Purview of the Baseline's Construction for Vehicle Fuel Economy and its Statistical Limitations

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Abstract

A baseline in fuel economy is the indicator from which to start to evaluate consumption and raise awareness of the current state. Since what is not measured cannot be improved, the determination of a baseline helps to locate a starting point to establish further goals and best practices based on actual behavior. This paper explores and reviews the studies for fuel economy to determine the measurement and analysis methods that aim to the construction of fuel consumption and/or gas emission baselines by conducting a systematic literature review (SLR). The overview of literature published globally in the last ten years shows hardly any research focused on HDVs, as well as few investigations reporting gross and load weight values. Studies committed to measuring fuel consumption and/or gas emissions show small sample sizes due to limitations in scope related to the methods used, explaining the tendency to make estimates through statistical and estimation tools. Furthermore, it is important to emphasize that by abounding in the methods and the literature itself, the recent interest in expanding the sample sizes in line with the precision of the data, has presented new techniques for the measurement and estimation.

Keywords
Fuel consumption; Heavy duty vehicles; Baseline; Sustainability.

1. Introduction
The United Nations Environment Program (UNEP) is implementing a new transportation project which aims to promote a global transition to a low emission mobility that improves air quality and mitigates climate change. To achieve this objective, countries and cities are supported to develop and implement transportation policies and strategies looking out for three main results: a regional change to more efficient vehicles (including electric mobility), a national change to cleaner fuels (low-sulfur content in fuels) and standard vehicle emissions, and a regional or national take into action by developing and implement policies that prioritize walking and biking infrastructures.

Fuel consumption baselines explain the fuel economy for a certain population of vehicles in a certain region, which allows a deeper analysis of the vehicular fleet and its significant factors. By understanding this, it is possible to position the fuel consumption and gas emissions in contrast with historical data or even other regions, making it possible to develop best practices and transportation policies. Around the world, more than ten countries have determined a fuel consumption baseline for passenger and light duty vehicles (LDVs) with at least six years of fleet inventories, but no region has worked on the development of a fuel consumption baseline for heavy duty vehicles (HDVs). The UNEP has supported the Latin American and Caribbean region since 2009 to adopt cleaner and more efficient fuels and vehicles, and now the objective is to determine the first fuel consumption baseline for HDVs in the Mexican region.

As of 2021, Mexico has no policies that limit the fuel consumption or the gas emissions for HDVs, mainly because of the lack of studies on the regional fleet which comes from the non-existence of a vehicle registry that presents information related to consumption, emissions, or weights. It is important to take in consideration that manufacturers' information may differ with the actual behavior of the fleet due to factors such as antiquity, gross weight, or mean velocities, and therefore, the measurement of the fuel consumption of the vehicle fleet cannot be obtained directly from this information.

This paper looks for and analyzes some of the measurement, estimation, and analysis methods that other studies have used to determine the base consumption of fuels by conducting a systematic literature review (SLR). The trends of data reported by the papers are studied, as well as a comparation between the methods applied by the authors. With this, the writing aims to determine the best tools for determining the fuel consumption baseline for HDVs in the UNEP project.

2. Research Methodology

The determination and analysis of fuel consumption and gas emissions has attracted authors to explore new measuring methods in different conditions, including estimation models that use information from measuring small samples. This paper analyses the published literature using a systematic literature review (SLR) adapted from Garza-Reyes (2015), visible in Figure 1 that describes how SLR phases are adopted for this research. Papers and articles were searched supported on a Boolean phrase (see in Figure 1) which uses the keywords "Vehicle", "Fuel", and "Inventory" or "Baseline". These were accessed using SCOPUS (www.scopus.com) and reports from European official organizations that aim to identify fuel consumption for different vehicular samples.

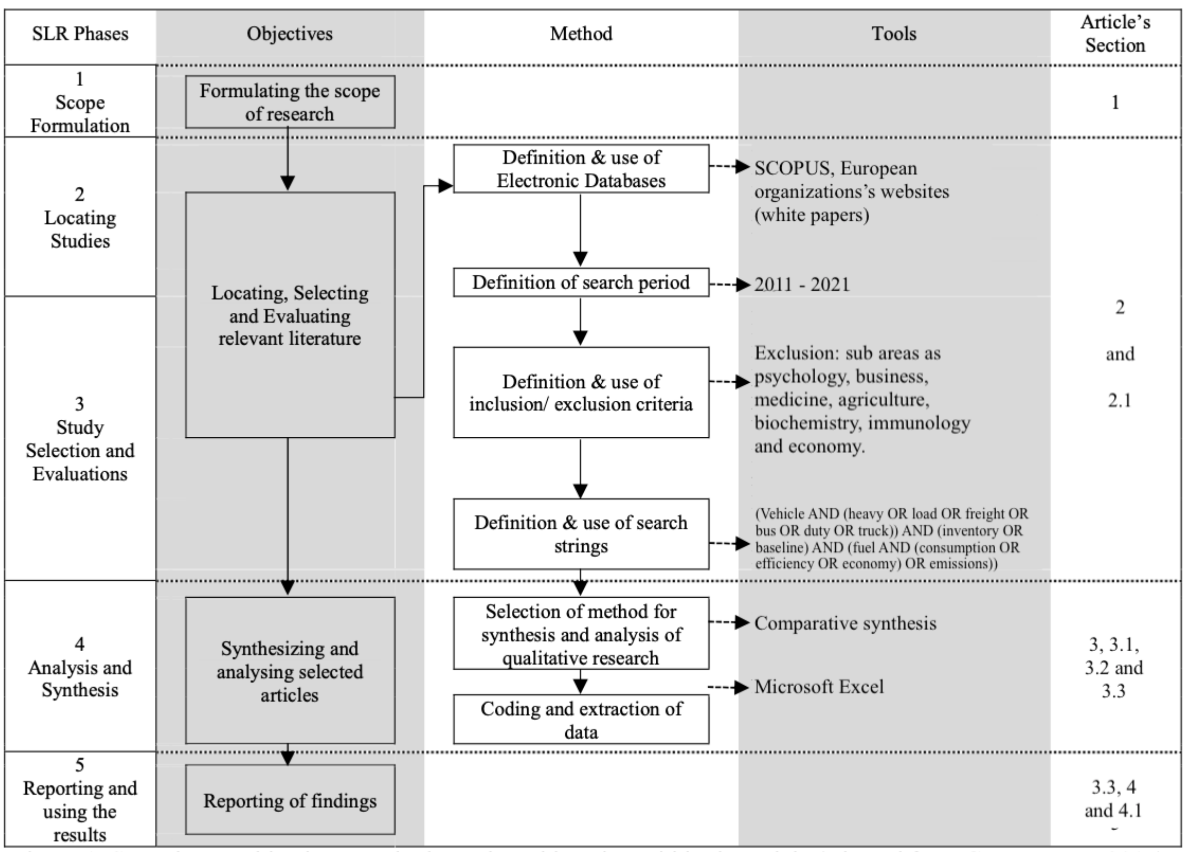
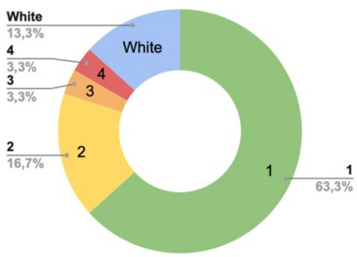


Figure 1: SLR phases, objectives, methods, tools and article's section (adapted from Garza-Reyes, 2015).

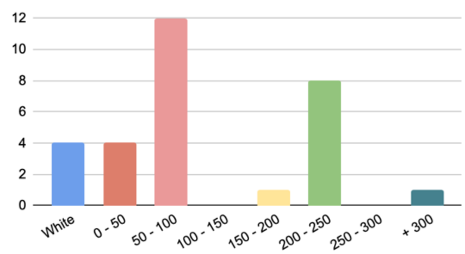
These databases were chosen due to the validation processes needed to be published on the mentioned platforms, and a period of ten years (2011 to 2021) was stablished, and papers written with similar concepts but addressing sub sectors or areas such as psychology, business, medicine, agriculture, biochemistry, immunology, and economy were excluded. The major criteria for the selection process involved a screening and/or full reading of the papers to exclude all titles and papers that were not aiming for the estimation or measurement of either mean fuel consumption and/or gas emissions. For practical purposes of the UNEP's project, papers were classified by type of vehicles studied but types different from HDVs were not excluded.

2.1 Descriptive Analysis

The research included the preview of 85 papers and the selection of 30 studies. The review consisted of 26 papers and 4 white papers to determine practices, methods and tools used to estimate and measure fuel economy in vehicular samples. To understand the relevance of the selected studies, the quality factor was studied, Figure 2 (a) below presents that 63.3% of the total selected and reviewed papers are on among top 25% journals in the same field.



(a)



(b)

Figure 2: Relevance of studies - (a) Proportion of Q-factor of selected papers, (b) Frequency of papers' h indexes.

On the other hand, Figure 2 (b) illustrates the frequency of Scopus h index per ranges, measuring productivity and impact of the selected studies. As of August 2021, most of the papers present an h index of 50 or above, stating that selected literature is greatly cited for similar studies.

3. Fuel economy determination

Along the review of selected literature, fuel economy baselines vary in objective, method, sample studied, and data reported. Papers may be focused on analyzing raw data or the vehicular fleet information, but also may cover the estimation and/or measurement of either fuel consumption and/or gas emissions (mainly CO_2). This does not exclude studies that determine specific fuel consumption (SFC) or CO_2 emissions when comparing vehicular technologies or fuels used.

3.1 Overview of published literature

In the Table 1, it is possible to understand the vehicular samples studied per author as well as the gross weights in tonnes of this vehicle types. At a first glance it is important to notice that not all the literature reports the model-year or weight of the vehicles under study, and that 9 of 30 researches do not study HDVs, which reembraces the decision of including other land vehicle types. Likewise, 26.7% of the global literature studies fuel economy for HDVs, and only 2 out of 3 researches in the Mexican region study this vehicle type.

Table 1: General information of the selected literature

No.	Author	H	Q	Vehicle type	Model year	Weight (tonnes)	Place
1	Baek et al. (2021)	213	1	UB	✓		Seoul, Korea
2	Davison et al. (2021)	397	1	LDV and PC	✓		UK
3	Doumbia et al. (2021)	93	2	LDV and HDV			Yopoungon, Africa
4	Zachiotis & Giakoumis (2020)	31	2	LDV			USA
5	Quirama et al. (2020)	99	1	Buses			Toluca and CDMX, Mexico

6	Giraldo & Huertas (2019)	99	1	HDV			Toluca and CDMX, Mexico
7	Mbandi et al. (2019)	93	2	LDV, HDV, MTRCL and PC			Nairobi, Africa
8	Chong et al. (2018)	99	1	LDV	✓		Korea
9	Jia et al. (2018)	240	1	LDV and HDV	✓		Mainland, China
10	Song et al. (2018)	244	1	LDV, HDV, UB and PC			China
11	Policarpo et al. (2018)	99	1	LDV, HDV, UB, MTRCL and PC	✓		Ceará, Brasil
12	Díaz-Ramirez et al. (2017)	99	1	HDV	✓	10.40-49.1	Colombia
13	Qiu et al. (2016)	55	2	LDV, HDV, UB, PC and Others	✓		Xi'an, China
14	Sandhu et al. (2016)	240	1	Others	✓	24.13-29.02	USA
15	Rodríguez et al. (2016)	99	1	LDV	✓		Bogota, Colombia
16	Fameli & Assimakopoulos (2015)	244	1	LDV, HDV, UB, MTRCL, PC and Others	✓		Attica, Grecia
17	Goel et al. (2015)	26	1	LDV, HDV, UB and PC	✓	6.14	Delhi, India
18	Chavez-Baeza & Sheinbaum-Pardo (2014)	193	1	UB, MTRCL and PC	✓		CDMX, México
19	Zhang et al. (2013)	240	1	LDV and HDV		4.5 - 12	Guangzhou, China
20	Goyal et al. (2013)	52	4	LDV, HDV, UB and PC	✓		Delhi, India
21	Cai & Xie (2013)	89	2	LDV, HDV, MTRCL and PC	✓	13-16	China
22	Delgado et al. (2012)	41	1	HDV		44.31*	South California, USA
23	Wang et al. (2011)	99	1	HDV			Beijing, China
24	Nix et al. (2011)	21	3	UB	✓		Washington, USA
25	Tung et al. (2011)	244	1	LDV and MTRCL	✓		Hanoi, Vietnam
26	Wang et al. (2011)	240	1	HDV and UB			Beijing, China
27	Delgado et al. (2017)	W	W	HDV	✓	12 - 40	Europe
28	ACEA. (2020)	W	W	HDV		2.7 - 13.8	Europe
29	Delgado et al. (2016)	W	W	HDV	✓	9.7- 40	Europe
30	Lujan et al. (2019)	W	W	HDV		3.5 - 40*	US, Canada, EU, Japan, Korea and China

*Estimated from graphics of the paper (units may be converted), W - White pape

3.2 Trends of published literature

For practical purposes, the information that each study presents were simplified in a table which may be segregated by approach of the analysis of each author. Therefore, the analysis of the selected literature is presented along the text in three focuses: (i) fleet inventory, (ii) fuel consumption, and (iii) CO_2 emissions.

In the case of studying vehicular fleet inventories, Table 2 shows the sample sizes (in vehicular units) of the papers that study inventories, which could be from either a region, a company, or a specific vehicular fleet. In both focuses, SFC and CO_2 emissions, is a more common practice to use an inventory to make further measurements than to limit the study to estimations. Nevertheless, sample sizes are bigger by thousands or even millions when estimating, limiting the scope of studies or even the significance of the results for regional applications.

Table 2: Preview of selected literature's content (Fleet inventory)

No.	Author	Sample size	Weight (tonnes)	Vehicle type	Model year	SFC Modality	CO_2 Modality
1	Baek et al. (2021)	1		UB	✓		M
2	Davison et al. (2021)	0.3 Millions		LDV and PC	✓		M
3	Doumbia et al. (2021)			LDV and HDV		E	

4	Zachiotis & Giakoumis (2020)	1		LDV		E	M
5	Quirama et al. (2020)	15		Buses		E	
6	Giraldo & Huertas (2019)	15		HDV		M	M
7	Mbandi et al. (2019)	824		LDV, HDV, MTRCL and PC		M	
8	Chong et al. (2018)	4		LDV	✓	M	M
9	Jia et al. (2018)			LDV and HDV	✓	E	E
10	Song et al. (2018)			LDV, HDV, UB and PC			M
11	Policarpo et al. (2018)	1.2 Millions		LDV, HDV, UB, MTRCL and PC	✓	E	E
12	Díaz-Ramirez et al. (2017)	38	10.40-49.1	HDV	✓	M	
13	Qiu et al. (2016)	161,451		LDV, HDV, UB, PC and Others	✓		E
14	Sandhu et al. (2016)	6	24.13-29.02	Others	✓	M	M
15	Rodríguez et al. (2016)			LDV	✓		E
16	Fameli & Assimakopoulos (2015)	3.7 Millions		LDV, HDV, UB, MTRCL, PC and Others	✓	E	
17	Goel et al. (2015)	7.0 Millions	6.14	LDV, HDV, UB and PC	✓	E	E
18	Chavez-Baeza & Sheinbaum-Pardo (2014)	4.2 Millions		UB, MTRCL and PC	✓		E
19	Zhang et al. (2013)	21,638	4.5 - 12	LDV and HDV			E
20	Goyal et al. (2013)			LDV, HDV, UB and PC	✓		E
21	Cai & Xie (2013)		13-16	LDV, HDV, MTRCL and PC	✓		E
22	Delgado et al. (2012)		44.31*	HDV		M	E
23	Wang et al. (2011)			HDV			M
24	Nix et al. (2011)			UB	✓		M
25	Tung et al. (2011)	12		LDV and MTRCL	✓	M	M
26	Wang et al. (2011)			HDV and UB		M	M
27	Delgado et al. (2017)		12 - 40	HDV	✓	E	
28	ACEA. (2020)		2.7 - 13.8	HDV			E
29	Delgado et al. (2016)		9.7- 40	HDV	✓	E	E
30	Lujan et al. (2019)		3.5 - 40*	HDV			E

*Estimated from graphics of the paper (units may be converted)
E Estimated
M Measure

A key finding is that 16 out of 30 studies, which is slightly above the half, estimate either SFC or CO_2 emissions. This can be explained due to the limitations most of measuring techniques present in time, cost, and scope. Also, information such as sample size, weight and model-year of the vehicular sample may not be mentioned or graphically displayed due to the papers' focus on methodologies.

In the other hand, the literature that estimates or measures SFC can be understood with the information in Table 3, which shows if there was a simultaneous measurement or estimation of CO_2 emissions. Even though only three studies measure SFC for HDVs, it is important to emphasize that the totality of papers measuring SFC quantify in roads aiming for actual behavior results. As for tools and models, the use of PEMS and Dynamometers cover most of the measuring methods, while VECTO simulation model is the most common tool for estimating but is found exclusively on white papers.

Table 3: Preview of selected literature's content (Fuel consumption)

No.	Author	Fuel consumption (SFC)					CO_2 Modality
		Modality	Tool / Model	Place	Sample size	SFC (L/ton-100km)	
1	Baek et al. (2021)						M
2	Davison et al. (2021)						M
3	Doumbia et al. (2021)	E	Bottom Up	R			
4	Zachiotis & Giakoumis (2020)	E	Sinusoidal Elevation Profiles	R	1	1.423*	M
5	Quirama et al. (2020)	E	EBMT	R	15		
6	Giraldo & Huertas (2019)	M	PEMS, Multiple linear correlation	R	15	0.41*	M
7	Mbandi et al. (2019)	M	Surveys and ANOVA	A	824		
8	Chong et al. (2018)	M	PEMS and GPS	R	4	0.208*	M
9	Jia et al. (2018)	E	China Statistical Yearbooks	A		0.249*	E
10	Song et al. (2018)						M
11	Policarpo et al. (2018)	E	COPERT	A			E
12	Díaz-Ramirez et al. (2017)	M	Dyn	R	18	1.716	
13	Qiu et al. (2016)						E
14	Sandhu et al. (2016)	M	PEMS	R	6	0.601-1.306*	M
15	Rodríguez et al. (2016)						E
16	Fameli & Assimakopoulos (2015)	E	EMEP/CORINAIR	A			
17	Goel et al. (2015)	E	Survey and GPS	A	1,295		E
18	Chavez-Baeza & Sheinbaum-Pardo (2014)						E
19	Zhang et al. (2013)						E
20	Goyal et al. (2013)						E
21	Cai & Xie (2013)						E
22	Delgado et al. (2012)	M	Dyn	R	56	0.427 - 0.625*	E
23	Wang et al. (2011)						M
24	Nix et al. (2011)						M
25	Tung et al. (2011)	M	Surveys and Dyn	R	12	0.102	M
26	Wang et al. (2011)	M	PEMS and SEMTECH-DS	R	6	0.301-0.497*	M
27	Delgado et al. (2017)	E	VECTO and Autonomie	A		0.8275 - 2.075*	
28	ACEA. (2020)						E
29	Delgado et al. (2016)	E	VECTO and WHCV	A		0.212-0.548*	E
30	Lujan et al. (2019)					0.253 - 0.357*	E

*Estimated from graphics of the paper (units may be converted)

E	Estimated	R	Roads	A	Analytics
M	Measure	L.	Laboratory	Dyn	Dynamometer

By abounding in the literature itself while focusing on HDVs, SFC variations are summarized in a sample of 15 vehicles of 0.41 L/km, equivalent to 41.0 L/100km (Giraldo & Huertas, 2019), a study of model-years between 2011 and 2015 of 24.9 L/100km (Quirama et al., 2020), a paper on 52 units with 44.11 tons of gross weight between 42.7 and 62.5 L/100km (Oscar Delgado et al., 2016), and a research on 28 vehicles with model-years between 2008 and 2012 of 1.716 L/ton-100km for gross weights between 10.4 and 49.1 tons (Díaz-Ramirez et al., 2017). Then, the expected range of SFC arounds between 17.85 and 62.5 L/100km, an important variation in the HDVs' SFC, which places great importance to making local exercises of determining baselines.

On Table 4, basic information about the papers can be understood with a focus on the CO_2 emissions factor, which shows how vehicular emissions are highly studied independently to its relationship with SFC. Since 2018, a recent interest is present for measuring CO_2 emissions, and a collateral trend can be visible since 2017 when techniques start diversifying to unconventional methods in an effort to enable bigger sample sizes when measuring CO_2 emissions.

Measuring techniques are mainly covered by high accuracy devices such as PEMS and Dynamometers, but the innovative tools recently applied such as the Remote sensing device (RSD) and laser detectors have shown an area of opportunity when the objective for investigating emissions is not necessarily aiming for a comprehension of multiple gases, or its behavior for specific vehicular characteristics (Davison et al., 2021).

Table 4: Preview of selected literature's content (CO_2 emissions factor)

No.	Author	SFC Modality	CO_2 emissions factor				
			Modality	Tool	Place	Sample size	CO_2 emissions (g/km)
1	Baek et al. (2021)		M	Dyn and WHVC	L	1	380
2	Davison et al. (2021)		M	Remote sensing device (RSD)	R	304,039	
3	Doumbia et al. (2021)	E					
4	Zachiotis & Giakoumis (2020)	E	M	Dyn	R	4	364.70
5	Quirama et al. (2020)	E					
6	Giraldo & Huertas (2019)	M	M	PEMS, GPS and ECU simultaneous readings	R	15	965.8 ± 111.7
7	Mbandi et al. (2019)	M					
8	Chong et al. (2018)	M	M	PEMS	R	4	12595
9	Jia et al. (2018)	E	E	China Statistical Yearbooks	A		
10	Song et al. (2018)		M	Laser detector	R		
11	Policarpo et al. (2018)	E	E	Bottom up model	A		
12	Díaz-Ramirez et al. (2017)	M					
13	Qiu et al. (2016)		E	MOVES	A		
14	Sandhu et al. (2016)	M	M	MOVES	A	6	
15	Rodríguez et al. (2016)		E	IVE	A		
16	Fameli & Assimakopoulos (2015)	E					
17	Goel et al. (2015)	E	E	ASIF	A	7.0 Millions	
18	Chavez-Baeza & Sheinbaum-Pardo (2014)		E	MOVES	A	422,9341	
19	Zhang et al. (2013)		E	MOBILE-China	A	21,638	
20	Goyal et al. (2013)		E	IVE	A		
21	Cai & Xie (2013)		E	COPERT	A		
22	Delgado et al. (2012)	M	E	MOVES	A		
23	Wang et al. (2011)		M	PEMS			
24	Nix et al. (2011)		M	Dyn	L	2	1534.78 - 1580.76**
25	Tung et al. (2011)	M	M	Dyn	R	12	29.68**
26	Wang et al. (2011)	M	M	PEMS, SEMTECH-DS	R	6	798.95 - 1127.78
27	Delgado et al. (2017)	E					
28	ACEA. (2020)		E	VECTO, Autonomie	A		633.92 - 866.98**
29	Delgado et al. (2016)	E	E	VECTO, WHCV	A		
30	Lujan et al. (2019)		E	VECTO	A		861.4 - 906.4

*Estimated from graphics of the paper (units may be converted)

E	Estimated	R	Roads	A	Analytics
M	Measure	L.	Laboratory	Dyn	Dynamometer

For emissions' estimations, the most common tools are VECTO and MOVES model, both limiting for multiple factor comparisons, but MOVES model along with a use of PEMS is useful when studying specifically a same type of vehicle with a not great difference of characteristic such as weight, model and roads transited (Sandhu et al., 2016). On the other hand, the IVE model has presented a greater use for LDVs in specific regions mainly because the program provides inventories of certain cities, but also because it narrows down the scope in terms of vehicular factors (Goyal et al., 2013).

3.3 In-depth comparison of tools and models

Focusing on measuring methods, accurate tools such as PEMS are limited to sample sizes do not surpass the 15 vehicular units due to measuring costs and periods (Giraldo & Huertas, 2019; A. Wang et al., 2011). Limitations involve as well, the need of additional technologies to measure SFC (X. Wang et al., 2011), and the assistance of GPS software and hardware to have more specific data regarding the external conditions or factors when a certain SFC or emission factor was reported (Chong et al., 2018). Likewise, dynamometers present great accuracy and close to real behavior results but same limitations occur when aiming to measure many variables for a variety of vehicles. However, using dynamometers might enable bigger sample sizes depending on the measuring place and vehicle type. Dynamometer measurements on urban buses (UB) taking place on laboratories are limited to 1 to 2 vehicles due weight and logistics for sample placement (Baek et al., 2021; Nix et al., 2011). In the other hand, the same technique applied on roads for either LDV or motorcycles, present sample sizes of 4 and 12 units (Tung et al., 2011; Zachiotis & Giakoumis, 2020). In the case of HDVs' studies, sample sizes of 18 and 56 were able through collaborations with and private companies, this is because of the high operational costs that SFC can present for transportation companies (O. F. Delgado et al., 2012; Díaz-Ramirez et al., 2017).

The unconventional methods for measuring either SFC or vehicular emissions have presented a spectrum to innovate based on geolocation devices. The RSD is an easier and simpler tool which might limit the data gathered in types of gases measured but enables sample sizes of more than thousands of units while providing real behavior data (Davison et al., 2021). The use of surveys and have shown great sample sizes but limitations come mainly due to the human factor which provides low reliability (Goel et al., 2015). Not less important, the use of laser detectors has shown a great advantages such as the automatization of data gathering, great sample sizes and a variety of gas emissions measurables but limitations arise in comparison because of the infrastructure conditions necessaries and the lack of data segmentation per vehicle (Song et al., 2018).

The analytical methods to either understand an inventory or estimate a characteristic parameter are basic tools such as ANOVAs and correlations, both limited to the data availability and its significance, requiring to dismiss multicollinearity (Mbandi et al., 2019). Other methods applied such as the bottom-up technique limit the scope of results on its analysis (Doumbia et al., 2021). Analyzing yearbooks and inventories with no supportive methods limit the process with long manual data preparations and also provide results not ascertainable with the real behavior (Jia et al., 2018).

On the other hand, estimation models used consist mainly of digital simulation tools such as VECTO, Autonomie, MOVES, COPERT, IVE, EMEP and MOBILE-China. All the listed platforms tend to estimate with great accuracy but are weak for massive samples if it involves an important variety in models, model-years, vehicle configurations, driving conditions, weights, and others. In the case of VECTO, the model's use is limited to studies made since 2016 by European organizations, this tool has shown a high complexity when aiming to study a high variety of vehicles due to the input specifications required (Lujan et al., 2019) but a proposed practice is to relate results of certain possible combinations with a fleet inventory (ACEA, 2020). The use of Autonomie has shown no significance difference when comparing results with VECTO (O. Delgado et al., 2017). For both COPERT and EMEP, the approach to specific model for a variety of vehicle types still enables important sample sizes to estimate SFC in a regional level, but limits the significance of the results due to the lack of real behavior study or comparison (Cai & Xie, 2013; Fameli & Assimakopoulos, 2015; Policarpo et al., 2018).

Focusing on vehicular emissions estimations, MOVES and IVE models are commonly used amidst the literature, but no research reports the resulting CO_2 emission factor. Both models provide high accuracy on output data, but limitations come to the input data processing due to the specifications required by the programs (Rodríguez et al., 2016). Specifically for MOVES model, the emissions are mostly defined as a function of vehicle-specific power (VSP) which may relate to data such as AC conditioning status, humidity, temperature, maintenance, road type, speed, and more variables that require a previous measurement since fleet inventory itself may skew results (Chavez-Baeza & Sheinbaum-Pardo, 2014; Qiu et al., 2016). In the case of MOBILE-China, this model is narrowed down in scope for the Chinese region, but the model MOBILE itself is more accurate for gas emissions estimations on highway vehicles (Zhang et al., 2013).

4. Conclusions

The literature reviewed is mainly interested in vehicular emissions with a preference in measuring to aim for real behavior results. Nevertheless, limitations present on measuring techniques due to time, costs, and scope, have presented a recent trend (since 2018) on testing unconventional methods and techniques. Likewise, estimation models have been type-casted to the same common models until 2017, when new tool start taking place and studies attempt to combine estimation model with measured data instead of studying inventories alone. Limitations from both measuring and estimating methods are summed-up on costs, time, reliability of the data, sample sizes and significance in comparison with real behavior data. The purview of this methods presents an opportunity to choose unconventional geolocation tools along with new proposed estimation models for the determination of the fuel consumption baseline for HDVs in the Mexican region for the new UNEP's project.

4.1 Further research

Measuring techniques with specific data outputs limit sample sizes and analysis for high variety of factors, pointing out how geolocation tools and simple measurement related ones have a greater area of opportunity for the project purposes. For estimation models, to bet for programs used to extrapolate or even estimate for massive sample sizes applied is more promising than limiting to basic statistical analysis. With this being stated, further research is expected for innovative methods and their availability on the studied region to make possible the determination of the fuel consumption baseline for HDVs in the UNEP project.

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