden (1990) and Naqvi and Peter (1996) describe several such Australian examples. Dynamic versions of such models have followed (Giesecke, 1997). The best- known example of this type of regional model is the Monash Multiregional Forecasting model, MMRF-Green (Adams, Horridge, & Wittwer, 2003). Of late, Victoria University Regional Model (VURM), which represents an extension of the MMRF model which, itself, is an extension of the Monash Multi-Regional (MMR) model[3]. In the later version of MMRF and in VURM, a range of new features have been added to enhance the model's capacity for addressing the issues relating to fiscal, demographic, labour market and environmental analysis. For a detailed description on the aspects which distinguish regional and national CGE models, and in-depth summary on regional CGE modelling with theoretical and illustrative applications, refer (Giesecke and Madden 2013).

Bottom-up models allow simulations of policies that have region-specific price effects, such as

[1] Marwah (1991) notes that 40 of the 80 models developed for the Indian economy during the preceding four decades have been econometric models.

[2] The only exception is the state-level E3 model of India (see Mukhopadhyay, 2021). However, there are a limited number of sectors in this model although all states are captured.

[3] MONASH is a dynamic CGE model of the Australian economy built and maintained at the Centre of Policy Studies, Monash University. Refer, Dixon and Rimmer (2002).

state-sponsored industrial subsidies in only one region. They also allow us to model imperfect factor mobility (between regions as well as sectors). Thus, increased labour demand in one region may be both choked off by a local wage rise and accommodated by migration from other regions. Moreover, regional divisions are desirable for several reasons. Policy-makers who are concerned about areas of high unemployment or about disparities between urban and rural areas desire more detailed regional results. Environmental issues, such as green transition, and water management, often call for smaller regions especially if dirty industries are located in one part of the country whereas clean energy's growth is taking place in another part of the country due to a regional advantage.

Of late, COPs has developed a new class of regional models, namely, bottom-up TERM (The Enormous Regional Model) that allows for greater disaggregation of regional economies than previously available. This type of model has now been developed for several large economies, such as Brazil, China, USA, and Indonesia, with technical support from the COPs research team. This paper outlines the TERM-India model that has been developed recently at NCAER with support from the COPs research team. Subsequently, the model has been used to understand the implication of a hypothetical drought in a region (South India) of India and how the effect transmits to the rest of India. As each region within the model has its own input–output database and agricultural product mix, TERM-India is uniquely equipped to estimate the varying impact of the drought on different regions. The present version of the model is a static one and so our simulation depicts short-run effects.

The plan of the rest of the paper is as follows. Section 2 provides an overview of the structure of the TERM-India model. The subsequent section (section 3) describes the process of collation of data for the regional model. Section 4 discusses the results at the regional and national levels for our hypothetical simulation. Finally, Section 5 summarises our findings.

2. The Structure of the TERM-India Model[4]

A key advantage of TERM is its ability to handle a greater number of regions or sectors. The greater efficiency arises from a more compact data structure with a detailed dataset on flow of goods and services across different regions and sectors. This is captured in the model by various assumptions. For instance, a simplifying assumption in the TERM-India model is that all users in a particular region of, say, vegetables, source their vegetables from other regions according to common proportions. The data structure is the key to TERM's strength.

Figure 1 is a schematic representation of the model's input-output database. It reveals the basic structure of the model, which is key to its efficiency. The rectangles indicate matrices of flows. Core matrices (those stored on the database) are shown in bold type; the other matrices may be calculated from the core matrices. The dimensions of the matrices are indicated by indices (c, s, i, m, etc.) which correspond to the following sets[5].

The matrices in Figure 1 show the value of flows valued according to three methods:

Basic values = Output prices (for domestically-produced goods), or CIF prices (for imports)

Delivered values = Basic + Margins

Purchasers' values = Basic + Margins + Tax = Delivered + Tax

The matrices on the left-hand side of the diagram (Figure 1) resemble (for each region) a conventional single-region input-output database. For example, the matrix USE at top left shows the delivered value of demand for each good (c in COM) whether domestic or imported (s in SRC) in each

[4] The structure of the write-up follows the generic format of the TERM model, which is given in Horridge (2011).
[5] The sets DST (destination), ORG (origin) and PRD (produced) are, in fact, the same set, named according to the context of use.

destination region (DST) for each user (USER, comprising the industries, IND, and 4 final demanders: households, investment, government, and exports). Some typical elements of USE might show:

USE("Wool","dom","Textiles","North"): domestically-produced wool used by the textile industry in North

USE("Food","imp","HOU","West"): imported food used by households in West
USE("Meat","dom","EXP","North"): domestically-produced meat exported from a port in North. Some of this meat may have been produced in another region.

All these USE values are "delivered"; they include the value of any trade or transport margins used to bring goods to the user. Note that the USE matrix contains no information about regional sourcing of goods.

The TAX matrix of commodity tax revenues contains an element corresponding to each element of USE. Together with matrices of primary factor costs and production taxes, these add to the costs of production (or value of output) of each regional industry.

In principle, each industry is capable of producing any good. The MAKE matrix at the bottom of Figure 1 shows the value of output of each commodity by each industry in each region. A subtotal of MAKE, MAKE_I, shows the total production of each good (c in COM) in each region d.

TERM recognises inventory changes in a limited way. First, changes in stocks of imports are ignored. For domestic output, stock changes are regarded as one destination for industry output (i.e., they are dimension IND rather than COM). The rest of production goes to the MAKE matrix.

The right-hand side of Figure 1 shows the regional sourcing mechanism. The key matrix is TRADE, which shows the value of inter-regional trade by sources (r in ORG) and destinations (d in DST) for each good (c in COM) whether domestic or imported (s in SRC). The diagonal of this matrix (r=d) shows the value of local usage which is sourced locally. For foreign goods (s="imp") the regional source subscript r (in ORG) denotes the port of entry. The matrix IMPORT, showing total entry of imports at each port, is simply an add-up (over d in DST) of the imported part of TRADE.

The TRADMAR matrix shows, for each cell of the TRADE matrix, the value of margin good m (m in MAR) that is required to facilitate that flow. Adding together the TRADE and TRADMAR matrix gives DELIVRD, the delivered (basic + margins) value of all flows of goods within and between regions. Note that TRADMAR makes no assumptions about where a margin flow is produced (the r subscript refers to the source of the underlying basic flow).

Matrix SUPPMAR shows where margins are produced (p in PRD). It lacks the good-specific subscripts c (COM) and s (SRC), indicating that, for all usage of margin good m used to transport any goods from region r to region d, the same proportion of m is produced in region p. Summation of SUPPMAR over the p (in PRD) subscript yields the matrix SUPPMAR_P which should be identical to the subtotal of TRADMAR (over c in COM and S in SRC), TRADMAR_CS. In the model, TRADMAR_CS is a CES aggregation of SUPPMAR; margins (for a given good and route) are sourced according to the price of that margin in the various regions (p in PRD).

TERM assumes that all users of a given good (c,s) in a given region (d) have the same sourcing (r) mix. In effect, for each good (c,s) and region of use (d) there is a broker who decides for all users in d whence supplies will be obtained. Armington sourcing is assumed: the matrix DELIVRD_R is a CES composite (over r in ORG) of the DELIVRD matrix.

A balancing requirement of the TERM database is that the sum over user of USE, USE_U, shall be equal to the sum over regional sources of the DELIVRD matrix, DELIVRD_R.

It remains to reconcile demand and supply for domestically-produced goods. In Figure 1, the connection is made by arrows linking the MAKE_I matrix with the TRADE and SUPPMAR matrices.

For non-margin goods, the domestic part of the TRADE matrix must sum (over d in DST) to the corresponding element in the MAKE_I matrix of commodity supplies. For margin goods, we must consider both the margins requirement SUPPMAR_RD and direct demands TRADE_D.

At the moment, TERM-India distinguishes only 4 final demanders in each region:

(a) HOU: the representative household

(b) INV: capital formation

(c) GOV: government demand

(d) EXP: export demand

For many purposes, it is useful to break down investment according to destination industry. The satellite matrix INVEST (subscripted c in COM, i in IND, and d in DST) in the TERM-India model structure serves this purpose. It allows us to distinguish the commodity composition of investment by industry; for example, we would expect investment in agriculture to use more machinery (and less construction) than investment in dwellings.

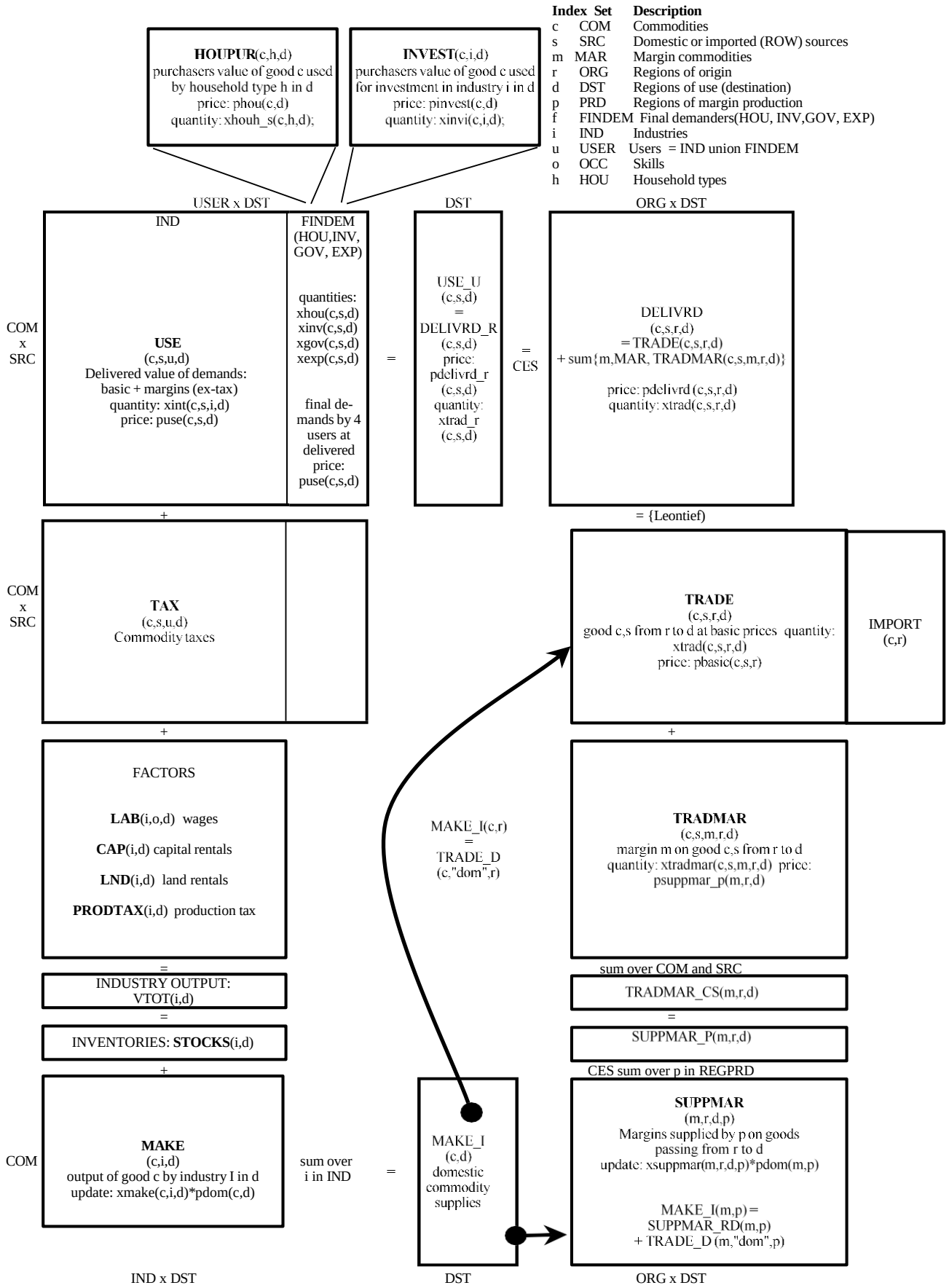
Even though TERM-India has the flexibility to incorporate several household types with different budget shares, the present version of the TERM-India model considers one representative household category.

2.1 The TERM equation system

By and large, the equations of the TERM model are similar to those of the ORANI-India CGE model, constructed by the NCAER-COPs research team. Producers choose a cost-minimising combination of intermediate and primary factor inputs, subject to production functions which are structured by a series of CES "nesting" assumptions, illustrated in Figure 2. Two high-level aggregates, of primary factors and of intermediate inputs, are each demanded in proportion to industry output (Leontief assumption). The primary factor aggregate is a CES composite of capital, land and a labour aggregate—the latter being itself a CES composite of labour by skill groups[6]. The aggregate intermediate input is again a CES composite of different composite commodities, which are, in turn, CES composites of commodities from different sources—as described in detail in Subsection 2.2. Industry outputs are transformed into commodity outputs via a CET mechanism that is calibrated from the MAKE matrix of Figure 1.

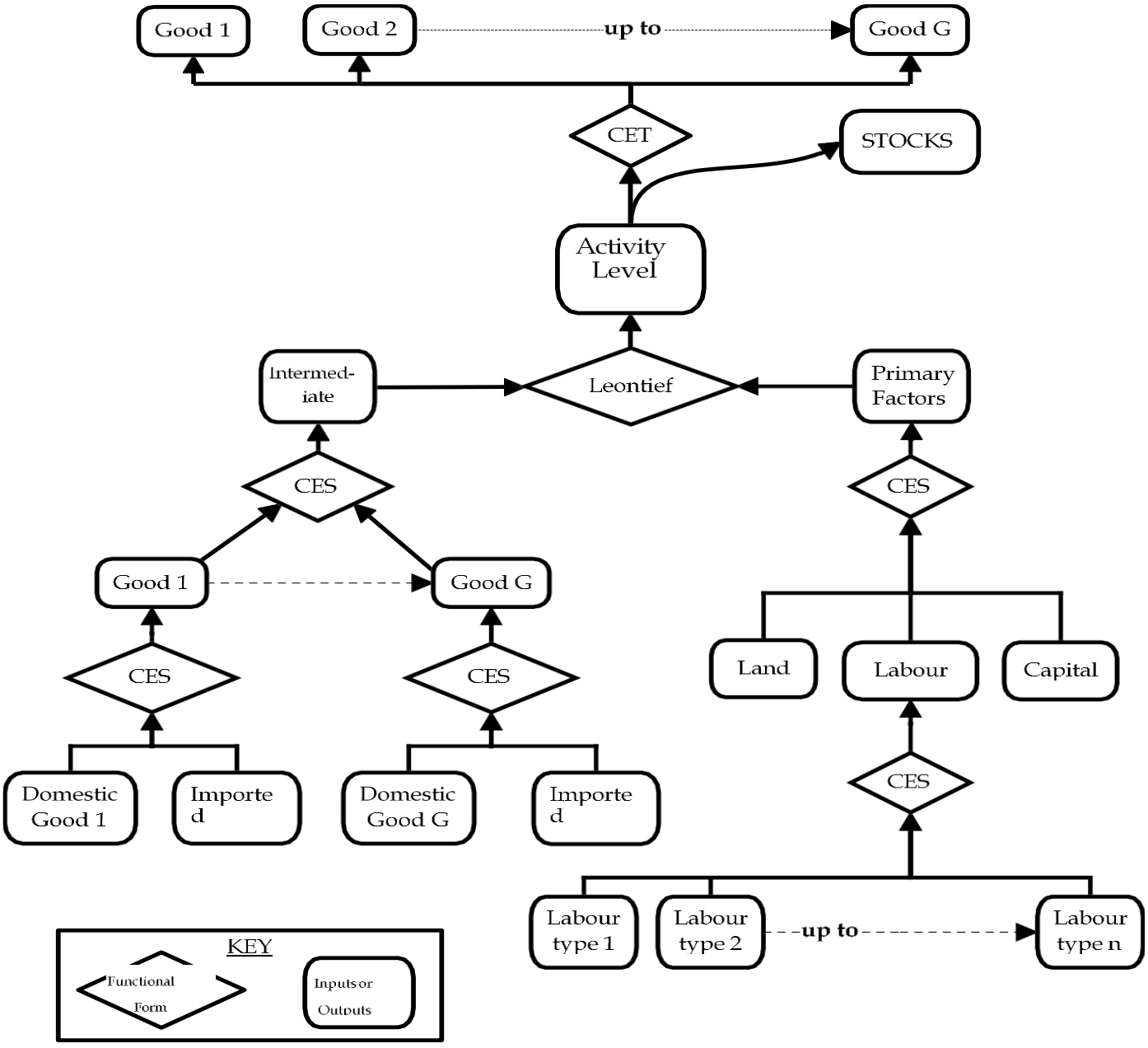
[6] At present, two labour groups--skilled and unskilled--are considered in the TERM-India model.

Figure 1: The TERM flows database



Source: Adapted from Horridge et al (2005)

Figure 2: TERM production structure



Source: Adapted from Horridge et al (2005)

2.2 TERM sourcing mechanism

Figure 3 illustrates the details of the TERM system of demand sourcing. Although the figure covers only the demand for a single commodity (Vegetables) by a single user (Households) in a single region (North), the same diagram would apply to other commodities, users and regions. The diagram depicts a series of 'nests' indicating the various substitution possibilities allowed by the model. Down the left side of the figure, boxes with dotted borders show in upper case the value flows associated with each level of the nesting system. These value flows may also be located in Figure 1. The same boxes show in lower case the price (p....) and quantity (x....) variables associated with each flow. The dimensions of these variables are critical both to the usefulness of the model and to its computational tractability; they are indicated by subscripts c, s, m, r, d and p, as explained in Table 1.

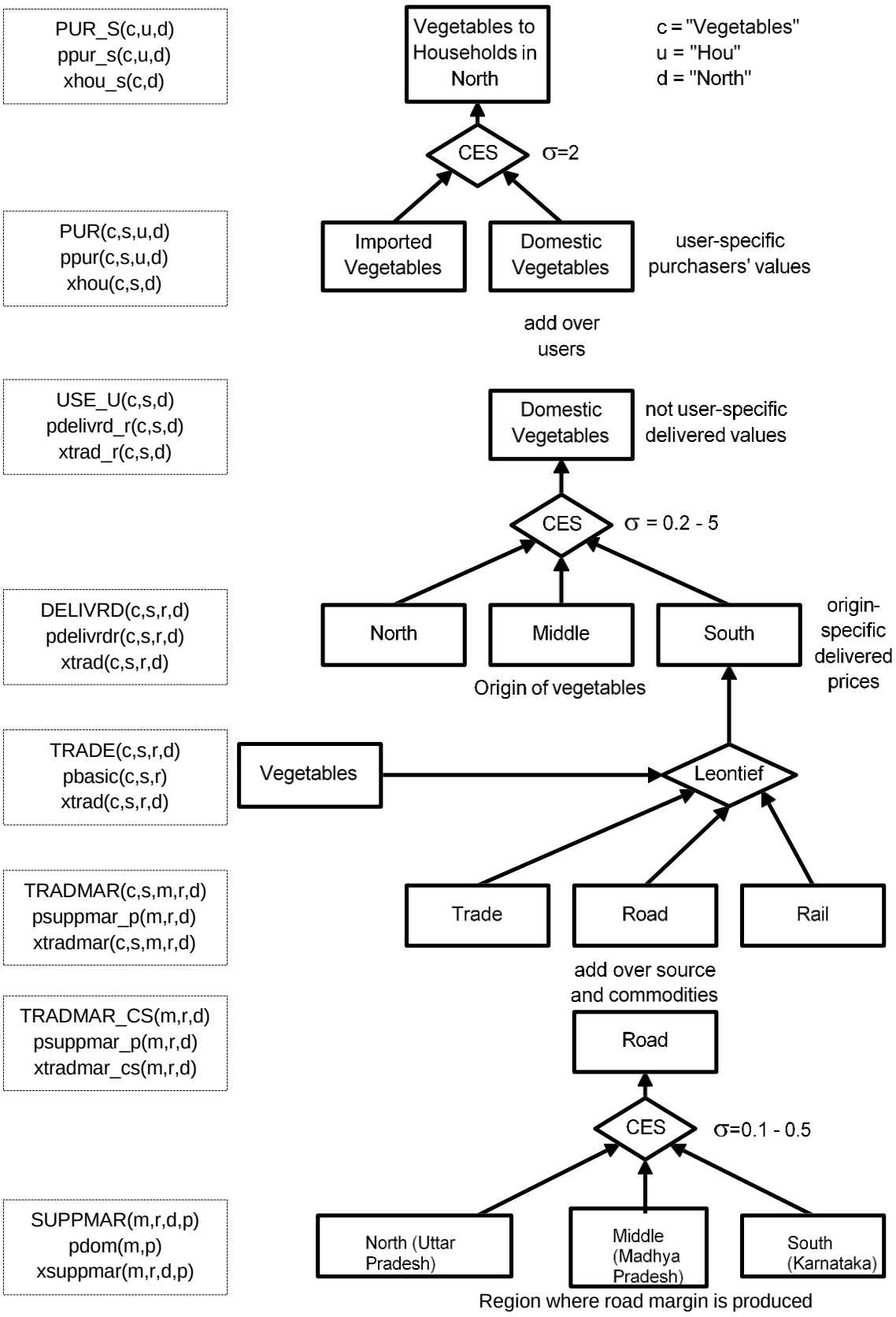
Table 1: Main sets of the TERM-India model

Index	Set name	Description	Typical size
S	SRC	(dom, imp) Domestic or imported (ROW) sources	2
C	COM	Commodities	147
M	MAR	Margin commodities (Trade, Road, Rail, Boat)	4
I	IND	Industries	147
O	OCC	Skills	2
D	DST	Regions of use (destination)	31
R	ORG	Regions of origin	31
P	PRD	Regions of margin production	31
F	FINDEM	Final demanders (HOU, INV, GOV, EXP)	4
U	USER	Users = IND union FINDEM	151

Note:

1. The sets DST, ORG and PRD are, in fact, the same set, named according to the context of use.
2. The size of region is 31 which corresponds to 30 states in the base year of the model (2018-19) plus one aggregate region composing all Union Territories.
3. The commodities correspond to 140 commodities of supply use table of India. Further, the electricity sector is decomposed by sources of production plus one aggregate sector of distribution and transmission.

Figure 3: TERM sourcing mechanisms



Source: Adapted from Horridge et al (2005)

At the top level, households choose between imported (from another country) and domestic vegetables. A CES or Armington specification describes their choice—as pioneered by ORANI and adopted by later CGE models. Demands are guided by user-specific purchasers' prices (the purchasers' values matrix PUR is found by summing the TAX and USE matrices of Figure 1). Here, 2 is a typical value for the elasticity of substitution commonly used in many CGE models.

Demand for domestic vegetables in a region is summed (over users) to give a total value USE_U (the "_U" suffix indicates summation over the user index u). The USE_U matrix is measured in "delivered" values—which include basic values and margins (trade and transport), but not the user-specific commodity taxes.

Moving down, the next level treats the sourcing of USE_U between the various domestic regions. The matrix DELIVRD shows how USE_U is split between origin regions r. Again, a CES specification controls the allocation; substitution elasticities range from 5 (merchandise) to 0.2 (services).[7] The CES implies that regions which lower production costs more than other regions will tend to increase their market share. The sourcing decision is made on the basis of delivered prices— which include transport and other margin costs. Hence, even with growers' prices fixed, changes in transport costs will affect regional market shares. Notice that variables at this level lack a user (u) subscript—the decision is made on an all-user basis (as if wholesalers, not final users, decided where to source vegetables).

The next level down shows how a "delivered" vegetable from, say, a hypothetical state Uttar Pradesh of India, is a Leontief composite of basic vegetables and the various margin goods. The share of each margin in the delivered price is specific to a particular combination of origin, destination, commodity and source. For example, we should expect transport costs to form a larger share for region pairs that are far apart, or for heavy or bulky goods. The number of margin goods will depend on how aggregated the model database is. Under the Leontief specification we preclude substitution between Road and Retail margins, as well as between Road and Rail. For some purposes it might be worthwhile to construct a more elaborate nesting (say, CES) that accommodates Road/Rail switching.

The bottom part of the nesting structure shows that margins on vegetables passing from the state of Uttar Pradesh of northern India to the state of Karnataka of southern India could be produced in different regions. The figure shows the sourcing mechanism for the road margin. We might expect this to be drawn more or less equally from the origin (Uttar Pradesh), the destination (Karnataka) and regions between (say, Madhya Pradesh in middle). There would be some scope (σ=0.5) for substitution, since trucking firms can relocate depots to cheaper regions. For retail margins, on the other hand, a larger share would be drawn from the destination region, and scope for substitution would be less (σ=0.1). Once again, this substitution decision takes place at an aggregated level. Similarly, a parallel system of sourcing is also modelled for imported vegetables, tracing them back to port of entry instead of region of production.

2.3 Other features of the TERM-India Model

The remaining features of TERM-India are common to the ORANI-India model. Industry production functions are of the nested CES type: Leontief, except for substitution between primary factors and between sources of goods. Exports from each region's port to the ROW face a constant elasticity of demand. The composition of household demand follows the linear expenditure system, while the composition of investment and government demands is exogenous. A variety of closures are possible. For the short-run simulation, we might hold fixed industry capital stocks and land endowments, while allowing labour to be fully mobile between sectors within a region and partially mobile between

[7] Given the lack of availability of elasticity parameters for India, we have used values sourced from various versions of existing TERM models developed for other countries.

regions. At the regional level we may link household consumption to regional factor incomes.

3. Collating data for the TERM-India Model

Expectedly, the data need of a multi-regional CGE model far exceeds what is required for a national CGE model. The data flow of our COPs type TERM model as depicted in Figure 1 are not available for the Indian economy. So, our strategy has been to estimate a database from what limited data are available at the regional (state) level for India.

The salient features of our data buildup with base year 2018-19 for the TERM-India model are as follows.

(a) The process starts with a national input-output table. At present, the Indian government only publishes supply-use tables (SUT). So, naturally, it involves the construction of a balanced input-output table for the base year of the model.

(b) At the outset, the construction also involves gathering certain regional (state-level) data. The requirements for regional data for the TERM-type model are modest: the distribution between regions of industry outputs and of final demand aggregates. This distribution can be conceived as a set of regional shares.

(c) The database is constructed at a high level of detail: 147 sectors and 31 states/UT (see Table A1 for the list of sectors). All states of India are considered as separate entities. We have considered only one aggregated union territory where all union territories are combined.

Of course, published regional input-output tables may form part of the inputs to the TERM data process. However, regional input-output tables exist only for a few states in the Indian context and at a very aggregated level. Moreover, the methodology is not documented at a transparent level. So, in this exercise, we have not used such tables.

3.1 The national input-output database

As shown in Figure 4, the TERM-India data process starts from the 2018-19 India Supply-Use Table which is available for 140 commodities and 66 industries. We have expanded the industries at first to 140 industries, each representing one commodity.

The initial SUT/IOT contains information on a commodity and industry called “Electricity”. Further, this single sector is decomposed into 7 electricity generators namely; (1) nuclear, (2), solar (3), wind (4), hydro (5), natural gas (6), coal and (7) other fuel sources. Information was collated on the cost and sales shares of electricity from the different generation fuels. This information is then used to replace the single electricity information with the extended electricity information. After this step, the database included 147 commodities and industries.

The above data along with data sources from other sources and sectoral level elasticity estimates are used first to create the full database of an ORANI-G standard single-country CGE model[8].

3.2 Estimates of the regional distribution of output and final demands

The next step is to obtain, for each industry and final demander, an estimate of each states’/UT’s share of national activity (these shares are the R001, R002, etc. of Figure 4). To develop a full input-output

[8] The construction procedure from SUT to full database of a single country ORANI-G model is described in Pohit et al. (2023b).

table for each region, we required estimates of industry shares (i.e., each region's share of national activity for a given industry), industry investment shares, household expenditure shares, international export and import shares, and government consumption shares.

The main data sources of data for the industry split are the following:

- Agricultural statistics are sourced from data published by the Ministry of Agriculture (Government of India).
- Employment data by industry at the state level are sourced from Periodic labour force survey data of the Ministry of Labour and Employment (Government of India).
- Industry-related data are collated from the Annual survey of industries published by MOSPI (Ministry of Statistics and Programme Implementation).
- Statistics on state domestic product etc. are sourced from Department of Economic and Statistics at the state level;
- Mining Statistics Year book of the Government of India provides information related to mining statistics[9].

As noted earlier, our sectoral split included a split of electricity into generation by fuel type plus a distribution sector. We have relied on published statistics collated from the Central Electricity Authority of India in this respect.

The data drawn from National Sample Survey Organisation's survey on consumption expenditure is used to decompose national-level private consumption expenditure collated from SUT to the various states and aggregate of union territories.

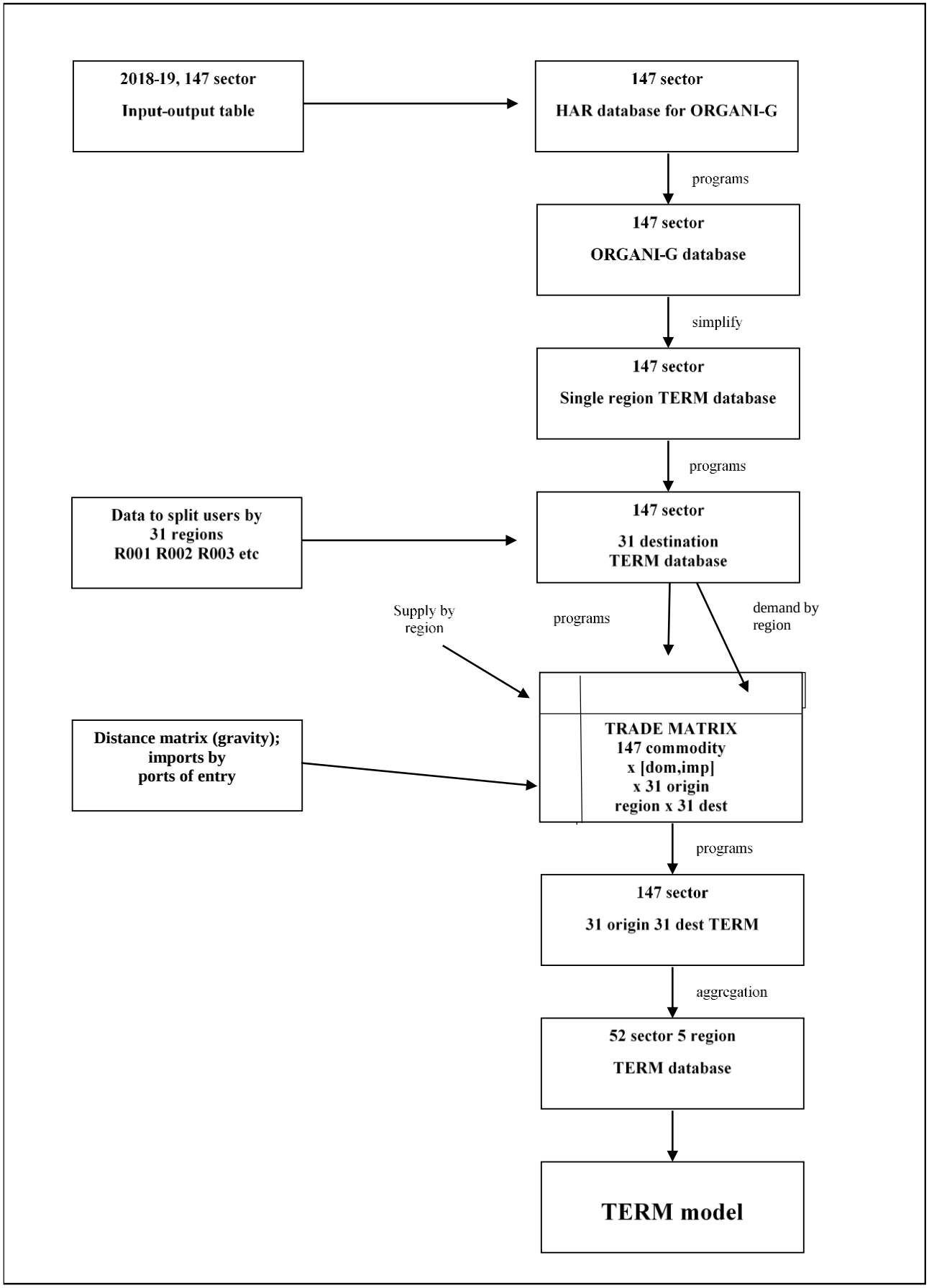
In compiling international trade data by state, we have first collated published trade data of the DGCIS (Government of India) by port of exit or entry. While DGCIS does not publish official estimates of import data by state, it does publish official exports by states /UTs. This forms our control total for exports by states/UTs.

The state accounts data collated from audited CAG sources provides government spending in each state/UT.

By applying these shares to the national CGE database, we compute the USE, FACTOR, and MAKE matrices on the left-hand side of Figure 1. None of these matrices distinguish the source region of inputs.

[9] The list is not exhaustive.

Figure 4: Producing regional database for TERM



Source: Adapted from Horridge et al (2005)

3.3 The TRADE matrix

The next stage was to construct the TRADE matrix on the right-hand side of Figure 1. For each commodity either domestic or imported, TRADE contains a 31x31 submatrix, where rows correspond to region of origin and columns correspond to region of use. The diagonal elements indicate production which is locally consumed. As shown in Figure 4, we already know both the row totals (supply by commodity and region) and the column totals (demand by commodity and region) of these submatrices.

The inter-regional trade data for India by model rail is available in public domain. However, the same by road, the predominant mode of transport is not available. Presently, such data can be estimated using GST record. However, in spite of our best effort, we have not yet got access to such data. Once, we have access to such data, we plan to use same for estimating inter-regional trade flows.

Currently, we have used the gravity formula (trade volumes follow an inverse power of distance) to construct trade matrices consistent with pre-determined row and column totals.

For a particular commodity the traditional gravity formula may be written:

$$V(r,d) = \lambda(r).\mu(d).V(r,*).V(*,d) /D(r,d)^2 \qquad r \neq d$$

where

$V(r,d)$ = value of flow from r to d (corresponding to matrix TRADE in Fig. 1)

$V(r,*)$ = production in r (known)

$V(*,d)$ = demand in d (known)

$D(r,d)$ = distance from r to d

The $\lambda(r)$ and $\mu(d)$ are constants chosen to satisfy:

$\Sigma_r V(r,d) = V(*,d)$ and $\Sigma_d V(r,d) = V(r,*)$.

For TERM, the formula above gave rather implausible results, especially for service commodities. Instead we set:

$$V(r,d)/V(*,d) \propto \sqrt{V(r,*)}/D(r,d)^k \qquad r \neq d$$

where K is a commodity-specific parameter valued between 0.5 and 2, with higher values for commodities not readily tradable. Diagonal cells of the trade matrices were set according to:

$V(d,d)/V(d,*)$ = locally-supplied demand in d as share of local production

$= MIN\{ V(d,*)/V(*,d),1\} \times F$

where F is a commodity-specific parameter valued between 0.5 and 1, with a value close to 1 if the commodity is not readily tradable.

The initial estimates of V(r,d) were then scaled (using a RAS procedure) so that:

$\Sigma_r V(r,d) = V(*,d)$ and $\Sigma_d V(r,d) = V(r,*)$.

Transport costs as a share of trade flows were set to increase with distance:

$$T(r,d)/V(r,d) \propto \sqrt{D(r,d)}$$

where T(r,d) corresponds to the matrix TRADMAR in Fig. 1. Again, the constant of proportionality is chosen to satisfy constraints derived from the initial national IO table.

3.4 Aggregation

Even though TERM is computationally efficient, it will be too slow to solve if a full 147-sector, 31- region database is used. The next stage in the data procedure is to aggregate the data to a more manageable size to solve the model. The aggregation choice is application specific. For example, to analyse the impact of the western-dedicated freight corridor, we may capture all states that fall under the location of the western-dedicated freight corridor as separate entities while we aggregate some of the states that have weak linkages with the state encompassing the dedicated-western freight corridor. Depending on the commodities that will be transported through the corridor, we may treat those sectors as separate entities and merge some of the other sectors.

4 The Policy Application and Aggregation Map

The policy application that we plan to use to examine the scope and versatility of the TERM-India model is the economic implication of a drought in South India on the same economy and how it transmits to the rest of India. In our test policy run, we assume that agricultural yield declines by 20% in a southern state in the agricultural sector. For the rest of India, we assume that yield in the agriculture sector remains unchanged. Given the nature of the policy simulation, we have designed our aggregation map for sector/industry/region.

Table 2 shows the concordance map between 147 sectors and 52 aggregated commodity sectors of our model for this policy simulation.

Table 2: Concordance Map for Commodity Aggregation

SL. No.	52 Commodities	147 Sectors
1	Crops	Paddy, Wheat, Cereals, Gram, Arhar, OtherPulses, Groundnut, RapeSeeds, OthOilSeeds, Kapas, Jute, Sugarcane, Coconut, Tobacco, TeaFarm, CoffeeFarm, Rubber, Fruits, Vegetables, Othfoodcrop
2	Livestock	Milk, Wool, EggPoultry, OthLivestoc
3	Forests	IndWood, FireWood, OthForestPr
4	Fish	InlandFish, MarineFish
5	CoalLignite	CoalLignite
6	NaturalGas	NaturalGas
7	CrudePetrol	CrudePetrol
8	MetalOre	IronOre, ManganeseOr, Bauxite, CopperOre, OthMetMin
9	NonMetMin	Limestone, Mica, OthNonMetMi
10	MeatPrd	Meat, OthMeat
11	FishPrd	FishPrd
12	OthFoodPrd	FruitVeg, DairyPrd, OilsFats, GrainPrd, Sugar, BakeryPrd, OthFoodPrd
13	Drinks	Alcohol, NonAlcohBev, TeaPrd, CoffeePrd
14	TobaccoPrd	TobaccoPrd
15	Textiles	CottonPrd, SyntheticPr, WoolPrd, SilkPrd, CarpetWeave, OthTextiles
16	Clothing	Clothing
17	ShoesLeather	LeaFootwear, OthLeathPrd
18	WoodPaperPrd	WoodPrd, PaperPrd, PublishPrin
19	RubrPlastic	RubberPrd, PlasticPrd
20	PetroleumPrd	PetroleumPrd
21	Chemicals	CoalPrd, InorganChem, OrganChem, Fertilisers, Pesticides, PaintVarn,

SL. No.	52 Commodities	147 Sectors
		Pharma, SoapCostmti, SyntheticFi, OthChemPrd
22	Cement	Cement
23	NonMetMinPrd	NonMetMinPrd
24	IronSteel	ISFerrloAlo, ISCasting, ISFoundries
25	NonFerBasMet	NonFerBasMe
26	OthMetalPrd	Hardware, OthMetalPrd
27	Machinery	AgricMachin, FoodTextMac, OthIndusMac, MachineTool OthNonEleMa, ElecIndMach
28	ShipBoats	ShipBoats
29	RailEq	RailEq
30	MotorVeh	MotorVeh
31	MotorCycle	MotorCycle
32	Bicycles	Bicycles
33	Aircrafts	Aircrafts
34	OthTrnsEq	OthTrnsEq
35	OthManuf	Furniture, EleCableWir, Batteries, ElecAppl, CommunicEq OthElecMach, ElectronicE, MedicalInst, WatchClocks, Jewellery, OthManuf
36	Construction	Construction
37	RawElec	Elec_nuclea, Elec_solar, Elec_wind, Elec_hydro, Elec_gas Elec_coal, Elec_other,
38	ElecDist	ElecDist
39	Gas	Gas
40	WaterSupply	WaterSupply
41	Trade	Trade
42	OthSrv	RepairMV, RentMachEq, CommunicSrv, FinanceSrv, InsuranceSr, RD, LegalSrv, OthBusSrv, CompterSrv, SocialPvtSr, RecEntertai
43	HotelRest	HotelRest
44	RailTrns	RailTrns
45	LandTrns	LandTrns
46	AirTrns	AirTrns
47	WaterTrns	WaterTrns
48	OthTrnSrv	OthTrnSrv, Warehouse
49	RealEstate	OwnerDwel, RealEstSrv
50	PublicAdmin	PublicAdmin
51	Education	Education
52	Health	Health

Source: Author's Estimates

The regional structure of the TERM-India model used for the present paper is shown in Figure 5. As Figure 5 shows, the 30 states of India are grouped under 6 aggregated regions. Table 3 shows the concordance map for aggregation of states for running our TERM-India model.

Figure 5: Regional structure in India

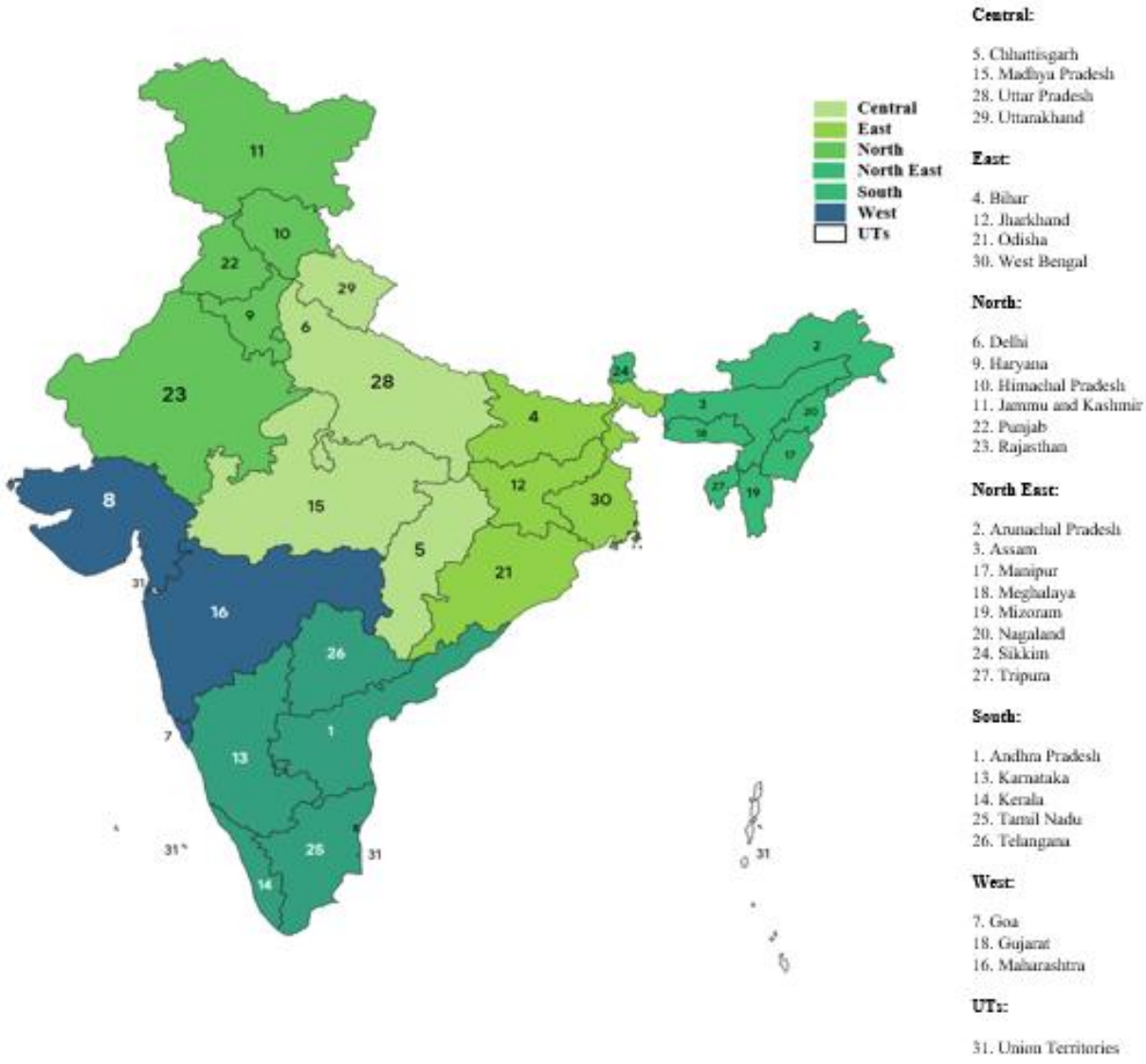


Table 3: Mapping of States/UTs into Aggregate Regions

S. No.	States/UTs	State Code	Region
1	Andhra Pradesh	AndhraPrd	South
2	Arunachal Pradesh	ArunachalPrd	North-East
3	Assam	Assam	North-East
4	Bihar	Bihar	East
5	Chhattisgarh	Chhattisgarh	Central
6	Delhi	Delhi	North
7	Goa	Goa	West
8	Gujarat	Gujarat	West
9	Haryana	Haryana	North
10	Himachal Pradesh	HimachalPrd	North
11	Jammu and Kashmir	JammuKashmir	North
12	Jharkhand	Jharkhand	East
13	Karnataka	Karnataka	South
14	Kerala	Kerala	South
15	Madhya Pradesh	MadhyaPrd	Central
16	Maharashtra	Maharashtra	West
17	Manipur	Manipur	North-East
18	Meghalaya	Meghalaya	North-East
19	Mizoram	Mizoram	North-East
20	Nagaland	Nagaland	North-East
21	Odisha	Odisha	East
22	Punjab	Punjab	North
23	Rajasthan	Rajasthan	North
24	Sikkim	Sikkim	North-East
25	Tamil Nadu	TamilNadu	South
26	Telangana	Telangana	South
27	Tripura	Tripura	North-East
28	Uttar Pradesh	UttarPrd	Central
29	Uttarakhand	Uttarakhand	Central
30	West Bengal	WestBengal	East
31	Union-Territory	UTerritory	Union Territory

Source: Author's Estimates

Note: i) We aggregated UTs as one region (UTerritory).

4. Results

Table 4 provides a snapshot of the macroeconomic impact of a hypothetical drought in South India on the economies of India as generated from our TERM-India model run. Due to the effect on agriculture and livestock sector, the drought is likely to lower the national GDP by 0.95%. Among this, 0.09 percentage point of this reduction corresponds to a decrease in value added in the agriculture sector, while 0.86 percentage point is contributed by other industries arising from the interlinkage of these industries with the agriculture sector. Our model allows for labour migration. The poor conditions in the South, due to the drought, cause workers to move to other regions increasing those regions' GDP. There is a regional difference in the effect on real GDP, with South, West and North-East India facing a reduction in GDP to varying extents. On the other hand, Central, North and East regions are likely to experience an increase in GDP because of the migration of labour stimulated by wage-differential favouring these regions[10].

[10] As Territories is a negligible part of overall GDP of India, we are not reporting those results here.

Table 4: Macroeconomic impacts of drought in Southern India: percentage change relative to base case

	North	North-East	Central	East	West	South	National
Real GDP	0.12	-0.04	0.39	0.08	-0.15	-3.43	-0.95
Agriculture contribution	0.01	0.00	0.06	0.01	-0.01	-0.24	-0.09
Other industries contribution	0.11	-0.04	0.33	0.07	-0.14	-3.19	-0.86
Real consumption	0.76	0.18	1.65	0.60	-0.22	-3.62	-0.58
Real investment	-0.42	-0.51	0.45	-0.59	-1.16	-3.50	-1.42
Export volume	-1.35	-1.18	-2.31	-1.55	-0.54	-0.33	-0.66
Import volume	0.28	0.20	0.72	0.17	-0.18	-1.62	-0.29
Export prices	-0.77	-0.81	-0.34	-0.62	-1.01	-0.97	-0.92
Employment	0.24	-0.06	0.70	0.16	-0.27	-2.06	-0.46
Average wage rate	0.18	-0.10	0.60	0.10	-0.29	-1.92	-0.46

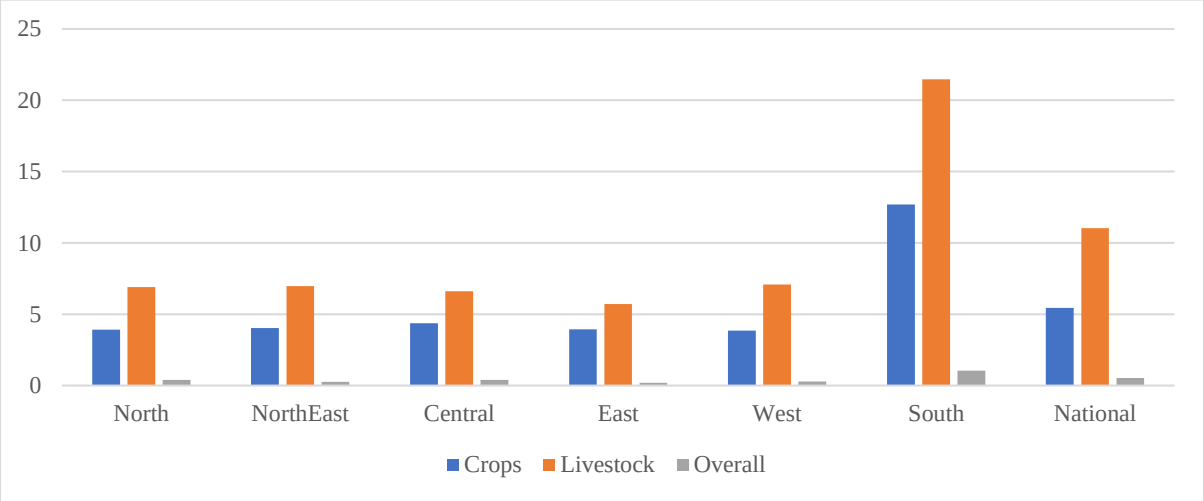
Source: Author's Estimates

Table 4 also shows the effect of the drought on the labour market in terms of effect on employment and real wage. The results show that at the national level, employment is facing an adverse effect to the extent of around 0.5%; and the average real wage at the national level is also going to be affected in a similar way. The basic assumption in this model is that a temporary effect of drought on the labour market would be on both employment and real wage; both would be reduced as a consequence of drought in South-India, while capital stock in each sector in each region is assumed to be fixed. The effect of the drought on GDP at the national level is led by reduction in employment, which accounts for 0.21 percentage points of the projected negative effect, and indirect tax, which accounts for 0.04 percentage point of the reduction. It can be perceived from Table 4 that, as an effect of the drought, average wage rate is experiencing a dip in the South, West and North-East regions, while the average wage rate increases in Central, North and East regions, leading the migration of labourers across regions.

The national average value of the real consumption reduces by 0.58 percentage points as an effect of the drought. With reduced household income, there is reduced disposal income for the consumption expenditure of households. Real investment, on the other hand, reduces at the national level, as well as in all regions except the Central region. There is 1.42 percentage point reduction in real investment at the national level, which is caused by significant reduction in investment in South India, i.e. reduction of 3.5 percentage points. Sectoral analysis shows that there is 20.21 percentage point reduction in crops in South India, while investment in the crop sector in other regions has increased, signifying mobilisation of resources in regions that are not affected by drought. Livestock, on the other hand, is experiencing low increase in investment in South India, while investment in this sector is increasing significantly in other regions.

Figure 6 shows the effect of the drought on price level for different regions and sectors, especially for the agriculture sector. As a result of drought, the overall price level at the national level is likely to increase by 0.53 percentage point. It is perceived that the increase in price level of crops and livestock at national levels is much higher, by 5.5% and 11%, respectively. The inflation in agricultural products and livestock products in the highest in the Southern region, but it is important to note that the increase in price in these industries can also be noticed in all other regions due to transmission effects.

Figure 6: Percentage Change in price level in agriculture, livestock and overall sectors



Source: Author's Estimates

Expectedly, the drought affects gross state domestic product (GSDP) at the state level. There is a substantial fall in projected GSDP in all the states in South India, i.e. Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Telangana (Table 5). The negative effect can also be seen in all the Western states, namely Goa, Gujarat and Maharashtra. However, among other states, the effect of the drought in GSDP is negative in Chhattisgarh, Uttarakhand, Jharkhand, Delhi, Nagaland, Sikkim etc. It is important to note that the GSDP of Andhra Pradesh, which has the highest agricultural output among the Southern states, is highly affected. Among the other states with high agricultural output, in 2018-19 Uttar Pradesh, Madhya Pradesh, West Bengal, and Punjab remain unaffected, while Maharashtra and Gujarat face a slight dip in GSDP. So, a drought in South India is also likely to have an impact on a few other states, though on a smaller scale.

Table 5: Impact of drought on major aggregates in selected regions (Percentage change)

	Real household consumption	Real GSDP	Aggregate employment	Real wage rate
		Central		
Chhattisgarh	0.76	-0.13	-0.16	0.82
Madhya Pradesh	1.72	0.41	0.76	1.78
Uttar Pradesh	1.97	0.56	1.01	2.03
Uttarakhand	-0.09	-0.5	-0.93	-0.02
		East		
Bihar	0.75	0.19	0.33	0.59
Jharkhand	0.25	-0.12	-0.19	0.1
Odisha	0.7	0.13	0.24	0.55
West Bengal	0.57	0.06	0.13	0.42
		North		
Delhi	-0.74	-0.67	-1.04	-0.69
Haryana	1.11	0.29	0.5	1.15
Himachal Pradesh	0.7	0.09	0.16	0.75
Jammu & Kashmir	0.36	-0.01	0.01	0.41
Punjab	1.55	0.53	0.94	1.6
Rajasthan	1.22	0.37	0.64	1.27
		North-East		
Arunachal Pradesh	0.15	-0.04	-0.07	0.07
Assam	0.26	0.01	0.02	0.19
Manipur	0.38	0.15	0.23	0.31
Meghalaya	-0.12	-0.2	-0.29	-0.2
Mizoram	0.16	-0.02	-0.03	0.09
Nagaland	-0.14	-0.22	-0.51	-0.22
Sikkim	-0.09	-0.13	-0.2	-0.17
Tripura	0.3	0.07	0.1	0.22
		South		
Andhra Pradesh	-3.76	-5.17	-2.18	-3.07
Karnataka	-3.7	-2.48	-2.15	-3.01
Kerala	-3.53	-2.17	-1.97	-2.84
Tamil Nadu	-3.65	-2.92	-2.09	-2.96
Telangana	-3.45	-3.23	-1.89	-2.76
		West		
Goa	-0.86	-0.42	-0.83	-0.92
Gujarat	0.05	-0.01	-0.06	-0.01
Maharashtra	-0.34	-0.17	-0.36	-0.4

Source: Author's Estimates

The drought also causes changes in wages in certain states. The states in the Southern region, i.e., Andhra Pradesh, Karnataka, Tamil Nadu, Kerala and Telangana, face adverse effects on wages. But in states like Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, Haryana, wages increase by more than 1 percentage point, because of inflow of investment in these states. As a consequence, there is a change in employment, which varies in extent and magnitude across states. The major shrinkage in employment happens in Southern states like Andhra Pradesh, Karnataka, Tamil Nadu, Kerala and Telangana. But employment is also affected in other major states like Maharashtra, Uttarakhand, and Chhattisgarh due to the

interlinkage between the states' economies. However, our model assumes out-migration in other states because of the wage differential. It is seen that employment is likely to increase in states like Uttar Pradesh, Punjab, Madhya Pradesh, Rajasthan, Haryana, Bihar, Odisha, Manipur, Himachal Pradesh, West Bengal, Tripura etc.

In Table 6 we show the change in output in agricultural industries across regions due to the onset of drought. The results show that all agricultural productions have been affected in Southern India. Paddy is one of the major cereals consumed in India. Andhra Pradesh, which produces 7% of the total paddy in India, shows around 5% decline in output. However, the major paddy-producing states like West Bengal, Uttar Pradesh and Punjab remain unaffected due to drought. Paddy production in states like Karnataka, Kerala, Tamil Nadu and Telangana is also affected. But, since the share of these regions in total paddy yield is not very high, the effect on loss in output is moderate. Another major cereal, wheat, is mostly produced in Northern states like Uttar Pradesh, Punjab, Madhya Pradesh, and Haryana, and remains mostly unaffected due to drought in South India. On the other hand, Karnataka produces 37% of total pulses and the state is quite affected by drought; as a result, the output of Gram (0.63%), Arhar (1.07%), and Other Pulses (0.34%) reduces. However, the arhar pulse output of Karnataka is affected although the state is a major producer of arhar pulses. Among other agricultural sectors, Kapas production in Telangana is affected, in Andhra Pradesh and Karnataka it is coconut production, and rubber production in Kerala is affected. Fruitsand vegetable production in all Southern states are affected.

Table 6: Effect of drought on select agriculture industries (% change in output)

	Paddy	Wheat	Cereals	Gram	Arhar	Other Pulses	Oil seeds	Kapas	Jute	Sugarcane	Coconut	Tobacco	Tea Farm	Coffee Farm	Rubber	Fruits	Vege-tables	Other food crops
Andhra Pr	-4.88	0.00	-0.73	-0.26	-0.05	-0.50	-1.12	-0.76	0.00	-0.48	-0.39	-0.80	0.00	-0.07	0.00	-7.24	-3.39	-0.23
Arunachal Pr	0.89	0.02	0.21	0.00	0.01	0.09	0.12	0.00	0.00	0.02	0.00	0.00	0.06	0.00	0.00	0.87	0.46	0.05
Assam	0.85	0.00	0.01	0.00	0.00	0.05	0.05	0.00	0.03	0.02	0.04	0.00	0.62	0.00	0.02	0.52	0.52	0.06
Bihar	0.58	0.50	0.15	0.01	0.01	0.07	0.02	0.00	0.03	0.15	0.00	0.02	0.00	0.00	0.00	0.45	0.50	0.14
Chhattisgarh	0.79	0.02	0.03	0.08	0.01	0.03	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.25	0.92	0.23
Delhi	0.14	0.45	0.03	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	1.54	0.00
Goa	0.45	0.00	0.00	0.00	0.00	0.09	0.02	0.00	0.00	0.03	0.27	0.00	0.00	0.00	0.02	1.49	0.40	0.00
Gujarat	0.13	0.13	0.09	0.04	0.04	0.02	0.54	0.58	0.00	0.12	0.01	0.06	0.00	0.00	0.00	0.50	0.52	0.00
Haryana	0.37	0.69	0.04	0.01	0.00	0.00	0.15	0.15	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.06	0.34	0.43
HP	0.03	0.11	0.14	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.47	1.28
J & K	0.33	0.24	0.23	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.52	0.00
Jharkhand	0.73	0.07	0.09	0.15	0.14	0.14	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.76	0.00
Karnataka	-2.25	-0.09	-2.45	-0.63	-1.07	-0.34	-0.73	-0.81	0.00	-2.69	-1.28	-0.19	-0.01	-1.70	-0.10	-4.49	-2.09	0.00
Kerala	-1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-7.50	0.00	-0.34	-0.42	-5.80	-4.77	-0.71	0.00
Madhya Pradesh	0.18	0.45	0.12	0.25	0.01	0.12	0.37	0.07	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.37	0.43	0.01
Maharashtra	0.21	0.05	0.13	0.14	0.08	0.05	0.34	0.34	0.00	0.51	0.01	0.00	0.00	0.00	0.00	0.76	0.15	0.00
Manipur	0.69	0.00	0.07	0.00	0.00	0.10	0.06	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.72	1.11	0.00
Meghalaya	0.68	0.00	0.07	0.01	0.01	0.04	0.05	0.00	0.05	0.00	0.00	0.01	0.02	0.00	0.06	1.05	0.74	0.00
Mizoram	0.35	0.00	0.03	0.00	0.00	0.03	0.06	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.94	1.25	0.08
Nagaland	0.75	0.01	0.17	0.00	0.01	0.05	0.10	0.00	0.00	0.01	0.03	0.00	0.11	0.00	0.02	0.39	0.41	0.75
Odisha	0.86	0.00	0.01	0.01	0.03	0.05	0.02	0.04	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.31	0.73	0.55
Punjab	0.80	0.82	0.02	0.00	0.00	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.27
Rajasthan	0.04	0.51	0.30	0.24	0.00	0.24	0.76	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02	0.01
Sikkim	0.14	0.00	0.43	0.00	0.00	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	1.17	0.00
Tamil Nadu	-3.64	0.00	-1.73	-0.01	-0.06	-0.60	-1.09	-0.13	0.00	-0.98	-1.25	-0.01	-0.26	-0.10	-0.07	-6.18	-3.04	-1.77
Telangana	-8.11	-0.01	-1.67	-0.40	-0.43	-0.20	-1.22	-4.23	0.00	-0.43	0.00	-0.10	0.00	0.00	0.00	-1.63	-2.45	0.00
Tripura	0.99	0.00	0.01	0.00	0.01	0.04	0.04	0.00	0.00	0.00	0.01	0.00	0.11	0.00	0.14	0.54	0.86	0.04
Uttar Pradesh	0.19	0.27	0.03	0.02	0.01	0.03	0.03	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.14	0.10	1.34
Uttarakhand	0.36	0.39	0.09	0.00	0.00	0.08	0.02	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.66	0.31	0.00
West Bengal	0.73	0.01	0.05	0.00	0.00	0.03	0.08	0.00	0.13	0.00	0.02	0.00	0.07	0.00	0.00	0.43	1.02	0.04

Source: Author's Estimates

5. Conclusion

This attempt of this paper is to demonstrate the scope of the newly constructed TERM-India model with the example of a test run of the model in the form of a hypothetical drought that affects a region of India like South India.

Our study assesses the impact of a hypothetical drought in South India on the national and regional level through a 58-sector TERM model for 7 regions in India encompassing 31 states and Union Territories. The study shows that despite being limited to some states in South India, the drought is likely to have a moderate impact on the overall Indian economy. Both GDP and employment are going to be affected at the national level, and the parameters are affected in many states in India that are not necessarily situated in the Southern region. The interconnectedness of the regions causes reduction in employment and wage rate, leading to migration of labour and redistribution of investment. At the national level, crop output is going to reduce by 1.56 percentage points and livestock output is going to be reduced by 2.53 percentage points. Our study indicates that as a result of the drought, employment is going to be affected to the extent of a reduction of 0.46 percentage points, with regional variations, with maximum effect on Southern India.

The result of our application suggests that the type of modelling activity can quantify the impact at the state level of any region-specific shock due to policy intervention or natural phenomenon. Since the model incorporates inter-linkages across states, our model can capture how regional impacts are transmitted across India.

Like the top-down ORANI-India (NCAER-COPS) model, it is possible to incorporate a top-down decomposition of the effects at the state level to the corresponding district. We plan to have a top-down variant of the TERM-India model in future to expand this modelling exercise.

References

Adams, P., Horridge, M. and Wittwer, G. (2003), *MMRF-Green: A dynamic multi-regional applied general equilibrium model of the Australian economy, based on the MMR and MONASH models*, General Working Paper No. G-140, Centre of Policy Studies , Monash University. https://www.copsmodels.com/ftp/workpapr/g-140.pdf

Adams, P., Dixon, Janine, Horridge, M (2015) The Victoria University Regional Model (VURM): Technical Documentation, Version 1.0, Centre of Policy Studies Working Paper No. G-353, Victoria University, July. https://www.copsmodels.com/ftp/workpapr/g-254.pdf

Dixon, P. B. Parmenter, and & Vincent D. (1978). Regional Developments in the ORANI Model, in Dixon, P., Parmenter, B., Sutton, J. and Vincent, D. 1982, *ORANI: A Multisectoral Model of the Australian Economy*, North-Holland, Amsterdam.

Dixon, P. B., & Rimmer, M. T. (Eds.). (2001). Dynamic general equilibrium modelling for forecasting and policy: a practical guide and documentation of MONASH. Training document for the Dynamic CGE modelling courses, Centre of Policy Studies, Monash University, Melbourne. *Emerald Group Publishing Limited*,

Dixon, P. B., & Rimmer, M. T. (2002). Dynamic General Equilibrium Modelling for Forecasting and Policy: A Practical Guide and Documentation of MONASH, *Contributions to Economic Analysis series, vol. 256*, North Holland, Amsterdam.

Giesecke, J. (1997), The FEDERAL-F model, CREA Paper No. TS-07, Centre for Regional Economic Analysis, University of Tasmania, November.

Giesecke, J and John R Madden (2013), Regional Computable General Equilibrium Modelling, in Dixon Peter B and Jorgenson, Dales W (2013) Handbook of General Equilibrium Modeling (Eds), Vol 1A, Elsevier, North Holland, Amsterdam, pp. 379-475

Horridge, M. (2011). The TERM model and its database, Centre of Policy Studies, *General Paper No. G-219 July*, Monash University.

Horridge, M. (2012). The TERM model and its database, *Economic modelling of Water: The Australian CGE Experience* (pp. 13-35). Springer Netherlands.

Horridge, M. (2014). ORANI-G: A generic single-country computable general equilibrium model. *Centre of Policy Studies and Impact Project, Victoria University, Australia*. Available at: https://www.copsmodels.com/ftp/gpextra/oranig06doc.pdf

Horridge, M., Madden, J., & Wittwer, G. (2005). The impact of the 2002–2003 drought on Australia. *Journal of Policy Modeling*, *27*(3), 285-308.

Liew, L. (1984), "Tops-Down" Versus "Bottoms-Up" Approaches to Regional Modeling, Journal of Policy Modeling, Vol. 6, No. 3, pp. 351-368.

Madden, J. (1990), FEDERAL: A two-region multi-sectoral fiscal model of the Australian economy, Ph.D. thesis, University of Tasmania, Hobart.

Marwah, K. (1991). Macroeconometric modelling of South-East Asia: the case of India, in R.G. Bodkin, L.B. Klein and K. Marwah (eds.), *A History of Macro Economic Model Building*, Edward Elgar, UK.

Mukhopadhyay, K. (Ed.). (2021). Economy-Wide Assessment of Regional Policies in India: Applications of E3-India Model. Springer Nature.

Naqvi, F. and Peter, M. 1996, "A Multiregional, Multisectoral model of the Australian

Economy with an Illustrative Application", Australian Economic Papers, 35:94-113.Pal, B. D., Pohit, S., & Rajeev, M. (2024). Unpacking India's fiscal responses to COVID-19: a computable general equilibrium modelling analysis. *Indian Economic Review*, *59*(1), 201-231. https://doi.org/10.1007/s41775-024-00222-2.

Pohit, S., Pratap, D., Mathur, S., Dixon, P., Giesecke, J., & Roos L., (2023a). Building Cutting-edge General Equilibrium Modelling Capacity in India for Robust Economic Policy Analysis: Documentation and Policy Applications, unpublished mimeo, *NCAER*.

Pohit, Sanjib, Devender Pratap, Somya Mathur, Peter Dixon, James Giesecke, & Louise Roos (2023b). Building Cutting-edge General Equilibrium Modelling Capacity in India for Robust Economic Policy Analysis: Documentation and Policy Applications, unpublished mimeo, *NCAER*.

Pohit, S., Pratap, D., Bhattacharya, A., Chaudhuri, C., Mathur, S., Das, A., Meena, M.K., Thampi, M., and Datta, S. (2024). *Challenges and Policy Implications of a Low Carbon Pathway for Odisha: An Integrated Assessment Modelling Approach*, National Council of Applied Economic Research (NCAER), New Delhi. https://www.ncaer.org/publication/challenges-and-policy-implications-of-a-low-carbon-pathway-for-odisha

Table A1. Sectors of our TERM-India database

S. No.	Sector	Code	S. No.	Sector	Code
1	Paddy	Paddy	53	Tea processed	TeaPrd
2	Wheat	Wheat	54	Coffee processed	CoffeePrd
3	Coarse cereals	Cereals	55	Tobacco Products	TobaccoPrd
4	Gram	Gram	56	Cotton Yarn and Cotton Textiles	CottonPrd
5	Arhar	Arhar	57	Synthetic yarn and synthetic textiles	SyntheticPr
6	Other pulses	OtherPulses	58	Wool yarn and woolen textiles	WoolPrd
7	Groundnut	Groundnut	59	Silk yarn and silk textiles	SilkPrd
8	Rapeseed and mustard	RapeSeeds	60	Carpet weaving	CarpetWeave
9	Other oil seeds	OthOilSeeds	61	Ready-made garments	Clothing
10	Kapas	Kapas	62	Misc. textile products	OthTextiles
11	Jute, hemp and mesta	Jute	63	Leather footwear	LeaFootwear
12	Sugarcane	Sugarcane	64	Leather and leather products except footwear	OthLeathPrd
13	Coconut	Coconut	65	Wood and wood products except furniture	WoodPrd
14	Tobacco	Tobacco	66	Paper, Paper products and newsprint	PaperPrd
15	Tea	TeaFarm	67	Publishing, printing and allied activities	PublishPrin
16	Coffee	CoffeeFarm	68	Furniture & Fixtures	Furniture
17	Rubber	Rubber	69	Rubber products	RubberPrd
18	Fruits	Fruits	70	Plastic products	PlasticPrd
19	Vegetables	Vegetables	71	Petroleum products	PetroleumPr
20	Other food crops	Othfoodcrop	72	Coal tar products	CoalPrd
21	Milk	Milk	73	Inorganic chemicals	InorganChem
22	Wool	Wool	74	Organic chemicals	OrganChem
23	Egg and poultry	EggPoultry	75	Fertilizers	Fertilisers
24	Other livestock products	OthLivestoc	76	Pesticides	Pesticides
25	Industry Wood	IndWood	77	Paints, varnishes and lacquers	PaintVarn
26	Firewood	FireWood	78	Drugs and medicine	Pharma
27	Other forestry products	OthForestPr	79	Soaps, cosmetics and glycerin	SoapCostmti
28	Inland Fish	InlandFish	80	Synthetic fibres, resin	SyntheticFi
29	Marine Fish	MarineFish	81	Other chemicals and chemical products	OthChemPrd
30	Coal and Lignite	CoalLignite	82	Cement	Cement
31	Natural Gas	NaturalGas	83	Non-metallic mineral products	NonMetMinPr
32	Crude petroleum	CrudePetrol	84	Iron and steel Ferro alloys	ISFerrloAlo
33	Iron ore	IronOre	85	Iron and steel casting and forging	ISCasting
34	Manganese ore	ManganeseOr	86	Iron and steel foundries	ISFoundries
35	Bauxite	Bauxite	87	Non- ferrous basic metals (including alloys)	NonFerBasMe

S. No.	Sector	Code	S. No.	Sector	Code
36	Copper ore	CopperOre	88	Hand tools, hardware	Hardware
37	Other Metallic minerals	OthMetMin	89	Miscellaneous metal products	OthMetalPrd
38	Limestone	Limestone	90	Tractors and other agricultural implements	AgricMachin
39	Mica	Mica	91	Industrial machinery for food & textile industry	FoodTextMac
40	Other non-metallic minerals	OthNonMetMi	92	Industrial machinery (except food and textile)	OthIndusMac
41	Processed poultry meat & poultry meat products	Meat	93	Machine tools	MachineTool
42	Processed other meat & meat products	OthMeat	94	Other non-electrical machinery	OthNonEleMa
43	Processed fish & fish products	FishPrd	95	Electrical industrial machinery	ElecIndMach
44	Processed fruits & Processed Vegetables	FruitVeg	96	Electrical cables, wires	EleCableWir
45	Dairy products	DairyPrd	97	Batteries	Batteries
46	Edible Oils and Fats	OilsFats	98	Electrical appliances	ElecAppl
47	Grain Mill products, starch and starch products	GrainPrd	99	Communication equipment	CommunicEq
48	Sugar	Sugar	100	Other electrical machinery	OthElecMach
49	Bread & Bakery products	BakeryPrd	101	Electronic equipment including T.V	ElectronicE
50	Miscellaneous food products	OthFoodPrd	102	Medical precision, optical instrument	MedicalInst
51	Alcoholic beverages	Alcohol	103	Watches and clocks	WatchClocks
52	Non-alcoholic beverages	NonAlcohBev	104	Ships and boats	ShipBoats
105	Rail equipment	RailEq	126	Hotels & Restaurant	HotelRest
106	Motor vehicles	MotorVeh	127	Railway Transport	RailTrns
107	Motor cycles and scooters	MotorCycle	128	Land transport	LandTrns
108	Bicycles, cycle-rickshaw	Bicycles	129	Air transport	AirTrns
109	Aircrafts & Spacecrafts	Aircrafts	130	Water Transport	WaterTrns
110	Other transport equipment	OthTrnsEq	131	Supportive and Auxiliary transport activities	OthTrnSrv
111	Gems & jewellery	Jewellery	132	Storage and warehousing	Warehouse
112	Miscellaneous manufacturing	OthManuf	133	Communication services	CommunicSrv

S. No.	Sector	Code	S. No.	Sector	Code
113	Construction and construction services	Constructio	134	Financial services	FinanceSrv
114	Nuclear Electricity	Elec_nuclea	135	Insurance services	InsuranceSr
115	Solar Electricity	Elec_solar	136	Ownership of dwellings	OwnerDwel
116	Wind Electricity	Elec_wind	137	Real estate services	RealEstSrv
117	Hydro Electricity	Elec_hydro	138	Renting of machinery & equipment	RentMachEq
118	Gas Electricity	Elec_gas	139	Research & Development Services	RD
119	Coal Electricity	Elec_coal	140	Legal services	LegalSrv
120	Other Electricity	Elec_other	141	Other Business services	OthBusSrv
121	Transmission and Distribution	ElecDist	142	Computer related services	CompterSrv
122	Gas	Gas	143	Public administration and defence	PublicAdmin
123	Water Supply	WaterSupply	144	Education services	Education
124	Trade	Trade	145	Human health and social care services	Health
125	Repair & Maintenance of Motor Vehicle	RepairMV	146	Community, social and personal services	SocialPvtSr
			147	Recreation, entertainment and radio & TV broadcasting and other services	RecEntertain

Source: Author's Estimates

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