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Trase 'SEI-PCS Brazil pork v2.0.1' supply chain map: Data sources and methods

Trase maps supply chains for agricultural commodities, making it possible to link products and supply chain actors with specific areas of production, and associated sustainability risks and opportunities. It uses an approach called Spatially Explicit Information on Production to Consumption Systems (SEI-PCS) as the basis for this work (see this webpage or our manual for more detail). This document describes the data and methods that Trase used to map the subnational supply chain for Brazilian pork exports from 2015-2017, using a model called **'SEI-PCS Brazil pork v2.0.1'.**

For all pork exports, this model determined the likely municipality in which pigs were raised, where they were slaughtered, and the 'embedded' deforestation risk associated with the production of their soy feed. It used trade and production data, as well as information on company assets ownership (e.g. slaughterhouse, meat processing factory), tax registrations, export licences, sanitary inspections and licenses to export per country and asset, and data from the Federal Inspection Service (SIF) on the origin of animals per slaughterhouse. The model used a logic-based decision tree to link exports to slaughterhouses. To link slaughterhouses to the municipalities where the pigs were raised, we used an optimisation approach using linear programming techniques. This maximised the sourcing from municipalities with trader activity based on taxation records, as well as the state origin of the pig per slaughterhouse and minimised distances between alternative options. We used a linear program to estimate the origin of the soy that the pigs were fed. It used data on feed consumption for Brazil's animal sector, data on carcass weight per region of production, and the sourcing of soy for the domestic market developed from Trase's **'SEI-PCS Brazil soy v2.5.0'** supply chain map. Table 1 provides an overview of key statistics.

Table 1. Summary statistics

	2015	**2016**	**2017**	**2018**
Pork exports (tonnes*)	535,000	712,000	679,000	730,000
Soy feed consumed (tonnes) to produce exported pork	696,000	769,000	749,000	1,290,000
Area required to produce soy consumed to produce exported pork (hectares)	236,000	225,000	206,000	386,000
Number of exporter groups	46	67	64	58
Number of importing countries	69	80	68	141
Domestic market (% share of production)	83	78	79	75
Exports with unknown origin (%)	6	6	4	5

*= metric tons

Data and sources

Trade data

The model used per-shipment data (such as customs data, bills of lading or cargo manifests) for 2015-2017 covering all exports of pork products classified under the 'HS' customs codes in Table 2. These products include pork meat, live animals, and pork offal. We used a commodity-equivalence factor (see Table 2) to convert different products to a standard commodity equivalent, in this case pork meat equivalent. We confirmed the quality of the data by comparing it with data from other sources and data in different aggregated forms (such as the aggregated data of the Ministry of Development, Industry and Foreign Trade; MDIC).

Table 2. Pork products, their HS customs codes, commodity-equivalence factors and the share of each product in total exports in 2017

Product	**HS code**	**Commodity-equivalence factor**
Swine, live, pure-bred breeding animals	10310	89.16
Swine, live, other than pure-bred breeding animals, weighing less than 50kg	10391	89.16
Swine, live, other than pure-bred breeding animals, weighing 50kg or more	10392	89.16
Meat, of swine, carcasses and half-carcasses, fresh or chilled	20311	1.000
Meat, of swine, hams, shoulders and cuts thereof, with bone in, fresh or chilled	20312	1.000
Meat of swine, N.E.C. in in item no. 0203.1, fresh or chilled	20319	1.000
Meat, of swine, carcasses and half-carcasses, frozen	20321	1.000
Meat, of swine, hams, shoulders and cuts thereof, with bone in, frozen	20322	1.000
Meat of swine, N.E.C. in in item no. 0203.1, frozen	20329	1.000
Offal edible, of swine, fresh or chilled	20630	0.347
Offal edible, of swine, livers, frozen	20641	0.347
Offal edible, of swine, other than livers, frozen	20649	0.347
Meat, salted, in brine, dried or smoked, of swine, hams, shoulders and cuts thereof, with bone in	21011	1.000
Meat, salted, in brine, dried or smoked, of swine, bellies (streaky) and cuts thereof	21012	1.000
Meat, salted, in brine, dried or smoked, of swine, N.E.C. in in item no. 0203.1	21019	1.000

Production data

We obtained production data for 2015-2017 from the quarterly reports on slaughtered animals that the Brazilian Institute of Geography and Statistics (IBGE) produces. These reports provide statistics on the numbers of pigs slaughtered in each Brazilian state and the municipality in which the pigs were raised[1]. We used data from the Federal Inspection Service's Information Management System

[1] We avoided using IBGE´s municipal animal production data, because it only reports the size of the herd as of 31 December. This would underestimate pork production because, given their short life cycles, more pigs are slaughtered in any one year than are ever alive at any specific moment in time in that year.

(SIGSIF) to link slaughterhouses with production municipalities, given that all exports of pork are inspected by the Federal Inspection Service (SIF).

We calculated carcass weights using state-specific and year-specific data, dividing the IBGE quarterly slaughter survey data (i.e. total tonnes of pig carcasses per state) by the number of slaughtered pigs (IBGE 2019). Where carcass or slaughter data were missing (as was the case for some States with low levels of production), we used the nationwide average carcass weight per quarter.

Supply chain data

Asset data

The National Registry of Legal Entities (CNPJ) provides the data we needed to identify all the assets — such as farms, slaughterhouses, warehouses, etc. — owned by a given exporter, and all the assets associated with a given activity, such as pig slaughtering or pig breeding.

Slaughterhouses

The Ministry of Agriculture, through its Federal Inspection Service (SIF), provides a list of inspected slaughterhouses (a subset of the total) and which slaughterhouses meet international sanitary requirements

Transportation data

We used the transportation network data from the Ministry of Transport.

Company data

We used the National Registry of Legal Entities (CNPJ) for company data. This enabled us to link customs records with taxation records, and to identify the subsidiaries of the main traders (e.g. BRF or Seara), which we then combined into corporate groups according to their parent company.

Boundaries

The model's municipal boundaries are based on 2017 data from the Brazilian Institute of Geography and Statistics (IBGE).

SEI-PCS implementation

Pork supply chain mapping

We used a logic-based decision tree to link exports back to slaughterhouses and municipalities of production. The decision tree allocated exports to logistics hubs based on a series of conditional rules. It triangulated information in the customs data against asset-level tax registration numbers.

This made it possible to link exports to assets in production municipalities where assets are linked to production activities (e.g. pig breeding) or linked to logistics hubs — slaughterhouses e.g. pig slaughtering operations, and association to a slaughterhouse that is SIF-registered and can therefore export pork. Where more information was needed, we used other datasets including export

permissions per asset and country, Ministry of Trade data on the Brazilian State of production, as well as SIF information on pig slaughtering per state.

By constraining the observed trade data to meet these conditions, we found linkages to specific slaughterhouses for more than 95% of pork exports in volume. We labelled exports as having an 'unknown source of origin' if we could not link them to a slaughterhouse.

Once the link between exports and specific slaughterhouses was made, we used SIGSIF data to identify the municipalities in which the pigs were reared. Often industrial production breeding and slaughter occur in the same facility and/or municipality. In a small number of cases the link between slaughterhouses and the municipalities where the pigs were reared is not straightforward, for example where SIGSIF reported more than one possible municipality of production. In these cases we used optimisation techniques to estimate the flows from candidate municipalities of origin. The optimisation used linear programming techniques, maximizing the flows from municipalities where the trader has taxation records associated to pig production/slaughter/wholesale activities, minimising the overall distance between the municipalities in which the pigs were sourced (supply nodes) and the logistics hubs – the municipalities of slaughterhouses (demand nodes).

Deforestation embedded in the soy feed consumed by the pigs

We used an optimisation approach using linear programming techniques to link the municipality of origin of domestic soy (as per Trase´s SEI-PCS Brazil soy v2.5.0 analysis) with the municipalities in which the pigs were raised according to SIF. This was done through a simple optimisation of distances, using linear programming techniques, minimising the overall distance between the municipalities of soy production (supply nodes) and the municipalities that demanded soy for animal production, including pork (both for exports and domestic consumption) chicken, beef, eggs, dairy and aquaculture. Supply nodes were constrained by soy for domestic consumption, available from Trase's sub-national supply-chain mapping of Brazilian soy exports (SEI-PCS Brazil soy v2.5.0). Demand nodes were constrained by both demand for soy from all animal production, including chicken, beef, eggs, dairy, and aquaculture. Data on this demand was obtained by considering total production per municipality from IBGE and aggregated consumption of soy per animal and year from the National Union of the Animal Feed Industry.

Subnational and company sustainability indicators

Once we had allocated soy from municipalities of production to pig rearing, we also applied the ratios of this volume allocation to municipal sustainability indicators associated with soy production, such as deforestation and carbon emissions. These indicators therefore provided a measure of soy deforestation and soy carbon emissions embedded in the feed consumed by pigs for exported pork.

The Trase indicator manual for Brazil describes the data sources and methods to calculate these municipal level sustainability indicators including soy feed deforestation risk and cover agriculture, environment, territorial governance, actor commitments, and socio-economic and contextual indicators (e.g. biomes).

Changes from previous version(s)

Version	Publication date	Changes
2.0.1	June 2020	• The version includes revised soy deforestation risk for feed (as per update to Brazilian soy 2.5.0). Exporter trader names have been cleaned to better reflect mergers and acquisitions.
2.0.0	December 2019	• First release

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Annex: Glossary

Term	Definition	Example
Asset	In the context of Trase, a physical or material resource owned by a business or an economic entity that relates to the production, storage or processing of a commodity.	Soy silo, slaughterhouse, refinery, mill, farm.
Commodity equivalent	Measure used to relate the trade flows of different products to a commodity equivalent. This is obtained by using the commodity equivalence factor.	Soy oil and cake products are converted into soybean equivalents.
Commodity-equivalence factor	Factor used to convert the amount of a product into a commodity equivalent.	1 kg of soy meal and oil are equivalent to 1.031 kg of soybeans (3 g are waste).
Decision tree	Outlines the conditional filtering of trade data in order to link commodity exports to a logistic hub.	Each supply chain map manual contains a figure of their respective decision trees.
Distance matrix	The distances between different demand and supply nodes. This is used in the linear programming step to solve the problem of minimising the total distance incurred in meeting all of the demand.	Supply nodes are jurisdictions of production. Demand nodes include exports from ports and domestic demand nodes such as chicken farms for Brazil soy. Distances are based on the available road networks.
HS code	Unique code from the Harmonized System (HS) which describes the nature of the products being traded internationally.	1201: Soya beans, whether or not broken 120110: Soya beans, seed; whether or not broken
Jurisdiction	The territorial administrative units into which a country is divided.	Municipality in Brazil, kabupaten (district) in Indonesia, department in Argentina, department in Paraguay (lower resolution, with departments comprised of districts).

Linear programming	Linear programming (LP, also called linear optimisation) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships.	Use linear program to minimise the distance between logistic hubs and production municipalities.
Logistics	Activities related to the production, storage, processing, transport, trade, etc., of commodities in supply chains.	Chicken rearing, cattle slaughtering, soybean crushing, palm oil bulking, shipping.
Logistics hub	Jurisdiction containing one or more assets that are nodes in the commodity supply chain.	Municipality, department of silo location, slaughterhouse, palm oil mills.
Node	Jurisdiction, asset, trader or country representing a point of aggregation or transfer of a commodity through its supply chain.	
Supply chain	Sequence of nodes linking a jurisdiction of production to a country of import.	