Scope 3 Emissions from Business Travel

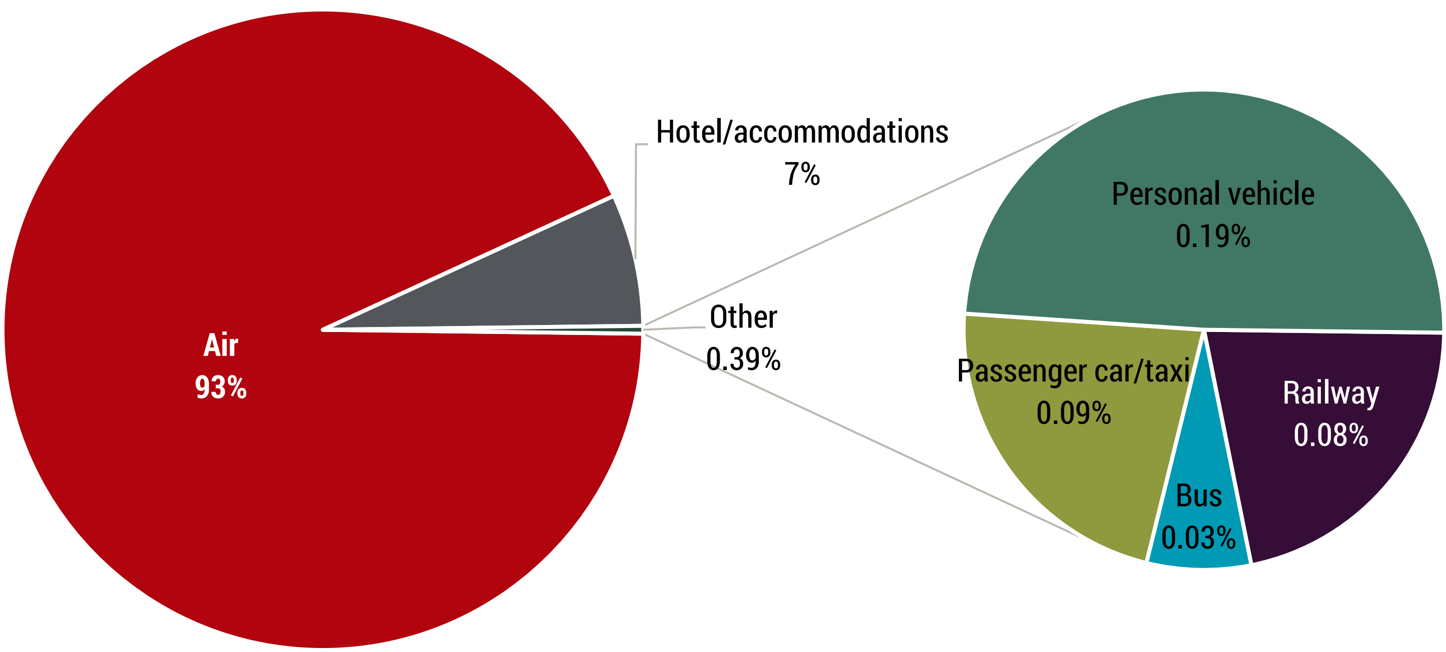
Category Overview: Definition, Boundary, Methodology, and Preliminary Results

Executive Summary

Business travel emissions are calculated on a regular basis for Stanford University by the Scope 3 Emissions Program in Business Affairs. This paper details the boundary and methodology for developing baseline business travel emissions for calendar year 2019. More information on the Scope 3 Emissions Program and baseline calculations in other scope 3 emissions categories can be found in the Stanford University CY2019 Scope 3 Emissions Program Description & Inventory.

Business travel emissions at Stanford include greenhouse gas emissions from all university-sponsored travel by all modes, including air travel, lodging and ground transportation. As quantified to date, business travel emissions represent the second highest scope 3 emissions category but remain lower than combined scope 1 & 2 emissions (both current and peak) and scope 3 emissions from student travel. In 2019, business travel emissions comprised approximately 17% of Stanford's currently quantified total carbon footprint, and 22% of Stanford's currently quantified scope 3 emissions. The breakdown of Stanford's emissions in the business travel category between air travel, lodging, and ground transportation is illustrated in Figure 1.

Figure 1. Breakdown of Selected Business Travel Emissions by Transit Mode using Combination of Tools



The emissions from air travel are based on an internally developed methodology including the following steps:

- Data collection for all university purchased or reimbursed trips including departure and arrival airport codes
- Calculation of flight distance for each trip based on airport codes

- Application of greenhouse gas emission factors based on flight distance
- Application of a radiative forcing factor that captures increased global warming potential of emitting greenhouse gases higher in the atmosphere

Emissions for lodging and ground transportation were determined using unit-based emissions factors to the extent possible. Emissions calculations for lodging apply emissions factors to the total number of room nights purchased by Stanford in 2019. Emissions for ground transportation apply distance-based emissions factors for bus and railway transit, but use spend-based emissions factors for all car transport.

Changes to the university's new spend intelligence initiative and refinements to the Stanford Travel Program will enable future modifications to this process that should both streamline data collection and improve accuracy. Additionally, these changes will allow for the use of unit-based emissions factors as much as possible.

Category Definition

Scope 3 emissions from business travel are defined by the WRI Greenhouse Gas Protocol as "transportation of employees for business-related activities in vehicles not owned or operated by the reporting company."[1] Emissions from travel in vehicles owned or operated by the reporting company are classified as scope 1 emissions.

At Stanford, we have expanded this definition to include all university-sponsored travel for students and visitors. This is an exception within higher education that does not typically apply in other industries. In addition, we include emissions associated with lodging while on business travel, which is listed as optional in the Greenhouse Gas Protocol.

Boundary

Based on the category definition laid out above, all travel funded by the university is included in this category, except for scholarships or stipends provided to students for travel to/from home or study abroad locations. This includes the cost of air travel and ground transport funded via both travel cards (Tcards) or reimbursements. Because mitigation strategies for student travel differ significantly from those for university-sponsored travel, the Scope 3 Emissions Working Group resolved to account for student travel emissions as a separate category within the university's scope 3 emissions reporting. For that reason, this whitepaper will exclude emissions from student travel. Table 1 illustrates common traveler types and funding sources and the respective scope 3 categories to which they have been assigned. Finally, the boundary also covers all relevant greenhouse gas emissions, which include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Table 1. Scope 3 Emissions Category Designation by Traveler Type & Funding Source

Traveler Type & Funding Source	Business Travel	Student Travel	Other Scope 3 Category or Excluded
Employee travel directly funded by university or reimbursed	✓		
Employee travel funded by others			✓

[1] Greenhouse Gas Protocol. "Technical Guidance for Calculating Scope 3 Emissions." World Resource Institute. 2013. https://ghgprotocol.org/sites/default/files/standards/Scope3_Calculation_Guidance_0.pdf

Student travel directly funded by university (i.e., student researchers, student athletes)	✓		
Visitor travel directly funded by university	✓		
Student travel to/from main campus, funded by students and families, scholarships, or stipends		✓	
Student travel for study abroad programs, funded by students and families, scholarships, or stipends		✓	
Student intra-quarter travel (leisure, trips during abroad programs)			✓
Parent/other student visitor travel (Convocation, Commencement)			✓

Calculation Methodology

Scope 3 emissions are notoriously difficult to quantify accurately due to their indirect nature, which makes it difficult for institutions to ascertain accurate input data and emissions factors. When data and emissions factors are not perfectly accurate, assumptions need to be made that can dramatically influence the magnitude of the emissions. Thus, in any given scope 3 emissions calculation, there may be a significant margin of error.

For example, some calculation methodologies use spend data as the primary input, and therefore deploy corresponding spend-based emissions factors. These are convenient if the data is only available in dollars, which often occurs because the data is pulled from purchasing platforms that do not automatically track other metrics. On the other hand, other calculation methodologies do incorporate more detailed input data based on the relevant units for each category; for example, for business travel, the most relevant unit is passenger miles traveled. These methodologies in turn deploy distance-based emissions factors that are widely considered to be more accurate.

To experiment with different calculation methodologies and attempt to quantify the margin of error between them, we elected to use three distinct approaches to quantify emissions as applicable to each category. The approaches are explained below.

- **Internal calculations:** To the extent that publicly available emissions factors could be identified for each category, sustainability staff and student researchers applied these emissions factors to the data collected to generate emissions estimates internally.
- **The Sustainability Indicator Management & Analysis Platform (SIMAP):** Created by the University of New Hampshire, the SIMAP tool helps universities quantify emissions in scope 1, 2, and some scope 3 categories that are particularly applicable to higher education, including commuting, business travel & study abroad, student travel to/from home, food, paper, and waste & wastewater. The tool is publicly available for a minor membership fee of $600 per year.
- **VitalMetrics Carbon360 Platform:** Carbon360 is a proprietary, cloud-based solution developed at the University of Santa Barbara and now owned by VitalMetrics. The tool pulls emissions factors from a combination of databases to make it simple for customers to calculate scope 1, 2, and 3 emissions across the fifteen categories defined by the GHG Protocol. This tool cost Stanford $10,000 in its first year to employ.

For business travel, these three approaches were all used to quantify emissions for both air travel and ground transport. On the other hand, only the internal calculations and the VitalMetrics Carbon360 platform were able to calculate emissions from lodging. The process of collecting, cleaning, and preparing this input data is delineated in the "Data Collection & Analysis" section below. A summary of the methodology and outputs for each tool are described in the subsequent "Tool Details & Outputs" section.

Data Collection & Analysis

In 2020, the Office of Sustainability calculated emissions for air travel, lodging, and ground transport, as described below. Historically, only emissions from air travel had been quantified. Additionally, the Office of Sustainability made some changes to the methodology for quantifying air travel, all of which are discussed below. While the current process is more accurate than the historical process, it also presents a reporting challenge if emissions from years prior to 2019—which were calculated using a simpler methodology—are to be included in the program's ongoing reporting.

Air Travel

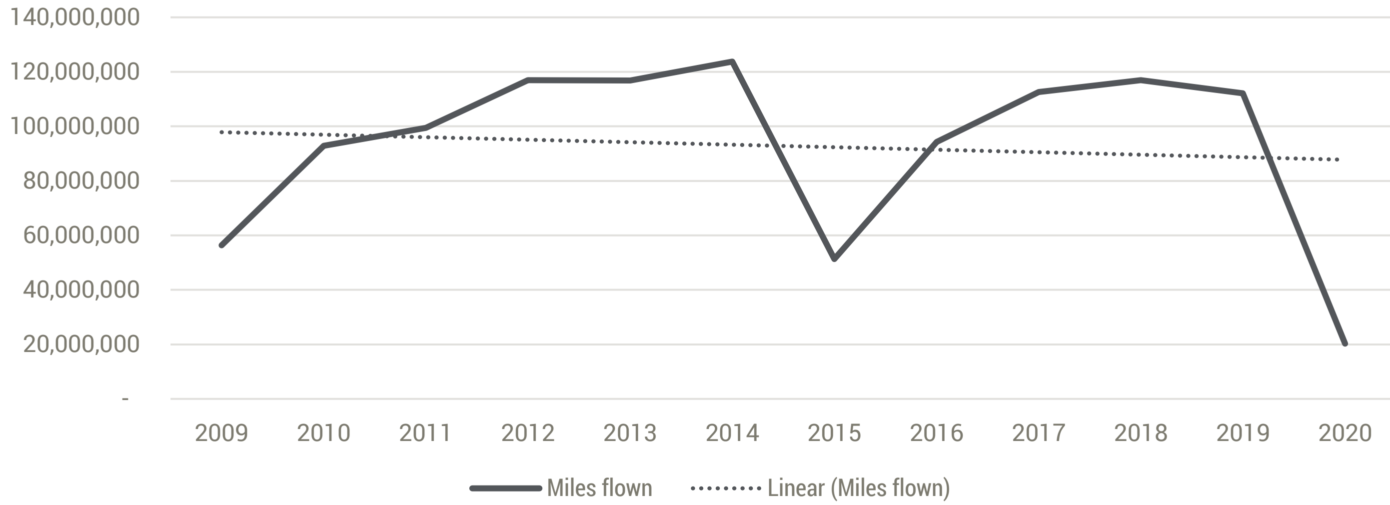
Since 2009, Financial Management Services (FMS) has pulled an annual report titled "Air Travel CO2 Emissions Report" from the Oracle Business Intelligence (OBI) database. This report includes the transaction number, flight cost, departure date, departure airport code, destination airport code, department, expenditure type code, and the expenditure type description. For calendar year 2019, the report included all travel from January 1, 2019 through December 31, 2019.

The data for the report is generated based on at least one of the following steps:

- If flights are purchased using a credit card, the spend data is provided by banks and input into Oracle. It incudes airport codes for departure airport, destination airport, and any layovers to the extent possible.
- Air expenditures are all classified under the same expenditure type code
- The administrative guide requires that all employees record departure and destination airports for all flights purchased in the business purpose justification description for each trip

The data in this report is then run through a script developed by Stanford Transportation to calculate the mileage of each trip based on the departure and arrival codes. The total miles flown by year since 2009 are illustrated in Figure 2.

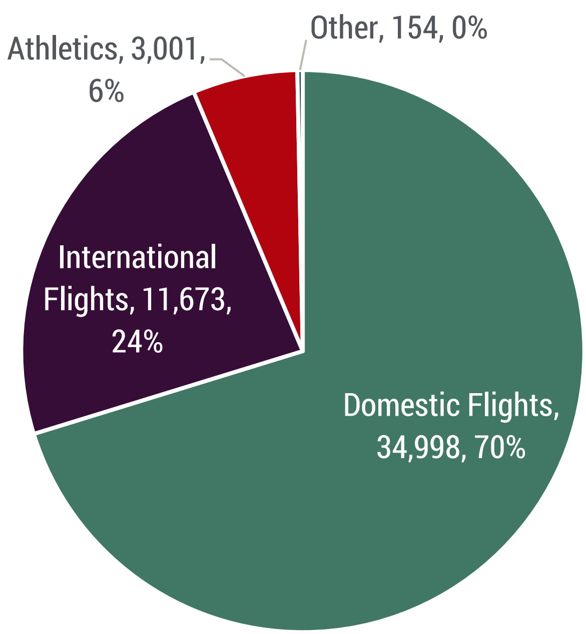
Figure 2. Annual Miles Flown for University-Sponsored Trips



The volatility of annual miles flown, as shown in Figure 2, is notable. This volatility likely derives from a combination of changes to tracking systems, lack of thorough data cleaning, and actual changes in travel patterns. A new requirement in 2020 for employees to book all business travel through the Stanford Travel program, with Egencia as the primary vendor, will allow for more consistency in data tracking that should help us better understand travel trends over the long-term.

For 2019, this entire process encompassed 49,826 flights totaling 112,120,534 miles and $15,240,286 of flight expenditures. Figure 3 shows the breakdown of these flights across expenditure descriptions.

Figure 3. CY2019 Number of Flights by Expenditure Description



Ground Transport & Lodging

FMS also provided data for ground transport and lodging emissions for calendar year 2019. FMS pulled the data from multiple financial databases provided it to the Office of Sustainability in an Excel spreadsheet. The data encompassed expenditures via credit cards, invoices, and reimbursements. An expenditure code filter and/or keyword search were performed on each type of data before providing it to the Office of Sustainability to filter it for travel-related expenditures. This process inherently leaves room for error, especially in the keyword search feature which typically relies on the business purpose text submitted by the traveler that may or may not contain all the relevant information.

Next, Office of Sustainability staff further sorted the data set manually to identify relevant expenditures and sort them by travel type. This was a time-consuming process that also has a high likelihood for error based on the manual nature of the process and the lack of clarity in many of the text entries regarding mode of travel.

The entries were manually sorted into the following travel types.

- Railway
- Bus
- Rideshare/taxi /rental car
- Personal vehicle

The ground transport mode types include ground transport both while traveling and to/from the traveler's home airport.

Lodging

To identify the correct mode, further keyword searches were deployed for words associated with each category, such as "train," "bus," "taxi," "uber," etc. The only exceptions were the personal vehicle and lodging categories, which both relied solely on coded expenditure type descriptions, such as "Mileage" and "Parking" for personal vehicles and "Lodging" and "Hotel Expenses" for lodging. Among the ground transport mode types, there were 55,905 data entries that clearly indicated the mode type out of 138,125 total data points provided by FMS.

To calculate mileage for each trip, the number of trips for each mode type was multiplied by an average distance. For railway, bus, and personal vehicle trips, the number of trips was multiplied by the national average distance to the airport[2], since most trips by these modes were described as transport to/from the airport. The mileage was then multiplied by two to cover trips both to and from the airport. For rideshare/taxi/rental car trips, the number of trips was multiplied by the national average taxi trip distance.[3]

For the mode types that are not clearly associated with expenditure type descriptions (railway, bus, and rideshare/taxi/rental car), the same mode split between the 55,905 sortable entries was then applied to the remaining 82,220 unmarked entries to extrapolate mileage by mode for all ground transport data entries.

Because the lodging category was more directly linked to coded expenditure types, there was no extrapolation necessary. In fact, most vendors who provide Stanford with lodging data, including JP Morgan and credit card issuers, provide fairly robust reporting on lodging details, including room nights. For CY19, these vendors reported 63,189 room nights purchased, totaling $13,658,451, which represents 56% of the $24,196,302 of total lodging spend. On the other hand, for Expense Reimbursements

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[2] Pearson, Mark. "How Far are People on Average from Their Nearest Decent-Sized Airport?" 2012. https://www.mark-pearson.com/airport-distances/

[3] Schaller Consulting. "Taxi Fares in Major U.S. Cities." 2006. http://www.schallerconsult.com/taxi/fares1.htm

(ERS) (where travelers have used their personal credit cards and subsequently submit a reimbursement request), there is less clarity on lodging details and room nights. It is possible that lodging details get combined with other expenditures (such as meals or transportation) as a single line item on an expense request, although this practice is discouraged. Thus, the 44% of lodging spend for which room nights are not reported directly may be less accurate. To generate room nights from this data, the average spend per room night was calculated to be $216.15 per room night based on the 56% of total lodging spend for which room nights were reported. This average was applied to the remaining $10,537,851 lodging spend to generate an estimated 48,752 additional room nights, for a grand total of 111,941 room nights in CY2019.

Tool Details & Outputs

Internal Air Travel Calculations

Historically, the script developed by Stanford Transportation calculated emissions using an average emissions factor of 0.227 kg CO2e per passenger mile. For 2019, the Office of Sustainability began pulling the mileage from the report and using publicly available emissions factors from the U.S. Environmental Protection Agency (EPA) to calculate emissions. These EPA emissions factors are not only more recent, but they also account for varying airplane fuel efficiency for different flight lengths, as shown in Table 2. These emissions factors take into account aircraft fuel burn by size of plane, freight and load factors, and average number of seats occupied by flight distance to derive different emissions factors for different flight lengths. In particular, the most fuel intensive portion of each flight is take-off. Thus, the average fuel efficiency for shorter flights is lower; for long-haul flights, the increased plane size and weight offset this and lead to higher emissions factors.

Table 2: 2020 EPA Air Travel Emission Factors

Trip Length	CO2 (kg/passenger mile)	CH4 (g/passenger mile)	N2O (g/passenger mile)	Overall CO2e (kg/passenger mile)
Short Haul (less than 300 miles)	0.215	0.007	0.007	0.217
Medium Haul (between 300 and 2,300 miles)	0.133	0.0006	0.0042	0.134
Long Haul (over 2,300 miles)	0.165	0.0006	0.0052	0.166

Each greenhouse gas is associated with a different global warming potential (GWP), as defined by the International Panel on Climate Change (IPCC).[4] The IPCC has set the GWP of carbon dioxide equal to 1 and has determined factors for all other greenhouse gases based on their atmospheric impact relative to carbon dioxide. There are several versions of GWPs.[5] Stanford

[4] Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

[5] Greenhouse Gas Protocol. "Global Warming Potential Values." https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

has elected to use the most recently released iteration from the IPCC's Fifth Assessment Report, referred to as AR5. AR5 has been used for the university's scope 1 & 2 emissions since 2018 and is now also being used to calculate scope 3 emissions.

In addition to carbon dioxide, methane, and nitrous oxide, which can be directly accounted for using the emissions factors above, other more reactive gases and particles are also emitted from the burning of jet fuel. These include nitric oxide (NO), nitrogen dioxide (NO2), water vapor, sulphates, and soot. The climate impact of these additional gases and particles is more variable and thus more difficult to quantify. Scientists have addressed this to date by proposing a "radiative forcing factor" that aggregates the variable impact of these gases and particles into a single multiplier that is applied to CO2 emissions. Emissions from CH4 and N2O are then added on top of this figure. However, there is a lack of consensus in the scientific community regarding the exact magnitude of the radiative forcing factor, as discussed in depth in our Radiative Forcing Memo. For now, Stanford uses a radiative forcing factor of 2.7, as published by the International Panel on Climate Change (IPCC) and consistent with the factor used by over 200 institutions currently reporting air travel emissions via SIMAP.

The CO2 emissions factors in Table 2 were multiplied by the number of passenger miles flown in CY2019 within each flight distance range and converted from kilograms to metric tons. The radiative forcing factor of 2.7 was subsequently applied to the total CO2 emissions. Then, the emissions factors for methane (CH4) and nitrous oxide (N2O) in Table 2 were multiplied by the gases' respective global warming potentials (GWPs) and by the number of passenger miles flown in CY2019 by flight distance and converted to metric tons. This process converts all emissions into MTCO2e so they can be added together to calculate total emissions, including radiative forcing. Notably, the GWPs for methane and nitrous oxide are both higher than that of carbon dioxide, but the magnitude of emissions is so much lower that together they add less than 1% to the overall emissions per passenger mile for air travel.

This process resulted in total air travel emissions for CY19 of 40,613 MTCO2e.

Internal Lodging Calculations

Publicly available emissions factors from U.K. DEFRA were assigned to the total number of room nights purchased by Stanford in CY2019. To our knowledge, these are the only publicly available emissions factors for lodging by room night. The emissions factor for U.S. hotel stays of 19.7 kgCO2e per room night was applied to the 76% of domestic hotel stays, whereas an average emissions factor of 46.1 kgCO2e for hotel stays across all included countries was applied to the 24% of international hotel stays.[6] In the future, this process could be improved by categorizing the lodging data by country and applying country-specific lodging emissions factors. The format of the 2019 data received did not easily allow for this, but this refinement may be possible in coming years.

This process resulted in estimated lodging emissions of 2,914 MTCO2e.

Internal Ground Transport Calculations

Publicly available emissions factors from the EPA were assigned to each transit mode, as shown in Table 3. It was not possible to distinguish from the data whether a rideshare was taken alone (i.e., UberX) or shared with someone else (i.e., UberPool), so all rideshares were categorized in the "Rideshare/taxi/rental car" category and none were accounted for in the "Rideshare/taxi – shared with someone else" category. This category has been greyed out in Table 3 for that reason.

[6] Greenhouse gas reporting: conversion factors 2021." United Kingdom Department of Environment, Food and Rural Affairs. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

This process resulted in total estimated emissions of 676 MTCO2e.

<u>Table 3.</u> Emission Factors by Transit Mode used for Internal Ground Transport Estimates

Transit Mode	Emission Factor (kg CO2e/passenger)
Railway	0.12
Bus	0.06
Rideshare/taxi/rental car	0.35
Rideshare/taxi – shared with someone else	0.17
Personal vehicle	0.35

SIMAP Air Travel Calculations

The air emissions factor in Table 4 was applied to the mileage for each flight, as well as the radiative forcing factor of 2.7. This resulted in a per flight emissions total that was summed across all trips.

SIMAP Ground Transport Calculations

Ground transport emissions were calculated using the remaining emissions factors in Table 4. These emissions factors are derived from the US GHG Inventory and the Bureau of Transportation Statistics. Note that they tend to be higher (especially for bus travel) than those published by the EPA and used internally (as shown in Table 3).

<u>Table 4.</u> Emission Factors by Transit Mode used in SIMAP

Transit Mode	Emissions Factor (kg CO2e/passenger mile)
Air (all distances)	0.16
Train	0.12
Public Bus	0.33
Taxi/Ferry/Rental Car	0.36
Personal Mileage Reimbursement	0.36

These inputs produced a total emissions output from SIMAP of 50,090 MTCO2e, across all modes of travel.

VitalMetrics Air & Ground Transport Calculations

Air and ground transport emissions were calculated using emissions factors from VitalMetrics' proprietary Comprehensive Environmental Data Archive (CEDA) database, which is the most referenced suite of environmentally extended economic input-output (EEE-IO) databases. While the ground transportation results are comparable to those generated from other methods, VitalMetrics does not include a radiative forcing factor, so air travel emissions reported by VitalMetrics are significantly lower than those resulting from the other two tools.

Finally, the Carbon360 tool can accommodate data inputs in either passenger miles or dollars spent, depending on institutional data availability. For two modes of ground transportation—passenger car/taxi and personal vehicle—the Office of Sustainability elected to enter data in both passenger miles and dollars, which provided an interesting mechanism for comparing emissions factors. Most notably, the spend-based approach for the passenger car/taxi category turns out to produce significantly lower emissions (132 MTCO2e) than the distance-based approach (611 MTCO2e). We can infer one of two things from these findings: either the spend-based emissions factor used by VitalMetrics is low (which is often the case for spend-based emissions factors), or the mileage we have calculated is artificially high based on the listed assumptions.

VitalMetrics Lodging Calculations

The VitalMetrics Carbon360 platform incorporates a spend-based emissions factor for "hotels & accommodations." The hotels & accommodations data in the CEDA database is based on a combination of 17 inputs for the accommodations sector, the largest of which are commercial structures (16.1%), real estate (6.9%), advertising (6.2%) and legal services (3.7%). Since most tools do not calculate a spend-based emissions factor for hotels & accommodations, there is little mechanism for comparison. Generally, when we divide the proportional emissions (by spend) from VitalMetrics for hotels & accommodations by the total known room nights from Stanford's data, we get 63.76 kg CO2e per room night, which is equivalent to 160 miles driven by an average passenger vehicle.

Using the spend-based emissions factors for passenger cars/taxis, and including emissions for hotels & accommodations, the total business travel emissions generated by VitalMetrics equate to 36,010 MTCO2e.

Results Comparison

Table 5 shows emissions by mode and in total in the business travel category for each tool.

<u>Table 5:</u> Emissions Summary by Mode Type and Tool

Tool	Air Emissions (MTCO2e)	Railway Emissions (MTCO2e)	Bus Emissions (MTCO2e)	Passenger car or Taxi Emissions (MTCO2e)	Personal Vehicle Emissions (MTCO2e)	Lodging Emissions (MTCO2e)	Total Emissions (MTCO2e)
Internal	40,613	37	12	193	434	2,914	**44,203**
SIMAP	49,332	37	70	185	466	N/A	**50,090**
Vital Metrics	28,258	36	11	38	94	7,137	**36,010**

Overall, there is a 75% variance for emissions related to air travel (primarily driven by the decision to include a radiative forcing factor); a 172% variance for emissions related to lodging, and a 23% variance for ground transport (both primarily driven by unit-based vs. spend based emissions factors). Values in red text are considered the most accurate and/or applicable to Stanford's boundary, with the following considerations:

- The internal methodology is the only one that uses emissions factors specific to the length of each flight. SIMAP uses an average emissions factor of 0.16kg CO2e per passenger mile for all flights but does use the same radiative forcing factor of 2.7 (although there is an option in SIMAP to switch this to the UK DEFRA value of 1.9.) VitalMetrics does not include a radiative forcing factor.
- The unit-based emissions factors for lodging seem to generate more reasonable emissions values than the spend-based emissions factors used by VitalMetrics. Even though some extrapolations were performed in order to generate comprehensive room night estimates, visibility into lodging data is likely to improve in the future, which will merit continued use of the internal methodology.

- VitalMetrics includes the ability to calculate emissions based on spend. While there is uncertainty in the field regarding the accuracy of spend-based emissions factors—and the spend-based emissions factor resulted in significantly lower emissions at Stanford than the distance-based methods—this tool should be considered as a viable alternative to making assumptions internally that may or may not be accurate. This drives the selection of the VitalMetrics values for passenger car/taxi and personal vehicle emissions.
- Railway emissions are quite similar across all tools. All else being equal, the internal methodology has been selected.
- There is a large range in the emissions factors used by the tools for bus travel. Because the emissions factors used internally and by VitalMetrics are quite similar—and because that used by SIMAP seems quite high—the internal value has been selected.

Based on the selected values in Table 5, Figure 1 in the Executive Summary displays the final breakdown of emissions by mode type in the business travel category. This figure highlights the fact that ground transport comprises only 0.39% of total business travel emissions according to this methodology. This in turn suggests that the benefit of spending time on this category may not be worth the cost. Specifically, staff time could likely be better spent elsewhere than on determining a precise methodology for ground transport emissions and re-calculating those emissions on an annual basis. To that end, we suggest an approach of re-calculating these emissions every five years. On the other hand, emissions from air travel and hotels/accommodations should both continue to be calculated on an annual basis.

Future Changes

The largest potential change to this process will be introduced this year (2021-2022) in the form of a new spend intelligence platform launched by Procurement Services that will allow for easier access to data in all spend categories, including air travel, lodging, and ground transport. Because the ground transport process involves manual work from both FMS and sustainability staff, we hope that the new spend intelligence platform will not only alleviate the time burden but will also allow for more accurate results through improved data tagging that may eventually eliminate the need to use any spend-based emissions factors.

For air travel, not only will the spend intelligence platform make accessing air travel data easier, but the new requirement to book all business travel through Stanford Travel (and the associated vendor, Egencia), will also allow for even more accurate tracking of flight data. As staff explore both the spend intelligence platform and the data available from the required Stanford Travel service, we will evaluate which data collection methods are most accurate for different modes of travel and update our methodology accordingly. For example, right now some of the air travel data sources populate the full flight path (including layovers), while others only populate the arrival and departure airports. As we evaluate new data collection methods, we will consider how layovers are recorded as one potential selection criteria.

Conclusion

Quantifying scope 3 emissions requires a careful balance of accurate input data, precise emissions factors, and relevant assumptions. In the business travel category, the input data used was the same across all tools; while the process of pulling and evaluating this data comprehensively has been sharpened since 2009, there is room for future improvement through the university's new spend intelligence initiative and recent refinements to the Stanford Travel Program. Of the various approaches to quantifying air travel and lodging emissions specifically, Stanford's internally developed methodology uses the most precise emissions factors and should continue to be used in the future.

The input data required several assumptions, particularly in the ground transport category. The VitalMetrics tool allows us to avoid making some of these assumptions by introducing spend-based emissions factors. We recommend that these spend-based emissions factors continue to be considered in scenarios where assumptions are weak or not broadly applicable, such as in the passenger vehicle/taxi and personal vehicle categories.

Finally, it is important to consider time and budget tradeoffs in evaluating this data. Evaluating emissions from ground transport is by far the most time-consuming part of this process, but the emissions are negligible compared to emissions from air travel. This suggests that updating these emissions and/or paying for the use of a tool like VitalMetrics annually may not be the wisest allocation of resources. We recommend evaluating these emissions once every five years.

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