Technical Report

Consumption-Based Greenhouse Gas Emissions Inventory for Oregon - 2005

Technical Report

Prepared for DEQ by
Stockholm Environment Institute - US Center

August 2, 2011

State of Oregon
Department of
Environmental
Quality

GREENHOUSE GAS IMPACTS OF OREGON'S CONSUMPTION

ESTIMATES OF THE GREENHOUSE GASES RELEASED TO PRODUCE, TRANSPORT, SELL, USE, AND DISPOSE GOODS & SERVICES CONSUMED IN OREGON

TECHNICAL REPORT: FINAL
AUGUST 2, 2011

Stockholm Environment Institute – U.S. Center
for the Oregon Department of Environmental Quality

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Technical report citation: Stanton, E.A, Bueno, R., Ackerman, F., Erickson, P., Hammerschlag, R, and Cegan, J. (2011). Greenhouse Gas Impacts of Oregon's Consumption: Technical Report. Somerville, MA: Stockholm Environment Institute-U.S. Center. http://www.sei-us.org.

CBEI model citation: Stanton, E.A., Bueno, R. and Ackerman, F. (2011). *Consumption-Based Emissions Inventory (CBEI)*. Version 1.2 (March 2011). Somerville, MA: Stockholm Environment Institute-U.S. Center. http://sei-us.org/projects/id/143.

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1. OVERVIEW

Oregon's Consumption-Based Emissions Inventory (CBEI)[1] estimates the greenhouse gas emissions resulting from the purchase of goods and services (including fuels and electricity) by Oregon consumers in 2005. CBEI follows the commodities (goods and services) purchased by Oregon's consumers and assigns to these commodities their total life-cycle emissions, from cradle (the production phase) to grave (the post-consumer disposal phase). For example, the cookies consumed by an Oregon resident may be produced in California or in Canada, but – when considered on a consumption basis – Oregon has a responsibility for these emissions. A consumption-based inventory takes the purchase of a final good or service as the act that defines whether a commodity's life-cycle emissions should be in or out of the inventory; in CBEI the life-cycle emissions of anything consumed (or in economic terms, "demanded") in Oregon belong to Oregon.

In contrast, a more traditional "production-based inventory" or "geographic inventory" assigns responsibility for emissions based on the location of their release. Using a production-based methodology, Oregon would be assigned emissions from in-state forestry and paper industries regardless of whether these final products were consumed by residents of Oregon, or were instead exported for consumption in another state or country. In a "consumption-based inventory," Oregon is only assigned the life-cycle emissions for the paper and other wood products purchased by Oregon consumers, or otherwise part of the supply chains that satisfy other purchases by Oregon consumers.[2]

CBEI encompasses the complete life-cycle impacts of the state's consumption, divided into five phases: production, pre-purchase transportation (transport of materials used in production and transport of the final product from producer to wholesaler or retailer), wholesale and retail distribution, use, and post-consumer disposal. CBEI's first three "pre-purchase" phases include direct and indirect emissions; that is, they include both the direct emissions from the production of goods and service purchased by Oregon consumers and the indirect emissions from production of intermediate goods or inputs into production. The use phase includes the direct and indirect emissions from fuel use by the state's households and government entities, and the direct and indirect emissions from the generation of electricity used by households and governments. The post-consumer disposal phase includes the direct and indirect emissions from households' and governments' waste disposal, both from landfilling and the combustion of solid wastes.

CBEI estimates consumption-based emissions for Oregon; it does not measure these results, and, indeed, measurement of consumption-based emissions would be impossible given existing data. The relative error at the aggregated level (e.g., all consumption for the entire state) is very likely to be narrower than the relative error at the level of an individual commodity. The accuracy of results, therefore, likely decreases as the focus becomes more refined (statewide all-consumption estimates are probably more accurate than estimates of emissions associated with individual categories, which in turn are probably more accurate than estimate of emissions associated with subcategories, which in turn are

[1] This analysis for Oregon 2005 uses CBEI version 1.2.

[2] Note that Oregon's traditional inventory's treatment of electricity, while sometimes called a "consumption-based treatment of electricity" is different from CBEI in two important regards: 1) CBEI includes life-cycle emissions, while Oregon's traditional inventory only counts emissions at the point of electricity generation; and 2) CBEI's use of "consumption" is different from the traditional inventory's inclusion of emissions associated with all electricity *used* in Oregon (both final *and* intermediate demand of electricity).

more accurate than estimates of specific commodities). Note also that model results are based on commodity sector averages, and that there is potential for significant variability between similar products (brands) and/or producers. CBEI results should not be used to characterize the emissions or emissions intensity of any individual product (brand) or producer.

CBEI emissions are calculated in three steps:

Step One: Three-Phase Pre-Purchase "Standard" Model

Emissions calculations begin with the dollar value of Oregon's consumer purchases (called final demand) – classified into 509 types of commodities – and use "input-output" analysis to calculate the upstream (supply chain) production requirements of these purchases, also called "intermediate" or "indirect" demand. For example, the purchase of a washing machine by a household (final demand) requires an upstream chain of business-to-business purchases: the washing machine factory purchases steel, plastic, wiring, and electricity; the steel foundry purchases iron and coal; and so on. Final demand for each commodity creates intermediate demand for other commodities. The sum of final demand and intermediate demand for any given commodity is called "gross demand." For example, the gross demand of clothing would be the final demand of clothing (direct purchases of clothing by consumers) plus the intermediate demand for clothing resulting from all final demand of all commodities (such as the purchase of uniforms by hotels and the purchase of scrubs by hospitals). Demand is measured in dollars.

In the "standard" calculations, the gross (final plus intermediate) demand for all final commodities purchased by Oregon consumers is multiplied by the appropriate emissions intensity (emissions per dollar) for each commodity to calculate the resultant emissions. This gross demand is divided into production in three regions: Oregon, the other 49 states, and other countries. Gross demand for products made in Oregon is multiplied by Oregon's emissions intensities; gross demand for products made in the other 49 U.S. states is multiplied by U.S. emissions intensities; and gross demand for products made in other countries is multiplied by the emissions intensities for foreign imports into the United States.[3] Land use emissions are not included in the CBEI model. For this reason, CBEI may underestimate total GHG emissions, and is insensitive to impacts of products that may have significant indirect land-use impacts, such as wood from unsustainably-managed tropical forests, and food made with palm oil from tropical plantations.

These emissions are classified as production, pre-purchase transportation, or wholesale/retail, and are reported on an industry and location basis.[4] For example, in order to produce cars sold in Oregon, auto companies must purchase steel and other inputs. The emissions from production of the steel used to make these cars are included in the calculation of production emissions, since they are part of the life-cycle emissions of cars sold in Oregon. Those emissions, however, are reported as steel industry emissions. A similar principle of classification applies to all other emissions from production of inputs or intermediate goods: All emissions are assigned to the industries that produce them (e.g. steel), even when the emissions are embedded in a final good in another industry (e.g. autos). CBEI three-phase pre-

[3] The CBEI methodology for calculating the emissions embodied in Oregon's foreign imports is slightly different from that of Oregon's domestic imports and Oregon production for in-state consumption. These differences are explained in detail in Section 4.

[4] Emissions emitted in foreign countries as a result of Oregon consumption are reported on a commodity basis.

purchase "standard" is a life-cycle emissions analysis not for each type of consumer good, but for total Oregon consumption for a single year.

CBEI "standard" emissions are reported by emission location as well as industry, distinguishing emissions that occur in Oregon, in the rest of the United States, and in other countries. This reporting convention does not reflect causation: for example, Oregon purchases of domestically produced cars may cause emissions from steel produced in Mexico or Korea, and imported for use in U.S. automobile production. The emissions from steel production are reported in CBEI as foreign steel industry emissions, while the emissions from the assembly of the same automobile would be reported as U.S. auto industry emissions.

Step Two: Three-Phase Pre-Purchase "LCA" Model

The CBEI "standard" model performs a life-cycle emissions analysis on Oregon's total consumption of goods and services where emissions "upstream" of the consumer (pre-purchase three-phase emissions) are classified according to producing industry. CBEI's "standard" results do not classify emissions according to commodities consumed. "Standard" emissions in the clothing category, for example, are not the life-cycle emissions of clothing; if a consumer's purchase of clothing results in upstream emissions from the clothing industry's purchase of appliances, electronics, or fuel, these emissions are classified as appliances, electronics or fuel, and are not readily observable as having resulted from the purchase of clothing. Similarly, if a consumer's purchase of hotel stays, doctor's visits, or computers results in upstream emissions from the clothing industry (associated with the manufacture of clothing for housekeeping staff or medical scrubs, or clean-room "bunny suits"), these emissions are classified as clothing, and are not readily observable as having resulted from the purchase of hotel stays, doctor's visits, or computers.

Rerunning CBEI in its "LCA" mode reorganizes the three-phase results according to the commodities consumed; we refer to these results as "CBEI-LCA" emissions. Both modes (the "Standard" mode and the "LCA" mode) result in the same grand total of emissions for the Oregon consumption-based inventory, but very different allocations of emissions among sectors. CBEI's "LCA" results are the life-cycle emissions of each and every sector of Oregon consumption *separately*. Emissions are assigned to the sector of the good or service consumed. For example, emissions from the production of any good or service that are associated with the consumption of clothing (cotton growing, dye manufacture, and advertising) are assigned to clothing.

Note that a given commodity category's CBEI's "LCA" results do not include emissions from wholesalers, retailers, or the transportation of a final commodity from factory to wholesaler to retailer; rather, these results are broken out in the pre-purchase transportation and wholesale/retail phases. For example, beer emissions, as currently calculated, are the result of final demand for beer (or the dollar value of beer purchased at the factory), not of the dollar value of beer purchased in a store or bar. This is consistent with the treatment of final demand in CBEI's underlying economic data. In these economic data, a consumer purchase of any one commodity (such as beer) is treated as four separate purchases: a purchase of beer (from the beer producer), a purchase of transportation services (from the final producers to the retailer), a purchase of wholesale services, and a purchase of retail services.

Step Three: CBEI Five-Phase Final Results

The final step in CBEI calculations adds two additional phases to the pre-purchase "LCA" results. The calculation of CBEI's use and post-consumer disposal phases includes additional emissions from direct fuel use (not included in the three-phase pre-purchase model) and direct electricity (the direct electricity results modeled in the three-phase model are discarded in favor of Oregon DOE inventory results), and a transfer of some emissions from the production phase to the use and disposal phases. Fuels are an important category of Oregon's consumer purchases, but the three-phase pre-purchase model only includes the upstream impacts of refining and distributing fuels, and of businesses' burning fuels to make and transport products; it does not include the use phase impacts of consumers burning fuels in their cars and furnaces.

Use phase calculations take the emissions from consumers' burning fuels (which are not included in the pre-purchase model) and add to them two transfers from the production phase:

- The upstream emissions from refining and distributing fuels purchased directly by consumers (such as personal vehicle and home heating fuels); and
- The total emissions from consumers' purchase of electricity, including both direct emissions from power generation, and the upstream emissions of materials (predominantly fuel) purchased by power plants for consumers' electricity use.

These emissions are subtracted from the three-phase pre-purchase "LCA" model's calculation of the production phase and transferred to the use phase (or in the case of direct electricity emissions, discarded), allocated to the various appliances, lights, electronics and vehicles that use fuels and electricity. To be clear, use phase emissions are not classified according to the commodity purchased (fuel, electricity, etc.); instead, these emissions (both direct and upstream) are allocated to the commodities that use fuel and electricity, in proportion to the average Oregon consumer's use of appliances, lights, electronics and vehicles.

Post-consumer disposal phase emissions calculations make an additional transfer from the production phase:

- The total emissions from consumers' purchase of waste disposal services, including both direct emissions from waste landfilling and combustion, and the upstream emissions of materials, energy and services purchased by disposal businesses.

These emissions are subtracted from the three-phase pre-purchase "LCA" model's calculation of the production phase and transferred to the post-consumer disposal phase, allocated to all various commodities in proportion to the types of items found in Oregon's municipal waste. Again, post-consumer disposal phase emissions are not classified according to the commodity purchased (waste disposal services), but instead according to the types of commodities that Oregon consumers throw away.

The CBEI methodology is described in detail in Section 4, below. In Section 2, Oregon CBEI results for 2005 are presented including a discussion of the relationship between the Oregon Global Warming Commission and CBEI inventories. Section 3 offers analysis of the CBEI results, including a detailed example of Oregon's consumption of clothing. Limitations and further research are discussed in Section 5.

2. CBEI RESULTS

CBEI totals 78.1 million mT of CO_2-e resulting from Oregon consumption for calendar year 2005. These emissions are classified by commodity type, life-cycle phase, location of emission, and type of consumer. Before reporting specific results, we present a short primer on each of the classifications systems. The remainder of this section describes the reconciliation between the Oregon Global Warming Commission and CBEI inventories, and presents CBEI results.

Type of consumer:

- Oregon ***households*** purchase commodities for their final use, including goods (like food, electronics, household furnishings, and cars), services (like haircuts or tax preparation), fuel for vehicles and home heating, and electricity for household lights, electronics, and appliances. Sixty-eight percent of Oregon's final demand comes from households.
- Oregon-based local, state and federal ***government*** entities purchase commodities for final use, including goods (like office supplies or food consumed in a prison), fuel, and electricity used in government facilities. Oregon-based federal government activities are responsible for 2 percent of final demand, while local and state government activities account for 12 percent. Transfer payments are not included Oregon-based federal government activities (except to the extent that Oregon state/local governments or households use the transfer payments to engage in consumption). CBEI does not estimate Oregonian's "share" of or "contribution" to (via taxes or voting) out-of-state emissions resulting from federal government activities (e.g. foreign affairs, military, etc.).
- The vast majority of business' purchases are not consumption, but one small category is: ***investment*** purchases, or the equipment or inventory that businesses purchase but do not sell in a given year. (The inventory that firms purchase or produce and then sell in a given year creates emissions that are measured in the CBEI, but these purchases do not constitute final consumption – the organizing principle of our model – and therefore only enter into the consumption-based inventory when the resulting final good is purchased by an Oregon consumer.) Business investment accounts for 18 percent of Oregon's final demand. Emissions associated with construction of nonresidential buildings are included as "investment," while emissions associated with construction of residential buildings are modeled as "investment" expenses but then transferred to "households."

Commodity type:

- ***Commodities:*** CBEI data are calculated and reported in 509 types of commodities. More than half of these commodity sectors have little or no "final demand" in Oregon, that is, Oregon's consumers do not purchase these products; instead, many products have an "intermediate" use in production and are purchased by businesses that use them to make other products, both additional intermediate products and commodities for final consumption.
- ***Sub-categories:*** The 509 commodity sectors are grouped into 60 sub-categories.
- ***Categories:*** The 60 sub-categories are grouped into 17 categories: appliances; clothing; construction; electronics; food and beverages; foundries and metal processing; fuel and utilities; healthcare; manufactures (a category primarily consisting of commodity sectors for which there

is no final demand for consumer products); media and furnishings; mining, oil, and gas; retailers; services; transportation services; vehicles and parts; wholesalers; and other.
- All 509 commodities, and their associated sub-categories and categories, are listed in Table 18.

Life-cycle phases:

- ***Production phase:*** Emissions from the manufacture of consumer goods are classified as production phase emissions. For example, in the case of a cookie, this phase includes not only the emissions released by the cookie factory but also the emissions that resulted from all of the supplies purchased by the manufacturer: flour, chocolate, water, and electricity. Final consumer products can also be services, like a haircut or tax preparation. Emissions that result from the operation of a hair salon, and all of the emissions from the products purchased for use in the salon, are also production phase emissions.
- ***Pre-purchase transportation phase:*** Consumer products, and the supplies necessary to manufacture them, often make several stops on their way from factory to retail store. Transportation emissions from intermediate producer (the makers of the flour and chocolate in the example of cookie manufacture) to final producer (the cookie factory) to wholesale warehouse to retail store are classified as pre-purchase transportation. To be clear, this life-cycle phase does not include post-purchase transportation (bringing the cookies home from the store).
- ***Wholesale and retail phase:*** Wholesale warehouses and retail stores cause greenhouse gas emissions primarily from lighting, electronics and temperature control. This phase includes direct and upstream (including electricity and fuel) emissions of wholesalers and retailers.
- ***Use phase:*** Some products cause emissions in their use by the final consumer. For example, heating fuel causes emissions when burned in the consumer's furnace and gasoline causes emissions when burned in the consumer's car engine. Electricity emissions are also classified as a part of the use phase – the use of a computer or a light cause emissions from electricity generation. Use phase emissions include emissions at the point of combustion, as well as supply chain emissions associated with the fuels that are combusted (e.g., emissions from petroleum refineries and coal mines).
- ***Post-consumer disposal phase:*** The final life-cycle phase is disposal. This phase includes only the emissions that result from the post-consumer landfilling or combustion of products. This phase does not include emissions that result from industrial or commercial waste, which are instead classified as production emissions. This phase does not include any "credits" for emissions reductions resulting from recycling or composting, except to the extent that recycling and composting reduce emissions from landfilling and combustion.

Location of emission:

- ***Oregon in-state*** emissions are Oregon production for Oregon consumption. It includes upstream requirements of production for Oregon consumption only when the intermediate products are made in Oregon.
- ***Other-49-state*** emissions are U.S. (other than Oregon) production for Oregon consumption. It includes U.S.-made upstream requirements of production for Oregon consumption.
- ***Foreign*** emissions are foreign production for Oregon consumption. It includes foreign-made upstream requirements of production for Oregon consumption.

2.1.OREGON GLOBAL WARMING COMMISSION EMISSIONS INVENTORY

The ultimate goal of the CBEI model is the construction of a consumption-based inventory for Oregon, but in order to accomplish this goal it is necessary to begin with the Oregon Global Warming Commission (GWC) Inventory (Oregon Global Warming Commission 2011). The Oregon Global Warming Commission Inventory is used to construct CBEI's emission intensities for Oregon-based production. This section reports a rough classification of the Oregon Greenhouse Gas Inventory by life-cycle phase, and reconciles the GWC and CBEI inventories.

2.1.1. "Oregon Global Warming Commission Inventory" by life-cycle phase

The Oregon Global Warming Commission Inventory reports the estimated emissions that physically originate within Oregon's borders, with two important exceptions: electricity and land use/forestry.

When it comes to electricity, the inventory does not include emissions from in-state generation of electricity, except to the extent that some electricity generated in-state is ultimately used in-state. Rather, the Global Warming Commission Inventory includes an estimate of the regional (grid) emissions associated with generation of electricity used in Oregon. The 2011 version of the inventory counts emissions at the point of electricity generation only; emissions of high global warming potential gases associated with electricity transmission and distribution are not included.

In addition, the Oregon Global Warming Commission has recently begun including estimates of carbon flux associated with changes in land use, land use change, and forestry. These estimates have not been completed for 2005, and by extension, are not included in CBEI.

Table 1 compresses Oregon's 67.8 million mT CO_2-e existing Oregon Global Warming Commission Inventory (Oregon Global Warming Commission 2011) into a small number of broad categories of emissions and then roughly sorts these emission categories into life-cycle phases.

Table 1: "Oregon Global Warming Commission Inventory" by Life-Cycle Phase, 2005

(million mT CO2-e)	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
Oregon Gross Emissions	**21.2**	**10.2**	**7.5**	**27.3**	**1.6**	**67.8**
Production-based emissions	**21.2**	**10.2**	**7.5**	**10.3**	**1.5**	**50.7**
Agriculture	5.6					5.6
Direct fuel use, pre-consumer	5.2		1.2			6.4
Electricity	6.2		6.4	10.3		22.9
Industrial processes	3.1					3.1
Natural gas and oil systems	0.8					0.8
Transportation, pre-consumer		10.2				10.2
Waste incineration, landfills, sewage	0.4				1.5	1.8
Consumption-based emissions				**17.1**	**0.1**	**17.1**
Direct fuel use for heating and appliances				3.0		3.0
Direct fuel use for transportation				14.0		14.0
Out-of-state waste incineration					0.1	0.1

Source: Authors' calculations based on Oregon Global Warming Commission Inventory (Oregon Global Warming Commission 2011)

In Table 1, "consumption-based emissions" are largely (with the exception of out-of-state waste incineration) emissions that are under the direct control of consumers. These are emissions that occur in furnaces, appliances, and vehicles operated by consumers. By contrast, "production-based emissions" are emissions occurring at production facilities (either in Oregon, or, in the case of electricity, generating facilities that provide electricity that is used in Oregon). "Direct fuel use, pre-consumer" is oil, natural gas and propane used in the production of goods and services. "Electricity" is divided into production (electricity used in production activities, such as paper mills), wholesale/retail, and use (representing the electricity used by consumers). The total for electricity includes all electricity used in Oregon, which is significantly larger than the emissions associated with electricity generated in Oregon. "Transportation, pre-consumer" refers to any transportation of goods (or related to services) up to the moment of purchase; this includes shipping intermediate goods to factories and shipping final goods to warehouses and retailers.

Using the life-cycle phase classifications, the largest phase in the Oregon GWC inventory is use, with 40 percent of emissions; the use phase includes the emissions from fuel and electricity used by final consumers (primarily households and government). The production phase is the second largest with 31 percent of emissions, including industrial electricity and fuel needs, emissions released in manufacturing and agriculture, and the consequences of industrial waste. Pre-consumer transportation is responsible for 15 percent of emissions, wholesale and retail establishments for 11 percent, and post-consumer waste for just 2 percent.

2.1.2. Reconciling the Oregon Global Warming Commission Inventory and Oregon CBEI

Oregon CBEI is derived, and results are explained, later in this report. For the purpose of comparing CBEI to the Oregon Global Warming Commission Inventory (for 2005), this section describes the key commonalities and differences.

Both the Oregon Global Warming Commission Inventory (Oregon Global Warming Commission 2011) and the Oregon CBEI include:

- Emissions at the point of combustion of fuels (vehicle, appliances) used by Oregon consumers.
- Emissions at the point of electricity generation for electricity used by Oregon consumers.
- Emissions from Oregon's in-state production for Oregon consumers.

The Oregon Global Warming Commission Inventory uniquely includes:

- Emissions from Oregon's production of exports to the other 49 U.S. states and foreign countries.

In contrast, the Oregon CBEI uniquely includes:

- Emissions from goods and services imported from the other 49 U.S. states and from foreign countries (including both emissions associated with final consumer goods imported into Oregon, and emissions associated with imported intermediate materials used in Oregon in-state production for Oregon consumers). This includes emissions associated with the supply chain of fuels and electricity consumed in Oregon (mining coal, refining petroleum, etc.).

The difference between the GWC and CBEI inventories, therefore, is equal to the difference in Oregon's emissions exports and its emissions imports (see Table 2):

GWC Inventory – Emissions Exports + Emissions Imports = CBEI Inventory,

or alternatively:

GWC Inventory – CBEI Inventory = Emissions Exports – Emissions Imports

CBEI uses Oregon DOE emissions in two ways.

First, Oregon's commercial and industrial emissions form the basis of CBEI's emission intensities for Oregon. The 2005 inventory from Oregon's Global Warming Commission, minus direct fuel use and emissions from exported waste, is Oregon's "production-based inventory" – the emissions from Oregon's production of final commodities and intermediate materials used to produce other goods. The production-based inventory is an important ingredient in CBEI calculations. Oregon's production-based emissions are classified into 509 types of industries (as explained in Section 4.2.1) and are then divided by the dollar value of Oregon's production in each industry; the result is the set of Oregon direct coefficients, or the Oregon-specific emissions intensity for each type of industry. (CBEI calculations

include three sets of emissions intensities, for Oregon, the United States as a whole, and foreign imports into the United States.)

Second, Oregon DOE's direct fuel use by consumers and direct electricity use by consumers are included in the CBEI inventory as a part of post-consumer use emissions. In Table 2, the CBEI model calculates Oregon's pre-purchase (three-phase) consumption-based emissions, adds the Oregon DOE direct fuel use and direct electricity use consumer emissions, and then adjusts for double counting. Three-phase pre-purchase emissions in CBEI (before including burning direct fuels or transfers from the production phase to the use and disposal phases) consist of:

- Emissions from in-state production for in-state consumption;
- Emissions embedded in imports (both final imports, and also intermediate imports, but only to the extent that they support final demand in-state) from the other 49 states ; and,
- Emissions embedded in imports (both final imports, and also intermediate imports, but only to the extent that they support final demand in-state) from foreign countries.

The result is a consumption-based inventory for Oregon of 78.1 million mT of CO_2-e.

Table 2: Final Consumption-Based Emissions, Oregon 2008

	(million mT CO2-e)
Pre-Purchase Emissions	56.6
Oregon DOE Direct Fuel Use by Consumers	17.0
Oregon DOE Direct Electricity by Consumers	10.6
Correction for Double-Counting Direct Emissions from Electricity and Waste	-6.1
Final Consumption-Based Emissions for Oregon	**78.1**

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

2.2. OREGON'S CONSUMPTION-BASED INVENTORY

Oregon's consumption in 2005 was the cause of 78.1 million mT of CO_2-e emitted into the atmosphere. Table 3 breaks these emissions down by life-cycle phase and 17 categories of commodities, and Table 4 repeats these data as percentages of each life-cycle, with categories ranked from highest to lowest contribution to total emissions. Table 5 shows the same results disaggregated by both category and sub-category of commodity.

These results do not represent life-cycle emissions analyses for each of these categories as commodities (the life-cycle emission of Oregon's fleet of vehicles, for example), but rather the life-cycle emissions of Oregon's consumption for 2005 broken down into these categories. CBEI reports the production, pre-purchase transportation, and wholesale/retail emissions resulting from Oregon's total consumption of final commodities, sorted into categories based on the type of commodity consumed, together with the use and post-consumer disposal emissions resulting from Oregon's consumption, sorted by the commodity used and the commodity that is thrown away. For example, production emissions for vehicles are for the vehicles purchased in Oregon in 2005 and not for all vehicles in Oregon, whereas use emissions for vehicles are the emissions resulting from the use of all household and government vehicles in Oregon in 2005 (and not just the ones purchased this year).

Table 3: Oregon Consumption-Based Emissions by Life-Cycle Phase

(million mT CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
Oregon Total Emissions	**39.0**	**3.4**	**2.9**	**32.0**	**0.8**	**78.1**
Appliances	0.3	0.0	0.0	11.4	0.0	11.7
Clothing	1.8	0.0	0.0	0.0	0.0	1.8
Construction	5.1	0.0	0.0	0.0	0.1	5.2
Electronics	2.1	0.0	0.0	1.4	0.0	3.5
Food and beverages	8.9	0.0	0.0	0.0	0.3	9.1
Foundries, metal processing	0.1	0.0	0.0	0.0	0.0	0.1
Fuel and utilities	0.3	0.0	0.0	0.0	0.0	0.3
Healthcare	4.0	0.0	0.0	0.0	0.0	4.0
Manufactures	4.8	0.0	0.0	0.0	0.0	4.8
Media and furnishings	2.7	0.0	0.0	2.9	0.3	5.8
Mining, oil and gas	0.1	0.0	0.0	0.0	0.0	0.1
Retailers	0.0	0.0	2.1	0.0	0.0	2.1
Services	5.5	0.0	0.0	0.0	0.1	5.6
Transportation services	0.0	3.4	0.0	0.0	0.0	3.4
Vehicles and parts	2.6	0.0	0.0	16.3	0.0	18.9
Wholesale	0.0	0.0	0.8	0.0	0.0	0.8
Other	0.9	0.0	0.0	0.0	0.0	0.9

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

Table 4: Oregon Consumption-Based Emissions Ranked by Commodity Category

(million mT CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
Vehicles and parts	6.6%	0.0%	0.0%	51.0%	3.0%	24.2%
Appliances	0.8%	0.0%	0.0%	35.6%	0.3%	15.0%
Food and beverages	22.8%	0.0%	0.0%	0.0%	33.4%	11.7%
Media and furnishings	6.8%	0.0%	0.0%	8.9%	31.3%	7.4%
Services	14.2%	0.0%	0.0%	0.0%	8.8%	7.2%
Construction	13.1%	0.0%	0.0%	0.0%	15.0%	6.7%
Manufactures	12.3%	0.0%	0.0%	0.0%	2.5%	6.2%
Healthcare	10.2%	0.0%	0.0%	0.0%	2.3%	5.1%
Electronics	5.4%	0.0%	0.0%	4.5%	1.2%	4.5%
Transportation services	0.0%	100.0%	0.0%	0.0%	0.1%	4.3%
Retailers	0.0%	0.0%	73.3%	0.0%	0.0%	2.7%
Clothing	4.5%	0.0%	0.0%	0.0%	1.4%	2.3%
Other	2.3%	0.0%	0.0%	0.0%	0.6%	1.1%
Wholesale	0.0%	0.0%	26.7%	0.0%	0.0%	1.0%
Fuel and utilities	0.7%	0.0%	0.0%	0.0%	0.1%	0.4%
Foundries, metal processing	0.2%	0.0%	0.0%	0.0%	0.0%	0.1%
Mining, oil and gas	0.2%	0.0%	0.0%	0.0%	0.0%	0.1%

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

Production phase emissions account for 50 percent of this total, the use phase for 41 percent, the pre-purchase transportation phase for 4 percent, and the wholesale and retail phase for 4 percent. Post-consumer waste disposal is not a greenhouse gas emissions intensive industry in comparison to the scale of Oregon's total consumption-based inventory. Vehicles and parts are the category responsible for the largest share of emissions, 24.2 percent, which is predominantly emissions from the fuel burned to operate cars. Appliances are the second greatest source of emissions at 15.0 percent, followed by food and beverages at 11.7 percent.

Table 5: Oregon Consumption-Based Emissions by Commodity Sub-category

(million mT CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
Oregon Total Emissions	**39.0**	**3.4**	**2.9**	**32.0**	**0.8**	**78.1**
Appliances	**0.3**	**0.0**	**0.0**	**11.4**	**0.0**	**11.7**
Heating and cooling appliances	*0.0*	*0.0*	*0.0*	*8.6*		*8.6*
Ranges and microwaves	*0.1*	*0.0*	*0.0*	*0.7*		*0.7*
Refrigerators and freezers	*0.1*	*0.0*	*0.0*	*1.0*		*1.1*
Washers and dryers	*0.1*	*0.0*	*0.0*	*0.9*		*1.0*
Other appliances	*0.1*	*0.0*	*0.0*	*0.2*		*0.3*
Clothing	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**
Construction	**5.1**	**0.0**	**0.0**	**0.0**	**0.1**	**5.2**
Concrete, cement and lime	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Residential construction and remodeling	*3.3*	*0.0*	*0.0*	*0.0*		*3.3*
Non-residential construction/remodeling	*1.8*	*0.0*	*0.0*	*0.0*		*1.8*
Electronics	**2.1**	**0.0**	**0.0**	**1.4**	**0.0**	**3.5**
Computers and peripherals	*1.5*	*0.0*	*0.0*	*0.4*		*1.8*
Computer service and equipment	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Other electronics	*0.6*	*0.0*	*0.0*	*1.0*		*1.7*
Food and beverages	**8.9**	**0.0**	**0.0**	**0.0**	**0.3**	**9.1**
Beverages	*0.8*	*0.0*	*0.0*	*0.0*		*0.8*
Condiments, oils and sweeteners	*0.2*	*0.0*	*0.0*	*0.0*		*0.2*
Dairy and eggs	*1.3*	*0.0*	*0.0*	*0.0*		*1.3*
Frozen food	*0.2*	*0.0*	*0.0*	*0.0*		*0.2*
Fruit, nuts and vegetables	*0.8*	*0.0*	*0.0*	*0.0*		*0.8*
Grains, baked goods, cereals	*0.8*	*0.0*	*0.0*	*0.0*		*0.8*
Pet food	*0.1*	*0.0*	*0.0*	*0.0*		*0.1*
Poultry	*0.5*	*0.0*	*0.0*	*0.0*		*0.5*
Red meat	*1.7*	*0.0*	*0.0*	*0.0*		*1.7*
Restaurants	*2.1*	*0.0*	*0.0*	*0.0*		*2.1*
Seafood	*0.1*	*0.0*	*0.0*	*0.0*		*0.1*
Other animal products	*0.1*	*0.0*	*0.0*	*0.0*		*0.1*
Other food and agriculture	*0.2*	*0.0*	*0.0*	*0.0*		*0.2*
Foundries, metal processing	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**
Fuel and utilities	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**
Gasoline, heating fuels, other petroleum	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Natural gas distribution	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Power generation and supply	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Water- sewage and other systems	*0.3*	*0.0*	*0.0*	*0.0*		*0.3*

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

Table 5 (continued): Oregon Consumption-Based Emissions by Commodity Sub-category

(million mT CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
Oregon Total Emissions	**39.0**	**3.4**	**2.9**	**32.0**	**0.8**	**78.1**
Healthcare	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**
Medicines	*1.1*	*0.0*	*0.0*	*0.0*		*1.1*
Healthcare services	*2.9*	*0.0*	*0.0*	*0.0*		*2.9*
Manufactures	**4.8**	**0.0**	**0.0**	**0.0**	**0.0**	**4.8**
Forestries, mills, paper	*0.1*	*0.0*	*0.0*	*0.0*		*0.1*
Machinery manufacture	*1.9*	*0.0*	*0.0*	*0.0*		*1.9*
Mobile homes	*0.2*	*0.0*	*0.0*	*0.0*		*0.2*
Prefabricated buildings	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Missiles, weapons	*1.4*	*0.0*	*0.0*	*0.0*		*1.4*
Other manufactures	*1.3*	*0.0*	*0.0*	*0.0*		*1.3*
Media and furnishings	**2.7**	**0.0**	**0.0**	**2.9**	**0.3**	**5.8**
Furnishings	*0.6*	*0.0*	*0.0*	*0.0*		*0.6*
Household supplies	*1.0*	*0.0*	*0.0*	*0.0*		*1.0*
Lawn and garden	*0.2*	*0.0*	*0.0*	*0.0*		*0.2*
Lighting fixtures	*0.0*	*0.0*	*0.0*	*2.9*		*2.9*
Media	*0.4*	*0.0*	*0.0*	*0.0*		*0.4*
Office supplies	*0.4*	*0.0*	*0.0*	*0.0*		*0.4*
Mining, oil and gas	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**
Oil and gas	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Other mining	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Retailers	**0.0**	**0.0**	**2.1**	**0.0**	**0.0**	**2.1**
Services	**5.5**	**0.0**	**0.0**	**0.0**	**0.1**	**5.6**
Banks and financial services	*0.7*	*0.0*	*0.0*	*0.0*		*0.7*
Building services	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Car rental, repair and wash	*0.4*	*0.0*	*0.0*	*0.0*		*0.4*
Education and day care	*0.5*	*0.0*	*0.0*	*0.0*		*0.5*
Entertainment and media	*0.5*	*0.0*	*0.0*	*0.0*		*0.5*
Hotels and motels	*0.2*	*0.0*	*0.0*	*0.0*		*0.2*
Legal, real estate, insurance	*1.4*	*0.0*	*0.0*	*0.0*		*1.4*
Personal services	*0.3*	*0.0*	*0.0*	*0.0*		*0.3*
Waste management	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*
Other services	*1.6*	*0.0*	*0.0*	*0.0*		*1.6*
Transportation services	**0.0**	**3.4**	**0.0**	**0.0**	**0.0**	**3.4**
Vehicles and parts	**2.6**	**0.0**	**0.0**	**16.3**	**0.0**	**18.9**
Vehicle parts	*0.4*	*0.0*	*0.0*	*0.0*		*0.4*
Vehicles	*2.1*	*0.0*	*0.0*	*16.3*		*18.5*
Wholesale	**0.0**	**0.0**	**0.8**	**0.0**	**0.0**	**0.8**
Other	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.9**

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

Using Oregon-specific production and disposal data, the CBEI model used to develop these results accounts for some reductions to disposal and production emissions that result from using recycled materials. The life-cycle emission savings from recycling (by consumers) include avoided disposal emissions, and reduced production emissions resulting from use of recycled rather than virgin materials. (EPA holds that recycling paper and wood materials also results in increased carbon storage in forests, but these types of changes in carbon flux are not included in CBEI.) Current levels of recycling by Oregon consumers have already reduced disposal emissions in the GWC Inventory, and by extension, the disposal emissions in CBEI. Current use of recycled feedstocks by producers (both in- and out-of-state) satisfying final demand in Oregon have also reduced producer emissions, and these reductions are embodied in the CBEI model's production calculations, and its emission factors. However, the production emissions factors in CBEI account for average levels of recycled content use, and, by extension, average levels of recycling. To the extent that Oregon consumers contribute to recycling rates that are higher (or lower) than the averages, changes in disposal-related emissions are reflected in CBEI, but changes in production-related emissions will not necessarily be. For example, Oregon's bottle bill may lead to higher-than-average recycling rates for aluminum and certain plastic resins.

2.2.1. Consumption-based emissions by location of emission

The CBEI inventory can also be reported by the location of each emission-producing activity, as shown in Table 6 (here, presented without transfer of electricity, upstream fuel, and waste disposal emissions to the sectors representing the commodity used or thrown away).

Table 6: Oregon Consumption-Based Emissions by Location of Emission

(million mT CO2-e)	GHG Emissions by Location of Emission				
	In-State Production	Imports from U.S.	Foreign Imports	Use and Disposal (less double-counting correction)	Total
Oregon Total Emissions	**14.6**	**24.6**	**17.5**	**21.5**	**78.1**
Appliances	0.0	0.1	0.2		0.3
Clothing	0.0	0.1	1.6		1.8
Construction	1.3	2.3	1.5		5.1
Electronics	0.3	0.3	1.5		2.1
Food and beverages	2.3	4.7	1.9		8.9
Foundries, metal processing	0.0	0.0	0.0		0.1
Fuel and utilities	4.4	4.8	1.7		10.9
Healthcare	0.9	2.0	1.0		4.0
Manufactures	0.4	1.8	2.7		4.8
Media and furnishings	0.2	1.0	1.4		2.7
Mining, oil and gas	0.0	0.0	0.0		0.1
Retailers	0.7	1.1	0.3		2.1
Services	1.7	3.6	1.1		6.3
Transportation services	2.0	0.8	0.6		3.4
Vehicles and parts	0.1	1.0	1.4		2.6
Wholesale	0.3	0.4	0.1		0.8
Other	0.1	0.4	0.3		0.9

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

In-state production for in-state consumption is responsible for 19 percent of all emissions, imports from the other 49 states for 31 percent and imports from foreign countries for 22 percent. The final 28 percent of Oregon's consumption-based emissions results from Oregon consumers' burning fuels in cars and appliances (mostly furnaces), and waste emissions; these direct fuel use emissions take place in-state, but are the result of fuels that are imported into Oregon.

It is important to note a caveat with regards to IMPLAN data: IMPLAN's developers acknowledge that "estimating regional trade flows (imports and exports) across regional boundaries is perhaps the largest source of error in deriving non-survey I/O models."[5] The accuracy of IMPLAN's division of U.S. production into smaller jurisdictions within the United States is a limitation to the accuracy of CBEI's results. To our knowledge, however, no better data source exists. To the extent that emissions factors are not significantly different for production in Oregon versus other states (see Section 3.1), this error takes on less significance in the context of CBEI results.

[5] MIG, Inc. website, http://implan.com; please refer to Section 5.1.3 of this report for additional details.

2.2.2. Consumption-based emissions by type of consumer

Table 7 reports CBEI results by type of consumer: households, government, and business investment. Household consumption is responsible for 81 percent of Oregon's emissions, government consumption for 9 percent, and business investment for 11 percent.

Table 7: Oregon Consumption-Based Emissions by Type of Consumer

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Households	**Government**	**Business Investment**	**Total**
Oregon Total Emissions	**63.0**	**6.7**	**8.4**	**78.1**
Appliances	10.4	1.3	0.0	11.7
Clothing	1.7	0.0	0.0	1.8
Construction	3.3	0.6	1.3	5.2
Electronics	2.0	0.4	1.1	3.5
Food and beverages	8.5	0.5	0.2	9.1
Foundries, metal processing	0.0	0.0	0.1	0.1
Fuel and utilities	0.3	0.0	0.0	0.3
Healthcare	3.9	0.1	0.0	4.0
Manufactures	0.5	0.4	3.9	4.8
Media and furnishings	4.4	1.0	0.3	5.8
Mining, oil and gas	0.0	0.0	0.0	0.1
Retailers	2.1	0.0	0.1	2.1
Services	5.0	0.4	0.2	5.6
Transportation services	2.8	0.3	0.2	3.4
Vehicles and parts	16.6	1.6	0.8	18.9
Wholesale	0.6	0.0	0.2	0.8
Other	0.8	0.0	0.1	0.9

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

3. ANALYSIS OF OREGON'S CONSUMPTION-BASED EMISSIONS

3.1.COMPARING EMISSIONS INTENSITIES BY PRODUCTION GEOGRAPHY

Emission intensities (CBEI-LCA emissions per dollar of final demand), for three-phase pre-purchase emissions, organized by their consuming sectors, are presented in Table 8, given the 2005 mix of in-state, other domestic, and foreign producers serving Oregon. Emissions per dollar are highest for fuel and utilities, and transportation services. Emission intensity are presented for pre-purchase emissions only because the denominator of the intensities (final demand) is organized by pre-purchase activity whereas five-phase emissions includes pre- and post-purchase activities. For example, final demand for vehicles and parts refers to consumer dollars spent on vehicles and parts. In contrast, five-phase emissions for vehicles and parts include emissions from the purchase, use (driving) and disposal of vehicles and parts.

Table 8: Three-Phase Emissions Intensities, using CBEI-LCA

	Three-Phase LCA Emissions *(million mT CO2-e)*	Final Demand *(in millions 2005$)*	Emissions to Final Demand Ratio *(kg/$)*
Appliances	0.3	430	0.69
Clothing	1.8	1,607	1.10
Construction	5.1	12,449	0.41
Electronics	2.1	3,794	0.55
Food and beverages	8.9	9,967	0.89
Foundries, metal processing	0.1	59	1.53
Fuel and utilities	10.9	4,898	2.22
Healthcare	4.0	18,077	0.22
Manufactures	4.8	8,255	0.58
Media and furnishings	2.7	5,419	0.49
Mining, oil and gas	0.1	95	0.63
Retailers	2.1	12,051	0.18
Services	6.3	28,747	0.22
Transportation services	3.4	2,092	1.62
Vehicles and parts	2.6	4,842	0.53
Wholesale	0.8	5,521	0.14
Other	0.9	27,610	0.03
Total	**56.7**	**145,913**	**0.39**

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

Oregon consumers purchase commodities that are made in Oregon, made in the other 49 states, and made in foreign countries. Because emissions intensities (emissions per dollar) differ in each of these production locations, if Oregonians were to change their purchasing habits – buy more foreign-made products, for example – Oregon's CBEI emissions inventory would change. Table 9 compares Oregon's current consumption-based emissions (for 2005) with the estimated emissions if Oregon consumers continued to buy exactly the same items, but chose to buy them from the U.S. or from foreign countries.

"Oregon Three-Phase CBEI-LCA" is the Oregon three-phase pre-purchase emissions (before adding the use and post-consumer disposal phases) organized by the sector of the consumed good or service.

Table 9: Comparison of Three-Phase Emissions Intensities, using CBEI-LCA

	(millions of mT CO2-e)				
	Oregon Three-Phase CBEI-LCA (Oregon)	**In-State Final Demand at US Intensities** (OR at US)	**In-State and Other 49 Final Demand at US-Import Intensities** (OR&US at Foreign)	**Ratio of OR-at-US to Oregon**	**Ratio of OR&US-at-Foreign to Oregon**
Oregon Emissions	**56.7**	**67.7**	**113.5**	**1.2**	**2.0**
Appliances	0.3	0.3	0.4	1.0	1.3
Clothing	1.8	1.8	2.1	1.0	1.2
Construction	5.1	5.8	12.8	1.1	2.5
Electronics	2.1	2.1	2.8	1.0	1.3
Food and beverages	8.9	9.1	13.8	1.0	1.6
Foundries, metal processing	0.1	0.1	0.2	1.0	1.7
Fuel and utilities	10.9	18.3	21.7	1.7	2.0
Healthcare	4.0	4.5	15.3	1.1	3.8
Manufactures	4.8	4.9	7.2	1.0	1.5
Media and furnishings	2.7	2.8	5.1	1.1	1.9
Mining, oil and gas	0.1	0.1	0.2	1.0	3.9
Retailers	2.1	2.7	6.8	1.3	3.2
Services	6.3	7.5	14.1	1.2	2.2
Transportation services	3.4	3.4	4.2	1.0	1.2
Vehicles and parts	2.6	2.6	3.2	1.0	1.2
Wholesale	0.8	1.0	2.8	1.3	3.6
Other	0.9	0.9	0.9	1.0	1.0

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org
Note: These emissions are calculated for the three-phase pre-purchase model.

"In-State Final Demand at U.S. Intensities" is the CBEI-LCA results using the following assumption: All Oregon in-state production for in-state consumption is produced at the U.S. emissions intensities (this includes Oregon's production of intermediate goods used to make final products purchased in Oregon). "In-State and Other 49 Final Demand at U.S.-Import Intensities" assumes that all of Oregon's consumption is of foreign-made products. "In-State Final Demand at U.S. Intensities" and "In-State and Other 49 Final Demand at US-Import Intensities" do not reflect additional emissions associated with longer transportation distances.

Oregon consumers switching from Oregon to U.S.-produced products would cause a small (19 percent) increase in Oregon's three-phase consumption-based emissions. In contrast, Oregon consumers switching from Oregon and U.S-produced to foreign-produced products would cause a doubling of Oregon's three-phase pre-purchase consumption-based emissions. U.S.-import intensities are far higher than U.S. and Oregon emissions intensities in almost all sectors.

3.2.USING CBEI TO PERFORM DETAILED LIFE-CYCLE ANALYSIS

The CBEI model's primary purpose is to perform a life-cycle emissions analysis on Oregon's total annual consumption of goods and services, but the three-phase pre-purchase model can also be used to perform more detailed life-cycle analysis of annual purchases of specific commodities. The CBEI "LCA-Modeler" is an additional user-interface tool that allows for calculations of any user-defined demand matrix (that is, dollar values of Oregon demand defined by IMPLAN sector and by institutions – households, federal government, local and state government, and investment). Here, only the emissions from the production of any good or service that are associated with the dollars values of consumption specified by the user are calculated. This method can be used to determine the sector-by-sector emissions associated with a single consumption sector. For example, if the user enters a demand matrix representing Oregon's final demand for beer, the CBEI "LCA-Modeler" results would show sector-by-sector emissions from all of the upstream purchases associate with Oregon's final demand for beer (see Table 10).

Table 10: CBEI-LCA of Emissions Oregon Consumer's Purchase of Beer

(million mT CO2-e)	**Total**
Oregon Total Emissions from Beer Purchase	**0.158**
Appliances	0.000
Clothing	0.000
Construction	0.002
Electronics	0.000
Food and beverages	0.078
Foundries, metal processing	0.005
Fuel and utilities	0.030
Healthcare	0.000
Manufactures	0.013
Media and furnishings	0.003
Mining, oil and gas	0.003
Retailers	0.000
Services	0.005
Transportation services	0.019
Vehicles and parts	0.000
Wholesale	0.001
Other	0.001

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

3.3.INTERNATIONAL EXAMPLE: OREGON'S CLOTHING CONSUMPTION

This section uses clothing consumption to illustrate the level of detail that is possible with additional analysis of international emissions. As a category, clothing does not have particularly high consumption-based emissions; much of the clothing purchased in the United States, however, is made in other countries. As such, clothing makes a convenient and accessible example. Similar analysis could be performed on other categories of commodities. In any event, this example helps to illustrate the global nature of consumption-based emissions and some of the variables that determine changes in such emissions.

Each dollar of Oregon's clothing consumption results in 1.1 kilograms of CO_2-e emissions (see Table 8). Oregon consumers purchase $1.6 billion worth of clothing each year, of which $1.2 billion, or 74 percent, originates overseas. Because of higher foreign import intensities, 93 percent of all of the emissions generated by Oregon's consumption of clothing originate overseas. These emissions include only the purchase of clothing as if from the factory; they do not include the contribution of wholesalers, retailers or the transport of final goods, or emissions associated with use of clothes (such as washing and drying) or disposal of clothes at end-of-life.

Table 11: CBEI-LCA of Emissions Oregon Consumer's Purchase of Clothing

(million mT CO2-e)	GHG Emissions by Location of Production			
	In-State Production	Imports from U.S.	Foreign Imports*	Total
Oregon Total Emissions from Clothing Purchases	**0.030**	**0.087**	**1.649**	**1.767**
Appliances	0.000	0.000		0.000
Clothing	0.015	0.009	1.649	1.673
Construction	0.000	0.001		0.001
Electronics	0.000	0.000		0.000
Food and beverages	0.000	0.002		0.002
Foundries, metal processing	0.000	0.001		0.001
Fuel and utilities	0.004	0.039		0.043
Healthcare	0.000	0.000		0.000
Manufactures	0.001	0.012		0.013
Media and furnishings	0.000	0.002		0.002
Mining, oil and gas	0.001	0.002		0.003
Retailers	0.000	0.000		0.000
Services	0.002	0.005		0.007
Transportation services	0.007	0.012		0.019
Vehicles and parts	0.000	0.000		0.000
Wholesale	0.001	0.001		0.001
Other	0.000	0.001		0.002

Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

** Note that in-state and other-49 emissions are assigned to their producing sectors, while "foreign imports" emissions are all rolled together into "clothing." This reporting convention is made necessary by the availability of emissions intensity data for U.S. imports.*

3.3.1. Oregon Clothing Production

Most of Oregon's demand for clothing made within Oregon ($278 million) is concentrated in two specific clothing production sectors: cut and sew apparel manufacture ($35 million in IMPLAN 110, NAICS 3152[6]) and footwear manufacture ($221 million in IMPLAN 107, NAICS 3162[7]). Only a very small percentage of

[6] The NAICS definition for this sector is as follows: "This industry group comprises establishments primarily engaged in manufacturing cut and sew apparel from woven fabric or purchased knit fabric. Included in this industry group is a diverse range of establishments manufacturing full lines of ready-to-wear apparel and custom apparel: apparel contractors, performing cutting or sewing operations on materials owned by others; jobbers performing entrepreneurial functions involved in apparel manufacture; and tailors, manufacturing custom garments for individual clients. Establishments weaving or knitting fabric, without manufacturing apparel, are classified in Subsector 313, Textile Mills." See http://www.census.gov/econ/census02/naics/sector31/3152.htm.

[7] The NAICS definition for this sector is as follows: "This industry group comprises establishments primarily engaged in manufacturing rubber and plastics footwear with vulcanized rubber or plastics soles, molded or cemented to rubber, plastics, or fabric uppers, and rubber and plastics protective footwear." See http://www.census.gov/econ/census02/naics/sector31/3162.htm.

U.S. cut and sew apparel manufacturing and footwear manufacturing establishments are located in Oregon (see Table 12).[8]

Table 12: U.S. and Oregon Clothing Industry, 2002

	Establishments		Employees	
	United States	Oregon	United States	Oregon
Cut and sew apparel manufacture	10,785	63	265,000	1,100
Footwear manufacture	348	5	19,000	<250

Source: U.S. Census Bureau, 2002 Economic Census, www.census.gov.

3.3.2. Oregon Clothing Imports

Ninety-four percent of Oregon's clothing emissions are associated with clothing imported from other countries. Table 13 reports the share of U.S. clothing imports by country of origin, for countries or groups of countries with the largest clothing imports and/or clothing emissions imports. In CBEI, Oregon's imports are assumed to have the same country of origin mix as the United States. Note that these data are for 2001, the latest international emissions intensity data available; since that time China's clothing imports to the United States have increased enormously (see section on updates to 2001 data below). In 2001, the greatest shares of wearing apparel imports into the United States (and, by assumption, to Oregon) came from four countries or regions: Mexico (13 percent), China (10 percent), Central America (9 percent), and Hong Kong (7 percent). The balance of clothing emissions imports today, however, looks quite different.

[8] There are an additional 28,000 apparel manufactures in the United States, and 552 in Oregon, that do not have employees; non-employee establishments are not available for cut and sew apparel specifically. There are an additional 905 footwear manufactures in the United States, and 8 in Oregon, that do not have employees.

Table 13: U.S. Clothing Imports by Region of Origin, 2001

	Share of Imported Clothing by Value	Share of Imported Clothing Emissions	Emissions Intensity (kg/$)
China	10.0%	17.1%	1.9
India	3.3%	5.8%	2.0
Indonesia	4.5%	5.6%	1.4
Central America	9.0%	5.4%	0.7
Hong Kong	7.1%	5.3%	0.8
Mexico	12.8%	4.8%	0.4
Bangladesh	4.0%	4.6%	1.3
Korea	3.7%	4.6%	1.4
Middle East	3.0%	4.6%	1.7
Philippines	3.8%	3.9%	1.2
Rest of East Asia	1.9%	3.9%	2.2
Thailand	3.4%	3.5%	1.2
Taiwan	2.7%	3.4%	1.4
Rest of FTAA	5.0%	2.6%	0.6
Rest of South Asia	2.2%	2.4%	1.2
Italy	3.0%	1.8%	0.7
Canada	3.0%	1.7%	0.6

Source: Multi-Regional Input-Output (MRIO) international model developed by Glen Peters and his colleagues at CICERO (Center for International Climate and Environmental Research – Oslo) in Norway. See also, (Peters and Hertwich 2008)). Note: This table includes only regions that contributed at least 1.5 percent of U.S. clothing imports in 2001. Emissions intensities are specific to U.S. imports and include both direct and indirect emissions. Regions are based on GTAP classifications (see https://www.gtap.agecon.purdue.edu/models/current.asp).

Seventeen percent of clothing emissions imported to the United States originates in China, 6 percent in each of India and Indonesia, and 5 percent in each of Central America, Hong Kong, Mexico, Bangladesh, South Korea, and the Middle East. Large differences in emissions intensities for clothing manufacture explain this discrepancy (see Table 13). China and India have far higher emissions intensities for clothing manufacture (1.9 and 2.0 kg CO_2-e per dollar) than do Mexico (0.4 kg CO_2-e per dollar), Central America (0.7) or Hong Kong (0.8). Mexico, with the greatest share of clothing imports to the United States, has the lowest clothing emissions intensity among the countries with the largest clothing imports to the United States; for this reason, Mexico ranks only sixth in terms of the greatest clothing emissions imports to the United States. In comparison, Oregon's emissions intensity for clothing production sectors ranges from 0.12 to 0.14 kg CO_2-e per dollar, while the United States ranges from 0.26 to 0.45 kg CO_2-e per dollar.[9]

[9] These values are the emissions coefficients that would apply if all of Oregon's (the United States') intermediate inputs to clothing production originated in Oregon (the United States); that is, these are the direct+indirect emissions coefficients.

Two factors are likely to be of particular importance in explaining international differences in the emissions intensity of clothing manufacture. The first is the labor to capital balance in each country's manufacturing sector: countries that employ more machinery will have higher emissions, while countries that employ more manual labor will have lower emissions. In the international clothing industry, manual labor without any machinery (hand-sewing, hand-weaving) is uncommon, and large international differences in clothing production technology are unlikely, but smaller differences could be the result of different emissions management practices and energy efficiency measures. The second factor is the emissions intensity of electricity in exporting countries and here large international differences do exist (see Table 14). China, India, and Hong Kong's electricity generation relies on 76, 71, and 61 percent coal, respectively – far more than any other leading clothing exporters to the United States. It is also possible that some of the difference is a result of the use of different supply chains; agricultural products used in clothing (cotton, wool, leather) may have different emissions depending on the country of production.

Table 14: Electricity Production Mix for Selected Countries, 2001

	Share of electricity production from:			
	Coal	Oil	Natural gas	Hydroelectric and nuclear
Bangladesh	0.0%	6.7%	87.6%	5.7%
Canada	20.0%	2.9%	6.1%	69.5%
China	76.2%	3.2%	0.3%	20.0%
Hong Kong	61.5%	0.4%	38.1%	0.0%
India	71.0%	4.2%	8.0%	16.0%
Indonesia	37.1%	19.7%	25.8%	11.5%
Italy	13.5%	27.6%	38.3%	17.2%
Korea	39.9%	11.5%	10.9%	37.6%
Mexico	11.1%	44.3%	23.9%	17.8%
Philippines	39.9%	21.0%	1.8%	15.1%
Thailand	19.1%	2.9%	70.5%	6.2%
United States	51.6%	3.4%	17.2%	25.5%

Source: World Bank (2007) World Development Indicators database.

3.3.3. Upstream Emissions of Clothing Exporters

Table 15 reports the share of each of the key exporting countries' clothing production emissions (including upstream emissions) that originates outside of that country. Countries with higher *non-domestic* emissions shares are importing intermediate inputs to clothing production that are high in embedded emissions. Countries with higher *domestic* emissions shares produce most of the emissions embedded in their clothing exports within their own borders. All but 9 percent of Hong Kong's clothing production emissions are generated elsewhere around the world – a result that is consistent with Hong Kong's role as an important center of international trade. Mexico generates 65 percent of the emissions embodied in its clothing exports domestically, while China and India generate 89 and 91 percent of their own clothing emissions exports, respectively.

Table 15: Non-Domestic Share of Clothing Production Emissions, 2001

Exporting Region	Non-domestic Emissions Share
Bangladesh	57.5%
Canada	76.0%
Central America	77.7%
China	11.5%
Hong Kong	91.5%
India	9.3%
Indonesia	36.4%
Italy	55.0%
Korea	45.5%
Mexico	35.3%
Philippines	66.9%
Rest of East Asia	25.6%
Rest of FTAA	49.8%
Rest of Middle East	40.4%
Rest of South Asia	30.9%
Taiwan	29.8%
Thailand	43.5%
United States	35.6%

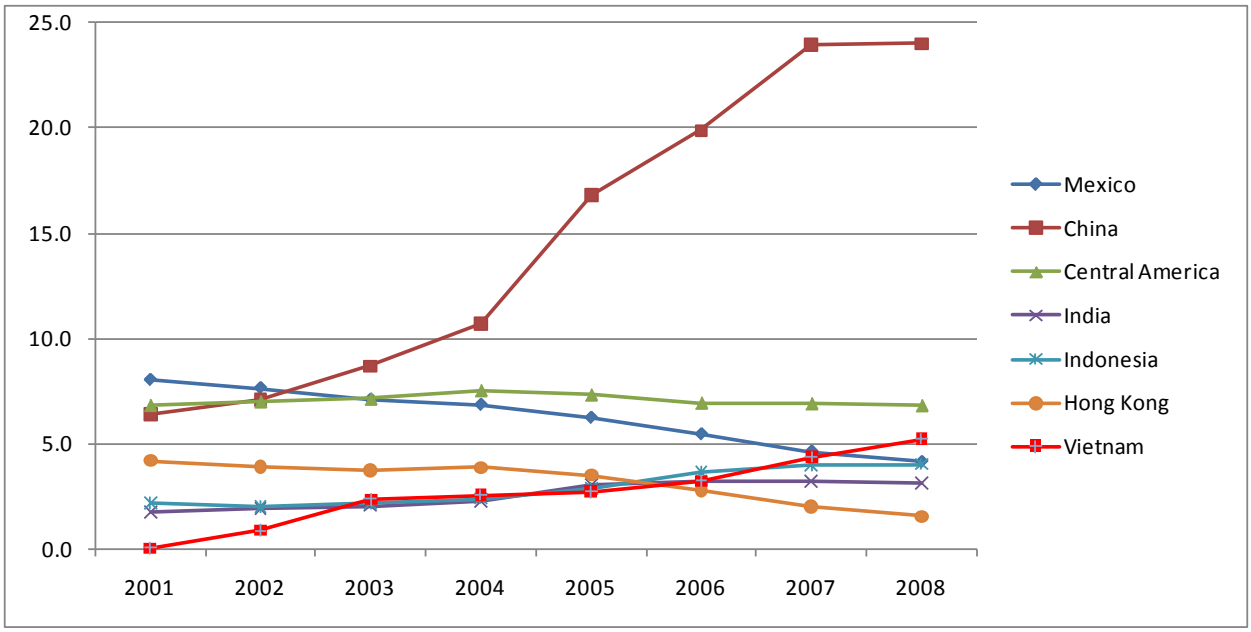
Source: MRIO data. Regions are based on GTAP classifications (see https://www.gtap.agecon.purdue.edu/models/current.asp).

3.3.4. U.S. Clothing Imports Since 2001

Since 2001, the year of all CBEI international data, the origin of clothing imports into the United States has changed. Mexico's exports of clothing to the United States have fallen to rank third after China and Central America. China's clothing exports to the United States have grown four-fold (before adjusting for inflation) over this period (see Figure 1). Assuming that clothing production emissions intensities have stayed fairly steady since 2001, today China far surpasses all other countries in clothing emissions imports to the United States. In this same time period, U.S. clothing imports from Vietnam have grown more than one-hundred-fold.

China generates most of the intermediate inputs to its clothing production domestically. Of the 11.5 percent of China's clothing emissions exports (including upstream emissions) that originate outside of China, the largest shares come from Korea and Taiwan (see Table 16). Both of these countries have clothing production emissions intensities that are approximately 25 percent smaller than that of China.

Figure 1: U.S. Clothing Imports, 2001 to 2008 (in billions 2008 $)



Source: U.S. Department of Commerce, TradeStats Express Database, http://tse.export.gov/.

Table 16: Share of China's Clothing Production Emissions by Region, 2001

Exporting to China	Share of China's Clothing Emissions
China	88.5%
Korea	1.7%
Taiwan	1.5%
United States	1.1%
Rest of Middle East	1.0%
Russian Federation	0.9%
Japan	0.9%
Australia	0.5%
India	0.4%
Rest of Former Soviet Union	0.3%
Brazil	0.3%
Indonesia	0.3%
Rest of South Asia	0.3%
Argentina	0.2%
Thailand	0.2%
Canada	0.2%

Source: MRIO data. Regions are based on GTAP classifications (see https://www.gtap.agecon.purdue.edu/models/current.asp).

4. CBEI METHODOLOGY

The Consumption-Based Emissions Inventory (CBEI) models life-cycle greenhouse gas (GHG) emissions for a given locality and year. This model description refers to CBEI version 1.2. Oregon 2005 CBEI combines four methodologies to encompass the entire life-cycle of goods and services. The primary method addresses production, wholesale, retail and transportation of goods and services up to the point of sale; these intensive, input-output-analysis calculations represent the bulk of CBEI. These primary, or "standard," results are then processed in CBEI's "LCA mode" to re-sort emissions according to the commodities consumed. Finally, two additional methods address the post-purchase use and disposal of goods. The results of these three types of calculations are brought together in a final step.

Oregon's production, pre-purchase transportation, wholesale, and retail emissions are calculated by multiplying GHG coefficients – also called "emissions intensities" – in kilograms of CO_2-e per dollar by 509 sectors of gross (final plus intermediate) demand in dollars. Final demand is the purchase of goods and services by households and government, and firms' investment in capital goods (like equipment) or inventory (when products are made but not sold in a given year). The intermediate demand included in CBEI is the upstream inputs needed to produce final demand. CBEI emission results are organized by producing industry.

This type of methodology is often referred to as "input-output life-cycle analysis," for its use of input-output matrices that track the flow of money (as a measure of production activity) through the supply chain for various commodities. Unlike traditional life cycle analysis, which typically traces the mass of materials through the life cycle, the elementary flows in input-output life-cycle analysis are in dollars.

Oregon 2005 CBEI consists of six main linked Excel 2007 workbooks and five supplemental (unlinked) workbooks.

Figure 2 (below) is a schematic diagram of the CBEI model.

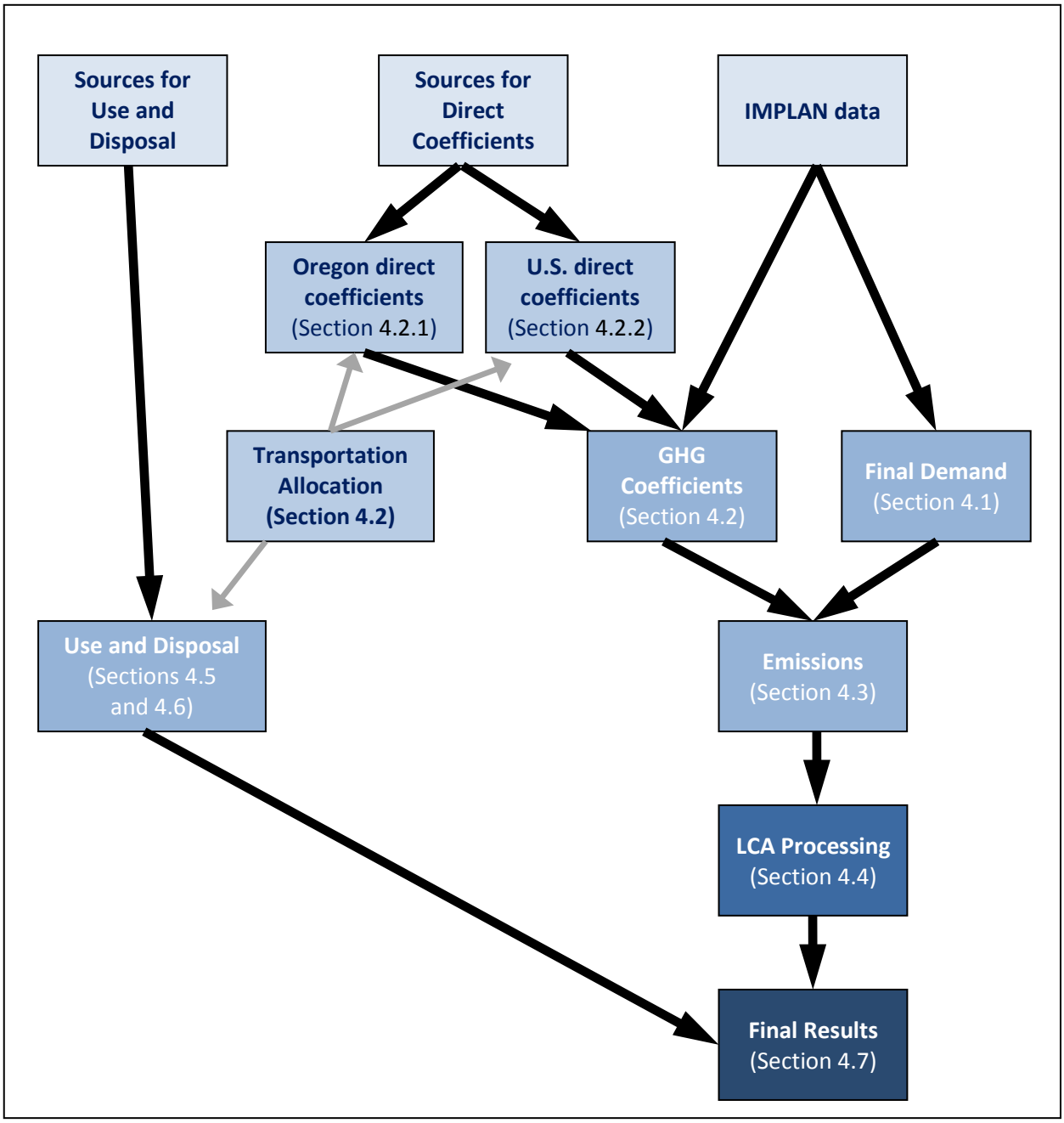
CBEI Model:

1. *OR2005 CBEI Final Results.xlsx*
2. *OR2005 CBEI Emissions.xlsx*
3. *OR2005 CBEI Final Demand.xlsx*
4. *OR2005 CBEI GHG Coefficients.xlsx*
5. *OR2005 CBEI Use and Disposal.xlsx*
6. *OR2005 CBEI Demand Modeler.xlsx*

Supplemental Materials to CBEI Model:

1. *OR2005 CBEI Oregon Direct Coefficients.xlsx*
2. *OR2005 CBEI US Direct Coefficients.xlsx*
3. *OR2005 CBEI Transportation Allocation.xlsx*
4. *OR2005 CBEI Sources for Use and Disposal.xlsx*
5. *OR2005 CBEI Sources for Direct Coefficients.xlsx*

Figure 2: Schematic Diagram of CBEI Model



Source: Oregon 2005 CBEI model, SEI-US, www.sei-us.org

The economic data used in CBEI are taken from the IMPLAN database (MIG 2007). IMPLAN is a leading economic modeling software product developed by MIG, Inc. that includes national and state income and production accounts data and input-output models of the U.S. and Oregon economies developed using data from the U.S. Commerce Department's Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, the U.S. Census Bureau, and other sources. IMPLAN's input-output matrices estimate the indirect (intermediate or upstream materials and equipment) requirements of production, from all sectors, that are needed to produce a unit of any one industry's output for both the United States and

Oregon; IMPLAN data also include estimates of foreign imports and imports from the other 49 states to Oregon. This input-output analysis makes it possible for CBEI to model upstream emissions impacts.

The Oregon CBEI was constructed for 2005 because, for most of the development of this report, this was the latest inventory data year available. All data for Oregon and U.S. demand, input-output matrices, and sales margins, as received from IMPLAN, referred to the economy in 2006, measured in 2006 dollars. [10] We adjusted these data to refer to the 2005 economy in 2005 dollars, by using the real GDP growth rates from 2005 to 2006, for Oregon and for the United States, and the CPI-U. This amounts to an assumption that every sector and category of emissions in the state (and separately, in the nation) grew at the identical rate from 2005 to 2006. Other data are introduced and cited in *OR2005 CBEI Use and Disposal.xlsx*, *OR2005 CBEI Oregon Direct Coefficients.xlsx*, *OR2005 CBEI U.S. Direct Coefficients.xlsx,* and *OR2005 CBEI Transportation Allocation*. Full citations for these additional data sources can be found in *OR2005 CBEI Sources for Use and Disposal.xlsx* and *OR2005 CBEI Sources for Direct Coefficients.xlsx*; sources for allocating transportation emissions are located in *OR2005 CBEI Transportation Allocation*.

IMPLAN reports 2006 data for 509 commodity sectors. IMPLAN 2006 data are used (adjusted to 2005 levels) in CBEI because there are no IMPLAN data for 2005. The CBEI model is based on data for 2005, the most recent year for which a complete, consistent emissions data set was available. When applying its results to future years, it is important to remember that demand can shift significantly from year to year, both in aggregate and in relative composition. Nonetheless, the 2005 data provides a relatively recent, complete portrait of Oregon emissions.

[10] All data in this model is from IMPLAN 2006 unless otherwise stated (IMPLAN 2006). No IMPLAN data were released for 2005.

4.1.FINAL DEMAND

Final demand is the purchase of goods and services by households and government, and firms' investment in capital goods or inventory; this is Oregon's consumption of commodities and is therefore the basis of the economic data in CBEI. All final demand data used in CBEI are taken from IMPLAN (MIG 2006) databases. Final demand data are extracted from IMPLAN databases as "regional institutional demand"[11] for Oregon in producer prices and terms. IMPLAN reports final demand for four types of institutions responsible for expenditures: personal or household consumption, which accounts for approximately two-thirds of final demand; Oregon-based federal government; state and local government entities; and investment expenditures in capital formation and net inventory replacement (see Table 17). Final investment demand does not include other business-to-business transactions. (Note that, as is standard in economic analysis, these data include the "service" provided by government salaries and benefits, and government purchases, but exclude transfer payments such as Social Security or unemployment compensation.[12])

Final demand in IMPLAN is estimated (not actual). IMPLAN begins by estimating total U.S. household consumption by combining U.S. Bureau of Economic Analysis (BEA) benchmark input-output data, BEA National Income and Product Accounts personal consumption expenditures (PCE) data, and data from the Consumer Expenditure Survey (CEX). Total U.S. household consumption is then apportioned to states (and counties and zip codes) using a combination of CEX data by state and region, and U.S. Census data on population and incomes. An important part of this process is determining the shares of nine PCE income categories for the study area in the data year; IMPLAN makes the assumption that individuals and households in these PCE income categories have similar consumption patterns throughout the United States.[13]

Oregon's final demand in 2006 was just over one percent of total final demand in the United States:

Table 17: Final Demand for Oregon and United States, 2006 (in millions of $2006)

	Oregon		United States		Oregon/U.S.
Institution Type	**Value**	**Share**	**Value**	**Share**	**ratio**
Households	109,706	68.0%	9,342,068	64.4%	1.2%
Federal Government	3,488	2.2%	942,599	6.5%	0.4%
State & Local Government	19,282	12.0%	1,916,482	13.2%	1.0%
Investment	28,851	17.9%	2,305,374	15.9%	1.3%
Total	**161,327**	**100.0%**	**14,506,523**	**100.0%**	**1.1%**

Source: IMPLAN SA001b crosstab query, 2006 USA and Oregon databases

[11] "Regional institutional demand" is IMPLAN's term for final demand for commodities by households, government, and firms' investment in equipment or inventory.

[12] Government expenditures on employment (just like other pure labor sectors like household domestic work) have direct emissions coefficients of zero; labor by itself does not cause greenhouse gas emissions. Any emissions associated with government employees spending their salaries (as consumers) is accounted for as part of "household" final demand, so there is no double-counting of emissions.

[13] For more information on regional adjustments to data see https://implan.com/V4/index.php?option=com_content&view=section&layout=blog&id=33&Itemid=2.

CBEI multiplies final demand by IMPLAN input-output matrices to calculate gross (or direct plus indirect) demand. Gross demand is calculated for Oregon (including Oregon's final and intermediate purchases of commodities produced in Oregon), the other 49 states (including Oregon's final and intermediate purchase of commodities produced in the other 49 states, where intermediate purchases are used to produce final products consumed in Oregon), and foreign (including Oregon's final and intermediate purchase of commodities produced in foreign countries). Gross demand for each location of production is then multiplied by the appropriate emissions intensity (Oregon, U.S., or foreign), as described in a subsequent section of this methodology.

"Producer prices and terms" indicates that IMPLAN's reported final demand in a given commodity sector reflects payments to that commodity's production sector, not the retail price paid by the ultimate purchasers of the commodity. Few retail purchases are made directly from industrial sectors. Instead, finished products typically pass through several hands before reaching the customer, and a portion of each consumer dollar spent on any product is retained by wholesale, retail, and transportation firms. For example, for a $1 dollar cookie purchase: $0.25 is estimated, on average, to be retained by the retailer, $0.09 by the wholesaler, $0.03 for transportation, and the remaining $0.63 is paid to the cookie manufacturer. The portions retained by businesses other than the producer are the "margins."

CBEI does not include any calculation of final demand from margining activities that would associate a particular good's emissions with the share of each consumer dollar spent on retail, wholesale, and transportation of a good before purchase. Instead, CBEI takes the dollars spent by Oregon consumers on margining activities (retail, wholesale, and transportation) to be separate purchases of these services – the convention followed in IMPLAN demand data.

All final demand calculations take place in the Excel workbook *OR2005 CBEI Final Demand.xlsx.*

4.1.1. Calculations by location of emission

Goods and services consumed in Oregon are produced in one of three geographic areas:

- In-state : Demand for commodities produced in Oregon
- Other-49: Demand for imports into Oregon from the other 49 states
- Foreign: Demand for international imports into Oregon

Calculation of the geographic breakouts in the final demand data proceeds as follows:

1. Oregon final demand for Oregon commodities is total final demand less total final imports to Oregon.

2. Calculate the U.S. foreign import rate for each of the 509 commodity sectors. Foreign import rates are calculated by commodity sector from the final (institutional) demand data from IMPLAN for the United States. The import rate is imported final demand divided by total final demand. IMPLAN reports identical import rates by type of institution (household, federal government, state and local government, and investment).

3. Oregon final demand for total U.S. (including Oregon) commodities is total final demand multiplied by one minus the U.S. foreign import rate. (IMPLAN does not have separate data for an Oregon foreign import rate. To avoid any data inconsistency, CBEI uses the assumption that Oregon's foreign imports cannot be larger than its total – domestic plus foreign – imports.) Oregon final demand for imports into Oregon from the other 49 states is the final demand for U.S.-made commodities less the final demand for Oregon-made commodities.

4. Oregon final demand for foreign imports is total final demand multiplied by the U.S. foreign import rate.

Using this four-step method, the calculation of Oregon's final demand by location of production is conducted separately for each of the four institution types:

- Households (10000)[14]
- Federal government (11000)
- State and local government (12000)
- Investment (14000)

These four sets of calculations are strictly parallel and therefore are described only once (above) in this methodology. The result is twelve categories of final demand: household Oregon-produced, U.S.-produced, and foreign-produced; federal government Oregon-produced, U.S.-produced, and foreign-produced; state and local government Oregon-produced, U.S.-produced, and foreign-produced; and investment Oregon-produced, U.S.-produced, and foreign-produced.

These calculations take place in the following worksheets: "OR-Final Demand (10000)"; "OR-Final Demand (11000)"; "OR-Final Demand (12000)"; and "OR-Final Demand (14000)." For further information, see the description of data sources 1 and 2 in Section 4.9 below, and the discussion of IMPLAN's trade data in Section 5.1.3.

4.1.2. Gross demand

Final demand for Oregon-produced commodities and U.S.-(including Oregon)-produced commodities is next multiplied by IMPLAN's input-output matrices to calculate gross demand.

Calculation of gross demand proceeds as follows:

1. Oregon gross demand for Oregon final and intermediate products is IMPLAN's Oregon Type I Multipliers (also called the Oregon Leontief inverse matrix) multiplied by Oregon final demand for Oregon commodities. (The Oregon Leontief inverse matrix only includes in-state production; when producers of final goods in Oregon purchase from out-of-state suppliers, that intermediate demand is not included in Oregon gross demand.)

2. Oregon gross demand for other-49 state final and intermediate products is Oregon gross demand for U.S. final and intermediate products (that is, IMPLAN's U.S. Type I Multipliers

[14] 10000, 11000, 12000, and 14000 are the IMPLAN codes for the four types of institutions with final demand.

multiplied by Oregon final demand for U.S. commodities) less Oregon gross demand for Oregon final and intermediate products.

3. We do not calculate Oregon gross demand for foreign final and intermediate products because upstream emissions are captured by our foreign emissions intensities (as discussed below).

The four sets of calculations, one for each consuming institution, are strictly parallel and therefore are described only once (above) in this methodology. The result is eight categories of gross demand: household Oregon-produced, and other U.S.-produced; federal government Oregon-produced, and other U.S.-produced; state and local government Oregon-produced, and other U.S.-produced; and investment Oregon-produced, and other U.S.-produced. These calculations take place in the following worksheets: "OR-Gross Demand (10000)"; "OR-Gross Demand (11000)"; "OR-Gross Demand (12000)"; and "OR-Gross Demand (14000)."

For further information, see the description of data sources 1 and 2 in Section 4.9 below.

4.2.GREENHOUSE GAS COEFFICIENTS

In the CBEI model, greenhouse gas (GHG) coefficients represent the quantity of emissions released per dollar of activity in each IMPLAN sector. CBEI calculates direct coefficients (the emissions intensity of a production process, not including upstream effects) for Oregon and the United States, and uses existing data for direct plus indirect coefficients (including upstream effects) for foreign imports to the United States. (The original data for foreign emissions intensities is available only in the direct+indirect form.)

CBEI's direct coefficients are the per dollar emissions, by sector, that result only from activities in the originating production sector; direct coefficients do not include indirect, or upstream, emissions. Production sectors are based on industrial and commercial IMPLAN codes (1 to 494), which correspond to NAICS codes 11 to 81. Sectors 495 to 509 do not have direct emissions,[15] although they may have direct+indirect emissions if their indirect emissions are positive.

Direct coefficients are presented in CBEI in kilograms of carbon dioxide equivalent per (2005) dollar spent on the consumption in a given commodity sector. Industrial and commercial outputs are for 2005 (reported in IMPLAN 2006 and converted to 2005 values). Separate direct coefficients are calculated for Oregon and the U.S., based on Oregon and U.S. emissions inventories, respectively. Note that emissions drawn from the Oregon and US inventories are all expressed in CO_2-e, where 100-year GWPs are used to express the GHG impact of methane, nitrous oxide and HGWP gases, in terms of CO_2-e.

Oregon and U.S. direct coefficients are calculated in two supplementary (unlinked) Excel workbooks: *OR2005 CBEI Oregon Direct Coefficients.xlsx* and *OR2005 CBEI US Direct Coefficients.xlsx.* Data sources for calculating the direct coefficients are described below; original source tables for these data are reproduced, with citations, in *OR2005 CBEI Sources for Direct Coefficients.xlsx.* Additional calculations for the allocation of transportation emissions along with source data are presented in *OR2005 CBEI Transportation Allocation.xlsx.*

4.2.1. Oregon direct coefficients

Oregon production-based emissions are calculated as the sum of carbon dioxide and other greenhouse gases for industrial and commercial uses (energy-related, non-energy related, and transportation – including in-state production of electricity) in metric tons of carbon-dioxide equivalent in the production, transportation (prior to final sale), and wholesale/retail phases of the production-based inventory created by excluding emissions from direct fuels (gasoline, and heating and cooking fuels) from Oregon Global Warming Commission Inventory (Oregon Global Warming Commission 2011). Total emissions for each sector are then converted to kilograms and divided by the total industry output for that sector in dollars, calculated as sum of in-state gross demand and direct plus indirect Oregon exports. Direct coefficients are reported in kilograms per (2005) dollar. For example, production of fruit

[15] IMPLAN sectors 495 to 509 have no direct greenhouse gas emissions, although they may purchase inputs that required emissions for their production. Most of these sectors are purely labor. A few (scrap, used goods) are trade in second-hand materials; all greenhouse gas emissions from the production of these materials are assigned to their first use. Owner-occupied dwellings refers to the "service" of owning or renting a home; the manufacturing and transport of construction materials, emissions associated with construction activities, and fuel and electricity emissions of owning or renting a home are counted elsewhere in the model.

in Oregon (sector 5) causes 0.32 million mT CO_2-e and the total value of Oregon fruit production is $361 million. The Oregon direct coefficient for fruit farming is, therefore, 0.88 kg CO_2-e per dollar.

Oregon's GHG emissions for 2005 totaled 35.9 million mT of CO_2-e on a production basis. These emissions are allocated among the 509 IMPLAN sectors as follows:

- Commercial direct fuel use, 1.5 million mT CO_2, allocated to all commercial sectors in proportion to their output. (Note that in the Oregon Global Warming Commission 2011 Inventory, commercial includes government; in CBEI government direct fuel use appears in the use phase and is not calculated as part of Oregon's emissions intensities for the production, pre-purchase transportation, and wholesale/retail phases.) No commercial emissions are directly allocated to specific sectors.
- Industrial direct fuel use, 5.2 million mT CO_2, allocated to all industrial sectors in proportion to their economic output.
- Commercial and industrial transportation, 9.4 million mT CO_2-e, allocated to transportation sectors as described below.
- In-state electricity production, 8.0 million mT CO_2, allocated to IMPLAN sector 30, power generation.
- Industrial, energy and non-energy related carbon dioxide, 0.9 million mT CO_2, allocated to the appropriate IMPLAN sectors according to Oregon DOE's inventory classifications and – wherever IMPLAN sectors are more disaggregate than DOE data – in proportion to their economic output.
- Other gases, 10.7 million mT CO_2-e, allocated to the appropriate IMPLAN sectors according to Oregon DOE's inventory classifications, and – wherever IMPLAN sectors are more disaggregate than DOE data – in proportion to their economic output.

Allocation of transportation emissions from the Oregon DOE inventory to IMPLAN sectors required multiple data sources which are described in detail in *OR2005 CBEI Transportation Allocation.xlsx.*

4.2.2. U.S. direct coefficients

U.S. emissions are calculated as the sum of carbon dioxide and other greenhouse gases for industrial and commercial uses (energy-related, non-energy related, and transportation) in metric tons of carbon-dioxide equivalent as reported in the EIA's (2006) *Emissions of Greenhouse Gases in the United States 2005*. Total emissions for each sector are then converted to kilograms and divided by the total industry output for that sector in dollars, as reported in IMPLAN; direct coefficients are reported in kilograms per (2005) dollar.

Carbon Dioxide, Industrial – Energy-Related: U.S. energy-related industrial CO_2 emissions were 1,708 million mT CO_2-e in 2002 (EIA 2007, Table 7) and 1,668 million mT CO_2-e in 2005 (EIA 2006a, p.5). Industrial sectors include: agriculture, forestry and fisheries (IMPLAN 1-18, NAICS 11), mining (IMPLAN 19-29, NAICS 21), utilities (IMPLAN 30-32, NAICS 22), construction (IMPLAN 33-45, NAICS 23), and manufacture (IMPLAN 46-389, NAICS 31-33).

Manufacturing energy-related industrial CO_2 emissions were 1,404 million mT CO_2-e in 2002 according to a survey of producers (Schipper 2006, Table 1) that disaggregates emissions by NAICS sector. Non-manufacturing industrial emissions for 2002 were calculated as the difference between total energy-related industrial CO_2 emissions for 2002 (EIA 2007, Table 7) and manufacturing energy-

related industrial CO_2 emissions for 2002 (Schipper 2006, Table 1), 304 million mT CO_2-e and allocated among non-manufacturing sectors according to their economic output.

CBEI assigns manufacturing energy-related industrial CO_2 emissions to IMPLAN codes in proportion to Schipper's NAICS classification (Schipper 2006, Table 1).[16] Some NAICS and IMPLAN codes do not match exactly. Where Schipper's NAICS classification is too aggregated, we assigned the emissions to all of the appropriate IMPLAN sectors in proportion to their output. Where Schipper's NAICS classification is too disaggregated, we assigned the emissions to the IMPLAN sector that included that NAICS sector.

One correction was made to Schipper's data: Schipper assigns to each industrial sector its direct emissions together with its indirect emissions from electricity only. We have used only the direct emissions contribution (or the non-electricity share) from each industrial sector in developing our direct coefficients. The non-electricity share of manufacturing energy emissions is taken from EIA (2007, Table 7); all manufacturing sectors are assumed to have an identical non-electricity share, about 62 percent. The total electricity share of emissions, including residential and commercial, is then assigned to IMPLAN sector 30, power generation.

Carbon Dioxide, Industrial – Non-Energy-Related: U.S. non-energy-related industrial CO_2 emissions were 109 million mT CO_2-e in 2005 (EIA 2006a, Tables 5 and 14). Energy Information Administration (EIA) data report non-energy-related industrial CO_2 emissions by source activity, but do not classify these categories by description of industrial sector, NAICS code, or IMPLAN code. Most source activities, however, are easily identified with their corresponding industries. Almost all (81 percent) of the non-energy industrial CO_2 emissions are attributable to cement manufacturing, lime manufacturing, and natural gas distribution. We assigned emissions to IMPLAN codes by matching source activities to the most closely related industrial sectors. Where the source activity description is too aggregated, we assigned the emissions to all of the appropriate IMPLAN sectors in proportion to their output. Where the source activity description is too disaggregated, we assigned the emissions to the IMPLAN sector that included that NAICS sector.

Carbon Dioxide, Commercial: U.S. commercial CO_2 emissions were 1,056 million mT CO_2-e in 2005 (EIA 2006a, p.5). No data are available disaggregating commercial CO_2 emissions into sectors. We have used only the direct emissions contribution (or the non-electricity share) to each commercial sector in developing our direct coefficients. The non-electricity share of commercial emissions is taken from EIA (2006a, Table 8); all commercial sectors are assumed to have an identical non-electricity share, about 20 percent. The total electricity share of emissions is then assigned to IMPLAN sector 30, power generation. We assigned direct emissions to all commercial IMPLAN codes in proportion to their output.

All Greenhouse Gases, Transportation – Commercial and Industrial: U.S. transportation CO_2 emissions were 1,867 million mT CO_2-e in 2003 (EPA 2006, Table 13-1) and 1,885 million mT CO_2-e in 2005 (EIA 2006a, p.5), including transportation by households as well as for commercial and industrial purposes. Allocation of transportation emissions from the EIA inventory to IMPLAN sectors required multiple data sources which are described in detail in *OR2005 CBEI Transportation Allocation.xlsx.*

[16] Note that Schipper's data are for 2002. To calculate 2005 energy-related industrial CO_2 emissions by sector, we multiplied the sector's 2005 emissions by the ratio of 2005 total energy-related industrial CO_2 emissions to 2002 total energy-related industrial CO_2 emissions.

Other Greenhouse Gases: U.S. industrial non-CO_2 GHG emissions were 767 million mT CO_2-e in 2005 (EIA 2006a, p.5). EIA data report industrial non-CO_2 GHG emissions by source activity, but do not classify these categories by description of industrial sector, NAICS code, or IMPLAN code. Although there are numerous activities involved, 60 percent of these emissions come from agriculture, and another 30 percent from methane released by oil, coal, and natural gas production and distribution. The majority of the agricultural emissions are nitrous oxide, a category that has often been overlooked or excluded in the development of industrial emissions coefficients.

U.S. commercial non-CO_2 GHG emissions were 231.3 million mT CO_2-e in 2005 (EIA 2006a, p.5). EIA data report non-CO_2 GHG emissions by source activity, but do not classify these categories by description of commercial or industrial sector, NAICS code, or IMPLAN code. We assigned emissions to IMPLAN codes by matching source activities to the most closely related sectors (including 63 percent to landfills), and then assigning emissions proportionally by each sector's share of GHG emissions. Where the source activity description is too aggregated, we assigned the emissions to all of the appropriate IMPLAN sectors in proportion to their economic output. Where the source activity description is too disaggregated, we assigned the emissions to the IMPLAN sector that included that NAICS sector.

4.2.3. Foreign direct+indirect coefficients

A separate set of direct+indirect GHG coefficients for U.S. final imports (finished products) from around the world is taken from the 57-sector Multi-Regional Input-Output (MRIO) international model.[17] These are referred to as "U.S. Import Coefficients." MRIO uses Global Trade Analysis Project (GTAP) data and sector definitions. We have mapped the 57 GTAP-based sectors to IMPLAN's 509 sectors by comparing detailed sector descriptions.[18]

Direct+indirect coefficient calculations from CBEI direct coefficients:

DIcoef_CBEI_US — U.S. direct+indirect coefficients (generated by CBEI model)

Step 1: Transpose Dcoef_US from column to row vector (where "Dcoef_US" are the US direct coefficients calculated above).

Step 2: $DIcoef\_CBEI\_US\_Transpose = Dcoef\_US\_Transpose \times TypeI\_Matrix\_US$

Step 3: Transpose DIcoef_CBEI_US_Transpose from row to column vector.

Definition of direct+indirect coefficients derived in CBEI model using Peters' data:

DIcoef_GL_US — U.S. "global" direct+indirect coefficients (for foreign intermediate goods used in U.S. final products)

DIcoef_IM_US — U.S. "imports" direct+indirect coefficients (for foreign final and intermediate goods used in foreign final products imported to the United States)

Both of these coefficients are derived below, starting with U.S. imports.

[17] MRIO has been developed by Glen Peters and his colleagues at CICERO (Center for International Climate and Environmental Research – Oslo) in Norway. See (Peters and Hertwich 2008).

[18] See GTAP (2009) https://www.gtap.agecon.purdue.edu/databases/default.asp for detailed descriptions of the sectors used in GTAP and in MRIO.

U.S. Import Coefficients: DIcoef_IM_US

1. Calculate values using Peters' International data set by sector (i), where (i) represents the 57 GTAP sectors:
    a. Emissions coefficient for final imports into the U.S. in i sectors:
    $$\text{PetersDIcoef\_Imports\_US} = \frac{(\text{US total emissions} - \text{US global emissions})}{(\text{US total output} - \text{US global output})}$$
    b. Value of final imports into the U.S. in i sectors:
    $$\text{PetersImports\_US} = \text{US total output} - \text{US global output}$$

    Note that we follow the MRIO naming conventions where "total" refers to final consumption including domestic production and imported final goods, and domestic and imported intermediate goods, and "global" refers to final production including domestic and imported intermediate goods.

2. Peters' International GHG coefficient data (2001 dollars) in sectors (i) are converted to 2005 dollars using the U.S. CPI-U.

3. Each IMPLAN sector (j) is mapped to 1 to 3 Peters' (2005 dollars) sectors (i). In some cases several GTAP sectors fall under a single IMPLAN sector, and vice versa. Groupings of GTAP sectors into IMPLAN sectors are unique such that 57 GTAP sectors (i) become 51 GTAP-sector groups (m):
    $\mathrm{i} = 57$ GTAP sectors
    $\mathrm{j} = 509$ IMPLAN sectors
    $\mathrm{k} = 1\text{st}/2\text{nd}/3\text{rd}$ GTAP sector per IMPLAN sector
    $\mathrm{i(j,k)}$ maps IMPLAN to GTAP
    $\mathrm{m(j)} = \mathrm{i(j,1)}$ - in practice, there are 51 unique values of m
    n = a GTAP sector or group of 2 or 3 sectors, all mapped to the same IMPLAN sector (i.e., a value taken on by m(j))

4. $$\text{DIcoef\_IM\_US\_unweighted}_{\mathrm{j}} = \frac{\sum_{\mathrm{k}}(\text{PetersDIcoef\_Imports\_US}_{\mathrm{i(j,k)}} * \text{PetersImports\_US}_{\mathrm{i(j,k)}})}{\sum_{\mathrm{k}} \text{PetersImports\_US}_{\mathrm{i(j,k)}}}$$

5. $\text{US\_TCO}_{\mathrm{n}} = \sum_{\mathrm{j}} \text{US\_TCO}_{\mathrm{j}}$, summed over all j for which $m(j) = n$

6. $\text{US\_TCOxDIcoef\_CBEI\_US}_{\mathrm{n}} = \sum_{\mathrm{j}}(\text{DIcoef\_CBEI\_US}_{\mathrm{j}} * \text{US\_TCO}_{\mathrm{j}})$, summed over all j for which $m(j) = n$

7. $$\text{DomesticWeight}_{\mathrm{j}} = \frac{\text{US\_TCOxDIcoef\_CBEI\_US}_{\mathrm{m(j)}}}{\text{US\_TCO}_{\mathrm{m(j)}}}$$

8. $$\text{DIcoef\_IM\_US}_{\mathrm{j}} = \text{DIcoef\_IM\_US\_unweighted}_{\mathrm{j}} * \left(\frac{\text{DIcoef\_CBEI\_US}_{\mathrm{j}}}{\text{DomesticWeight}_{\mathrm{j}}}\right)^{0.5}$$

Steps 1 – 8 above generate direct+indirect emissions factors for final commodities imported into the United States, as follows. Steps 1 and 2 take data from Peters' CICERO model, which is organized into 57 sectors. For each sector, a direct+indirect emissions coefficient for imports to the United States is calculated. Step 3 maps these sectors to the 509 IMPLAN sectors. Step 4 uses the CICERO results to calculate an "unweighted" direct+indirect emissions coefficient for each of the 509 IMPLAN sectors.

When any one IMPLAN sector corresponds to a single sector in Peters' model, the "unweighted" direct+indirect coefficients are the same. However, when any one IMPLAN sector corresponds to more than a single sector in Peters' model (two or three sectors), then the "unweighted" direct+indirect coefficient (in CBEI) is calculated as an average of the coefficients from Peters' model, weighted by value of imports into the U.S.

The result of step four is a series of "unweighted" direct+indirect emissions coefficients for each of the 509 sectors in CBEI. However, as these are drawn from Peters' model, and the mapping of IMPLAN to Peters' model results in only 51 unique "families" of sectors, only 51 direct+indirect emissions coefficients are calculated for imports into the U.S. At this point, different commodity sectors in CBEI that correspond to the same "family" are assumed to have the same emissions coefficients. Steps 5 – 8 further differentiate these "unweighted" coefficients using the assumption that within any given family of sectors, emissions coefficients for imports will be distributed in a manner similar (although not identical) to the distribution between domestic coefficients in the same family, calculated in a manner such that the weighted average of all import coefficients in any given family equals the overall import coefficient for that family as calculated in step 4 above. This is done by first calculating the total domestic commodity output for each "family" of sectors (step 5). For each "family," step 6 sums across all relevant IMPLAN sectors the product of domestic direct+indirect coefficients and total domestic commodity output. Step 7 divides this by the sum of total domestic commodity output for each family (from step 5), generating a weighted domestic coefficient. Finally, in step 8, "weighted" import emissions coefficients for each IMPLAN sector are calculated by multiplying the "unweighted" import coefficients (from step 4) by the square root of their unique domestic direct+indirect coefficient (from CBEI) divided by their "family's" weighted domestic coefficient (from step 7).

This mapping procedure takes place in *OR2005 CBEI GHG Coefficients.xlsx*, worksheet, "US Imports Coeff, Map." See data source 6 in Section 4.9 below.

U.S. Global Coefficients: DIcoef_GL_US

In addition to these U.S. imports coefficients for final demand of imported products, we use a second type of international coefficient, called "U.S. global," for a calculation of emissions from Oregon consumption associated with the foreign intermediate goods used in domestic U.S. production. "U.S. global" are the emissions coefficients for the global (including domestic) processes, including supply chain, that are associated with final production in the U.S. They include emissions both inside the U.S. and in other nations. (Section 4.3 explains how these are used.)

1. Calculate values using Peters International data set by sector (i), where (i) represents the 57 GTAP sectors:
    a. U.S. global emission coefficients (for U.S. final production including domestic and imported intermediate goods – direct+indirect):
    $$\text{PetersDIcoef\_Global\_US} = \frac{\text{US global emissions}}{\text{US global output}}$$
    b. U.S. domestic-only emissions (for U.S. final production including only domestic intermediate goods – direct+indirect):
    $$\text{PetersDIcoef\_DomesticOnly\_US} = \text{US domestic only}$$
    c. Ratio of Peters U.S. global to Peters U.S. domestic-only emissions:
    $$\text{PetersCoefRatio} = \frac{\text{PetersDIcoef\_Global\_US}}{\text{PetersDIcoef\_DomesticOnly\_US}}$$

d. Value of production in the U.S. by sector:
$$\text{PetersGlobal\_US} = \text{US global output}$$

2. Each IMPLAN sectors (j) is mapped to 1 to 3 Peters (2005 dollars) sectors (i). In some cases several GTAP sectors fall under a single IMPLAN sector, and vice versa. Groupings of GTAP sectors into IMPLAN sectors are unique such that 57 GTAP sectors (i) become 51 GTAP-sector groups (m):
$$\text{i} = 57 \text{ GTAP sectors}$$
$$\text{j} = 509 \text{ IMPLAN sectors}$$
$$\text{k} = 1\text{st/2nd/3rd GTAP sector per IMPLAN sector}$$
$$\text{i(j, k)} \text{ maps IMPLAN to GTAP}$$

3. $$\text{CoefRatio}_{\text{j}} = \frac{\sum_{\text{k}}\left(\text{PetersCoefRatio}_{\text{i(j,k)}} * \text{PetersGlobal\_US}_{\text{i(j,k)}}\right)}{\sum_{\text{k}} \text{PetersGlobal\_US}_{\text{i(j,k)}}}$$

4. $$\text{DIcoef\_GL\_US}_{\text{j}} = \text{CoefRatio}_{\text{j}} * \text{DIcoef\_CBEI\_US}_{\text{j}}$$

Steps 1 – 4 above generate direct+indirect global emissions factors for commodities where the final production occurs in the United States, as follows. Step 1 takes data from Peters' CICERO model, which is organized into 57 sectors. For each sector, Peters' estimate of global direct+indirect emissions coefficients for the U.S. (1a) and domestic-only emissions (1b) are estimated. These are divided into each other to produce a ratio of global:domestic direct+indirect emissions coefficients (step 1c) for the U.S. Peters' estimates of U.S. global output by sector is also generated (1d). Step 2 maps these 57 sectors to the 509 IMPLAN sectors. Step 3 uses the CICERO results to calculate a ratio of global:domestic direct+indirect emissions coefficients for each of the 509 IMPLAN sectors. When any one IMPLAN sector corresponds to a single sector in Peters' model, the ratios of coefficients are the same. However, when any one IMPLAN sector corresponds to more than a single sector in Peters' model (two or three sectors), then the ratio is calculated as an average of the ratios from Peters' model, weighted by value of production in the U.S. Step 4 multiplies this ratio by the direct+indirect (domestic) emissions coefficients (calculated earlier) to generate the U.S. global coefficients.

These calculations take place in *OR2005 CBEI GHG Coefficients.xlsx*, worksheet, "US Global Coeff, Map."

4.3.GREENHOUSE GAS EMISSIONS

GHG emissions are calculated as follows:

1) In-state emissions from Oregon's consumption of Oregon-made final commodities are the product of Oregon's in-state gross demand and the Oregon direct coefficients for each of the 509 IMPLAN sectors, reported in CBEI in thousands of metric tons of CO_2-e.
2) All other domestic emissions from Oregon's consumption of U.S.-made final commodities (including U.S. upstream emissions from Oregon's consumption of U.S.-made final commodities) are the product of Oregon's U.S. gross demand and the U.S. direct coefficients less the product of Oregon's in-state gross demand and the Oregon direct coefficients.
3) Foreign emissions results from Oregon's consumption of final products is calculated in two pieces:
    a. Oregon's final demand for foreign-made goods is multiplied by the MRIO direct+indirect coefficients for U.S. imports.
    b. Emissions from the production of foreign-made intermediate goods used in Oregon and other-49 state production for Oregon's final consumption are the product of Oregon's U.S. final demand and the "U.S. global" direct+indirect coefficients less the product of Oregon's U.S. final demand and our U.S. direct+indirect coefficients.

We report total emissions, as well as emissions by location of production, type of consumer, and life-cycle phase. Total emissions are also sorted into commodity categories and sub-categories for ease of use of these data.

All emissions calculations take place in Excel workbook *OR2005 CBEI Emissions.xlsx*; these are our three-phase unreconciled emissions, which do not include the use and post-consumer disposal phases. Commodity sector results are aggregated to categories and sub-categories in *OR2005 CBEI Final Results.xlsx*; this workbook includes worksheets summarizing both three-phase unreconciled emissions and five-phase final emissions. Both of these workbooks include worksheets that summarize demand and GHG coefficients results from the calculations conducted in workbooks *OR2005 CBEI Final Demand.xlsx* and *OR2005 CBEI GHG Coefficients.xlsx,* respectively.

4.3.1. GHG emissions by phase

Oregon's total pre-purchase emissions by the 509 IMPLAN sectors are also divided into the three phases of life-cycle analysis addressed by this portion of CBEI: production, pre-purchase transportation, and wholesale/retail.

Calculation of the GHG emissions by phase proceeds as follows:

1. Emissions from the wholesale and retail IMPLAN sectors are assigned to the wholesale/retail phase.
2. Emissions from the transportation IMPLAN sectors are assigned to the transportation phase.
3. All other emissions are classified as production phase emissions.

These calculations are reported in *OR2005 CBEI Emissions.xlsx*, "GHG Emissions by Phase."

4.3.2. Category mapping

CBEI maps IMPLAN's 509 commodity sectors into aggregated categories and sub-categories for ease of final use of these data. The summary worksheets in *OR2005 CBEI Emissions.xlsx* are repeated in *OR2005 CBEI Final Results.xlsx* with the 509 sector results aggregated into 17 categories and 60 sub-categories. The *OR2005 CBEI Final Results.xlsx*, "Categories" worksheet provides a map of sectors, categories, and sub-categories as well as simplified sector descriptions.

4.4.LCA PROCESSING

The "Standard" CBEI results described thus far are the life-cycle emissions of Oregon as a whole. CBEI's "LCA" mode (running CBEI in its "Life-Cycle-Analysis" mode) calculates the life-cycle emissions for each single sector of final demand separately by re-running CBEI 509 times using the appropriately circumscribed demand vector (i.e., demand for each sector is run separately); these results are labeled "CBEI-LCA". Each time CBEI is run, the sum (across sectors) of emissions is recorded by institution, phase, and location of emission – effectively compressing 509 sectors of information into a single row of results. Note that emissions coefficients are not impacted by the LCA processing – all coefficients remain constant.

By running CBEI analysis on each of Oregon's 509 sectors of demand individually and recording the total emissions generated by that run as that sector's emissions, consumption-based emissions are reorganized from producing sector to consuming sector. This method results in the same total CBEI emissions for the Oregon as a normal run, but a different distribution of emissions across sectors.

The technical process behind the LCA mode is as follows. In Excel, a Visual Basic Macro was constructed that repeats these steps 509 times:

1. Erase all original IMPLAN final demand and import data.
2. Replace original IMPLAN final demand and import data for all for institutions of sector X.
3. "Calculate" CBEI.
4. Record total emissions by institution, phase, and location of emission in the row labeled sector X.
5. Repeat for the next sector.

LCA Complete processing can be launched from the "Control" tab of the *OR2005 CBEI Demand Modeler.xlsm* workbook. The three-phase pre-purchase "LCA" model results are recorded in the "LCA 3Ph Emissions" tab of the *OR2005 CBEI Final Results.xlsx* workbook.

4.5.USE

The "use" life-cycle phase includes all post-purchase emissions, with the exception of disposal emissions. Specifically, the use phase consists of emissions from direct fuel use by households and government (for heating or other appliances), household and government transportation, the upstream emissions for household and government fuel purchases as calculated in the three-phase pre-purchase "LCA" model, direct electricity emissions for households and government as estimated in the Oregon DOE inventory, and upstream emissions for household and government purchases of electricity. Use phase calculations disaggregate the direct+indirect fuel and electricity emissions into the categories and sub-categories of commodities that utilize fuel and electricity – cars, furnaces, appliances, electronics, lighting, etc. (Double-counting is corrected by subtracting from the production phase the fuel and electricity emissions included in the use phase; see Section 4.7 below.) All use emission calculations take place in *OR2005 CBEI Use and Disposal.xlsx.* Data sources for calculating the use phase emissions are described below; original source tables for these data are reproduced, with citations, in *OR2005 CBEI Sources for Use and Disposal.xlsx.*

Direct residential and government fuel use emissions are calculated using Oregon DOE data and weights constructed from consumption data from the EIA's (2008b) *State Energy Data System*. All household direct fuel use is assumed to be for heating, cooling, ranges and dryers (EIA 2008a, Tables E7A and E9A). Data for government direct fuel consumption is subsumed under the category "commercial." To present government consumption data independently we assume that it represents 21 percent of all commercial direct fuel consumption; this is the share of government building floor space out of all commercial building floor space (EIA 2008a). Government direct fuel use is then allocated between the "heating and cooling appliances" and "ranges and microwaves" sub-categories according to data from EIA (2008a, Table E7A and E9A).

Residential and government transportation use emissions are disaggregated into CBEI's commodity sub-categories in *OR2005 CBEI Transportation Allocation.xlsx* using multiple data sources. These emissions include transfers for upstream petroleum, natural gas, and final-consumer electricity emissions calculated in the three-phase model.

Direct electricity use emissions for households and governments are taken from the Oregon DOE inventory. CBEI then calculates the indirect to direct emissions ratio using data from the National Renewable Energy Laboratory for the Western Interconnection (the regional electrical grid serving the Western United States); this ratio is applied to the Oregon DOE direct emissions to estimate indirect electricity emissions associated with the life cycle of fuels used in electricity generation. Direct+indirect electricity emissions are disaggregated into CBEI's commodity sub-categories using consumption data from EIA (2008b). Household electricity emissions are disaggregated into CBEI's commodity sub-categories using data from NPCC (2009). Government electricity emissions are disaggregated into CBEI's commodity sub-categories using data from EIA (2008c).

Emissions factors from EIA (2006b) and EPA (2009) are reported in worksheet "Use emissions factors." Use emissions calculations take place in worksheet "Use emissions" and final results are presented in "Use and disposal results." Use and disposal emissions are consistent with "100-year GWPs" (Intergovernmental Panel on Climate Change 2001).

4.6.DISPOSAL

The "disposal" life-cycle phase consists of emissions from post-consumer waste in landfills and waste combustion.[19] Emissions from composting facilities are not included in Oregon's GHG inventory and are a very small contributor to the U.S. GHG Inventory; for the purpose of CBEI we treat these emissions as zero. Emissions from household and government purchase of waste disposal services are calculated in the three-phase pre-purchase "LCA" model and transferred to the post-consumer disposal phase, this time disaggregated into the categories of commodities that become waste products. (Double-counting is corrected in the final model reconciliation; see Section 4.7 below.) All disposal emission calculations take place in *OR2005 CBEI Use and Disposal.xlsx.* Data sources for calculating the disposal phase emissions are described below; original source tables for these data are reproduced, with citations, in *OR2005 CBEI Sources for Use and Disposal.xlsx.*

Total disposal emissions by waste category (Oregon DEQ 2004a) are divided into landfilled and combusted waste categories according to the appropriate shares of state total wastes (Oregon DEQ 2005/06, Table 2).[20] Landfilled and combusted wastes (by ton) are then multiplied by the appropriate emissions factors. The emission factors are based on EPA estimates for emissions from landfilling and combustion of each waste material (EPA 2006b exhibits 5-1, 6-6), with lifetime landfill emissions adjusted for Oregon's projected current and future rates of capture of landfill methane (using data from Oregon DEQ) (2004b). They are reported in worksheet "Disposal emissions factors." Emissions by waste category are reported in worksheet, "Disposal emissions." Landfilled and combusted emissions by waste category are used to construct weights for allocating the direct+indirect emissions from household and governments purchase of waste services.

These final disposal emissions by waste category are then mapped onto CBEI categories.[21] Most waste categories correspond directly to a single CBEI category; in these cases, total disposal emissions are divided into household and government institutions according to these institutions share of final demand by category. Construction wastes in the disposal phase refer only to residential construction and are, therefore, allocated according to the household and government shares of residential construction final demand (and not the shares of final demand in the greater category, construction).

The exceptions to this simple mapping process are paper and plastic packaging, which are, instead, apportioned into CBEI commodity categories using IMPLAN data. Shares of the value of intermediate products in final goods are calculated using a "partial products matrix," i.e. by multiplying IMPLAN's unadjusted final demand by the Type I input-output multipliers (those multipliers, which are at the heart of the input-output calculation, measure the direct and indirect production requirements per unit of final demand). Partial products for IMPLAN sectors 126 and 128-130 are summed for paper packaging;

[19] Landfill emissions here are calculated on the basis of future lifetime emissions from each year's disposal (sometimes called "methane commitment"). An alternative method, "waste in place," estimates each year's actual emissions from past and present disposal; the existing Oregon GHG inventory uses the latter method.
[20] Personal communication from David Allaway, Oregon DEQ, on April 20, 2009.
[21] Disposal emissions are mapped directly to categories but are not mapped to sub-categories because of insufficient data.

sectors 172 and 175 are summed for plastic packaging.[22] These shares by sector are then mapped to aggregate shares by CBEI category, which are used to assign paper and plastic packaging emissions.

Consistent with the logic of the input-output calculation, energy generated by waste-to-energy plants and by landfill methane capture and combustion is treated as part of the energy sectors, not the disposal process. Carbon sequestration in landfills does not appear in the model, since that carbon was never emitted as CO_2 or methane by any economic activity, and the CBEI model does not include carbon flux associated with land use, land use change, and forest carbon changes.

All calculations mapping waste categories to CBEI categories take place in worksheet, "Mapping disposal categories"; these results appear in "Use and disposal results."

[22] 126: Paperboard container manufacturing; 128: Surface-coated paperboard manufacturing; 129: Coated and laminated paper and packaging materials; 130: Coated and uncoated paper bag manufacturing; 172: plastics packaging materials – film and sheet; 175: plastics bottle manufacturing.

4.7.MODEL RECONCILIATION

Results for CBEI's five model phases – production, wholesale and retail, transportation, use, and disposal – are presented in *OR2005 CBEI Final Results.xlsx*, "Final Oregon Results." Some double-counting occurs between the production/wholesale/retail/transportation, use, and disposal portions of the model: fuel and disposal emissions are calculated in the three-phase pre-purchase "LCA" model and then allocated to the appropriate commodities in the use or disposal phases; electricity emissions are calculated in the three-phase pre-purchase "LCA" model and then deleted. The results presented in "Final Oregon Results" have been corrected for all double-counting by removing the double-counted emissions from the production phase of the five-phase model.

Finally, household residential construction emissions are reclassified from the investment institution to the household institution. In national income and product accounting – the basis of all IMPLAN data – household investment in new homes is grouped with business investments in plants, machinery and inventory. We have reclassified household investment in new homes as part of the institution "household" for greater consistency with CBEI's overall presentation of data.

4.8.LCA DEMAND MODELER

CBEI "Demand Modeler" is a separate tool used to calculate emissions for a user-determined subset of Oregon final demand. The "Modeler" can be used, for example, to view the life-cycle emissions of the demand for a single IMPLAN sector, where emission results are disaggregated by producing industry, type of consumer, life-cycle phase, and location of emission. Emission results for a single sector of demand can be viewed in CBEI "LCA" emissions summed across sectors, but to see emissions by contributing producing industries, it is necessary to do a sector-specific analysis using the "Modeler."

In the "Control" tab of the *OR2005 CBEI Demand Modeler.xlsm* workbook, the user can enter an original demand matrix either by entering new values or by selecting which sectors, sub-categories, or categories of demand to include or exclude. The user then launches a macro (see label "Run LCA Modeler").

The LCA Modeler performs analysis for each filtered sector, F_x, and the entire filtered set of sectors, F, where $0 \leq x \leq 509$. In Excel, a Visual Basic Macro was constructed to run both Standard and LCA results.

The Standard run performs these steps 1 time:

1. Erase all original IMPLAN final demand and import data.
2. Replace original IMPLAN final demand and import data in producer prices for all institutions of filtered set F.
3. "Calculate" CBEI.
4. Record emissions by institution, phase, and location of emission for the filtered set F.

The LCA run repeats these steps for each sector, F_x, represented in the set F:

1. Erase all original IMPLAN final demand and import data.
2. Replace original IMPLAN final demand and import data in producer prices for all for institutions of sector F_x.
3. "Calculate" CBEI.
4. Record total emissions by institution, phase, and location of emission in the row labeled sector F_x.
5. Repeat for the next sector.

LCA Modeler processing can be launched from the "Control" tab of the *OR2005 CBEI Demand Modeler.xlsm* workbook. The three-phase pre-purchase Standard and LCA model results are recorded in the "Standard" and "LCA" tabs respectively in the *OR2005 CBEI Demand Modeler.xlsm* workbook. (See worksheet "Instructions" for additional details.)

In using LCA Modeler, it is important to remember that all expenditures need to be expressed in "producer prices and terms". This is consistent with the treatment of final demand in CBEI's underlying economic data. A consumer purchase of any one commodity (such as beer) needs to be treated as four separate purchases: a purchase of beer (from the beer producer), a purchase of transportation services (from the final producers to the retailer), a purchase of wholesale services, and a purchase of retail services. Results in LCA Modeler for any single purchase (such as beer) will show emissions in the

transportation, wholesale and retail sectors. These results, however, only reflect the emissions "upstream" of the final producer, and do not include transportation, wholesale, and retail sector emissions as the product moves from the final producer to the retailer.

This is an important part of the CBEI model that is still under development. The organization of IMPLAN data makes it necessary for CBEI to treat the services of the retailer as a separate purchase – the dollars spent to buy bread are not readily connected to the retail "margin" (the mark-up that the retailer charges). IMPLAN data includes estimated margins by sector for Oregon, and in a future version of CBEI, we hope to use IMPLAN's margin data to make this connection and present emissions for purchases made at the store, not the factory.

4.9.DATA SOURCES

Data source #1: Institutional Demand by Institution Type. This is the main source of final demand, later adjusted for use in the GHG emissions calculations.

Source: Stored query in IMPLAN's Oregon 2006 database (iap file), File/Export via Microsoft Access, then copy/pasted into the model:

IMPLAN query name: SA001b: Crosstab Query
Model input location: OR2005 CBEI Final Demand.xlsx!IMPLAN 2006 Demand

Data source #2: Institutional Commodity Imports by Institution Type. Supplementary data used in creating the geographic splits in final demand.

Source: Stored query in IMPLAN's Oregon 2006 database (iap file), File/Export via Microsoft Access, converted to crosstab format using Excel's Pivot Table, then copy/pasted into the model:

IMPLAN query name: Commodity Import – FD: Select Query
Model input location: OR2005 CBEI Final Demand.xlsx!IMPLAN 2006 Demand

Sample: as entered in worksheet IMPLAN 2006 Demand

Data source #3: Oregon Input-Output Type I Multipliers. Used to calculate the Oregon direct+indirect GHG coefficients from the Oregon direct GHG coefficients, accounting for the upstream inter-industry effects of final demand consumption. This matrix of coefficients reflects the structure of production within Oregon between all commodity sectors. The matrix excludes intermediate demand that "leaks" out of state (when in-state producers purchase from out-of-state suppliers).

Source: Table in IMPLAN's Oregon 2006 database (iap file), File/Export via Microsoft Access, converted to crosstab format using Excel's Pivot Table, then copy/pasted into the model – and expanded to a full 509x509 matrix.

IMPLAN table name: Regional Multipliers Type I
Model input location: OR2005 CBEI GHG Coefficients.xlsx!Type_I-OR06

Note: The Oregon Type I multipliers are more sparse than the national U.S. multipliers (compare to next source), reflecting the fact that not all of the nation's productive activities among the 509 IMPLAN sectors take place in Oregon.

Data source #4: U.S. Input-Output Type I Multipliers. Used to calculate the U.S. direct+indirect GHG coefficients from the direct GHG coefficients, accounting for the upstream inter-industry effects of final demand consumption. This matrix of coefficients reflects the structure of production nationwide between all commodity sectors.

Source: Table in IMPLAN's U.S. 2006 database (iap file), File/Export via Microsoft Access, converted to crosstab format using Excel's Pivot Table, then copy/pasted into the model – and expanded to a full 509x509 matrix.

IMPLAN table name: Regional Multipliers Type I
Model input location: OR2005 CBEI GHG Coefficients.xlsx!Type_I-US06

The U.S. multipliers are not fully populated for all 509 rows and columns in the Pivot Table created from IMPLAN's export, which only includes non-zero values.

Data source #5: Foreign direct+indirect coefficients. Input directly into the model, adjusted to map to IMPLAN sectors, and used in the weighted coefficients.

Source: MRIO, Glen Peter's international model; copy/pasted into the model, plus adjustments.

Model input location: OR2005 CBEI GHG Coefficients.xlsx!Foreign Sectors Coeffs, Map

Sample: as entered in worksheet Foreign Sectors Coeffs, Map

Data source #6: U.S. Gross Commodity Demand. Used to produce two sets of factors: (1) foreign import ratio per commodity sector, (2) relative shares of domestic vs. foreign total gross commodity demand for each commodity sector.

Source: Table in IMPLAN's U.S. 2006 database (iap file), File/Export via Microsoft Access, then copy/pasted into the model.

IMPLAN table name: Regional Commodity Balances
Model input location: OR2005 CBEI Final Demand.xlsx!IMPLAN 2006 Demand

The import ratios are the key to the geographic split of demand data by production origin. The gross demand shares are used to produce weighted GHG coefficients.

Note that unlike the final institutional demand (data source #1), gross demand is only used in the model to generate factors and has no further details beyond the commodity sectors (i.e., no institution type, etc.).

Data source #7: Oregon Gross Commodity Demand. Used to produce the relative shares of the state's gross commodity demand for each commodity sector by origin: in-state, other-49 states and foreign.

Source: Table in IMPLAN's Oregon 2006 database (iap file), File/Export via Microsoft Access, then copy/pasted into the model.

IMPLAN table name:	Regional Commodity Balances
Model input location:	OR2005 CBEI Final Demand.xlsx!IMPLAN 2006 Demand

Note: Unlike the Oregon final institutional imports (data source #2), gross imports only are used in the model to generate factors and has no further details beyond the commodity sectors (i.e., no institution type, etc.).

5. LIMITATIONS AND FURTHER RESEARCH

5.1.LIMITATIONS TO CBEI

Emissions and economic data limitations cause uncertainty in model results that could benefit from both sensitivity analysis – to determine the importance of uncertain data elements to model results – and refinements to the CBEI model should improved data become available.

5.1.1. Disaggregating emissions inventories

The Oregon DOE (2011) and U.S. EIA (2007) inventories are reported in far fewer, more aggregate categories than IMPLAN's 509 commodity sectors. For this reason it is necessary, in constructing CBEI's direct emissions coefficients, to assign emissions from all or portions of certain inventory categories to sectors in proportion to their economic output. In no case is an inventory category allocated across all 509 IMPLAN sectors in proportion to output; rather, inventory categories are allocated to a group of sectors and within this sector further allocation is made by output. This methodology is equivalent to the assumption that all sectors (within the group of sectors corresponding to the same inventory category) have the same emissions intensity (for the particular category of emissions in question; many sectors are subject to emissions from more than one inventory category). More detailed inventory data would make this assumption unnecessary.

5.1.2. Transportation emissions data

Transportation data is presented in a highly aggregate form in the OR DOE and U.S. EIA inventories, requiring the use of multiple sources to establish household, government, and industrial/commercial shares of transportation emissions as well as commodity sectors assignments within industrial/commercial transportation emissions. Combining data from different sources is very likely to result in misallocations. Collection and reporting of more specific transportation emissions data by government sources would likely improve CBEI's accuracy in this area.

5.1.3. IMPLAN's trade data

IMPLAN's "imports," i.e. its estimate for Oregon purchases from other states and foreign countries, are calculated from regional purchasing coefficients (RPCs), which are in turn the result of an econometric model first developed by the economist Jack Faucett in the 1980s, and now updated with data for each year.[23] The econometric model is a multi-region input/output model, with data for 51 "states," including the District of Columbia; it adopts a "gravity model" for trade flow patterns.[24] For commodities, the model estimates how much demand is met by local supply at the state level (and similarly for counties), and is constrained not to exceed local supply and demand; the fraction of demand supplied locally is the RPC, and the import share of the market is defined as (1-RPC). Services are assumed to be provided from a local supplier, if available.

[23] This section relies on a personal communication with IMPLAN co-founder, Doug Olson, July, 14, 2009.
[24] A gravity model of trade assumes that the strength of interaction between two locations is inversely proportional to the square of the distance between them, just as in the physical law of gravity.

IMPLAN's RPC-based estimates are only a first approximation to appropriate state-specific data. When better information is available, it should be incorporated into CBEI in order to develop more appropriate state data. CBEI currently uses institutional and intermediate demand (and imports) directly from IMPLAN tables; if there are better numbers for some sectors' regional commodity imports, they should certainly be used (and documented), which then will produce different in-state versus other-49 versus foreign sources for the commodities. By the same token, while using the U.S. national import rates is the best overall method, if there are better data for specific Oregon sectors' international import rates, then again they should be used (and documented).

Some but not all of these data problems are eliminated or better addressed in the new IMPLAN version, available for year 2007 data. For example, IMPLAN now uses Commodity Flow Survey data on the movement of goods, making adjustments for how far the average commodity travels.

Even in the absence of definitively better data, sensitivity analyses could be performed, testing the response of CBEI results to different assumptions about interstate and international commodity flows. This could be an important topic for further research.

5.1.4. Updating to IMPLAN 2007

The spreadsheet structure in the current CBEI is "hard-coded" for the number of sectors in the input-output model. Through 2006, IMPLAN used a 509-sector model; in 2007 they reorganized their data and switched to a 440-sector model. In order to accommodate IMPLAN data for 2007 or later, CBEI must be recoded to match the new, slightly smaller matrix. This update will require time-consuming but not conceptually difficult adjustments to every sheet of the linked workbooks. In addition, category and sub-category mapping will need to be updated to match the new IMPLAN sectors, as will mapping from the production inventories (U.S. and state) to the IMPLAN sectors. These remapping processes will require some research into the relationship between 2006 IMPLAN sectors, 2007 IMPLAN sectors, and NAICS sectors. Failure to perform the update to 2007 data would leave CBEI dependent on an increasingly obsolete database.

5.1.5. Reconciling U.S. and international emissions data

Another important area for further research and, potentially, for modifications to some of the data entered into CBEI is the use of the MRIO international emissions coefficients. These coefficients present several problems.

First, the MRIO model, spanning 87 regions worldwide, is based on a much more aggregated set of categories, with only 57 sectors compared to the 509 used in IMPLAN. As a result, CBEI maps multiple IMPLAN sectors into a single MRIO sector. No information is available from MRIO about the variations in emissions intensity within its relatively broad sectors. The method used in CBEI to estimate international emissions coefficients for each IMPLAN sector, described in Section 4.2.3 above, is an approximation based on the limited available data. Further research could develop more appropriate, sector-specific emissions coefficients for U.S. imports in the detailed IMPLAN sectors.

Second, the MRIO U.S. coefficients do not match well with the U.S. direct+indirect coefficients developed within CBEI. This lack of consistency raises questions about the compatibility of CBEI coefficients and the aggregate foreign coefficients extracted from MRIO. Further research would be

necessary to determine: what are the causes of this inconsistency, what are possible corrections for it, and whether there are alternative data sources for the emissions intensity of U.S. imports.

Third, the MRIO coefficients are for 2001, already four years behind the IMPLAN and emissions inventory data used in CBEI, and will become more out of date as CBEI is updated to 2007 IMPLAN data. Glen Peters, the developer of MRIO, is said to be planning a major update within the next year; when this occurs, it will again change categories and require adjustment in the portions of the model using international data. Research on this topic would explore Peters' plans to update the MRIO coefficients, our ability to update the MRIO coefficients independently, and the existence of alternative data sources.

5.2.FURTHER MODEL DEVELOPMENT

One of the most important areas for potential model revision is the possible transition from the existing Excel-based CBEI to a hybrid Excel-Access system. The current size and complexity of CBEI tests the limits of Excel: six linked workbooks, each with 6 to 12 worksheets and innumerable interconnections between all worksheets and workbooks. Already, several supplemental workbooks have been delinked from the system because of computational constraints, and changes to these workbooks must be transferred to the linked system manually. A hybrid Excel-Access version of CBEI could serve two purposes: 1) it could reduce Excel's computational burden and increase the potential scope of the model; and 2) it could allow for automated entry of much of the IMPLAN data as the model is revised for new years or new jurisdictions, simplifying recoding tasks.

5.2.1. Automating IMPLAN data entry

Because of its uniformity among states, IMPLAN data is well-suited to automation in its entry into a CBEI.v.2. The data requirements are, however, large and would necessitate recoding CBEI to be a hybrid Access-Excel model (instead of the current purely Excel-based system). Using Access, it would be possible to create a system whereby computer-savvy users could purchase IMPLAN for their state or county, download the IMPLAN data into Access, and instruct the CBEI.v.2 Access-based software to read the state-specific IMPLAN file. The CBEI.v.2 Access-based software would then automatically read the appropriate data into the CBEI.v.2 Excel-based model.

Some IMPLAN data cannot be downloaded through Access but must instead be developed through use of the IMPLAN software. CBEI.v.2 users would, therefore, need to purchase both IMPLAN state data and the IMPLAN software. Instructions for use of the CBEI.v.2 model could instruct users in what IMPLAN reports to download and how to enter the appropriate data into the Access-based data entry system. Because IMPLAN's margins cannot be downloaded via Access and are a 509x509 matrix represented as a series of compressed (that is, with row lengths that vary by sector) vectors in IMPLAN reports, this task would not be trivial for the CBEI.v.2 user.

CBEI as currently coded can only be used with year 2006 (or earlier) IMPLAN data. IMPLAN's 2007 (and future) data have been substantially reorganized. While a system of using Access to read IMPLAN data into the CBEI.v.2 Excel-based model could be designed for either the 2006 or the 2007 data structure, a single Access-based data entry system would not serve for both data years. In addition, an Access-based data entry system designed to read 2007 IMPLAN data into CBEI.v.2 could not function until the CBEI Excel-based model had itself been updated for 2007 data.

IMPLAN data used in CBEI must match the year of the emissions inventory for the state being modeled. In the event that a state's latest emissions inventory is for a year for which no IMPLAN data exist it will be necessary to scale the IMPLAN data to the appropriate emissions year. (In the Oregon CBEI for 2005, for example, IMPLAN data for 2006 is used because no 2005 IMPLAN data exist. When the CBEI model was created, Oregon's most current emissions inventory was for 2005; for this reason, all 2006 IMPLAN data in the Oregon CBEI is downscaled to 2005 levels using Oregon's real GDP growth.) While the CBEI.v.2 model could be coded with real GDP growth data for all states for past years, data for new years (after the model's release) would need to be added by model users.

5.2.2. Automating emissions data entry

State emissions inventories are idiosyncratic in their reporting categories and (as was the case for Oregon) may be production/consumption-based hybrids instead of using a strict production-based methodology. A purely production-based model is necessary for the construction of the state direct coefficients. Converting a hybrid production/consumption-based inventory into a production-based inventory can be both data and time intensive. This conversion process cannot be automated, nor can detailed instructions be written that would cover most contingencies. Use of CBEI.v.2 by state agencies would require that they can create or otherwise provide a strictly production-based inventory.

Even beginning with a strictly production-based inventory, the problem of idiosyncratic reporting categories remains. State inventories do not coincide in terms of their reporting categories, nor do most states coincide with national reporting categories. Mapping the reporting categories from the production-based inventory to the 509 IMPLAN sectors necessary to construct the direct coefficients cannot be automated. Users would instead need to painstakingly map each reporting category to one or more IMPLAN categories and, where significant omissions exist in the inventory, to adjust industry output (the denominator in the emissions coefficients) to take account of these omissions.

5.2.3. Automating use and disposal phase data entry

Use emissions for the Oregon CBEI for 2005 came from many different sources. Compiling and entering data for the CBEI.v.2 use phase would be labor intensive and would be complicated by state-to-state and year-to-year variations in data availability and data recording categories. It is extremely likely that data from different sources would be reported in different units or by different reporting categories in different states or localities.

It is equally likely that some states or counties would have superior or inferior local data in comparison to Oregon, making it necessary to allow for multiple possible data entry scenarios: from a locality that has an entire set of local data to a locality that has little or no local data. Unique CBEI.v.2 use phase data calculations would be necessary for each data availability scenario. It would be necessary to create a large number of contingency coding structures to accommodate each locality's data availability as well as a system of code by which the Access interface could instruct the Excel-based CBEI.v.2 as to which coding structure to use.

The reporting structure for disposal data differs enormously from state to state, and much of the Oregon-specific data came from internal (and not published) Oregon DEQ data. The concerns stated for automating the use-phase emissions data apply also to the disposal-phase data: variations in data availability could necessitate variations in the coding structure.

5.2.4. Automating data entry for counties

Before data automation could be attempted at the county level a base county-level CBEI would need to be created. First, it would be necessary to convert IMPLAN county data for use in the three geography model (in-county, out of county but in the United States, and foreign country), or rewrite CBEI to allow four production geographies (in-county, in-state but not in-county, other 49 states, and foreign country). In either case, a single Access-based data entry system could not accommodate both state and county data; a unique county-based automated data entry system would be necessary.

Second, emissions inventories, and use and disposal data are unlikely to be available for all but the most populous counties. If a four geography model is chosen, emissions data would need to be developed for both the state and the county; even in the three geography system, the option of using U.S. emissions intensities for the out of county but in the United States area would greatly reduce the county-specificity of the model. If a county is assumed to have identical emissions intensities to the state, thereby making data much more readily available, the utility of a three or four geography model quickly declines. A county without county-specific emissions data would get a superior result but simply scaling state results to county demand by sector, with adjustments for different levels of final demand. This approach, however, would make it impossible to make comparisons between the county's production and consumption-based inventories, a key analytical use of model results.

6. APPENDIX: CBEI CATEGORY MAPPING

Table 18: Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
1	Oilseed farming	Other food and agriculture	Food and beverages
2	Grain farming	Grains, baked goods, cereals	Food and beverages
3	Vegetable and melon farming	Fruit, nuts and vegetables	Food and beverages
4	Tree nut farming	Fruit, nuts and vegetables	Food and beverages
5	Fruit farming	Fruit, nuts and vegetables	Food and beverages
6	Greenhouse and nursery production	Lawn and garden	Media and furnishings
7	Tobacco farming	Other food and agriculture	Food and beverages
8	Cotton farming	Other food and agriculture	Food and beverages
9	Sugarcane and sugar beet farming	Other food and agriculture	Food and beverages
10	All other crop farming	Other food and agriculture	Food and beverages
11	Cattle ranching and farming	Other	Other
12	Poultry and egg production	Dairy and eggs	Food and beverages
13	Animal production, except cattle and poultry and eggs	Other animal products	Food and beverages
14	Logging	Forestries, mills, paper	Manufactures
15	Forest nurseries, forest products, and timber tracts	Forestries, mills, paper	Manufactures
16	Fishing	Seafood	Food and beverages
17	Hunting and trapping	Other	Other
18	Agriculture and forestry support activities	Other services	Services
19	Oil and gas extraction	Oil and gas	Mining, oil and gas
20	Coal mining	Other mining	Mining, oil and gas
21	Iron ore mining	Other mining	Mining, oil and gas
22	Copper, nickel, lead, and zinc mining	Other mining	Mining, oil and gas
23	Gold, silver, and other metal ore mining	Other mining	Mining, oil and gas
24	Stone mining and quarrying	Other mining	Mining, oil and gas
25	Sand, gravel, clay, and refractory mining	Other mining	Mining, oil and gas
26	Other nonmetallic mineral mining	Other mining	Mining, oil and gas
27	Drilling oil and gas wells	Oil and gas	Mining, oil and gas
28	Support activities for oil and gas operations	Oil and gas	Mining, oil and gas
29	Support activities for other mining	Other mining	Mining, oil and gas
30	Power generation and supply	Power generation and supply	Fuel and utilities
31	Natural gas distribution	Natural gas distribution	Fuel and utilities
32	Water, sewage and other systems	Water- sewage and other systems	Fuel and utilities
33	New residential 1-unit structures, nonfarm	Residential construction and remodeling	Construction
34	New multifamily housing structures, nonfarm	Residential construction and remodeling	Construction
35	New residential additions and alterations, nonfarm	Residential construction and remodeling	Construction
36	New farm housing units and additions and alterations	Other manufactures	Manufactures
37	Manufacturing and industrial buildings	Non-residential construction/remodeling	Construction
38	Commercial and institutional buildings	Non-residential construction/remodeling	Construction
39	Highway, street, bridge, and tunnel construction	Non-residential construction/remodeling	Construction
40	Water, sewer, and pipeline construction	Non-residential construction/remodeling	Construction
41	Other new construction	Non-residential construction/remodeling	Construction
42	Maintenance and repair of farm and nonfarm residential structures	Non-residential construction/remodeling	Construction
43	Maintenance and repair of nonresidential buildings	Non-residential construction/remodeling	Construction
44	Maintenance and repair of highways, streets, bridges, and tunnels	Non-residential construction/remodeling	Construction
45	Other maintenance and repair construction	Non-residential construction/remodeling	Construction

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
46	Dog and cat food manufacturing	Pet food	Food and beverages
47	Other animal food manufacturing	Pet food	Food and beverages
48	Flour milling	Grains, baked goods, cereals	Food and beverages
49	Rice milling	Grains, baked goods, cereals	Food and beverages
50	Malt manufacturing	Other manufactures	Manufactures
51	Wet corn milling	Condiments, oils and sweeteners	Food and beverages
52	Soybean processing	Other food and agriculture	Food and beverages
53	Other oilseed processing	Condiments, oils and sweeteners	Food and beverages
54	Fats and oils refining and blending	Condiments, oils and sweeteners	Food and beverages
55	Breakfast cereal manufacturing	Grains, baked goods, cereals	Food and beverages
56	Sugar manufacturing	Condiments, oils and sweeteners	Food and beverages
57	Confectionery manufacturing from cacao beans	Other food and agriculture	Food and beverages
58	Confectionery manufacturing from purchased chocolate	Grains, baked goods, cereals	Food and beverages
59	Nonchocolate confectionery manufacturing	Grains, baked goods, cereals	Food and beverages
60	Frozen food manufacturing	Frozen food	Food and beverages
61	Fruit and vegetable canning and drying	Fruit, nuts and vegetables	Food and beverages
62	Fluid milk manufacturing	Dairy and eggs	Food and beverages
63	Creamery butter manufacturing	Dairy and eggs	Food and beverages
64	Cheese manufacturing	Dairy and eggs	Food and beverages
65	Dry, condensed, and evaporated dairy products	Dairy and eggs	Food and beverages
66	Ice cream and frozen dessert manufacturing	Dairy and eggs	Food and beverages
67	Animal, except poultry, slaughtering	Red meat	Food and beverages
68	Meat processed from carcasses	Red meat	Food and beverages
69	Rendering and meat byproduct processing	Other manufactures	Manufactures
70	Poultry processing	Poultry	Food and beverages
71	Seafood product preparation and packaging	Seafood	Food and beverages
72	Frozen cakes and other pastries manufacturing	Frozen food	Food and beverages
73	Bread and bakery product, except frozen, manufacturing	Grains, baked goods, cereals	Food and beverages
74	Cookie and cracker manufacturing	Grains, baked goods, cereals	Food and beverages
75	Mixes and dough made from purchased flour	Grains, baked goods, cereals	Food and beverages
76	Dry pasta manufacturing	Grains, baked goods, cereals	Food and beverages
77	Tortilla manufacturing	Grains, baked goods, cereals	Food and beverages
78	Roasted nuts and peanut butter manufacturing	Fruit, nuts and vegetables	Food and beverages
79	Other snack food manufacturing	Grains, baked goods, cereals	Food and beverages
80	Coffee and tea manufacturing	Beverages	Food and beverages
81	Flavoring syrup and concentrate manufacturing	Other manufactures	Manufactures
82	Mayonnaise, dressing, and sauce manufacturing	Condiments, oils and sweeteners	Food and beverages
83	Spice and extract manufacturing	Condiments, oils and sweeteners	Food and beverages
84	All other food manufacturing	Other food and agriculture	Food and beverages
85	Soft drink and ice manufacturing	Beverages	Food and beverages
86	Breweries	Beverages	Food and beverages
87	Wineries	Beverages	Food and beverages
88	Distilleries	Beverages	Food and beverages
89	Tobacco stemming and redrying	Other food and agriculture	Food and beverages
90	Cigarette manufacturing	Other	Other
91	Other tobacco product manufacturing	Other	Other
92	Fiber, yarn, and thread mills	Other manufactures	Manufactures
93	Broadwoven fabric mills	Other manufactures	Manufactures
94	Narrow fabric mills and schiffli embroidery	Other manufactures	Manufactures
95	Nonwoven fabric mills	Other manufactures	Manufactures
96	Knit fabric mills	Other	Other
97	Textile and fabric finishing mills	Other manufactures	Manufactures
98	Fabric coating mills	Other manufactures	Manufactures

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
99	Carpet and rug mills	Furnishings	Media and furnishings
100	Curtain and linen mills	Furnishings	Media and furnishings
101	Textile bag and canvas mills	Other manufactures	Manufactures
102	Tire cord and tire fabric mills	Other manufactures	Manufactures
103	Other miscellaneous textile product mills	Other manufactures	Manufactures
104	Sheer hosiery mills	Clothing	Clothing
105	Other hosiery and sock mills	Clothing	Clothing
106	Other apparel knitting mills	Other manufactures	Manufactures
107	Cut and sew apparel manufacturing	Clothing	Clothing
108	Accessories and other apparel manufacturing	Clothing	Clothing
109	Leather and hide tanning and finishing	Other manufactures	Manufactures
110	Footwear manufacturing	Clothing	Clothing
111	Other leather product manufacturing	Clothing	Clothing
112	Sawmills	Forestries, mills, paper	Manufactures
113	Wood preservation	Other manufactures	Manufactures
114	Reconstituted wood product manufacturing	Other manufactures	Manufactures
115	Veneer and plywood manufacturing	Other manufactures	Manufactures
116	Engineered wood member and truss manufacturing	Other manufactures	Manufactures
117	Wood windows and door manufacturing	Other manufactures	Manufactures
118	Cut stock, resawing lumber, and planing	Forestries, mills, paper	Manufactures
119	Other millwork, including flooring	Other manufactures	Manufactures
120	Wood container and pallet manufacturing	Other manufactures	Manufactures
121	Manufactured home, mobile home, manufacturing	Mobile homes	Manufactures
122	Prefabricated wood building manufacturing	Other manufactures	Manufactures
123	Miscellaneous wood product manufacturing	Other manufactures	Manufactures
124	Pulp mills	Forestries, mills, paper	Manufactures
125	Paper and paperboard mills	Office supplies	Media and furnishings
126	Paperboard container manufacturing	Forestries, mills, paper	Manufactures
127	Flexible packaging foil manufacturing	Other manufactures	Manufactures
128	Surface-coated paperboard manufactuing	Other manufactures	Manufactures
129	Coated and laminated paper and packaging materials	Forestries, mills, paper	Manufactures
130	Coated and uncoated paper bag manufacturing	Forestries, mills, paper	Manufactures
131	Die-cut paper office supplies manufacturing	Forestries, mills, paper	Manufactures
132	Envelope manufacturing	Forestries, mills, paper	Manufactures
133	Stationery and related product manufacturing	Forestries, mills, paper	Manufactures
134	Sanitary paper product manufacturing	Household supplies	Media and furnishings
135	All other converted paper product manufacturing	Forestries, mills, paper	Manufactures
136	Manifold business forms printing	Other manufactures	Manufactures
137	Books printing	Other manufactures	Manufactures
138	Blankbook and looseleaf binder manufacturing	Other manufactures	Manufactures
139	Commercial printing	Other manufactures	Manufactures
140	Tradebinding and related work	Other manufactures	Manufactures
141	Prepress services	Other services	Services
142	Petroleum refineries	Gasoline, heating fuels, other petroleum products	Fuel and utilities
143	Asphalt paving mixture and block manufacturing	Other manufactures	Manufactures
144	Asphalt shingle and coating materials manufacturing	Other manufactures	Manufactures
145	Petroleum lubricating oil and grease manufacturing	Vehicle parts	Vehicles and parts
146	All other petroleum and coal products manufacturing	Oil and gas	Mining, oil and gas
147	Petrochemical manufacturing	Oil and gas	Mining, oil and gas
148	Industrial gas manufacturing	Oil and gas	Mining, oil and gas
149	Synthetic dye and pigment manufacturing	Other manufactures	Manufactures
150	Other basic inorganic chemical manufacturing	Other manufactures	Manufactures
151	Other basic organic chemical manufacturing	Other manufactures	Manufactures

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
152	Plastics material and resin manufacturing	Other manufactures	Manufactures
153	Synthetic rubber manufacturing	Other manufactures	Manufactures
154	Cellulosic organic fiber manufacturing	Other manufactures	Manufactures
155	Noncellulosic organic fiber manufacturing	Other manufactures	Manufactures
156	Nitrogenous fertilizer manufacturing	Other manufactures	Manufactures
157	Phosphatic fertilizer manufacturing	Other manufactures	Manufactures
158	Fertilizer, mixing only, manufacturing	Other manufactures	Manufactures
159	Pesticide and other agricultural chemical manufacturing	Lawn and garden	Media and furnishings
160	Pharmaceutical and medicine manufacturing	Medicines	Healthcare
161	Paint and coating manufacturing	Other manufactures	Manufactures
162	Adhesive manufacturing	Other manufactures	Manufactures
163	Soap and other detergent manufacturing	Household supplies	Media and furnishings
164	Polish and other sanitation good manufacturing	Household supplies	Media and furnishings
165	Surface active agent manufacturing	Other manufactures	Manufactures
166	Toilet preparation manufacturing	Household supplies	Media and furnishings
167	Printing ink manufacturing	Other manufactures	Manufactures
168	Explosives manufacturing	Other manufactures	Manufactures
169	Custom compounding of purchased resins	Other manufactures	Manufactures
170	Photographic film and chemical manufacturing	Other manufactures	Manufactures
171	Other miscellaneous chemical product manufacturing	Other manufactures	Manufactures
172	Plastics packaging materials, film and sheet	Household supplies	Media and furnishings
173	Plastics pipe, fittings, and profile shapes	Other manufactures	Manufactures
174	Laminated plastics plate, sheet, and shapes	Other manufactures	Manufactures
175	Plastics bottle manufacturing	Other manufactures	Manufactures
176	Resilient floor covering manufacturing	Other manufactures	Manufactures
177	Plastics plumbing fixtures and all other plastics products	Other manufactures	Manufactures
178	Foam product manufacturing	Other manufactures	Manufactures
179	Tire manufacturing	Vehicle parts	Vehicles and parts
180	Rubber and plastics hose and belting manufacturing	Other manufactures	Manufactures
181	Other rubber product manufacturing	Other manufactures	Manufactures
182	Vitreous china plumbing fixture manufacturing	Other manufactures	Manufactures
183	Vitreous china and earthenware articles manufacturing	Household supplies	Media and furnishings
184	Porcelain electrical supply manufacturing	Other manufactures	Manufactures
185	Brick and structural clay tile manufacturing	Other manufactures	Manufactures
186	Ceramic wall and floor tile manufacturing	Other manufactures	Manufactures
187	Nonclay refractory manufacturing	Other manufactures	Manufactures
188	Clay refractory and other structural clay products	Other manufactures	Manufactures
189	Glass container manufacturing	Other manufactures	Manufactures
190	Glass and glass products, except glass containers	Household supplies	Media and furnishings
191	Cement manufacturing	Concrete, cement and lime	Construction
192	Ready-mix concrete manufacturing	Concrete, cement and lime	Construction
193	Concrete block and brick manufacturing	Concrete, cement and lime	Construction
194	Concrete pipe manufacturing	Concrete, cement and lime	Construction
195	Other concrete product manufacturing	Other manufactures	Manufactures
196	Lime manufacturing	Concrete, cement and lime	Construction
197	Gypsum product manufacturing	Other manufactures	Manufactures
198	Abrasive product manufacturing	Other manufactures	Manufactures
199	Cut stone and stone product manufacturing	Other manufactures	Manufactures
200	Ground or treated minerals and earths manufacturing	Other manufactures	Manufactures
201	Mineral wool manufacturing	Other manufactures	Manufactures
202	Miscellaneous nonmetallic mineral products	Other manufactures	Manufactures
203	Iron and steel mills	Foundries, metal processing	Foundries, metal processing
204	Ferroalloy and related product manufacturing	Foundries, metal processing	Foundries, metal processing

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
205	Iron, steel pipe and tube from purchased steel	Other manufactures	Manufactures
206	Rolled steel shape manufacturing	Other manufactures	Manufactures
207	Steel wire drawing	Foundries, metal processing	Foundries, metal processing
208	Alumina refining	Foundries, metal processing	Foundries, metal processing
209	Primary aluminum production	Foundries, metal processing	Foundries, metal processing
210	Secondary smelting and alloying of aluminum	Other manufactures	Manufactures
211	Aluminum sheet, plate, and foil manufacturing	Foundries, metal processing	Foundries, metal processing
212	Aluminum extruded product manufacturing	Other manufactures	Manufactures
213	Other aluminum rolling and drawing	Foundries, metal processing	Foundries, metal processing
214	Primary smelting and refining of copper	Foundries, metal processing	Foundries, metal processing
215	Primary nonferrous metal, except copper and aluminum	Foundries, metal processing	Foundries, metal processing
216	Copper rolling, drawing, and extruding	Foundries, metal processing	Foundries, metal processing
217	Copper wire, except mechanical, drawing	Other manufactures	Manufactures
218	Secondary processing of copper	Other manufactures	Manufactures
219	Nonferrous metal, except copper and aluminum, shaping	Foundries, metal processing	Foundries, metal processing
220	Secondary processing of other nonferrous	Foundries, metal processing	Foundries, metal processing
221	Ferrous metal foundaries	Foundries, metal processing	Foundries, metal processing
222	Aluminum foundries	Foundries, metal processing	Foundries, metal processing
223	Nonferrous foundries, except aluminum	Other manufactures	Manufactures
224	Iron and steel forging	Foundries, metal processing	Foundries, metal processing
225	Nonferrous forging	Foundries, metal processing	Foundries, metal processing
226	Custom roll forming	Other manufactures	Manufactures
227	All other forging and stamping	Foundries, metal processing	Foundries, metal processing
228	Cutlery and flatware, except precious, manufacturing	Household supplies	Media and furnishings
229	Hand and edge tool manufacturing	Household supplies	Media and furnishings
230	Saw blade and handsaw manufacturing	Other manufactures	Manufactures
231	Kitchen utensil, pot, and pan manufacturing	Household supplies	Media and furnishings
232	Prefabricated metal buildings and components	Prefabricated buildings	Manufactures
233	Fabricated structural metal manufacturing	Other manufactures	Manufactures
234	Plate work manufacturing	Other manufactures	Manufactures
235	Metal window and door manufacturing	Other manufactures	Manufactures
236	Sheet metal work manufacturing	Other manufactures	Manufactures
237	Ornamental and architectural metal work manufacturing	Other manufactures	Manufactures
238	Power boiler and heat exchanger manufacturing	Machinery manufacture	Manufactures
239	Metal tank, heavy gauge, manufacturing	Other manufactures	Manufactures
240	Metal can, box, and other container manufacturing	Other manufactures	Manufactures
241	Hardware manufacturing	Other manufactures	Manufactures
242	Spring and wire product manufacturing	Other manufactures	Manufactures
243	Machine shops	Other manufactures	Manufactures
244	Turned product and screw, nut, and bolt manufacturing	Other manufactures	Manufactures
245	Metal heat treating	Foundries, metal processing	Foundries, metal processing
246	Metal coating and nonprecious engraving	Other manufactures	Manufactures
247	Electroplating, anodizing, and coloring metal	Other manufactures	Manufactures
248	Metal valve manufacturing	Other manufactures	Manufactures
249	Ball and roller bearing manufacturing	Other manufactures	Manufactures
250	Small arms manufacturing	Other manufactures	Manufactures
251	Other ordnance and accessories manufacturing	Missiles, weapons	Manufactures
252	Fabricated pipe and pipe fitting manufacturing	Other manufactures	Manufactures
253	Industrial pattern manufacturing	Other manufactures	Manufactures
254	Enameled iron and metal sanitary ware manufacturing	Other manufactures	Manufactures
255	Miscellaneous fabricated metal product manufacturing	Other manufactures	Manufactures
256	Ammunition manufacturing	Missiles, weapons	Manufactures
257	Farm machinery and equipment manufacturing	Machinery manufacture	Manufactures

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
258	Lawn and garden equipment manufacturing	Lawn and garden	Media and furnishings
259	Construction machinery manufacturing	Machinery manufacture	Manufactures
260	Mining machinery and equipment manufacturing	Machinery manufacture	Manufactures
261	Oil and gas field machinery and equipment	Machinery manufacture	Manufactures
262	Sawmill and woodworking machinery	Other manufactures	Manufactures
263	Plastics and rubber industry machinery	Machinery manufacture	Manufactures
264	Paper industry machinery manufacturing	Machinery manufacture	Manufactures
265	Textile machinery manufacturing	Machinery manufacture	Manufactures
266	Printing machinery and equipment manufacturing	Machinery manufacture	Manufactures
267	Food product machinery manufacturing	Machinery manufacture	Manufactures
268	Semiconductor machinery manufacturing	Machinery manufacture	Manufactures
269	All other industrial machinery manufacturing	Machinery manufacture	Manufactures
270	Office machinery manufacturing	Machinery manufacture	Manufactures
271	Optical instrument and lens manufacturing	Machinery manufacture	Manufactures
272	Photographic and photocopying equipment manufacturing	Other electronics	Electronics
273	Other commercial and service industry machinery manufacturing	Machinery manufacture	Manufactures
274	Automatic vending, commercial laundry and drycleaning	Other manufactures	Manufactures
275	Air purification equipment manufacturing	Machinery manufacture	Manufactures
276	Industrial and commercial fan and blower manufacturing	Machinery manufacture	Manufactures
277	Heating equipment, except warm air furnaces	Heating and cooling appliances	Appliances
278	AC, refrigeration, and forced air heating	Heating and cooling appliances	Appliances
279	Industrial mold manufacturing	Machinery manufacture	Manufactures
280	Metal cutting machine tool manufacturing	Machinery manufacture	Manufactures
281	Metal forming machine tool manufacturing	Machinery manufacture	Manufactures
282	Special tool, die, jig, and fixture manufacturing	Machinery manufacture	Manufactures
283	Cutting tool and machine tool accessory manufacturing	Machinery manufacture	Manufactures
284	Rolling mill and other metalworking machinery	Machinery manufacture	Manufactures
285	Turbine and turbine generator set units manufacturing	Machinery manufacture	Manufactures
286	Other engine equipment manufacturing	Machinery manufacture	Manufactures
287	Speed changers and mechanical power transmission equipment	Machinery manufacture	Manufactures
288	Pump and pumping equipment manufacturing	Machinery manufacture	Manufactures
289	Air and gas compressor manufacturing	Machinery manufacture	Manufactures
290	Measuring and dispensing pump manufacturing	Machinery manufacture	Manufactures
291	Elevator and moving stairway manufacturing	Other manufactures	Manufactures
292	Conveyor and conveying equipment manufacturing	Machinery manufacture	Manufactures
293	Overhead cranes, hoists, and monorail systems	Missiles, weapons	Manufactures
294	Industrial truck, trailer, and stacker manufacturing	Missiles, weapons	Manufactures
295	Power-driven handtool manufacturing	Other	Other
296	Welding and soldering equipment manufacturing	Machinery manufacture	Manufactures
297	Packaging machinery manufacturing	Machinery manufacture	Manufactures
298	Industrial process furnace and oven manufacturing	Machinery manufacture	Manufactures
299	Fluid power cylinder and actuator manufacturing	Machinery manufacture	Manufactures
300	Fluid power pump and motor manufacturing	Machinery manufacture	Manufactures
301	Scales, balances, and miscellaneous general purpose machinery	Other manufactures	Manufactures
302	Electronic computer manufacturing	Computers and peripherals	Electronics
303	Computer storage device manufacturing	Computers and peripherals	Electronics
304	Computer terminal manufacturing	Computer service and equipment	Electronics
305	Other computer peripheral equipment manufacturing	Computers and peripherals	Electronics
306	Telephone apparatus manufacturing	Other electronics	Electronics
307	Broadcast and wireless communications equipment	Other electronics	Electronics
308	Other communications equipment manufacturing	Machinery manufacture	Manufactures
309	Audio and video equipment manufacturing	Other electronics	Electronics
310	Electron tube manufacturing	Other manufactures	Manufactures

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
311	Semiconductors and related device manufacturing	Machinery manufacture	Manufactures
312	All other electronic component manufacturing	Other manufactures	Manufactures
313	Electromedical apparatus manufacturing	Machinery manufacture	Manufactures
314	Search, detection, and navigation instruments	Machinery manufacture	Manufactures
315	Automatic environmental control manufacturing	Machinery manufacture	Manufactures
316	Industrial process variable instruments	Machinery manufacture	Manufactures
317	Totalizing fluid meters and counting devices	Machinery manufacture	Manufactures
318	Electricity and signal testing instruments	Machinery manufacture	Manufactures
319	Analytical laboratory instrument manufacturing	Machinery manufacture	Manufactures
320	Irradiation apparatus manufacturing	Machinery manufacture	Manufactures
321	Watch, clock, and other measuring and controlling device manufacturing	Other	Other
322	Software reproducing	Computer service and equipment	Electronics
323	Audio and video media reproduction	Other manufactures	Manufactures
324	Magnetic and optical recording media manufacturing	Other manufactures	Manufactures
325	Electric lamp bulb and part manufacturing	Household supplies	Media and furnishings
326	Lighting fixture manufacturing	Lighting fixtures	Media and furnishings
327	Electric housewares and household fan manufacturing	Other appliances	Appliances
328	Household vacuum cleaner manufacturing	Other appliances	Appliances
329	Household cooking appliance manufacturing	Ranges and microwaves	Appliances
330	Household refrigerator and home freezer manufacturing	Refrigerators and freezers	Appliances
331	Household laundry equipment manufacturing	Washers and dryers	Appliances
332	Other major household appliance manufacturing	Other manufactures	Manufactures
333	Electric power and specialty transformer manufacturing	Machinery manufacture	Manufactures
334	Motor and generator manufacturing	Other manufactures	Manufactures
335	Switchgear and switchboard apparatus manufacturing	Machinery manufacture	Manufactures
336	Relay and industrial control manufacturing	Machinery manufacture	Manufactures
337	Storage battery manufacturing	Household supplies	Media and furnishings
338	Primary battery manufacturing	Household supplies	Media and furnishings
339	Fiber optic cable manufacturing	Other manufactures	Manufactures
340	Other communication and energy wire manufacturing	Other manufactures	Manufactures
341	Wiring device manufacturing	Machinery manufacture	Manufactures
342	Carbon and graphite product manufacturing	Other manufactures	Manufactures
343	Miscellaneous electrical equipment manufacturing	Machinery manufacture	Manufactures
344	Automobile and light truck manufacturing	Vehicles	Vehicles and parts
345	Heavy duty truck manufacturing	Missiles, weapons	Manufactures
346	Motor vehicle body manufacturing	Other manufactures	Manufactures
347	Truck trailer manufacturing	Missiles, weapons	Manufactures
348	Motor home manufacturing	Vehicles	Vehicles and parts
349	Travel trailer and camper manufacturing	Vehicles	Vehicles and parts
350	Motor vehicle parts manufacturing	Vehicle parts	Vehicles and parts
351	Aircraft manufacturing	Missiles, weapons	Manufactures
352	Aircraft engine and engine parts manufacturing	Missiles, weapons	Manufactures
353	Other aircraft parts and equipment	Missiles, weapons	Manufactures
354	Guided missile and space vehicle manufacturing	Missiles, weapons	Manufactures
355	Propulsion units and parts for space vehicles and guided missiles	Missiles, weapons	Manufactures
356	Railroad rolling stock manufacturing	Missiles, weapons	Manufactures
357	Ship building and repairing	Missiles, weapons	Manufactures
358	Boat building	Vehicles	Vehicles and parts
359	Motorcycle, bicycle, and parts manufacturing	Vehicles	Vehicles and parts
360	Military armored vehicles and tank parts manufacturing	Missiles, weapons	Manufactures
361	All other transportation equipment manufacturing	Other manufactures	Manufactures
362	Wood kitchen cabinet and countertop manufacturing	Other manufactures	Manufactures
363	Upholstered household furniture manufacturing	Furnishings	Media and furnishings

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
364	Nonupholstered wood household furniture manufacturing	Furnishings	Media and furnishings
365	Metal household furniture manufacturing	Furnishings	Media and furnishings
366	Institutional furniture manufacturing	Other manufactures	Manufactures
367	Other household and institutional furniture	Other manufactures	Manufactures
368	Wood office furniture manufacturing	Other manufactures	Manufactures
369	Custom architectural woodwork and millwork	Other manufactures	Manufactures
370	Office furniture, except wood, manufacturing	Other manufactures	Manufactures
371	Showcases, partitions, shelving, and lockers	Other manufactures	Manufactures
372	Mattress manufacturing	Furnishings	Media and furnishings
373	Blind and shade manufacturing	Furnishings	Media and furnishings
374	Laboratory apparatus and furniture manufacturing	Other manufactures	Manufactures
375	Surgical and medical instrument manufacturing	Other manufactures	Manufactures
376	Surgical appliance and supplies manufacturing	Other manufactures	Manufactures
377	Dental equipment and supplies manufacturing	Other manufactures	Manufactures
378	Ophthalmic goods manufacturing	Household supplies	Media and furnishings
379	Dental laboratories	Other manufactures	Manufactures
380	Jewelry and silverware manufacturing	Household supplies	Media and furnishings
381	Sporting and athletic goods manufacturing	Other	Other
382	Doll, toy, and game manufacturing	Media	Media and furnishings
383	Office supplies, except paper, manufacturing	Office supplies	Media and furnishings
384	Sign manufacturing	Other manufactures	Manufactures
385	Gasket, packing, and sealing device manufacturing	Other manufactures	Manufactures
386	Musical instrument manufacturing	Other	Other
387	Broom, brush, and mop manufacturing	Household supplies	Media and furnishings
388	Burial casket manufacturing	Other manufactures	Manufactures
389	Buttons, pins, and all other miscellaneous manufacturing	Other manufactures	Manufactures
390	Wholesale trade	Wholesale	Wholesale
391	Air transportation	Transportation services	Transportation services
392	Rail transportation	Transportation services	Transportation services
393	Water transportation	Transportation services	Transportation services
394	Truck transportation	Transportation services	Transportation services
395	Transit and ground passenger transportation	Transportation services	Transportation services
396	Pipeline transportation	Transportation services	Transportation services
397	Scenic and sightseeing transportation and support activities for transportation	Transportation services	Transportation services
398	Postal service	Personal services	Services
399	Couriers and messengers	Other services	Services
400	Warehousing and storage	Other services	Services
401	Motor vehicle and parts dealers	Retailers	Retailers
402	Furniture and home furnishings stores	Retailers	Retailers
403	Electronics and appliance stores	Retailers	Retailers
404	Building material and garden supply stores	Retailers	Retailers
405	Food and beverage stores	Retailers	Retailers
406	Health and personal care stores	Retailers	Retailers
407	Gasoline stations	Retailers	Retailers
408	Clothing and clothing accessories stores	Retailers	Retailers
409	Sporting goods, hobby, book and music stores	Retailers	Retailers
410	General merchandise stores	Retailers	Retailers
411	Miscellaneous store retailers	Retailers	Retailers
412	Nonstore retailers	Retailers	Retailers
413	Newpaper publishers	Media	Media and furnishings
414	Periodical publishers	Media	Media and furnishings
415	Book publishers	Media	Media and furnishings
416	Database, directory, and other publishers	Other manufactures	Manufactures

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
417	Software publishers	Office supplies	Media and furnishings
418	Motion picture and video industries	Media	Media and furnishings
419	Sound recording industries	Media	Media and furnishings
420	Radio and television broadcasting	Other services	Services
421	Cable networks and program distribution	Entertainment and media	Services
422	Telecommunications	Entertainment and media	Services
423	Information services	Other services	Services
424	Data processing services	Computer service and equipment	Electronics
425	Nondepository credit intermediation and related activities	Banks and financial services	Services
426	Securities, commodity contracts, investments	Banks and financial services	Services
427	Insurance carriers	Legal, real estate, insurance	Services
428	Insurance agencies, brokerages, and related	Other services	Services
429	Funds, trusts, and other financial vehicles	Banks and financial services	Services
430	Monetary authorities and depository credit intermediation	Banks and financial services	Services
431	Real estate	Legal, real estate, insurance	Services
432	Automotive equipment rental and leasing	Car rental, repair and wash	Services
433	Video tape and disc rental	Entertainment and media	Services
434	Machinery and equipment rental and leasing	Other services	Services
435	General and consumer goods rental except video tapes and discs	Other services	Services
436	Lessors of nonfinancial intangible assets	Other	Other
437	Legal services	Legal, real estate, insurance	Services
438	Accounting and bookkeeping services	Other services	Services
439	Architectural and engineering services	Other services	Services
440	Specialized design services	Other services	Services
441	Custom computer programming services	Computer service and equipment	Electronics
442	Computer systems design services	Computer service and equipment	Electronics
443	Other computer related services, including facilities management	Computer service and equipment	Electronics
444	Management consulting services	Other services	Services
445	Environmental and other technical consulting services	Other services	Services
446	Scientific research and development services	Other services	Services
447	Advertising and related services	Other services	Services
448	Photographic services	Other services	Services
449	Veterinary services	Personal services	Services
450	All other miscellaneous professional and technical services	Other services	Services
451	Management of companies and enterprises	Other	Other
452	Office administrative services	Other services	Services
453	Facilities support services	Other services	Services
454	Employment services	Other services	Services
455	Business support services	Other services	Services
456	Travel arrangement and reservation services	Other services	Services
457	Investigation and security services	Other services	Services
458	Services to buildings and dwellings	Building services	Services
459	Other support services	Other services	Services
460	Waste management and remediation services	Waste management	Services
461	Elementary and secondary schools	Education and day care	Services
462	Colleges, universities, and junior colleges	Education and day care	Services
463	Other educational services	Other services	Services
464	Home health care services	Healthcare services	Healthcare
465	Offices of physicians, dentists, and other health practioners	Healthcare services	Healthcare
466	Other ambulatory health care services	Healthcare services	Healthcare
467	Hospitals	Healthcare services	Healthcare
468	Nursing and residential care facilities	Healthcare services	Healthcare
469	Child day care services	Education and day care	Services

Table 18 (continued): Category, subcategory and sector mapping

ID	Sector Description	Subcategory	Category
470	Social assistance, except child day care services	Other services	Services
471	Performing arts companies	Entertainment and media	Services
472	Spectator sports	Entertainment and media	Services
473	Independent artists, writers, and performers	Other services	Services
474	Promoters of performing arts and sports and agents for public figures	Other services	Services
475	Museums, historical sites, zoos, and parks	Entertainment and media	Services
476	Fitness and recreational sports centers	Personal services	Services
477	Bowling centers	Other services	Services
478	Other amusement, gambling, and recreation industries	Other services	Services
479	Hotels and motels, including casino hotels	Hotels and motels	Services
480	Other accommodations	Other services	Services
481	Food services and drinking places	Restaurants	Food and beverages
482	Car washes	Car rental, repair and wash	Services
483	Automotive repair and maintenance, except car washes	Car rental, repair and wash	Services
484	Electronic equipment repair and maintenance	Other services	Services
485	Commercial machinery repair and maintenance	Machinery manufacture	Manufactures
486	Household goods repair and maintenance	Other services	Services
487	Personal care services	Personal services	Services
488	Death care services	Other services	Services
489	Drycleaning and laundry services	Personal services	Services
490	Other personal services	Other services	Services
491	Religious organizations	Other services	Services
492	Grantmaking and giving and social advocacy organizations	Other services	Services
493	Civic, social, professional and similar organizations	Other services	Services
494	Private households	Other	Other
495	Federal electric utilities	Other	Other
496	Other Federal Government enterprises	Other	Other
497	State and local government passenger transit	Other	Other
498	State and local government electric utilities	Other	Other
499	Other State and local government enterprises	Other services	Services
500	Noncomparable imports	Other	Other
501	Scrap	Other	Other
502	Used and secondhand goods	Other	Other
503	State & Local Education	Other	Other
504	State & Local Non-Education	Other	Other
505	Federal Military	Other	Other
506	Federal Non-Military	Other	Other
507	Rest of the world adjustment to final uses	Other	Other
508	Inventory valuation adjustment	Other	Other
509	Owner-occupied dwellings	Other	Other

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