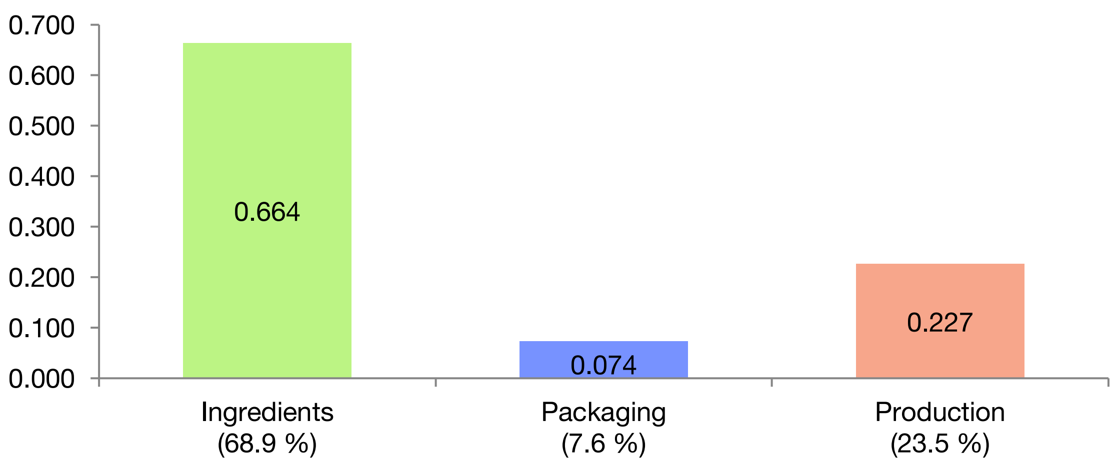
PLANET→FWD

Impossible Beef Lite

The **cradle-to-gate** (through production) greenhouse gas (GHG) emissions total is estimated to be **0.964 kg CO2e** for one unit of product, with a reference flow of 0.374 kg per unit.

What is contributing to my footprint?

The total carbon footprint of this product is 0.964 kg CO2e*. The primary components of the cradle-to-gate product-level carbon footprint are ingredients, packaging, and processing. Transport is built into ingredients and packaging and are outlined in each of the sections below.



Top Emissions Drivers

Category	kg CO2e	% of Total
Soy Protein	0.351	36.4 %
Direct Carbon Dioxide Emission - Production	0.136	14.1 %
Leghemoglobin	0.116	12.0 %
Electricity - Production	0.075	7.8 %
Liquid CO2	0.072	7.4 %

**This footprint includes emissions from other greenhouse gasses, in addition to carbon emissions. Greenhouse gas emissions measurements are normalized to carbon dioxide equivalents, CO2e, based on global warming potential.*

Ingredients

0.664 kg CO_2e

ASSUMPTIONS:

- Production and transport of the leghemoglobin is included in the ingredient emissions.

Packaging

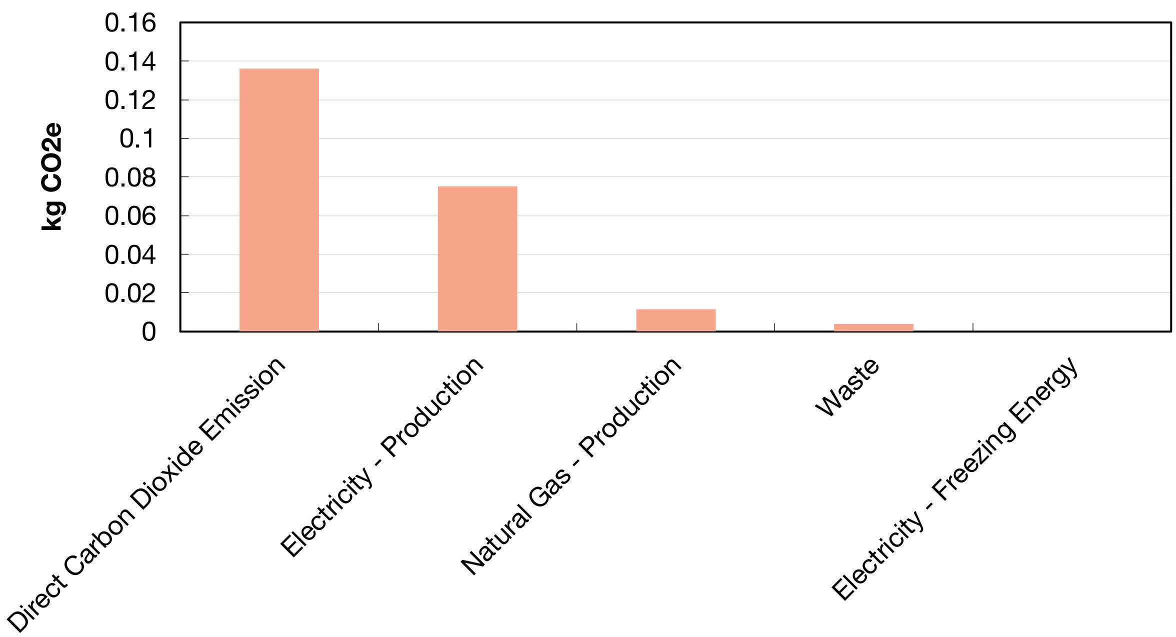
0.074 kg CO_2e

ASSUMPTIONS:

- All packaging components utilize the most aligned and appropriate match to Planet FWD's material database based off of Impossible Foods packaging specifications that were shared.

Production

0.227 kg CO2e



ASSUMPTIONS:

- Both the bulk and the finished goods production occur at a facility in Midwest, USA.
- 0.4 lbs liquid CO2 / lb of meat.
- The primary processing energy data from Impossible Foods' Oakland (OAK) manufacturing facility is used as a surrogate for the Midwest, USA facility. Additional freezing energy is added to represent average energy consumption related to ammonia freezer.
- Processing waste was assumed to be 0.8% for finished goods production.

Cradle-to-Gate Emissions Factors (including packaging):

Variants	GHG Emissions kg CO2e/kg	Water Use L/kg	Land Use m2-yr/kg
Impossible Foods Beef Lite	2.584	169	3.060
Generic 90/10 Animal-Ground Beef	18.667	1537	46.583
IF % less than Generic:	86%	90%	93%

To be labeled on-package:

Every time you eat Impossible Beef Lite (instead of **90/10 ground beef** from a cow) you are using approximately: **90%** Less Water, **86%** Less GHG Emissions, **93%** Less Land

WATER USE

Water use is defined as water consumption including blue water (the amount of surface water and groundwater required (evaporated or used directly) to produce an item) and grey water (the amount of freshwater required to dilute the wastewater generated in manufacturing as determined by state and local water quality standards). Green water (the amount of rainwater required, evaporated or used directly, to make an item) is not included.

Water use is highly dependent on the geographical region (including climate zone and moisture regime) in which a crop product is grown. The other impact category (GHG emissions) is far less sensitive to the physical location under steady-state conditions, which to a large extent allows data from specific regions to be used as representative or proxies for other regions. For example, the same crop grown in California and the Midwest could have quite different water use profiles while being similar on the other metrics, because of the different amounts of green water (i.e., rainwater) and blue water (such as groundwater) used on the farm. This report does not include water use from Clean-in-Place “CIP” during production, which could significantly impact results.

This study uses specific crop and production systems which have location-specific production data including water use. In order to characterize the water use metric more generally, water use has been modeled using average data for the US instead of data from those specific production systems. This applies to crops used as ingredients in the formulation.

LAND USE

This study quantifies land use as agricultural land occupation, which measures the area of agricultural land that is used for a certain time to produce a given product. This is a common choice in life cycle assessments (LCAs). Land use changes (such as converting forest land to cropland; also known as land transformation) and land management changes (such as changing tillage or other agricultural practices) are not included in the land use quantification.

Land use is calculated based on the annual yield for each specific crop and the quantity of that crop product used as an ingredient to produce 1 kg of the Impossible Foods Beef Lite formulation and 1 kg of the generic animal-beef.

ASSUMPTIONS:
The following assumptions were made, as agreed to by Impossible Foods.

Scope: The scope of the assessment is cradle-to-gate, including raw material extraction and processing, transportation, and production. The cradle-to-gate scope is used because of uncertainties in modeling of downstream stages, but also because they can be considered as essentially equal for all systems, Impossible Foods and other meats.

Impossible Foods Beef Lite:

- Listed in previous pages 2-4.

Generic Animal-Beef:

- Processing location: US
- Packaging material is held consistent to what is used for Impossible Beef Lite.

Reporting Requirements & Methodology

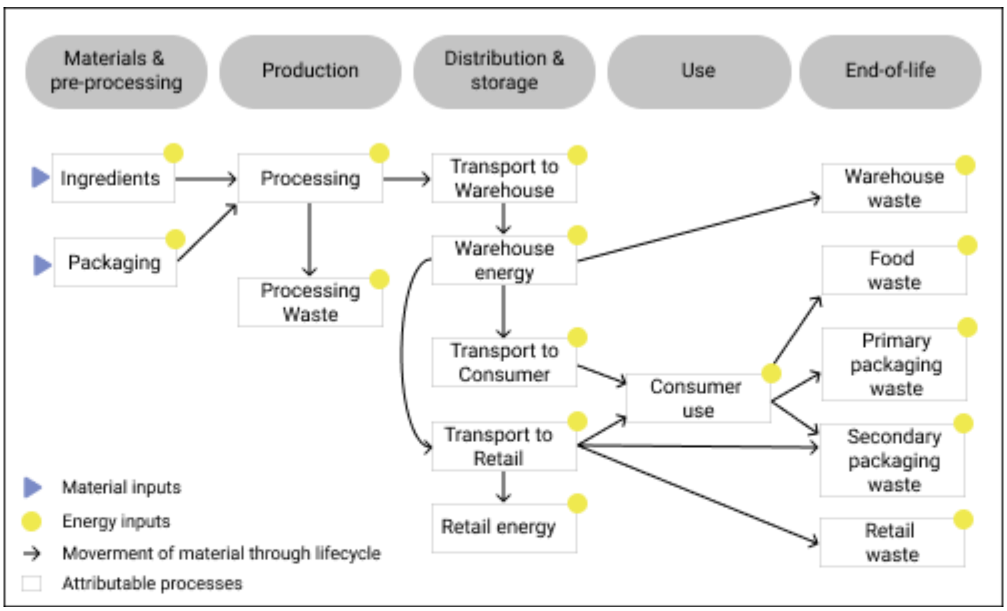
A. Goal, Scope Definition, and Assurance

This LCA is intended to describe the GHG emissions (kg CO2e) of one product to the manufacturing company for the purposes of:

(1) Identifying potential emissions reductions
(2) Communicating GHG emissions impact of a product to customers and the general public
(3) Quantifying product emissions to offset emissions through carbon credits

The results should not be used for comparison with other product's published GHG emissions numbers, due to potential differences in scope and methodology. To be used for comparison purposes, both LCAs must undergo a critical review process to evaluate the comparative assertion.

The **functional unit** for the LCAs is one unit of product. The **reference flow** is 0.374 kg. The **system boundary** is cradle-to-gate, starting from the extraction of raw materials and ending at the manufacturing hub for all the inputs required to create a single unit of product. Other potential emissions sources are outside the scope of the assessment.



This assessment uses the cradle-to-gate boundary to meet industry norms for labeling. Since product producers do not control downstream distribution, consumer use, and end-of-life, many industry reports do not include these components.

Assurance and Critical Review

This study has undergone critical review through independent internal experts at Planet FWD.

LCA commissioner: Impossible Foods Inc.
LCA practitioner: Weichang Yuan
Reviewer: Miranda Gorman
Assurance type: First party (Planet FWD)
Level of Assurance: Limited assurance

Summary of Assurance process: All methodology and individual reports go through an internal critical review process by an independent internal expert in accordance with GHG protocol requirements.

> “In the opinion of the assurance provider the reporting company’s assertion that the inventory product’s emissions are 0.964 kilograms CO2e is fairly stated, in all material respects, and is in conformance with Planet FWD’s product LCA methodologies, which are in conformance with the GHG Protocol Product Life Cycle Accounting and Reporting Standard with the exception listed in section 1 (separate reporting of biogenic emissions and carbon contained in the product not released during waste treatment).”

Relevant Competencies of Assurance Providers:

- Assurance expertise and experience using assurance frameworks
- Knowledge and experience in life cycle assessment and GHG corporate accounting
- Knowledge of the company’s activities and industry sector
- Ability to assess the emission sources and the magnitude of potential errors, omissions and misrepresentations
- Credibility, independence and professional skepticism to challenge data and information

Explanation of how any potential conflicts of interest were avoided: The assurance provider was not included in the project except for the assurance process. There is no disciplinary or economic dependence involved.

B. General Methodology

B.1 Standards

The LCAs are guided by the following international standards: ISO 14040/14044; and GHG Protocol Product Standard. This study has been conducted according to the requirements of ISO 14040/14044. The report follows all methodology and reporting requirements of the GHG Protocol Product Standard with the exception of separate reporting of biogenic emissions and carbon contained in the product that is not released during waste treatment. This information is available upon request, but it is not reported automatically due to limited relevance for the entity's business purposes and the increased burden of reporting.

B.2 GHG Emissions Equivalency and Global Warming Potentials

The GHG emissions calculated in this study are reported as kg CO2e and include CO_2, CH_4, N_2O, and HFCs. Global warming potentials for greenhouse gasses are based on the IPCC Fifth Assessment Report (AR5) (Global Warming Potential Values).

B.3 Data collection and selection

Primary data is used whenever practicable. Primary activity data is required for material inputs. Further specifications for each life cycle stage can be found in section C Lifecycle Stage Methodology.
For inputs that are less than 5% of the mass of a product, data for similar resources may be substituted. For processes with limited data available, assumptions are made based on the best available data. As such, the study favors completeness, in keeping with the goals of this study. More accuracy may be achieved by collecting additional primary data in subsequent reports.

The data sources used are continually being updated based on the latest research and new data availability. Planet FWD evaluates data from many different reliable sources such as peer-reviewed publications in renowned journals, government agencies and high quality LCA databases to ensure reliability of our outputs. When multiple high quality data sources are available, an average is used to ensure completeness. If quality data sources are not available, proxy data or modeling methods are used to represent the activity.

B.4 Transport

Transport is calculated using maps.google.com for road transport distances when there is no waterway between start and end points. When a water system is crossed, ocean transport distances are calculated using seadistances.org and is augmented with any road transport using above methods to get from start to end points. Emissions factors are described here and for cold transport, augmented with fuel demand required for refrigeration/freezing with data from Energy Star.

Emissions factors are described here and for cold transport, transport emissions are increased due to an increase in fuel use to power refrigeration units, as well as direct leakage of refrigerants. Leakage rates from refrigerated transport are highly variable and poorly documented, because they are largely under the regulated volume, so there is some uncertainty associated with this estimation, though ranges are within the indicated guidance from GHGP (see Table 2). Unless specific details are provided, the refrigerant used in refrigerated transport is assumed to be R404A, and global warming potential (GWP) is calculated accordingly.

B.5 Allocation

Planet FWD uses an attributional approach for carbon accounting, as laid out within ISO 14067 and the GHG Protocol. The attributional approach calculates the carbon impact of the individual components of the product, such as individual ingredients and packaging materials, which are then compiled to develop the final emissions value for the overall product.

Planet FWD carbon assessments allocate resource use and emissions between co-products by using mass-weighted economic value or a biophysical measure (such as mass, energy or nutrition content) as appropriate. Mass-weighted economic value has proven to be the most reliable method of allocation in many real-world scenarios, particularly for product systems that produce highly dissimilar co-products.

Recycled and upcycled materials are modeled using the "recycled content" method which allocates the costs and benefits of recycling to the original production of the material; the system boundaries are drawn such that the system that produces the recyclable waste is responsible up to the point of delivering the waste to a secondary production process or recycling facility, and then any subsequent transport, processing and use of that material is included within other systems that use the material in some form.

B.6 Capital goods
The production of capital goods such as buildings and equipment used in the product lifecycle is excluded from the LCAs. This is a common practice in product LCAs.

B.7 Non-product outflows
Both solid waste and waste water streams are modeled in detail based on methodologies and parameters adapted from IPCC tier 1/2 for a broad range of industries. Solid waste modeling includes aerobic/anaerobic landfilling, incineration, composting, and recycling/reuse. Waste water modeling includes aerobic and anaerobic treatments. Methane and energy recovery options are included with waste processing steps. Recycling is modeled as described in section B.5

Other types of outflows that may be useful elsewhere, such as manure from animal systems, are considered to be co-products. The product systems that use the material, such as organic crop systems that use manure as a substitute for fertilizers, are credited for avoiding the resource use and emissions associated with fertilizer manufacture; these systems also incur emissions associated with applying manure and subsequent nitrous oxide emissions from the soil.

B.8 Parameter and Model Uncertainty
In addition to the descriptions specified, parameter uncertainty exists where emissions factors are based on averages from industry samples, and model uncertainty exists in agricultural models (following GHG Protocol Agriculture Guidance). Planet FWD addresses these uncertainties by conducting sensitivity analysis and reviewing areas of high uncertainty.

C. Life-cycle Stage Methodology

C.1 Ingredients and Packaging - Material Acquisition and Pre-processing

- Definition: Materials acquisition and pre-processing are the embodied emissions of raw materials and inputs to production and packaging, including secondary packaging for distribution where applicable. It also encompasses inbound transportation of raw materials however it may not include emissions from packaging of raw materials (this information is estimated to be insignificant and is often unavailable).
- Data Sources and Methodology
    - Primary activity data (materials, material mass, origin location, and other characteristics) are provided by product producers (the company)
    - Emissions factors are sourced from the CleanMetrics CarbonScopeData life-cycle inventory (LCI) database.
    - Transportation of materials to the production site are calculated using the methodology outlined in section B.4 Transport Methodology.

  - Where indicated, soil carbon change as a result of land-use practices are included in the inventory results following GHG Protocol Agriculture Guidance and IPCC Guidelines (2019 Refinement) Tier 1 calculation methodology.
- Data Quality: For ingredients we use the closest match to our database based on agricultural category and ingredient form. For packaging, we use the closest material in our database. For inputs that are more than 5% of the mass of a product, if a required match is not available in our database, we create that entry based on LCI standards & methodology. Geographical variation is taken into account as an average when peer-reviewed published data is available for multiple geographies. For any pre-processing steps location-based grid information is used at the level of granularity accessible. Data quality can be improved by collected supplier-specific data for significant materials.

C.2 Production
- Definition: Emissions from energy usage are the direct emissions from outputs of manufacturing processes and emissions from waste generated during the manufacturing process. It does not include embodied emissions of manufacturing equipment.
- Data Sources and Methodology
  - The CarbonScopeData LCI database provides a number of unit processes to model commonly used food processing and cooking methods and are composed of the average energy demand of the machinery/equipment required to perform each process. Production methods in the LCAs are modeled using one or more of these unit processes as building blocks in conjunction with the appropriate electric grid for the processing location.
  - Energy sources used in these production methods include electricity from the local grid (assumed to be the US average grid) and other fuels. The emissions factors for these energy sources are based on data from IEA for international energy demand and USEPA data (available at USLCI) for domestic grid emissions footprints. An emissions factor of zero is assumed for the portion of energy that is attributable to renewable energy sources.
  - Non-product material outflows are described in section B.7. When non-product material outflow (waste) data is not available from the user a default of 5% is used, which is an average value for pre-consumer food loss as found by NRDC .
- Data Quality: If primary data is provided by the customer on any processing energy use, that is used over secondary data from the methods described above. For unit processes, we use the closest match to our database and if an entry is not available in our database, we create that entry based on LCI standards & methodology.

C.3 Distribution and Storage
- Definition: Distribution and storage consist of transportation of finished product to warehouse and retail outlets, emissions from energy usage, emissions from refrigeration and refrigerants used in product storage and transportation, and emissions from waste generated during distribution and storage.
- Data Sources and Methodology
  - Transportation of materials to distribution & storage locations are calculated using the methodology outlined in section B.4 with primary data on locations when available. If multiple locations exist, a weighted average based on production distribution is used to account for the variability in distances. If primary data does not exist, reasonable approximations based on country size and expected distribution radius are used.
  - For non-refrigerated shelf stable products, the energy use at the warehouse & retail locations is considered negligible & omitted from the analysis.
  - If there is refrigeration or freezing, the volume of the product as well as the average time it is in storage at the warehouse/distribution center is required to calculate the carbon footprint of the product warehousing phase. For warehouses, given the low probability

of HFCs and other high GWP refrigerants (Burek & Nutter, 2019) emissions are calculated based only on energy consumption.
        - For warehouses and distribution centers, natural refrigerants, primarily ammonia, are the most predominantly used (Burek & Nutter, 2019); because ammonia has a GWP of 0, any leakage is not considered, and emissions are calculated based only on energy consumption.
        - For retail locations, most refrigerants use HFCs and therefore leakage is included in emissions calculations in addition to emissions from energy consumption. The leakage rate is estimated based on the profile of an average U.S. supermarket (USEPA). The average emission of refrigerant is calculated based on kg of refrigerant per kWh of electricity, and is estimated based on data from U.S. EIA, 2012. A leakage rate of 25% is assumed, fitting into the range from GHGP and IPCC (Table 2). Electricity consumption is calculated based on ENERGY STAR data. For display cabinets specifically it is assumed 50% of the volume is not occupied.
        - If the product is fresh, we seek primary data from the warehouse management team; however if that data is unavailable, food loss can be estimated by USDA data or UN SDG Indicator 12.3.1. Secondary packaging that would be disposed of at retail locations are allocated to landfill or recycling with EPA values as defaults.
- Data Quality: When primary data is available for transportation distances, energy consumption and waste, that data is used. For times when secondary data is used, the methodology described above is followed. Geographical variability is expected to be at the country level and captured by using UN SDG Indicator data.

C.4 Use
- Definition: The use phase consists of emissions from product use by the end user and emissions from waste generated during product use. This includes energy use of appliances and other equipment needed to provide utility of the goods and excludes emissions from the manufacturing of these appliances and equipment.
- Data Sources and Methodology
    - Energy usage of sold products over their expected lifetime are modeled based on *product use instructions, energy demand of appliances, US household appliance distribution, and energy usage emissions factors*
    - *Product use instructions* (e.g. cooking time, water volumes, refrigeration space) are provided by the product producers (the company) Primary data for product use instructions are highly recommended. When primary data is not available, a reasonable approximation can be made on use instructions.
    - *Energy demand of appliances:* Appliances include ovens for baking/roasting, smaller convection ovens or toaster ovens, multiple methods for boiling water, microwaving, refrigeration, and more. The appliance type must match the stated use instructions and if that does not exist, a new appliance is added to our database. Data are collected from various sources, including Energy Star, the US EPA, and peer-reviewed journal articles (e.g. Oberasher et al., 2011; Hager & Morawicki, 2012).
    - *US appliance distribution:* Data from the EIA Residential Energy Consumption Survey to determine on average what proportion of the required appliance runs on what type of fuel: electricity, natural gas, propane, or other).
    - *Energy usage emissions factors:* The emissions factors for these energy sources are based on US EPA data (USLCI) for domestic grid emissions footprints and IEA for international energy usage. An emissions factor of zero is assumed for the portion of energy that is attributable to renewable energy sources.
- Data Quality: Data has good technological, temporal, and geographical representativeness, good completeness and fair reliability. Data quality is limited by lack of knowledge for specific

appliance types, energy usage, and grid emissions for the subset of the population that uses the company's products, but is representative of overall US usage.

C.5 End-of-Life

- Definition: Emissions from product and/or packaging disposal at end of life.
- Data Sources and Methodology:
  - End-of-life assumptions for primary packaging materials are based on documented consumer behavior in the relevant region.
  - Landfill, recycling, and composting rates of typical materials in the US are based on US EPA Sustainable Materials Management Data. International data are based on the World Bank What a Waste 2.0 study. Specific materials may be pulled from additional studies. Emissions factors for various end-of-life forms are from IPCC and EPA.
  - Food waste assumptions are from USDA ERS and NRDC.
  - Secondary packaging materials discarded during processing, distribution, and retail facilities are assumed to have landfill diversion rates of 80% at retail, in keeping with reporting from Walmart, Costco, Kroger, and Target. Recyclable materials (paper and board, metals) are recycled at this rate, and any non-recyclable materials (soiled papers, etc.) are assumed to be sent to landfill.
- Data Quality: Data has good temporal, good geographical, and poor technological representativeness. In aggregate, the data has good completeness and reliability. Data quality is limited by lack of knowledge of behaviors and end-of-life processing for the subset of the population that uses the company's product, but is representative of overall US usage and would be difficult to improve. Data quality could be improved by surveying the company's consumers about their specific end-of-life behaviors.

C.6 Data for Significant Processes

Data for processes that contribute more than 5% of the total emissions are available upon request. See above life cycle stage notes on data quality and methods to improve data quality.

Questions? Contact us at:

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