Chapter 2
Agriculture and Mining in Regional United States

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Abstract Agricultural sectors in USAGE-TERM are represented on a commodity basis. This requires converting available input–output tables from a farm-type basis. Agriculture's share of the national economy has declined with population growth and technological change. Farm lobbyists historically have wielded considerable influence in congress, so that for many decades, U.S. agriculture was highly distorted. In a new era of worsening global land and water scarcity, commodity prices may strengthen, boosting agriculture. A dramatic change in mining has arisen from the use of fracking techniques to extract coal seam gas.

Keywords Agriculture · Trade distortions · Mining

2.1 Overview of Regional Database Chapters

This is the first of four chapters that include a combination of background material on industries, information on data collection and processing of these data. When it comes to preparing a very detailed, multi-regional database for a CGE model, background information, data and policy issues often go together. The desirable extent of sectoral disaggregation depends on the policy issues. For example, modeling of the impacts of agricultural R&D may rely on a suitable representation of specific crops and types of livestock. From the outset, it is apparent that the default sectors in published input–output tables, regardless of how many sectors there are, do not necessarily give a sufficient representation of economic activities that are of interest to analysts. In agriculture, we require substantial database amendments to move the representation of agriculture from a farm-type basis in published input–output tables to a commodity basis for CGE analysis. This is discussed further in Sect. 2.2. In the electricity sector, discussed in Chap. 4, given the importance of carbon emissions in policy analysis, we wish to split electricity

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into generation and transmission/distribution sectors, and further into different types of electricity generation. A split of the electricity sectors will also help distinguish between types of generation suitable for base-load from those that are not.

While the approach of examining background and policy matters may provide a guide as to where in the database we could improve the sectoral representation, more deficiencies may emerge over time. In the mining sectors, Oil and gas is represented in USAGE-TERM as a single sector. In future database preparations, with the rise of fracking, separate oil and gas sectors would be more appropriate.

An important theme that emerges from the discussion of manufactures in Chap. 3 is that structural change in the economy has seen the broad sector move from a powerhouse of the U.S. economy several generations ago to a position of diminished importance now. The change is more dramatic at the regional than national level. Some cities have gone into long-term decline, due to their reliance on manufacturing in their heyday.

We devote an entire chapter to electricity (Chap. 4). The construction of major electricity grids in the 1930s provided a boost to rural regions at a time when there had been marked disparities between urban and rural access to electricity. The USAGE-TERM database is constructed from a register of every power station listed in the country compiled by Carbon Monitoring for Action (carma.org).

Health care in the U.S. is more expensive than in other OECD nations, to such an extent that direct comparisons of per capita income may overstate U.S. living standards, unless comparisons weigh health services carefully. Since health care involves large amounts of public expenditure, fiscal accounts may enhance the model. Health care, education, international trade and other services are covered in Chap. 5. Chapter 6 outlines modifications to improve the representation of tourism and transport in USAGE-TERM.

2.2 Introduction to Agriculture

Multi-regional computable general equilibrium (CGE) modeling has usually been undertaken with a small number of sectors. Without sectoral detail, CGE models become more abstract and less useful for scenario analysis. Many agricultural economists are driven by practical questions, such as returns to R&D, productivity, water management, market liberalization and risk management. Some of these issues have remained in the domain of partial equilibrium models, as they cover relatively small regions and specific agricultural activities. Such models capture details in production functions that may be relevant to a particular region. However, they lack detail on market conditions such as downstream demands, fluctuations in international demand and supply, and competition for land, labor and capital.

A CGE model can combine the detail of partial equilibrium models with market details that are external to an industry. The GTAP model (Hertel 1997) has opened up the field of CGE modeling to trade analysts by including 12 agricultural sectors in its representation of the global economy.

Data are available from the Food and Agricultural Organization of the United Nations (FAO) for almost 1,000 raw and processed agricultural commodities.[1] This indicates that there is scope for considerable expansion of representation of agriculture within a CGE database, be that in a single region model or multi-regional model. The TERM (The Enormous Regional Model) approach has revolutionized CGE modeling (Horridge 2012). Whereas the usual approach to devising a multi-regional database is to use more aggregated data than at the national level, so as to recognize the fall-off in data accuracy as one moves to smaller regions, the TERM approach usually involves splitting the available national input–output table into more sectors. This even applies in the U.S. case where the national database has more than 500 sectors.[2]

An important issue we may wish to model concerns the changing global food market and the consequent regional economic impacts of such changes. To investigate this further, we might require global demand and supply projections for individual farm commodities. From this, we would work out which commodities are most important in the U.S. context and what sort of representation we should include in the master database of USAGE-TERM.

In the context of agriculture, disaggregating the database further enhances the usefulness of the database. The national database with which we start represents agriculture by farm type. Data on farm types do not match data that are used in commodity analysis. Specific crop and livestock data on production, consumption and trade are readily available. Therefore, moving the sectoral representation from farm type to commodity output type is a priority in improving the representation of agriculture in a CGE database.

An objection to this approach is that farms exist as a type rather than being defined by a given commodity. A particular farm may produce a number of crops and also carry livestock. We can redress this objection by modifying the theory of the CGE model. Farm land, farm labor and farm capital can be made mobile between different outputs. If market conditions turn in favor of one crop over another, farm factors turn towards production of the relatively favorable crop. This movement from industry by farm type towards representation by output type enhances the model's capabilities. Moreover, relevant economic information such as output, export data and price data are available in detail at the commodity level.

[1]See http://www.fao.org/faostat/en/#data accessed 27 January 2017.

[2]The database from USAGE, a dynamic model of the national US economy, is the starting point for the USAGE-TERM database (Dixon and Rimmer 2012).

2.3 Splitting the National Database into More Types of Farm Outputs

Another advantage of a commodity representation of agriculture in the database is that the U.S. Department of Agriculture (USDA) produces agricultural census data that are based on specific crop and livestock outputs. The main source of county level agricultural data is the USDA website http://quickstats.nass.usda.gov/. The site provides data for individual crops and livestock activities. The split of the national database into more farm outputs is the first point at which USDA data are used. These data are available at the county level so that we can calculate county shares of state activity with relative ease. The only disadvantage of census data is that they tend to be dated relative to available state data. For example, we used 2007 census data to estimate county level farm outputs. However, these estimates are not the sole source of agricultural data. In particular, farm outputs are scaled so as to match state level value-added totals provided in national accounts data.

Table 2.1 shows agricultural classifications as they appear in NAICS (The North American Industry Classification System), the national USAGE database and in USAGE-TERM. The first objective of using USDA data is to split the commodities in the national CGE database further, in line with the right-hand column of Table 2.1. For example, the USDA data added across counties indicate that in 2007, among the food grain sectors, wheat sales totalled $10.3 billion, rice sales $1.9 billion and corn $39.7 billion. The USDA data provided shares for an initial split of the food grains. Both the absolute numbers and the shares alter via adjustments through subsequent scaling, balancing and updating of the database.

A key assumption in devising a multi-regional CGE database is that a given industry uses an identical technology or cost structure in all regions. At an aggregated level, this could be a burdensome assumption. For example, a database with a single livestock sector would impose the same cost structure on a region predominantly producing dairy cattle as on a region that produces mainly turkeys. This appears not to be defensible, whereas if there are separate dairy cattle and turkey industries, the assumption that each region produces dairy cattle with one technology and turkeys with another technology, each identical across regions, is more reasonable. As is evident in what follows, the disaggregation we end up with in USAGE-TERM does not free us entirely from examples in which industry technologies may differ between regions. That is, we may choose a set of industry splits with the expectation that they will enhance policy modeling capability. By the time we have completed the process of preparing a multi-regional database, we may be aware of a litany of examples in which the assumption of identical technologies does not hold. Whether or not we need to act on possible differences may depend on the nature of proposed studies, as is discussed in Sect. 2.6. The struggle to choose an appropriate sectoral representation is one that practical CGE modelers cannot avoid.

Table 2.1 Industry classifications in agriculture

NAICS code	NAICS industry (1)	USAGE industry (2)	USAGE-TERM industry (3)
1111	Oilseed and grain farming	Food grains Feed grains Oil bearing crops	Wheat, rice, Corn Soybean (part) Oilseeds
1112	Vegetable and melon farming	Vegetables	Vegetables, Potatoes, Tomatoes
1113	Fruit and tree nut farming	Fruits Tree nuts	Apples, Grapes, Citrus, Strawberries, Other fruit Other fruit & nuts, Almonds
1114	Greenhouse, nursery and floriculture production	Greenhouse, nursery and floriculture production	Nursery
1119	Other crop farming	Crops miscellaneous	Hay and forage, sorghum, sugar cane, sugar beet, Soybean (part), Cotton, Tobacco, Other broadacre Miscellaneous agriculture
11191	Tobacco farming	Tobacco	Tobacco
11192	Cotton farming	Cotton	Cotton
1121	Cattle ranching and farming	Meat animals (part)	Beef cattle
11212	Dairy cattle and milk production	Dairy farm products	Dairy cattle
1122	Hog and pig farming	Meat animals (part)	Hogs
1123	Poultry and egg production	Poultry and eggs	Poultry and eggs Turkeys
1124	Sheep and goat farming	Meat animals (part)	Other livestock (part)
1129	Other animal production	Livestock miscellaneous	Other livestock (part)

2.4 The Multi-Regional Representation in USAGE-TERM

The assumption that identical technologies apply to a given industry in every region simplifies the task of preparing a multi-regional CGE database. The regional shares of national output we obtain from regional data are used to split the national CGE database. That is, we aim to use all of the information in the national database without contradicting it. By treating regional activities as shares of national activities, we avoid the circumstance that may arise from independent estimation of regional input–output tables in which a particular industry has a larger output than is shown in the corresponding national table.

Our regional output shares of national activity provide two lots of regional data in USAGE-TERM. The bottom-up core of the CGE database includes 70 regions, including all states plus a split of some larger states into additional regions. In addition, we utilize county level census data to prepare a top-down county module with 3142 regions. All shares obtained using USDA data are scaled so as to be consistent with state level totals for the national accounts crops and livestock sector. In "bottom-up" modeling, each industry in each region has its own production function. Each region has its own household and consumption function. Inter-regional trade matrices link the regions. "Top-down" results are derived from the bottom-up results, based primarily, in the context of USAGE-TERM, on county shares of state/region activities. "Top-down" results, being a module without separate prices, do not affect bottom-up results (see Chap. 9).

In practice, USAGE-TERM is never run with the full dimensions of the master database. Not only are 512 sectors and 70 regions impossible to solve with the usual memory of a PC. The results would be rather difficult to present. In typical applications, we aggregate the sectors to fewer than 100 and the regions to fewer than 10. In addition, we calculate top-down county level results for those counties in regions of interest in a particular study. In most applications of USAGE-TERM, there is a composite "Rest of USA" region from which we omit top-down county-level results. That is, if we are not interested in the individual bottom-up regions within a composite region in a particular study, it follows that the corresponding top-down results are also of no interest.

Table 2.2 shows the top five regions for each agricultural output. Some crops are concentrated in a handful of regions. The extreme case is that of almonds, produced almost exclusively in the Rest of California, namely the portion of the state excluding the counties of Los Angeles, Sacramento, Riverside or Orange, and excluding the conglomerate of counties that cover San Francisco and its surrounds. Rest of California also dominates production of grapes (66% of the national total), strawberries (61%) and other tree nuts (61%). Citrus production is confined to regions where winter is relatively warm. Other agricultural activities are widely dispersed, including hay and forage. With a diversified base in animal feed, certain livestock activities are also highly diversified. No region dominates turkey production, ensuring a diversified supply for Thanksgiving festivities. But the least concentrated of all agricultural activities is poultry and eggs, with only one state, Georgia, accounting for more than 10% of national production. The geographic dispersion of poultry and egg production is in keeping with an industry not limited to a narrow range of climates.

In cattle production, the national sales value indicated by USDA data is several-fold larger than value-added indicated by the national input–output table. This reflects a high reliance on feedlots rather than grazing on rain-fed pastures, the former using intermediate inputs, the latter a primary factor that forms part of

Table 2.2 Top 5 states/regions for each agricultural output

Output	Rank 1	%	Rank 2	%	Rank 3	%	Rank 4	%	Rank 5	%		%	National value-added c$m 2010
HayForage	RoTexas	11.7	Kansas	6.8	SouthDakota	6.3	Nebraska	6.0	Wisconsin	4.7	Rest	64.6	9924
Almonds	RoCalifornia	99.5	SanFranCtyCA	0.4									2337
Apples	Washington	45.1	RoMichigan	12.7	RoNewYork	12.5	RoPnnsylvnia	6.1	RoCalifornia	4.4	Rest	19.2	861
OthTreeNuts	RoCalifornia	61.5	RoTexas	12.4	NewMexico	8.5	Oklahoma	7.1	Georgia	4.2	Rest	6.3	2676
Vegetables	RoCalifornia	33.4	Arizona	8.5	Washington	7.6	Wisconsin	5.0	Idaho	4.5	Rest	41.1	8227
OthBroadAcre	RoTexas	10.0	RoCalifornia	8.9	Minnesota	8.2	NewMexico	5.0	Idaho	5.0	Rest	62.8	215
PoultryEggs	Georgia	12.4	NorthCarolin	9.9	RoTexas	9.0	Alabama	7.7	Mississippi	7.6	Rest	53.4	10939
SugarCane	Louisiana	58.2	PalmBeachFL	27.7	RoTexas	8.0	RoFlorida	6.2			Rest	0.0	365
OilSeeds	NorthDakota	60.8	SouthDakota	19.2	Kansas	6.3	Minnesota	6.1	Colorado	2.9	Rest	4.8	879
BeefCattle	Nebraska	16.9	RoTexas	16.2	Kansas	15.4	Iowa	6.1	SouthDakota	5.0	Rest	40.2	6238
MiscelAgri	RoCalifornia	11.0	Iowa	9.0	Nebraska	7.7	Minnesota	6.5	RoIllinois	6.2	Rest	59.6	107
Corn	Iowa	18.1	Nebraska	15.4	RoIllinois	12.6	Minnesota	9.5	Indiana	7.4	Rest	37.0	16239
Cotton	RoTexas	51.8	RoCalifornia	10.1	Georgia	7.7	Mississippi	6.2	Arkansas	5.4	Rest	18.8	3461
DairyCattle	Wisconsin	20.2	RoCalifornia	14.5	NewMexico	9.7	RoNewYork	7.7	RoPnnsylvnia	5.9	Rest	42.0	4800
Grapes	RoCalifornia	66.0	SanFranCtyCA	11.1	Washington	8.0	RoNewYork	5.4	RoMichigan	2.0	Rest	7.5	2124
Nursery	RoCalifornia	24.2	Oregon	7.0	OrangeCA	6.0	RoTexas	4.5	RoFlorida	4.4	Rest	53.8	16833
Hogs	Iowa	33.3	Minnesota	16.1	NorthCarolin	11.9	Nebraska	6.7	Indiana	5.5	Rest	26.4	3653
OthFruit	HillsbrghFL	88.3	RoMissouri	4.0	Wisconsin	2.8	RoMichigan	2.1	Washington	1.8	Rest	1.0	1185
OthLivestock	RoTexas	14.0	Colorado	9.9	Kentucky	7.5	Wyoming	6.0	SouthDakota	5.8	Rest	56.8	75
Citrus	RoFlorida	43.9	RoCalifornia	40.6	RoTexas	6.4	Arizona	3.8	RiversideCA	3.6	Rest	1.8	915
Potatoes	Washington	27.1	Idaho	24.4	Wisconsin	10.2	Colorado	8.5	NorthDakota	5.0	Rest	24.8	3761
Rice	Arkansas	35.2	RoCalifornia	28.4	Louisiana	11.9	Mississippi	8.2	RoTexas	8.2	Rest	8.1	1149
Sorghum	Kansas	48.5	RoTexas	32.2	Nebraska	5.8	NewMexico	2.1	Louisiana	2.0	Rest	9.5	650
Soybean	Iowa	17.2	Minnesota	11.9	RoIllinois	10.8	Nebraska	10.4	Indiana	8.9	Rest	40.8	11964
Strawberries	RoCalifornia	61.2	HillsbrghFL	5.9	Washington	4.6	RoNewYork	3.9	OrangeCA	3.5	Rest	20.9	938

(continued)

Table 2.2 (continued)

Output	Rank 1	%	Rank 2	%	Rank 3	%	Rank 4	%	Rank 5	%		%	National value-added c$m 2010
Sugarbeet	Minnesota	37.8	NorthDakota	15.3	RoMichigan	12.0	Idaho	11.7	Montana	5.2	Rest	18.0	580
Tobacco	NorthCarolin	45.3	Kentucky	25.6	Virginia	6.6	SouthCarolin	5.8	Tennessee	4.6	Rest	12.1	1511
Tomatoes	RoPnnsylvnia	13.7	Hawaii	9.2	RoNewYork	7.7	Vermont	6.3	Washington	5.7	Rest	57.3	2941
Turkeys	Minnesota	22.5	NorthCarolin	17.3	RoMissouri	7.9	Arkansas	6.6	Virginia	6.3	Rest	39.4	658
Wheat	Kansas	17.0	NorthDakota	15.8	Montana	9.8	SouthDakota	8.8	RoTexas	7.0	Rest	41.6	4471

Source Estimates based on http://quickstats.nass.usda.gov/ and http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1#reqid=70&step=1&isuri=1 accessed 26 June 2015 value-added activity. For every broadacre livestock farmer relying on rain-fed pasture, the moment comes when handfeeding becomes necessary, as drought is an inevitable part of farming in most parts of the world. In some studies, there may be a case for dividing cattle production into rain-fed and feed-lotting technologies.

Corn production arguably best fits the traditional perceptions of a crop that has overtaken the prairies of the northern states: Iowa, Nebraska, Illinois, Minnesota and Indiana produce around two-thirds of the national crop. The U.S. is the world's largest producer of corn. The commodity has been the subject of debate after the enactment of NAFTA, which led to an increase in the volume of exports to another corn producer, Mexico. Nadal and Wise (2004) argue that an increase in exports from the United States to Mexico is detrimental to the environment, because corn production north of the border relies on production techniques less sustainable than those in Mexico.

Some cropping patterns reflect stark differences in climate. Sugar cane, typically grown only in tropical and sub-tropical regions, is confined to the states of Louisiana, Florida and Texas. Sugar beet, on the other hand, is grown in northern states with a severe winter: Minnesota, North Dakota, Michigan, Idaho and Montana produce more than four-fifths of the nation's crop. Sugarhas been subject to substantial market distortions historically. Since the 1981 Farm Act, U.S. domestic sugar prices have been maintained at above the world price. High levels of protection have persisted since then, despite the Uruguay Round opening up the U. S. market to imports. Separate tariff-rate quotas now apply to raw cane sugar and refined sugar. The quantity of sugar imported at the in-quota tariff rate is determined prior to the start of each fiscal year. No limit applies to the quantity that can be imported at the higher over-quota tariff rate.[3]

Wheat is among the commodities that has been the subject of considerable policy intervention over the past decades. In part, policies were aimed at dealing with the decline in farmers' terms of trade. For example, between 1978 and 2005, the price of farm outputs declined relative to the price of farm inputs at 2% per annum. In the 1960s, wheat export subsidies were provided by the U.S. government and remained in place for several decades. In 1993, these subsidies amounted to $1.3 billion on wheat alone but thereafter, declined to zero. In part, the Uruguay Round Agreement on Agriculture contributed to the end of export subsidies, to be replaced by direct support. The 1996 Farm Act made provision for assistance of $4.8 billion annually, with an expanded commitment under the 2002 Act. In 2004, commodities accounting for 42% of U.S. farm production received significant support (Gardner 2009). Since the global financial crisis, U.S. agriculture has been among the winners in the domestic economy. This is because a substantial depreciation of the U.S. dollar has enhanced agriculture's competitiveness. Moreover, agricultural prices have risen with the growing demands of China and

[3]See http://www.ers.usda.gov/topics/crops/sugar-sweeteners/policy.aspx#.UY9HGaL7CHc accessed 27 January 2017.

India. With an improvement in the international competitiveness of U.S. farm produce, the perceived need for domestic assistance has declined.

The common thread in cotton production between the relatively arid regions of California and the relatively moist humid regions of the southern Mississippi Valley is the need for abundant water. In some cotton-growing regions, particularly in the humid south-east of the nation, cotton is mainly rain-fed. In other regions, cropping is almost totally reliant on irrigation. Texas is the largest producer of cotton, accounting for just over half of national production. USDA statistics indicate that cotton is grown in around 120 Texan counties. The crop is grown across a range of climates. The largest contiguous cotton region is around Lubbock county in the highlands of Texas. Rainfall and snowfall in the region provide less than half the water required for cotton production in the region. Irrigation top-ups from the Ogallala Aquifer are depleting the aquifer. In the Far West region of Texas, between Pecos and El Paso, the arid climate implies that cotton is almost entirely reliant on irrigated water. In the Rolling Plains region east of Lubbock, a slightly higher rainfall average reduces the reliance on irrigation. Similarly, the Blacklands region south of Dallas and the more humid Coastal Bend and Upper Gulf Coast regions are substantially rain-fed (Texas AgriLife Extension Service, 2009). Mississippi production occurs mainly on ancient and existing creek beds within the Mississippi Delta.[4] In California, the relative abundance of land and dry climate contributed to more rapid mechanisation of cotton production than elsewhere historically (Musoke and Olmstead, 1982). Cotton is another example of a crop in which it may be worthwhile to split production into rain-fed and irrigation technologies, with factor mobility between the two. Since both irrigation practices and competition from urban uses are threatening future water availability, building such mobility into the model may enhance policy scenarios. The theoretical modifications required to reflect factor mobility between rain-fed and irrigation technologies are elaborated in Dixon et al. (2011; 2012). A version of this theory applies in Chap. 11 of this volume.

Rice is an even more intensive user of water than cotton. States with high levels of production include the Mississippi Valley states of Arkansas, Louisiana and Mississippi. The Rest of California region is second to Arkansas. Wharton, Colorado and Matagora counties account for around two-thirds of Texan rice production, with USDA data indicating that another nine counties produce some rice. Texas suffered its worst drought on record in 2011. In order to supply water to rice farmers downstream in that year, the Local Colorado River Authority[5] (LCRA) depleted the upstream Highland Lakes. The lakes fell below the trigger point (around 40% of capacity) on 1 March 2012. Consequently, for the first time ever,

[4]See http://www.nass.usda.gov/Education_and_Outreach/Reports_Presentations_and_Conferences/Presentations/Gregory_Beltwide10_MS_Statistics.pdf accessed 27 January 2017.

[5]This Colorado River flows in its entirety through Texas and drains into the Gulf of Mexico, unlike its better known namesake to the west which drains into the Gulf of California.

the LCRA stopped the flow of water to rice farmers in southeast Texas in 2012. Again in 2013, upstream dam levels were below the trigger point, so once again, rice farmers missed out on water.[6] The competing needs of irrigators has echoes of what occurred in Australia from 2006 to 2008 (Wittwer and Griffith, 2011). A severe three year drought resulted in rice mills in Australia closing as rice production virtually ceased. A key part of the response of farmers in Australia to the drought crisis was the ability to trade water. Since water rights are now separate from land ownership in Australia's Murray-Darling Basin, rice farmers found it profitable to sell their diminished allocations to farmers of perennial crops. Temporary water prices (i.e., the spot price, not the asset price) rise many-fold during drought. Hence, even with severe cuts to their usual allocations, rice farmers can earn income during drought through water sales.

The rapidly growing urban population of Texas is increasing urban demands for water. Climate change potentially will make water supply more variable. In these circumstances, aspects of Australian legislation dealing with the separation of water and land ownership may be of interest to policy makers in Texas as they explore options for future water management.

While there has been a recovery of seasonal rainfall in Texas, California endured four successive years of drought between 2012 and 2015. Chapter 11 details USAGE-TERM modifications to examine impacts of the Californian drought.

2.5 Agriculture's Share of Regional Economies

In pioneering research, Leontief (1936) devised an input–output table of the U.S. The Bureau of Labor Statistics hired Leontief to estimate the economic impacts of demobilization following the U.S. entry into World War II (Kohli 2008). Leontief's input–output analysis implied a multiplier impact on the economy arising from an initial demand stimulus. A key assumption in this analysis is that supplies are perfectly elastic. In 1938, the unemployment rate in the United States was 19%. Four years later, unemployment had fallen to only 4.7%.[7] With the initial unemployment rate being so high and many factories being idle, the assumption of elastic supply was valid in this unusual circumstance. Unfortunately, input–output has been used repeatedly since the Great Depression, in economic circumstances that bear little resemblance to those of the late 1930s. Input–output analysis is often called on by lobbyists in order to concoct multipliers arising from their industry of interest, which in turn may be used to justify industry subsidies.

To illustrate how such analysis is used to inflate an industry, we use the example of Georgia. USDA data indicate farm output sales in 2007 of $6.8 billion. The USAGE-TERM database has value-added of $2.4 billion in 2010 in Georgia,

[6]Source: http://stateimpact.npr.org/texas/tag/texas-rice-farming/ accessed 27 January 2017.

[7]Source: http://www.infoplease.com/ipa/A0104719.html accessed 27 January 2017.

contributing 1.6% of the state's GDP (Table 2.3). Even after adding all hunting and trapping, fishing, food processing and textile processing to farm output, the share of GDP rises to no more than 3.5%. Yet the Georgia Farm Bureau asserts that the contribution of farming to the state's economy is $74 billion, and that one in 7 Georgians workers is employed in agriculture and related sectors.[8] Such a figure can only arise from a combination of double-counting and the spurious use of multipliers. Curiously, the bureau's website notes that in 2012, Georgia's farms numbered 42,257, with an average size of 228 acres. It seems quite a stretch to go from this number of farms to a statewide employment share of one in seven in a state with almost 10 million citizens.

Despite agriculture contributing little more than 1% to U.S. GDP, it remains large in a number of states. North Dakota (21%) and South Dakota (25%) have the largest agricultural shares in regional income (Table 2.3). North Dakota's production includes oil seeds, wheat, corn, beef cattle and soybeans, sales of which all exceeded $700 million in 2007. The composition of farm production is quite similar in neighboring South Dakota. Other states in which agriculture's share of GDP exceeds 10% include Idaho, Iowa, and Nebraska, with Kansas next. In absolute terms, the Rest of California region has the largest farm output, with an estimated value-added more than double that of the second largest producer, Rest of Texas. The remainder of Texas, represented in the USAGE-TERM master database by the counties of Harris (the Houston-Sugartown-Bayland metropolis) and Tarrant (Fort Worth-Arlington), has almost negligible farm activity.

In developed nations, agriculture's percentage contribution to national income has declined over time. The United States is no exception. Agriculture's share of U.S. GDP in 1980 was closer to 3% than the present 1%.[9] Yet a temporarily favorable exchange rate, growing incomes in China and India, and climate change may all contribute to rising prices that result in agriculture's share of national and regional income rising in the future.

Agricultural shares matter when it comes to interactions between the United States and the rest of the world. In the wake of the global financial crisis, job losses and loan defaults in the U.S. received a great deal of attention. Another side of the story is that with a depreciation of the U.S. dollar against other major currencies following the GFC, sectors with a degree of export orientation such as farming enhanced their global competitiveness. The regional representation in USAGE-TERM with, for example, California split into a number of regions, provides us with the potential to examine winners and losers in considerable detail. For example, predominantly urban regions within California may have suffered substantial losses in the wake of the GFC, while more farm-intensive regions of the

[8]Source: http://www.gfb.org/aboutus/georgia_agriculture.html accessed 2 March 2016. The site records 2014 farm gate value of $14 billion which appears to be a reasonable estimate.

[9]World Bank: http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?page=6 accessed 2 March 2016.

Table 2.3 Contribution of agriculture to each region

Region	Agri/GDP (%)	Agri value-added $m 2012	Region	Agri/GDP (%)	Agri value-added $m 2012	Region	Agri/GDP (%)	Agr value-added $m 2012	Region	Agri/GDP (%)	Agri value-added $m 2012
Alabama	1.0	1809	PalmBeachFL	1.8	498	RoMissouri	4.9	3067	PhladlphiaPA	0	0
Alaska	0.0	11	Georgia	1.1	4703	StLouisCtyMO	0.0	17	RhodeIsland	0.1	30
Arizona	0.6	1546	Hawaii	0.7	472	Montana	4.4	1847	SouthCarolin	0.6	1054
Arkansas	2.4	2898	Idaho	6.1	3538	Nebraska	7.9	8152	SouthDakota	10.5	4591
SanFranCtyCA	0.2	867	RoIllinois	5.0	5852	Nevada	0.2	312	Tennessee	0.5	1439
RoCalifornia	6.0	21178	ChicagoCtyIL	0.1	582	NewHampshire	0.1	70	RoTexas	2.9	8514
LosAngelesCA	0.1	856	Indiana	1.5	4493	NewJersey	0.1	740	DallasTX	0	6
OrangeCA	1.0	1383	Iowa	7.1	11164	NewMexico	1.9	1672	HarrisTX	0.1	86
RiversideCA	2.3	883	Kansas	3.4	4753	RoNewYork	0.7	2030	TarrantTX	0	6
SacramentoCA	1.1	397	Kentucky	1.3	2324	NewYorkCity	0.1	387	Utah	0.5	608
Colorado	1.0	2697	Louisiana	0.8	2108	NorthCarolin	1.1	4874	Vermont	1.1	306
Connecticut	0.1	285	Maine	0.7	351	NorthDakota	10.6	5253	Virginia	0.3	1544
Delaware	0.6	335	Maryland	0.3	977	RoOhio	2.5	3887	Washington	1.3	5144
DC	0.0	0	Massachusett	0.1	298	CuyahogaOH	0	0	WestVirginia	0.2	173
RoFlorida	0.7	1859	RoMichigan	3.8	3646	ColumbusOH	0.3	62	Wisconsin	1.8	5018
BrowardFL	0.2	70	DetroitCtyMI	0.0	26	Oklahoma	1.6	2731	Wyoming	1.5	620
HillsbrghFL	4.5	1571	Minnesota	3.3	9819	Oregon	1.1	2376	**National**	**1.0**	**166,938**
MiamiDadeFL	0.8	586	Mississippi	2.4	2466	RoPnnsylvnia	0.6	3119			

Source Estimates based on http://quickstats.nass.usda.gov/ and http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1#reqid=70&step=1&isuri=1. Accessed 26 June 2015

Table 2.4 Natural gas marketed production by state, 2013 (cubic feet 10^9)

Alabama	196	Louisiana	2407	Oklahoma	2144
Alaska	338	Maryland	<0.1	Oregon	770
Arizona	<0.1	Michigan	124	Pennsylvania	3259
Arkansas	1140	Mississippi	59	South Dakota	16
California	252	Missouri	9	Tennessee	5
Colorado	1605	Montana	63	Texas	7445
Florida	0.3	Nebraska	1	Utah	471
Illinois	3	New Mexico	1195	Virginia	139
Indiana	8	New York	23	West Virginia	718
Kansas	292	North Dakota	236	Wyoming	1858
Kentucky	95	Ohio	186	**National**	**25,691**

Source U.S. Energy Administration, https://www.eia.gov/dnav/ng/ng_prod_sum_a_epg0_vgm_mmcf_a.htm accessed 18 May 2017

state may have benefited from the depreciation of the U.S. dollar—prior to the four year drought starting in 2012.

2.6 Mining in the United States

Three energy mining activities are at the forefront of policy issues in the United States. Coal mining remains important in U.S. energy production, especially in electricity generation, though relatively high labor costs, the rise of coal seam gas and concerns about high carbon emissions are leading to mine closures and output reductions. High oil prices, spurred on China's and India's burgeoning demands since the middle of the first decade of the new millennium, have reinvigorated oil exploration and extraction globally. In the U.S. context, the spread of hydraulic fracturing (fracking) techniques to extract coal seam gas has resulted in rapid growth in gas output Table 2.4.

The most striking changes have been in North Dakota. Between 2010 and 2012, the state's oil output doubled (Table 2.5). According the U.S. Energy Information Administration (2013), North Dakota produced no gas for three years from 1994 to 1996. For more than a decade thereafter, the state's gas production hovered between 50,000 and 60,000 million cubic feet (mcf) per annum. In 2010, output shot up 38% as marketed production totalled almost 82,000 mcf. In 2011, marketed production jumped another 19%, exceeding 97,000 mcf. A telling statistic in this growth phase is that the volume of vented and flared gas doubled in one year to nearly 50,000 mcf in 2011.[10] This has some relevance, if transient, in examining carbon emissions.

[10]See http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_snd_a.htm accessed 27 January 2017.

Table 2.5 Oil production by state/offshore region (thousands of barrels)

	2010	%	2011	%	2012	%
Florida	1777	0.1	2023	0.1	2157	0.1
New York	378	0.0	370	0.0	366	0.0
Pennsylvania	3226	0.2	3388	0.2	4257	0.2
Virginia	12	0.0	11	0.0	11	0.0
West Virginia	1842	0.1	2146	0.1	2193	0.1
Illinois	9067	0.5	9234	0.4	9792	0.4
Indiana	1835	0.1	1987	0.1	2354	0.1
Kansas	40,467	2.0	41,503	2.0	43,563	1.8
Kentucky	2519	0.1	2326	0.1	3198	0.1
Michigan	6790	0.3	6977	0.3	7251	0.3
Missouri	146	0.0	118	0.0	129	0.0
Nebraska	2327	0.1	2542	0.1	2941	0.1
North Dakota	113,064	5.7	152,985	7.4	242,486	10.2
Ohio	4753	0.2	4853	0.2	4866	0.2
Oklahoma	67,730	3.4	76,681	3.7	89,627	3.8
South Dakota	1606	0.1	1615	0.1	1742	0.1
Tennessee	257	0.0	245	0.0	288	0.0
Alabama	7102	0.4	8374	0.4	9569	0.4
Arkansas	5733	0.3	5877	0.3	6536	0.3
Louisiana	67,367	3.4	68,984	3.3	70,768	3.0
Mississippi	24,080	1.2	24,216	1.2	24,153	1.0
New Mexico	65,386	3.3	71,274	3.5	84,179	3.5
Texas	427,386	21.4	531,524	25.8	734,770	30.9
Colorado	32,574	1.6	39,125	1.9	49,007	2.1
Montana	25,333	1.3	24,151	1.2	26,424	1.1
Utah	24,670	1.2	26,272	1.3	30,254	1.3
Wyoming	53,242	2.7	54,710	2.7	58,192	2.4
Alaska	219,536	11.0	204,829	9.9	192,368	8.1
Arizona	40	0.0	37	0.0	52	0.0
California	201,385	10.1	193,691	9.4	195,680	8.2
Nevada	426	0.0	408	0.0	368	0.0
Federal Offshore West Coast	21,702	1.1	19,818	1.0	17,960	0.8
Federal Offshore–Gulf of Mexico	565,974	28.3	480,638	23.3	463,324	19.5
Total	1,999,732	100.0	2,062,932	100.0	2380825	100.0

Source Energy Information Administration, http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm accessed 17 March 2015

Although carbon emissions per unit of energy output are lower for natural gas than coal, at the observed levels of venting and flaring in North Dakota, much of this advantage is lost. In 2011, for each unit of marketed gas in North Dakota, 0.51 units of gas were vented or flared. As the gas pipeline infrastructure is developed, the ratio of waste gas emitted per unit of marketed gas will decline. North Dakota's state regulations allow producers to be exempt from paying royalties on gas vented or flared for 12 months. After that period, the practice is still permitted but waste gas is taxed at the same rate as if it were marketed. The national ratio of vented or flared to marketed gas for all of the U.S.A. in 2009 was 0.01 so that effectively natural gas remains a less greenhouse gas intensive fuel than coal.[11]

In USAGE-TERM, following USAGE which in turn is based on publicly available input–output tables, oil and gas production is treated as a single sector. In one sense, this adds to the difficulty of preparing a database. We need to combine data of each of oil and gas to calculate regional shares. Why do the compilers of input-output tables put us to this trouble? The short answer is that oil and gas represented as a single sector is an international convention in input–output tables. Oil and gas have often been joint products from oil wells. But this is changing with new extraction technologies. Gas can be extracted from oil wells, gas wells, shale gas wells or coal-bed wells. The present master database of USAGE-TERM retains oil and gas as a single sector, although some studies would be enhanced by a split.

The role of coal in the U.S. economy is changing. Growing concerns about greenhouse emissions and the rise of fracking to extract coal seam gas have diminished the role of coal. At the regional level, the most striking difference is between the labor intensity of open-cut mines in Wyoming and the underground mines in the other large producing states, including Kentucky and West Virginia. Wyoming's workforce in the coal mines was less than one fifth of that in West Virginia in 2010, yet its coal output was three times as large.

Black Thunder mine in Campbell county, Wyoming, opened in 1977. It accounts for more than one tenth of national production. Overall, Campbell county's coal production is over 36% of national production, yet it employs only 3% of the nation's coal miners. Jobs in traditional mining regions are being lost through a combination of cost pressures and environmental considerations, including the health hazards faced by underground workers. Once again, we may have a case for splitting a sector, by dividing coal into underground and open-cut technologies. Given the relatively high labor costs of underground mining, it is likely that this technology will make a decreasing share to national coal production and open-cut mining an increasing share in the future.

Although data are available on the output of various other minerals, including iron ore, copper and nickel, gold and other non-ferrous ores, stone, sand and gravel, and other non-metallic minerals, the primary source of data for the remaining mining products is employment data from the 2010 census. These remaining sectors are small compared with coal, oil and gas (Table 2.6).

[11]See http://www.eia.gov/todayinenergy/detail.cfm?id=4030 accessed 27 January 2017. Methane leaks remain an issue in natural gas extraction (Krauss 2016).

Table 2.6 Coal employment and output, 2010

	Employment	Tons 10^6		Employment	Tons 10^6
Alabama	4341	19.9	Montana	1206	44.7
Alaska	127	2.2	NewMexico	1269	21.0
Arizona	422	7.8	NorthDakota	1114	28.9
Arkansas	29	0.03	RoOhio	2826	26.7
Colorado	2247	25.2	Oklahoma	217	1.0
RoIllinois	3649	33.2	RoPnnsylvnia	7716	54.1
Indiana	3342	34.9	Tennessee	546	1.8
Kansas	36	0.1	RoTexas	2787	41.0
Kentucky	17,966	105.0	Utah	1822	19.4
Louisiana	261	3.9	Virginia	4957	22.4
Maryland	422	2.6	WestVirginia	21,643	139.7
Mississippi	232	4.0	Wyoming	3982	442.5
RoMissouri	23	0.5			

Source U.S. Energy Administration, http://www.eia.gov/coal/data.cfm accessed 17 March 2015

2.7 The Potential for Further Industry Splits in Agriculture and Mining in USAGE-TERM

This chapter started by outlining the advantages of undertaking sectoral splits from the initial national database. In both agriculture and mining, as we examine regional production, doubts set in as to whether the additional splits are sufficient for us to feel comfortable with using the same technology for a given industry in different regions. In livestock production, there may be a case for splitting beef cattle into rain-fed and feed-lotting technologies. The advantage of this would be that with the onset of drought, for example, a collapse in rain-fed productivity would induce a switch to feed-lotting. With a seasonal recovery, production would then revert to a rain-fed technology. In the case of cotton, regional differences in the reliance on rain-fed technologies are apparent.

Oil and gas appears as a single sector in the national USAGE database, yet oil wells are only one of several sources of gas. A split of oil and gas therefore may be a reasonable move, either in the master database or in subsequent data processing for a particular study. That is, we are not stuck with a particular sector once we have devised a multi-regional database. Coal produced in Wyoming uses relatively little labor and has relatively higher intermediate-input costs per ton of output. Underground mining elsewhere is much more labor-intensive and the value-added share of the output value is also higher. If we were undertaking a study examining coal scenarios, there would be a case for splitting coal into open-cut and underground technologies. There are traps. Although employment data suggest that open-cut mining dominates in Wyoming and underground mining dominates elsewhere, surface mining was introduced in the Central Appalachian coalfields in the 1940 and 1950s.[12] That is, there is open-cut mining in more traditional coal mining regions.

An optimal strategy in preparation of a multi-regional database might be to split sectors when the data are readily available and when the advantages of a split are immediately obvious. It may not be worthwhile to consider every possible split in response to concerns about different technologies. The effort that goes into such preparation should reflect the expectations of the modeling benefits that may arise from such splits.

2.8 A Tale of Two Colorado Rivers

In the 2010s, drought has led to unprecedented cuts in water allocations to irrigators by the Local Colorado River Authority (LCRA) in Texas. In addition to supplying water to irrigators, the LCRA caters for the water needs of around one million people.

Drought has also affected the better known Colorado River which drains a watershed across seven U.S. states straddling the Rockies and passes through two Mexican states before reaching the Gulf of California between Baja California and Sonora. This is a larger, economically more important waterway than its eastern namesake.

The southern Californian region relying on Colorado water currently has a population of 19 million, with the expectation that this will grow by several million over the next few decades (Wines 2014). It may be understandable for managers of water and electricity utilities to assume that consumption will grow in proportion to population. In the case of countries such as China in which household incomes are being lifted rapidly, such consumption growth may be more rapid than population growth. This is because households may now make regular use of a shower, washing machines and automatic dishwashers. With rising incomes, demand for recreational facilities that are relatively intensive in water usage, such as golf courses and artificial snowfields, also grows. But in high income nations, there is evidence that in response to worsening urban water scarcity, substantial per capita water savings have occurred. For example, in Sydney, Australia, a government media release noted that the city consumed the same volume of water in 2010 as 40 years earlier, despite the population growing by 50% in that time (Wittwer 2013). New technologies, including household appliances that are more water-efficient, and recycling technologies that are extending available water resources, are contributing to per capita reductions in water usage. Wines (2014)

[12]http://en.wikipedia.org/wiki/Eastern_Kentucky_Coal_Field_region accessed 17 March 2015.

notes that in Los Vegas, virtually all water used indoors is treated and returned to Lake Mead, the nation's largest reservoir, which is fed by the Colorado River. Consumers are modifying their behaviour, either through water restrictions or voluntary actions, with a reduction in water applied to suburban lawns and gardens.

What has urban water usage to do with the present chapter that deals mainly with agriculture? Quite simply, water used in agriculture accounts for 65% of water used for economic purposes in the United States (USGS Water Science School 2010), while agriculture accounts for only 1.1% of GDP (Table 2.3). For this reason, as urban populations grow, the pressure to divert water from agricultural to urban purposes grows.

In the US case, this is nothing new. The California Water Wars led to an aqueduct being completed in 1913 that diverted water from the Owens Valley to Los Angeles. While this made an important water source available to a growing metropolis, it devastated the local irrigation-based economy of the Owens Valley. Sauder (1994, Chap. 11) concludes that this should never happen again. He noted that there was considerable scope for water savings in irrigation production, particularly as in the absence of water markets, there may be high levels of water wastage.

The modeling relevance of the water issues concerning either Colorado River basin is that USAGE-TERM could be adapted to depict different scenarios. Such adaptations would require substantial research projects. In the Texan case, water trading may enhance the ability of irrigators to cope with diminished and variable water allocations: USAGE-TERM could be enhanced to include water accounts and water trading possibilities along the lines of the Dixon et al. (2011) study. A study of the Colorado River that wends through multiple states in the west would be in the spirit of Young et al. (2006) and Qureshi et al. (2012). These studies examined an urban water crisis in Australia that affected all mainland state capital cities after the turn of the millennium. They examined various policy options, including desalination and rural-urban water trading in response to changing urban demands and variable water supply.

2.9 The Prolonged Drought in California

Chap. 11 outlines the theory of USAGE-TERM-H2O, which includes water accounts for irrigation activities within California, concentrating on the Central Valley region. The chapter examines the potential role that water trading may have in alleviating water scarcity. Water trading could also reduce the extent to which new wells are bored in response to drought.

References

Dixon PB, Rimmer MT (2012) Validation in CGE modeling. In: Jorgenson D, Dixon P (eds) Elsevier, Handbook of computable general equilibrium modeling
Dixon PB, Rimmer MT, Wittwer G (2012) The theory of TERM-H_2O. In: Wittwer G (ed) Economic modeling of water, the Australian CGE experience. Springer, Dordrecht
Dixon PB, Rimmer MT, Wittwer G (2011) Saving the southern Murray-Darling basin: the economic effects of a buyback of irrigation water. Econ Rec 87:153–168
Gardner B (2009) Distortions to agricultural incentives in the United States and Canada. In: Anderson K (ed) Distortions to agricultural incentives: a global perspective, 1955-2007. Palgrave Macmillan, World Bank, London, Washington DC
Hertel T (ed) (1997) Global trade analysis: modeling and applications. Cambridge University Press, Cambridge
Horridge M (2012) The TERM model and its database. In: Wittwer G (ed) Economic modeling of water: the Australian CGE experience. Springer, Dordrecht, pp 13–36
Krauss (2016) Future of natural gas hinges on stanching methane gas leaks. http://www.nytimes.com/2016/07/12/business/energy-environment/future-of-natural-gas-hinges-on-stanching-methane-leaks.html. Accessed 18 July 2016
Kohli M (2008) Leontief and Bureau of Labor Statistics, 1941–54: an unfinished chapter in the history of economic measurement. http://www.bls.gov/ore/pdf/st020190.pdf. Accessed 18 July 2016
Leontief W (1936) Input and output relations in the economic systems of the United States. Rev Econ Stat 18(3):105–125
Musoke M, Olmstead A (1982) The rise of the cotton industry in California: a comparative perspective. J Econ Hist 42:385–412
Nadal A, Wise T (2004) The environmental costs of agricultural trade liberalization: Mexico-U.S. Maize trade under NAFTA. Working Group on Development and Environment in the America Discussion Paper No. 4. http://ase.tufts.edu/gdae/pubs/rp/DP04NadalWiseJuly04.pdf. Accessed 18 July 2016
Qureshi E, Proctor W, Young M, Wittwer G (2012) The economic impact of increased water demand in Australia: a computable general equilibrium analysis. Econ Pap 31:87–102
Sauder R (1994) The lost frontier: water diversion in the growth and destruction of Owens Valley agriculture. The University of Arizona Press, Tucson
Texas AgriLife Extension Service (2009) Crop profile for cotton in Texas. http://www.ipmcenters.org/cropprofiles/docs/TXcotton.pdf. Accessed 3 May 2013
USGS Water Science School (2010) Irrigation water use. http://ga.water.usgs.gov/edu/wuir.htm. Accessed 9 Jan 2014
Wines M (2014) Colorado River drought forces a painful reckoning for states. New York Times. January 5
Wittwer G (2013) Urban water management in response to prolonged droughts and urban growth. Econ Pap 32:41–50
Wittwer G, Griffith M (2011) Modelling drought and recovery in the southern Murray-Darling basin. Aust J of Agric Resour Econ 49:342–359
Young M, Proctor W, Qureshi ME, Wittwer G (2006) Without water: the economics of supplying water to 5 million more Australians. Water for a health country flagship report. CSIRO and Centre of Policy Studies, Monash University, Melbourne

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