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Full Length Research Paper

An empirical approach for experimental assessments in urban freight

Eduardo Betanzo-Quezada*, José A. Romero-Navarrete and Saúl A. Obregón-Biosca

Faculty of Engineering, Autonomous University of Queretaro, Mexico.

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Increasing concerns about sustainable urban freight transport have appeared recently in developed countries. While some methods and indexes exist today to evaluate economic and development sustainability, this paper holds up the need to develop a standard tool to evaluate how an urban freight system is functioning. In this sense, this paper presents the concept, the methodology and the application of a model named Urban Freight Transport Index (UFTI). The general objective of this paper is to propose and apply a methodology for rating and assessing the overall performance of urban freight systems. As a result of the experimental application of UFTI, a mid-size Mexican city was rated on 115 points out of 807 ideal points. It was concluded that the essayed experimental index could be the basis for a more extended standard to be used by local or regional authorities to help the decision making process in urban freight systems.

Key words: Freight transportation, urban development, ratings, city logistics, Mexico.

INTRODUCTION

Urban freight transport (UFT) affects the standard of living of urban population at different environmental and mobility levels, as a function of the relative amount of commercial traffic and affectations caused by heavy trucks. UFT-related issues involve different transportation actors: carriers, non-commercial road users, and authorities. In the one hand, authorities would have the responsibility to manage traffic and infrastructure in order to reduce the impact of UFT, while on the other hand, productivity of commercial carriers within urban areas is strongly affected by congestion or local traffic regulations. Such stakeholders try to do something to revert the negative effects of UFT or to organize more convenient urban freight practices to improve both city and business competitiveness.

In 1960 the Organization for Economic Co-operation and Development (OECD) created a working team for studying urban logistic issues, aiming at promoting public policies to achieve and to maintain a highly sustainable economic growth while keeping high employment rates, and increasing the population's overall standard of living. Recently, it has been estimated that 20% of the vehicular occupation of the French streets is attributable to the displacement of goods (Boudouin and Morel, 2002). In addition, the fastest growing type of freight vehicle in European urban areas is the light commercial vehicle, while 80% of road freight trips involve distances shorter than 80 km (EU, 2004), further suggesting the importance of promoting best practices in urban or urban-regional transportation (BESTUFS, 2005; 2006a). Some performance indicators of urban traffic have been also proposed by Ambrosini et al. (2010), focusing on the environmental impact of urban freight and traffic congestion.

BESTUFS (Best Urban Freight Solutions) was a two-phase European project active from 2000 to 2008, implemented to identify bottlenecks and to describe and disseminate successful practices for urban freight from the perspective of city logistics solutions. In that sense, some efforts were conducted to obtain a first urban freight transport data set and orientations to more specific information: dimensioning urban freight transport in the

*Corresponding author. E-mail: betanzoe@uaq.mx.

context of all (urban) traffic and quantifying the impact of BESTUFS policies (BESTUFS, 2006b, 2008).

In spite of such progress, freight is often not adequately addressed in the context of the integrated urban transportation planning process. While there is abundant logistics-oriented (that is, economics/operational) literature, there are fewer examples of previous works involving explicitly addressed environmental and social issues. While some general-purpose methods exist today and can be applied to promote sustainable development, a brief review of existing assessing tools shows a growing interest in promoting urban freight systems. Authors referenced in Table 1 have taken innovative paths to design newer or innovative tools under different situations.

Because urban freight information is scarce or difficult to gather, several attempts to base on useful information the decision making process have encouraged practitioners or planners to put in practice those newer or innovative monitoring or assessment tools. This review of the literature shows that most available or in progress tools aim to simulate and understand the behavior of stakeholders, or to predict the effect of transport policies as well as urban logistic initiatives in cities. Such tools rely on the deployment of easy-to-use indexes or indicators. This review reveals the importance of our proposal and supports the benefit of a new index in the field of urban freight.

The general objective of this paper is to propose and apply a methodology for rating and assessing the overall performance of urban freight systems. This contribution appears to be an attempt to develop a framework for capturing the sustainability (economic, social, environmental) aspects of urban freight. This attempt is also a challenge, considering that social, economic and environmental issues are quite difficult to measure, as opposed to physical phenomena measured through mechanical devices. This subject is crucial for the improvement of transportation planning. The evaluation of city freight issues and policies would benefit from the existence of globally accepted indicators and procedures to benchmark cities and to assess the evolution and effects of the freight delivery system.

The proposed index is one of the results of a research project, carried out in the Queretaro Metropolitan Area (QMA) in Mexico from 2003 to 2007 years (Betanzo, 2006; Betanzo, 2007). Since a non-exhaustive description of the methods has been published in previous works (Betanzo and Romero, 2010), this paper provides an in-deep explanation and discussion of the method as a guideline for interested planners and practitioners.

MATERIALS AND METHODS

This section explains the steps involved in the methodological development and implementation of UFTI Version 1.0, as illustrated in a block diagram of Figure 1. The 3-step process includes the basic concepts, followed by the development of the assessment tool and the computing routine to be followed.

Step 1: Basics of a standard

The Urban Freight Transport Index (UFTI) version 1.0 is characterized by an integrated scope, following the principles of May (2006) in urban transport strategies: “There is, in practice, a more strategic form of integration, which is directly relevant to strategy formulation: the integration of policy instruments to achieve greater performance from the overall strategy”.

Four fundamental questions are considered for approaching urban freight problems: (i) Is it possible to set up a scale where urban freight problems could be ranked in terms of its severity?; (ii) How big or near-to-critical condition is the status of the problem; (iii) How fast are the changes occurring in a city according to reference patterns?; and (iv) What reactive actions should be taken to alleviate the situation or to reverse the observed trend?

UFTI is based upon a fundamental hypothesis: a set of urban freight transport issues can be quantified into a unique index, reflecting a multi-factorial environment. To validate such hypothesis three conceptual and methodological questions were analyzed in the basics of the tool: (i) What kind of scales could be useful to manage urban freight problems?; (ii) How to operationally work all along the performing process?; and (iii) How to extend the methodology to other cities?

Defining the configuration of UFTI

Qualitative scales seemed to be more adapted to represent the urban freight activity, at least at the beginnings of this attempt. To start with, internationally recognized and well known scaling principles were studied as reference patterns. They include the physical states (Mohs scale), the seismic scales (that is, Mercalli), the Torino Impact Hazard Scale for collision consequences in asteroid events, and the Fujita’s scale for tornado disasters. Table 2 depicts the ranges of evaluation of these distinct scales.

In second place, in order to configure out an operational method to perform the assessment process, different organizational and industrial techniques were considered, including the Ishikawa Diagrams (Ishikawa, 2003), the Radar Diagrams, and the automotive industry Logistic Evaluation (ODETTE, 2002).

Benchmarking principles were also considered given that practices and services of any organization (a city) could be compared with those of the strongest competitors and organizational leaders (Camp, 2006). Benchmarking in urban freight transport thus consists in measuring and comparing a city with respect to those cities that have the best organizations and the highest level of urban freight transport organization.

The morphology of the UFTI approach represents the structural relationship between reagents and indicators, under the context of a certain thematic group to finally take the form of an index. The resulting hierarchical morphology is depicted in Figure 2.

Basic definitions

1. An *Index* formulates the aggregation of *groups* aiming at assessing the overall performance of the system.
2. A *Group* represents a collection of *indicators* pertaining to the same group (for example, political and institutional levels)
3. An *Indicator* includes sets of *reagents*.
4. A *Reagent* is considered as evidence-based signs or implemented actions concerning urban freight transport. In UFTI, a reagent is the most basic component of an indicator. A reagent is

Table 1. Review of urban freight related tools.

Author	Purposes/challenges	Method/tool
Mitchell, 1996.	To outline the fundamental steps that should be followed to produce any list of SDI's.	Sustainable Development Indicator (SDI's).
Ramanathan, 2001.	To capture the perceptions of stakeholders on the relative severity of different socio-economic impacts. To help authorities in prioritizing their environmental management plan, and strength the allocating decisions of the budget available for mitigating adverse socio-economic impacts.	Analytic Hierarchy Process method (AHP).
Allen et al. (2003) Anderson et al. (2005)	To model policy measures and company initiatives in the United Kingdom, to reflect the sustainability of the urban distribution operations.	A battery of indicators grouped as follows: i) Indicators reflecting the distribution operation; ii) Indicators reflecting the vehicle operating costs to the distribution companies; iii) Indicators reflecting the environmental impact of the vehicles.
Crainic et al. (2004).	How to measure social benefits to the collectivity and how to compare the performance of the proposed and current policies, or any other alternate system. Methodological challenges in developing the appropriate models and tools for the analysis, planning and operation of the system, to manage freight transportation in urban congested areas.	Introduce a possible organizational and technological framework, identifying associated planning and operation issues and models.
Hensher and Puckett (2004).	To study how supply agents interact, to reduce traffic congestion.	General framework using stated choice experiments.
Figliozzi, (2006), Taniguchi al. (2003).	To predict the effect of policy measures.	A multidisciplinary/multi-agent perspective. An approach that combines both optimization and simulation.
Puckett et al. (2007). Morris et al. (2006).	To assess the impact of urban freight on different transport aspects such as traffic congestion, exposure to risk and accidents To assess the impact of urban freight on different transport aspects such as theft/vandalism, inadequate docking space, and insufficient curbside parking for commercial vehicles.	An overall performance measure.
Wisetjindaw et al. (2006).	To assess the impact of urban freight on different transport aspects such as traffic congestion, exposure to risk and accidents, theft/vandalism, inadequate docking space, and insufficient curbside parking for commercial vehicles.	An overall performance measure is still missing.
Taniguchi et al. (2006).	Data collection as well as indicators to quantify, to evaluate or benchmark different city logistics initiatives.	Method still missing.
Taniguchi et al. (2008).	To improve data collection systems To find out complex relationships of stakeholders.	Creation of tools for extracting knowledge from data still missing.
Ruesch (2008).	To identify indicators associated with the urban freight systems and to create innovative methodologies.	An indicator scheme for the assessment of measures and the monitoring/controlling of urban and regional freight transport.

Table 1. Contd.

May et al. (2008).	To help local authorities in establishing an effective set of core indicators which encapsulate the objectives of stakeholders. For local authorities, indicators reflecting the ability to reflect objectives, their use in developing targets and the ease with which they are understood in the monitoring process.	A decision-support tools based on detailed survey information.
May et al. (2008).	To design urban transport and land-use systems to be more sustainable and the policies which are needed to achieve this.	Decision-support tools for sustainable urban transport.
Patier and Brown (2010).	Evaluation of successful urban logistics innovations, with full consideration of the impacts including social, economic, and environmental features of the innovations.	A methodology composed of 60 data items and ratios, based on a tree levels scale of importance (essential-3, important-2, and contextual-1). A tabulation was obtained showing results of scoring.
Filippi et al. (2010).	Assessment of the effects of implemented measures to alleviate the negative effects of freight transport in urban areas. Estimation of pollutant emissions from road vehicles.	A methodology for ex-ante assessment, combined with Revealed Preference surveys. Indicators to put in place policy making.
Tamagawa et al. (2010).	Evaluating city logistics measures considering the behavior of several stakeholders.	A methodology based on multi-agent model where performance scale ranges indicators from 0.5 to 1.5 values. Outputs represented by a five-corners radar diagrams.

Source: Own elaboration.

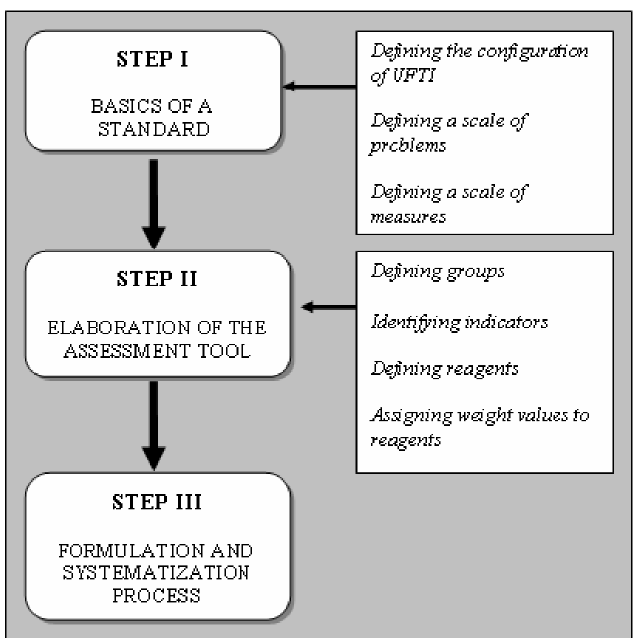

Figure 1. Steps for development of UFTI standard.

going to be translated onto a quantitative value (Table 11) to produce a cumulative effect passing up trough indicators and groups till the Index level. To design this tool we explained its components as depicted in Figure 1.

Table 2. Sample of international scales.

Scales	Applications	Rankings
Mohs Scale	This scale is a chart of relative hardness of the various minerals. The scale is not a linear scale.	1-Softest to 10-Hardest
Fujita Scale	It is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure.	F0.- Gale tornado, F1.- Moderate tornado, F2.- Significant tornado, F3.- Severe tornado, F4.- Devastating tornado, F5.- Incredible, F6.- Inconceivable tornado.
Torino Impact Hazard Scale (Binzel, 2000)	It is used to place into context the level of public concern that is warranted for any collision event by asteroids, and the estimated kinetic energy (collision consequence).	5 Colors scale: (White) Events having no likely consequences; (Green) Events meriting careful monitoring; (Yellow) Events meriting concern; (Orange) Treating events; (Purple) Certain Collisions
Mercalli Scale	The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures. Data is gathered from individuals who have experienced the quake. It is not defined in terms of quantifiable measurements.	12 Colored scale: I. Instrumental, II. Weak, III. Slight, IV. Moderate, V. Rather Strong, VI. Strong, VII. Very Strong, VIII. Destructive, IX. Violent, X. Intense, XI. Extreme, XII. Cataclysmic

Source: Own elaboration.

Hierarchical position	Component
n	Index
n.n	Group
n.n.n	Indicator
n.n.n.n	Reagents

Figure 2. Hierarchical morphology of the UFTI approach.

Defining a scale of problems

The first step in UFTI characterization considers the dimensioning of the UFT problem, to somehow determine the "size of the problem".For UFTI metrics, affectation levels (L) are ranked from the lowest to the highest, as depicted in Table 3, ranging from only marginal effects derived from minimal freight traffic, to an invasive presence of trucks, severely affecting urban environment, traffic and infrastructure. This characterization aims at dimensioning different sets of urban freight problems. Even if this assumption could be largely simplistic, the urban transportation phenomena suggest that problems can be characterized in five levels (Table 3). Negative consequences are easy to foresee: if no attention is given to a problem, it will become worst and will gain a growing complexity while the phenomena evolve. This assumption means necessarily more and more resources to revert and to step back the system to a better or satisfactory level.

Although this scale is not a quantitative guideline, as no threshold values are provided, it can be useful as a first attempt to simplify the complex understanding of an urban freight system.

Defining a scale of measures

UFTI uses a five-stage scale for assessing the attention paid by the city on urban freight transport. After dimensioning the UFT problem, a second basic scale involves the level of commitment of national or local institutions and private companies. This second scale reflects a studied pattern of measures that stakeholders put in practice to alleviate UFT issues. It should be noticed that OECD report (OECD, 2003) serves as a conceptual framework in the sequence as discussed later.

This second scale implies that a pattern of common corrective measures or policies could be schemed all along five *stages* of intervention. In this context, each stage describes the complexity of an evolving pattern, which can become more and more complex according to the local conditions of light and heavy freight traffic, industrial growth, urban sprawl, and so on. Measures should go ideally planned from S_1 to S_5 stages (Table 4). In fact, S_5 stage represents the maximum force, meaning that an extensive attention is paid to the problems, denoting that such measures are supported by one or several coordinated actions implemented in earlier phases. On the other hand, stage S_1 implies that the attention paid to the urban freight transport is minimal or isolated.

While the scale depicted in Table 3 tries to represent a non linear tendency in the progression of problems, scale pictured out in Table 4 represents a set of general or specific actions implemented to address the severity of the problems generated by commercial, industrial or services activity in cities, as explained later. As a consequence of this assumption, a 5-color scale has been

Table 3. Basic weight of symptoms, by level of severity.

Level of severity	Level (L)	Symptoms
Low	L_1	- Low presence of both commercial and heavy trucks in urban environments.
Under-Mean	L_2	- Growing urban freight transport problems.
Mean	L_3	- Urban freight problems appear on a regular basis: conflicting streets at specific times of the day. - Infrastructure maintenance effort is not sufficient to decrease road surface damages.
Upper-Mean	L_4	- Quality of life of the local population is environmentally affected by the type and number of circulating trucks. - Structural damages detected in urban roads.
High	L_5	- Invasive presence of trucks all over the city, including residential areas. - High levels of environmental pollution (air, noise), and congested streets. - Urban road network deteriorated at the primary, secondary and tertiary level. - Reactions of the inhabitants against the freight traffic.

Source: Own elaboration.

Table 4. Basic weight of measures, by degree of intervention.

Degree of intervention	Stage (S)	Measures
High	S_5	- Sustainable objectives are promoted in a global mobility plan, including urban freight transport. - Dedicated logistics infrastructure and technology modify urban distribution patterns. - Environmental legislation to maintain the standard of living of the population, and its general quality of life. - Available assessment (feed-back) tools for applied measures. - Information technology based solutions.
Upper-Mean	S_4	- Urban freight is considered as key component in urban planning. - Measures aim at tackling pollution, congestion and pavement damage problems. - Planning through a (public-private) partnership process. - Authorities bring stakeholders together to discuss urban freight problems.
Mean	S_3	- Urban freight is partially considered in urban planning. - Private sector addresses independent actions to improve efficiencies. - Existing basic studies on the reorganization of urban freight transport. - Lack of ad-hoc information, but efforts exist to create information.
Under-Mean	S_2	- Unilateral public initiatives to improve urban freight in conflictive zones. - Public measures not structured. - Focus on expanding the urban road infrastructure, instead of enhancing operation efficiency.
Low	S_1	- Authorities apply isolated measures in focused conflictive zones.

Source: Own elaboration, inspired in OECD, 2003.

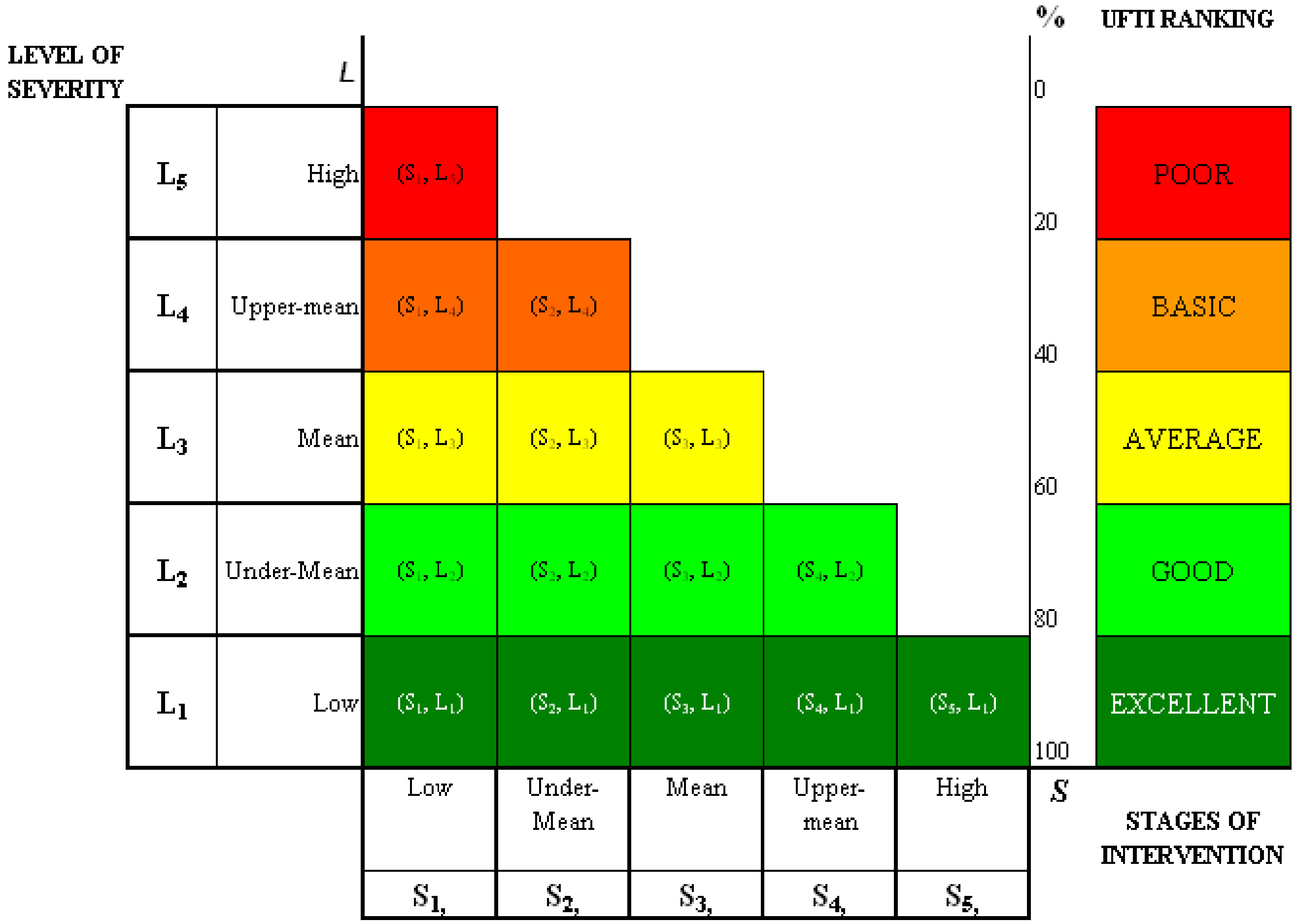

Figure 3. Idealized model to understand urban freight problems and stages of intervention, with a color-scaled ranking.

proposed to represent an idealized model to understand urban freight problems (Figure 3).

Step 2: Elaboration of the assessment tool

Defining groups

A review of urban freight practices in OECD countries (OECD, 2003) helps to state the type of actions implemented in urban freight. Under this basis, the experiences reveal four *groups* of issues to assess: (i) Measures planned or implemented at national level, (ii) Measures planned or implemented at local or regional level, (iii) Elements of analysis for the decision making process, and (iv) Measures implemented by the private sector (Table 5).

Identifying indicators

Indicators were tailored from different sources: A review of experiences in OECD countries (OECD, 2003); a previous diagnosis made in the QMA, as part of the same research project (Betanzo, 2006); and an analysis of comparative city cases. For the former, a methodology was created for establishing functional relationships for a set of 60 record cards of 45 cities in which we obtained valuable information (TMV, 2006a; TMV, 2006b). This procedure allows us to identify and classify sets of problems and key issues: growth of the freight vehicle fleet, increased traffic congestion, lack of sites for loading and unloading, increased pollution, inefficient traffic control, lack of planning on urban freight, measurement of logistics performance indicators and pavement damage (Betanzo, 2007).

Once the groups forming the index were defined, a list of indicators was constructed (Table 6). Indicators are a very important component of UFTI, because corrective actions must be addressed to raise a weak aspect of the city (that is, conditioning of loading/unloading areas or parking restrictions), as it can be observed in the study case. Cumulative synergy effects are expected to be consummated through the relationship between indicators.

Table 7 presents a summary of indicators of UFTI standards, by group of measure, totaling 34 possible interventions in any of the groups defined later.

Defining reagents

Reagents come from the sources named in previously. As stated previously, a reagent is the most basic component of an indicator. A reagent is a question or statement that is going to translate evidence-based signs or implemented actions on quantitative values. The baseline sets of reagents are defined within 34 indicators and 4 groups, totaling 234 reagents in UFTI version 1.0 (Table 8).

Table 5. Group of policies in UFTI.

Group of policies	Variable used in UFTI computings	Description
Policies planned or implemented at national level	**N**	Many of the decisions on urban freight transport depend on the financial support granted by national or federal authorities, in response to universal policies adopted by the nation. For example, international agreements.
Policies planned or implemented at local or regional level	**R**	Policies implemented by local authorities, in response to local or regional constraints of geographical, economical or environmental nature.
Promoting the development of supporting elements for the decision making process	**D**	Considers the implementation of public policies, at national and local levels, aiming at issues from a collective action approach.
Policies implemented by the private sector	**P**	Involves the awareness of the issue among carriers, producers, retailers and truck manufacturers.

Source: Own elaboration, inspired in OECD, 2003.

Table 6. Summary of indicators, by group of measures.

1	**Measures planned or implemented at national level (N)**
1.1	Rules on urban freight transport – general (e.g. environmental, safety, security)
1.2	Standardized procedures and standards (e.g. load tied on trucks´ platforms)
1.3	Restrictions to truck access (e.g. physical barriers, restrictive signs)
1.4	Truck parking restrictions
1.5	Standards for loading/unloading zones
1.6	Rules for the creation of urban distribution centers
1.7	Truck traffic bypasses and corridors
1.8	Measures to reduce noise pollution (e.g. standards on noise barriers)
1.9	Congestion charges for trucks
1.1	Subsidies or economic incentives to modernize transport units
1.11	Financing programs for research and development
1.12	Financing schemes for pilot projects to improve city logistics
1.13	Public dissemination channels on freight and transport issues
2	**Measures planned or implemented at local or regional level (R)**
2.1	Local rules and standards (state and municipal) – general
2.2	Standardized procedures and standards
2.3	Restrictions to truck access (e.g. physical barriers, restrictive signs)
2.4	**Preparedness of areas for loading and/or unloading operations**
2.5	Urban distribution centers supported by local authorities
2.6	Pilot projects to improve freight transport
2.7	Dedicated truck corridors
2.8	Intermodal facilities at urban level
2.9	Integration of freight transport into urban development plans
2.1	Truck traffic management tools
2.11	Pavement design standards for heavy truck traffic
2.12	Pollution control standard s and rules
3	**Elements of analysis for the decision making (D)**
3.1	Public data on the issue

Table 6. Contd.

3.2	Organized forums on urban freight transport
3.3	Published diagnostic reports and technical reviews
3.4	Assessment tools of the impact of specific policies
4	**Measures implemented by the private sector (P)**
4.1	Carriers: Reduction of fleets
4.2	Carriers: Use of intelligent transportation systems
4.3	Producers and retailers: optimizing fleet capacities and configurations
4.4	City logistics performance measures (e.g. deliveries per day, fuel consumption)
4.5	Automotive industry: performance-oriented innovations

Source: Own elaboration.

Table 7 Summary of indicators of UFTI standard, by group of measure.

Groups	Number of indicators
N	13
R	12
D	4
P	5
Total	**34**

Source: Own elaboration.

Table 8. Summary of reagents totaling the UFTI standard, by stage S.

	S1	S2	S3	S4	S5	UFTI
Number of reagents	16	37	55	78	48	234

Source: Own elaboration.

Table 9. Equivalent nominal weight of reagents by stage.

Degree of intervention	Stage	Numeric ratings assigned for positive answer (Nominal weight)
High	S5	5
Upper-mean	S4	4
Mean	S3	3
Under-Mean	S2	3
Low	S1	1

Source: Own elaboration.

Assigning weight values to reagents

Table 9 depicts the corresponding nominal weight of each reagent. This ranking procedure grants that a more complex intervention is better weighted during the evaluation process.

It is important to note that each stage S has an equivalent nominal value indicated in Table 9. Depending on whether the reagent at each group (*N*, *L*, *D* and *P*) is validated or not, the nominal value is picked up as follows:

Reagent in S_1: = 1; if a positive answer, = 0; otherwise
Reagent in S_2: = 2; if a positive answer, = 0; otherwise
Reagent in S_3: = 3; if a positive answer, = 0; otherwise
Reagent in S_4: = 4; if a positive answer, = 0; otherwise
Reagent in S_5: = 5; if a positive answer, = 0; otherwise

Table 10 contains the summary of maximal points totaling the UFTI standard, by stage S. The entire set of reagents of UFTI version 1.0 has not yet been released to public usage, given the possibility to register it as a patented system. Table 11 illustrates an example of a Group/Indicator/Reagent structure. In this case, being a component of the Measures Planned or Implemented at Local or

Table 10. Summary of maximal points totaling the UFTI standard, by stage S.

	S1	S2	S3	S4	S5	UFTI
Total of nominal points	16	74	165	312	240	**807**

Source: Own elaboration.

Table 11. Example of reagents collected in indicator 2.4: Preparedness of areas for loading and/or unloading operations.

2	**Measures planned or implemented at local or regional level (R)**	**UFTI**	**S1**	**S2**	**S3**	**S4**	**S5**
	Total of nominal points	807	16	74	165	312	240
	Total of nominal points in Group 2	384	1	10	15	4	5
	Total of nominal points for indicator 2.4	35					
2.4	***Preparedness of areas for loading and/or unloading operations***	35					
	Reagents of this indicator (ordered by stage sequence):						
2.4.5	Limits are defined for the time and interval of arrival and departure of cargo vehicles	1	1				
2.4.1	Adapted dedicated areas for on-street loading and/or unloading operations	2		2			
2.4.2	Established areas for on-street loading and/or unloading operations	2		2			
2.4.3	For commercial and industrial establishments it is compulsory to have their own bays for loading and/or unloading operations, according to building standards.	2		2			
2.4.4	Establishments must provide minimum areas for loading and/or unloading operations.	2		2			
2.4.9	In response to specific needs, night-time areas for loading and/or unloading operations are assigned within parking areas.	2		2			
2.4.6	Space provided for loading and/or unloading operations considers the free movement of pedestrians and vehicles over a sidewalk or street.	3			3		
2.4.8	Studies have been performed to determine the number and location of spaces for loading and/or unloading operations in congested spots within the city.	3			3		
2.4.11	As a result of proper measures, time for loading and/or unloading operations has shortened.	3			3		
2.4.12	As a result of proper measures, cargo damage during loading and/or unloading operations has decreased.	3			3		
2.4.13	As a result of proper measures, cargo theft during loading and/or unloading operations has decreased.	3			3		
2.4.10	Deliveries to establishments within congestion zones follow a schedule that reserves spaces for loading and/or unloading operations.	4				4	
2.4.7	Space provided for loading and/or unloading operations considers the free movement of other road users.	5					5
	Sub-total	35	1	10	15	4	5

Source: Own elaboration.

Table 12. Summary of UFTI elements.

Component	Number of elements
Index	1
Group	4
Indicator	34
Reagents	234

Source: Own elaboration.

Table 13. UFTI performance.

	Group	S1	S2	S3	S4	S5	UFTI
N	National policies decision	0	12	39	104	45	200
R	Local or regional policies decision	15	42	81	96	150	384
D	Decision making capabilities	1	16	33	64	0	114
P	Private sector decision	0	4	12	48	45	109
	Maximum UFTI value	16	74	165	312	240	807

Source: Own elaboration.

Regional Level group**,** the *Conditioning areas of loading and unloading* indicator cumulates 35 points if all reagents are positives. The standard values of the idealized overall performance of a city can be found in Table 13. General UFTI values in Table 10 are represented by rows 3 and 4, which have been extracted from the original spreadsheet. Row 5 was computed directly, following the procedure stated in Table 8, supposing that all reagents were positive. Shadowed boxes indicate the corresponding stage for the reagent. Finally, Table 12 summarizes the components of UFTI Version 1.0

Step 3: Formulation and systematization process

For UFTI calculations, a spreadsheet database software was used, to generate outputs that include charts and both executive and comprehensive reports. Four decision groups are considered for UFTI calculation, each one involving several reagents and five stages. Decision groups are designated as follows: *N*: National policies; *R*: Local or regional policies; *D*: Decision making capabilities; and *P*: Private sector decision. A generic formula to value the *k*- decision group, for the *j*-reagent at *i*-stage is as follows:

$$X_k = \sum_{i=1}^{5} \sum_{j=1}^{m_X} \left(X_j\right)_{s_i} \; ; \; \left(X_j\right)_{s_i} \geq 0 \tag{1}$$

where m_X refers to the number of reagents for the x- decision group.

UFTI calculation simply adds up X_k terms, as follows:

$$UFTI = \sum_{1}^{4} X_k \tag{2}$$

UFTI numbers for the evaluated urban area are nationally or internationally ranked to provide a feedback to the city administrators and authorities, in terms of each of the decision groups. Table 13 figures are the overall values proposed for UFTI. It should be noticed that each organization in charge of UFTI calculations, must figure out values for each stage, as well as for the overall maximum possible value for each stage and decision group. For such calculation, further additional performance measures could be applied, including standard measures such as the levels of traffic congestion and air pollution due to urban freight. Maximum values in this table correspond to ideal performances of an urban freight transport system, in which progressive and organized measures are put into practice to cope with problems while actively promote a healthy development of the industrial, commercial and services activities.

As a consequence of combining Tables 3, 4 and 13, a color-scaled ranking can be figured out (Figure 3) proposing an idealized model to understand urban freight problems and stages of intervention.

Under this conception, planners can use it as a boarding chart to see whether a city needs to embrace some specific issues or only some of them, as well as the remaining work to do in order to complete the idealized target stated by UFTI.

RESULTS

This section presents an experimental application of the tool in the Queretaro Metropolitan area. Queretaro City is the Capital of the State of Queretaro, Mexico. The state represents a small fraction (0.6%) of the two-million square kilometers of the Mexican territory. Its inhabitants contribute with 1.8% of the Gross Domestic Product (SIREM, 2005). In the last decades, the State of Queretaro has changed from a mainly rural to an urban state, with 31% of its population now living within QMA (QG, 2004). Such area has gained national recognition as having the highest integrated competitive media index, which assesses Mexican regions in terms of economical, institutional, social, demographic and urban factors (EGAP-IMCO, 2006). In particular, the local manufacturing

Table 14. UFTI results for QMA (in points).

Variable used in UFTI computings	Stage S1	Stage S2	Stage S3	Stage S4	Stage S5	Performance Mexico/QMA	UFTI
N (UFTI)	0	12	39	104	45		200
Mexico/QMA	0	2	6	0	0	8	
R (UFTI)	15	42	81	96	150		384
Mexico/QMA	11	16	9	16	20	72	
D (UFTI)	1	16	33	64	0		114
Mexico/QMA	1	2	0	0	0	3	
P (UFTI)	0	4	12	48	45		109
Mexico/QMA	0	0	3	4	25	32	
Total Mexico/QMA	12	20	18	20	45	115	
UFTI	16	74	165	312	240		807

Source: Own elaboration.

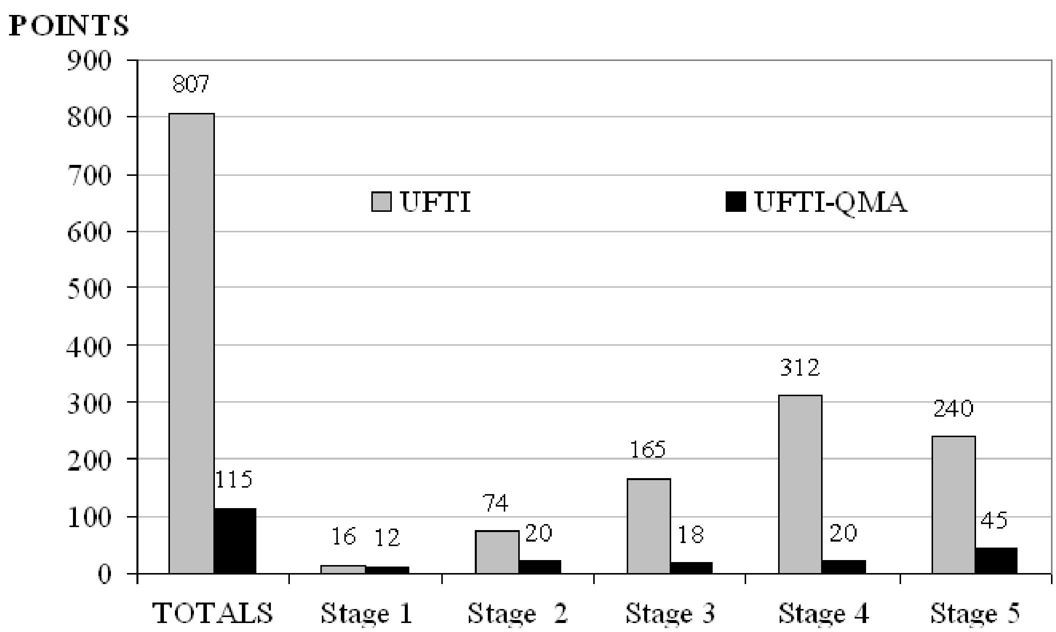

Figure 4. Comparisons between UFTI standard and UFTI applied to QMA, in points.

sector, ranging from auto to aerospace parts, has gained national notoriety. A key factor for such development is the geographic location of Queretaro, at the very centre of the country, with roads crossing the country from west to east and north to south. QMA thus represents not only one of the main national transportation nodes for passengers and freight, but also has become an important production and consumption center (Betanzo et al., 2008).

Overall UFTI results for QMA

The assigned weight value for each of the reagents was approved by consensus of the working group. Although judgments have been considered to be a questionable practice when objectivity is the norm, evidence shows that even when numbers are obtained from a standard scale and are considered to be objective, their interpretation is always, subjective (Saaty, 2008). Table 14 lists a summary of results for QMA.

Figure 4 describes UFTI outputs in the case of QMA, in terms of the level of compliance for each of the five stages considered in the assessment process. According to the ranking defined in Table 13, QMA exhibits a poor performance, by reaching 115 out of 807 points, that is, only 14% compliance, or a *"poor"* mark according to the color-scaled ranking in Figure 3.

Table 15. Comparative detailed results for groups, for QMA.

		Maximum	Value	% Of progress QMA
		UFTI value	UFTI QMA	
		807	115	
1	**Measures planned or implemented at national level**	**200**	**8**	**4**
1.1	Definition of national policies on urban freight transport	54	3	5.6
1.2	Standardization of applied measures	20	0	0
1.3	Restrictions for truck access	8	0	0
1.4	Restrictions for truck parking	4	0	0
1.5	Location of load/unloading zones	2	0	0
1.6	Creation of urban distribution centers	19	0	0
1.7	Traffic bypasses	6	3	50
1.8	Measures to reduce noise pollution	13	0	0
1.9	Taxes	8	0	0
1.1	Subsidies or economic incentives	15	0	0
1.11	Support for research and development	15	2	13.3
1.12	Support for undertaking pilot projects	11	0	0
1.13	Information dissemination	25	0	0
2	**Measures planned or implemented at local or regional level**	**384**	**72**	**18.8**
2.1	Definition of a local policy (state and municipal) on urban freight	14	3	21.4
2.2	Access restrictions	104	19	18.3
2.3	Parking restrictions	12	4	33.3
2.4	Preparedness of areas for loading and/or unloading operations	35	6	17.1
2.5	Urban distribution centers supported by local authorities	82	19	23.2
2.6	Pilot projects	4	0	0
2.7	Dedicated corridors for trucks	5	2	40
2.8	Intermodal options within urban scale	5	0	0
2.9	Integration of freight transport in urban planning	35	8	22.9
2.1	Traffic	21	0	0
2.11	Pavements	7	0	0
2.12	Pollution	60	11	18.3
3	**Elements of analysis for the decision making**	**114**	**3**	**2.6**
3.1	Perception of the importance of the urban freight transport in the society	41	0	0
3.2	Consultation and discussion forums on urban freight transport	44	2	4.5
3.3	Lack of awareness and technical knowledge	5	1	20
3.4	Lack of instruments for evaluation before and after	24	0	0
4	**Measures implemented by the private sector**	**109**	**32**	**29.4**
4.1	Carriers: Reduction of fleets	40	0	0
4.2	Carriers: Use of intelligent transportation systems	14	10	71.4
4.3	Producers and retailers: Processes	17	8	47.1
4.4	Indicators of logistic performance	24	0	0
4.5	Automotive industry: Technology innovation	14	14	100
	Overall performance of QMA under UFTI standard	**807**	**115**	**14.3**

Source: Own elaboration.

Figure 4 illustrates the evolution of UFTI compliance with the consecutive assessment stages, further revealing that a poor performance is exhibited in every stage, meaning a minimum level of effectiveness and a very little effort to address the problem in an integral manner, whether through national or local measures.

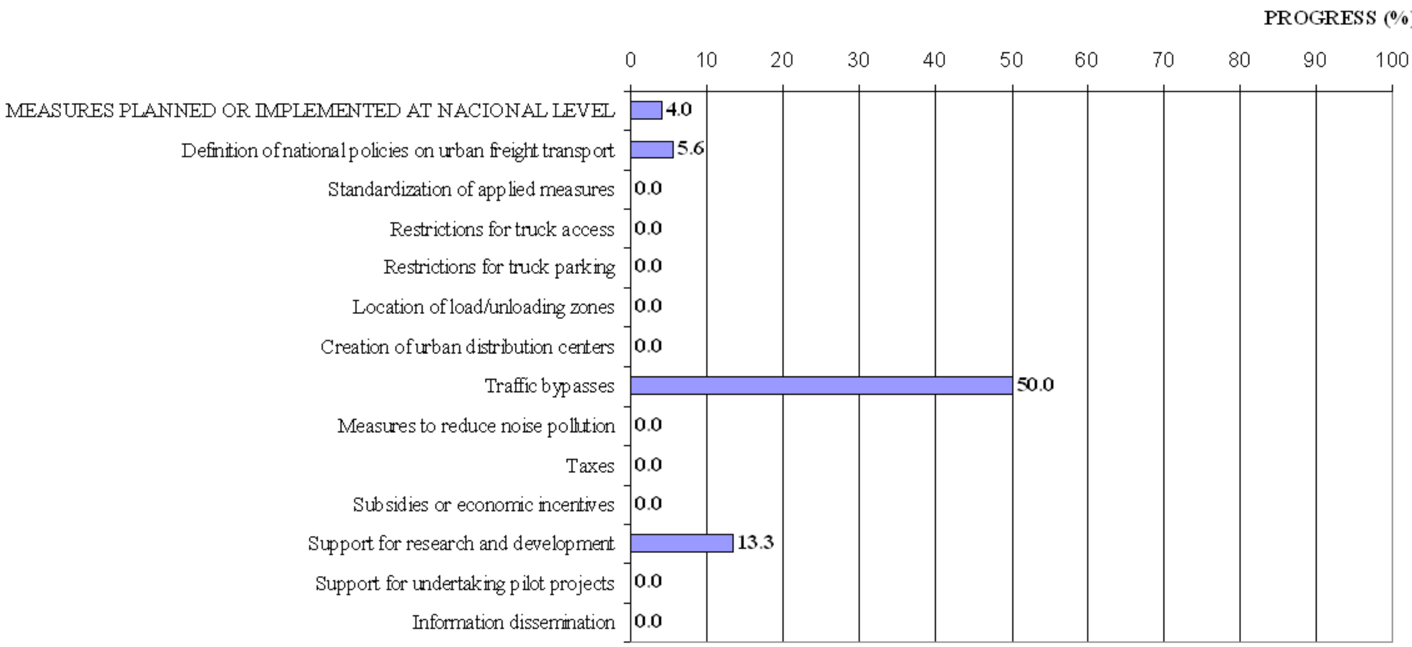

Figure 5. Progress and remaining work to do in QMA with respect to national measures.

Detailed results for groups

Table 15 lists specific performance numbers for the QMA according to the four groups defined earlier, considering the complete set of indicators for each group.

Measures planned or implemented at national level

Application of UFTI criteria to QMA revealed a poor performance, with a level of compliance of only 4% (Table 15). This clearly indicates that the problem has not been perceived as a national priority, regarding the commitment of improving the quality of life of people from Mexican cities, but also in terms of national policies aimed at improving the environment and business productivity in cities.

However, UFTI criteria serve to identify a series of specific actions to achieve a better functioning of the freight system. If compared to top-line countries and cities, Figure 5 can be used as a control board for the various indicators evaluated at national level and the remaining work to be done, if UFTI measures were considered within an improvement plan.

Measures planned or implemented at local or regional level

QMA performance regarding local measures revealed an insufficient performance at every stage of the process (Figure 6), with an overall performance of 19% (Table 15). UFTI numbers somehow confirmed that local authorities still do not have specific plans for urban freight transport so that urban freight is absent from the institutional planning process. This feature is characteristic in the state of Queretaro planning agencies, as well as in those pertaining to the three municipalities involved in the study. Relative high values for UFTI performance derives from investments in urban road infrastructure, including by-pass routes.

Future actions to improve the situation are listed in Figure 7, in order to reach UFTI standards. High priority efforts should be addressed in the field of access restrictions, parking restrictions, preparedness of areas for loading and/or unloading operations, creation of urban logistics infrastructure for last-mile deliveries and promotion of pilot projects. From this assessment, important changes in infrastructure can be suggested, for urban freight corridors requiring pavements reinforcement works.

Elements of analysis for the decision making

The overall performance in absolute terms in this field is around 2.6% (Table 15). This indicates a poor perception addressed to urban freight, so that the issue has not been discussed with authorities, private sector and society. The technical areas of municipal and state government are still focused on mass transportation. Consequently, somehow evaluation instruments related to urban freight are not available. Figure 8 illustrates the

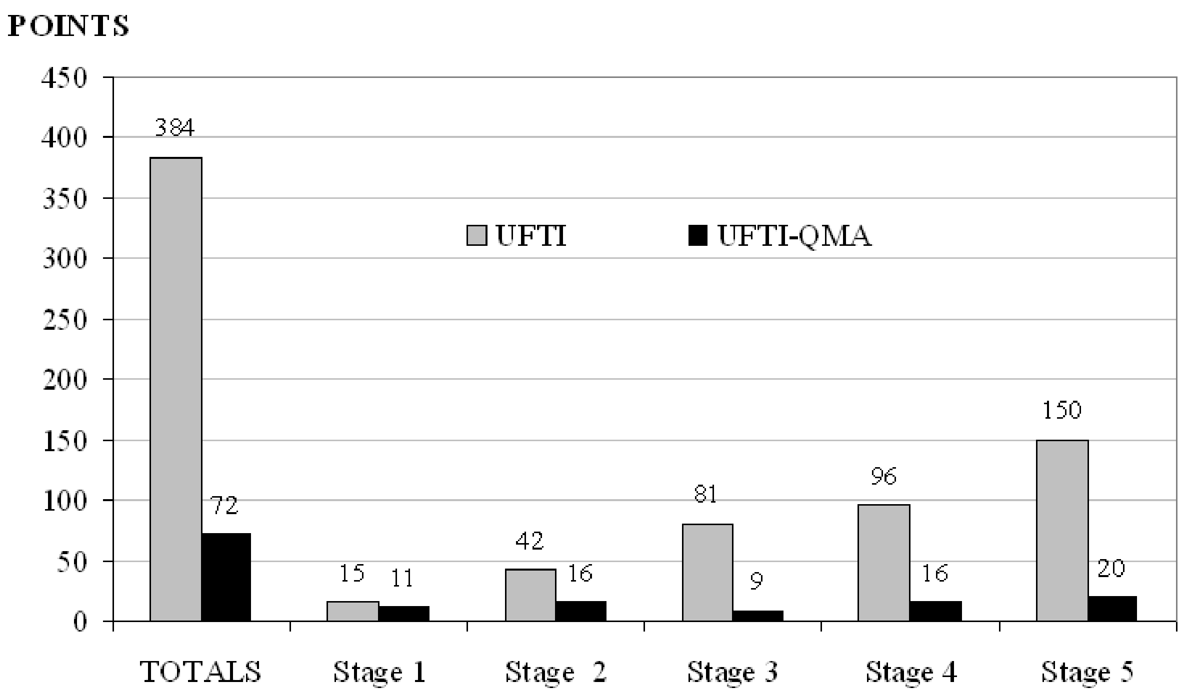

Figure 6. Assessment of local or regional measures in QMA.

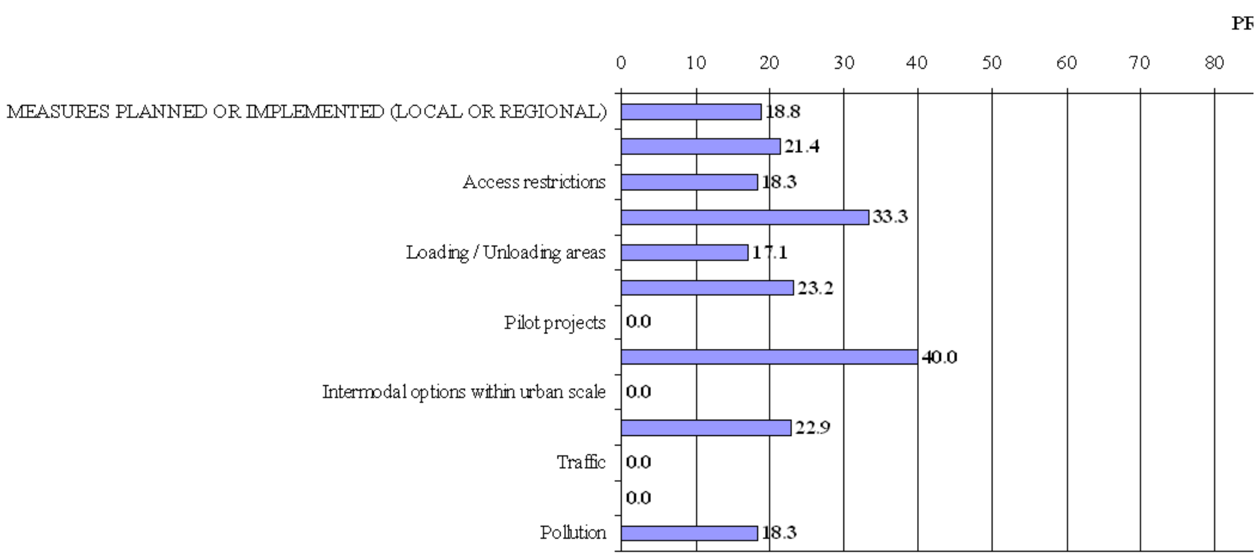

Figure 7. Progress and remaining work to do in QMA with respect to local o regional measures.

level of progress when compared to UFTI standards.

Measures implemented by the private sector

This module assesses some measures/technologies implemented by private stakeholders. UFTI results in this case revealed an overall performance in absolute terms of around 29.4%. It should be noticed that general-purpose information was available, and that a greater number of reagents could be necessary to add. In particular, a greater number of reagents are needed to get into the private stakeholders environment, in order to evaluate the performance of distribution routes, discover logistic process and so on. Figure 9 illustrates the level of progress of some actions carried out by the private sector

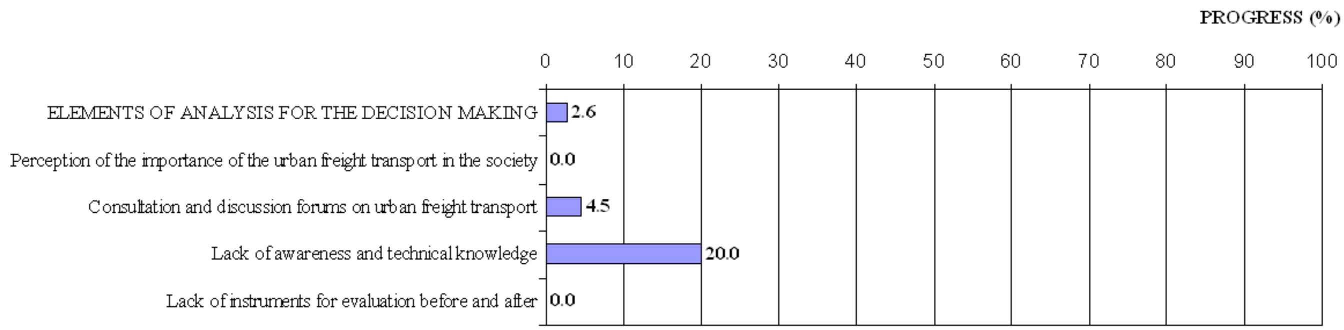

Figure 8. Progress and remaining work to do in QMA with respect to elements of analysis for the decision making.

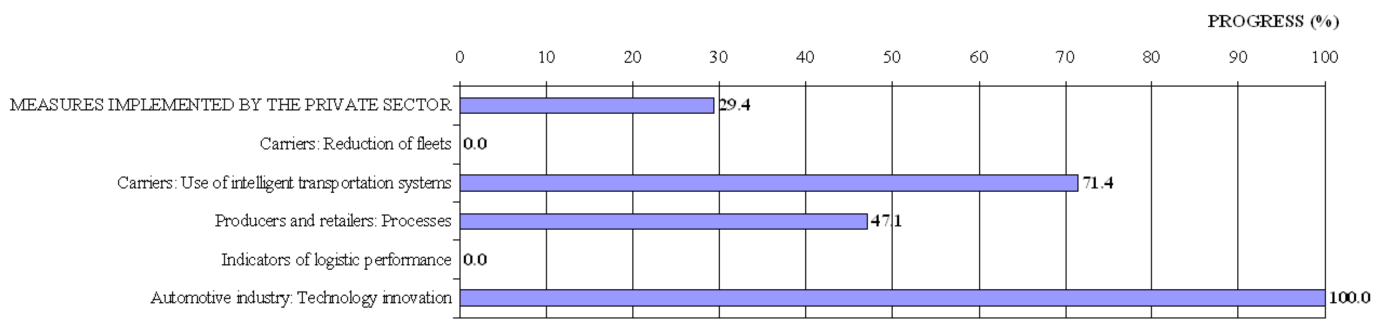

Figure 9. Progress and remaining work to do in QMA with respect to implemented measures by private sector.

in the QMA.

DISCUSSION

UFTI is designed to be practical, to identify urban freight issues to further recommend appropriate actions to move the system into a satisfactory status. Comparison made in UFTI with performances in developed countries can be considered an important international benchmarking in order to promote a sustainable urban freight transport.

Since UFTI methodology comes from experiences and previous works carried out in a variety of developed countries and cities, it could be easily applied in such kind of cities. It is expected that big cities in OCDE countries would reach the highest marks, whereas undeveloped cities which have never been exposed to city logistics approaches will remain probably at the bottom of the chart, as depicted in Figure 10.

Figure 10 represents an idealized pattern containing UFTI results in cities after a hypothetical use of this methodology. As it can be suggested, grouping criteria of cities could be made by: number of inhabitants, regions of the world, continental countries and countries affiliated to international organizations, cities pertaining to a unique country, and so on. In addition, it is clearly expected that most modern-organized cities be better ranked, due to their major technical organizations and a higher amount of financial resources to face urban issues. Instead of preparing a separated method for each situation, UFTI methodology groups basic city conditions to be evaluated (developed/undeveloped cities; large/small-size cities; national capitals/medium-sized cities). As a particular case, UFTI applicability in large-size cities could be also extended without any predictable difficulty.

UFTI version 1.0 provides a colored scale where an assessed city can be positioned. In terms of the maximum points allowed by this method, it is clear that a medium-size city from an undeveloped country has nothing to do with a capital city of an industrialized country. This is the reason why, a differentiated scale could be further established. This is a methodological challenge to engage within a long-term research program. This comparative study will allow researchers to discover on quantitative basis common positive or negative features in those cities (that is, awareness of public authorities at national or municipal level; how useful have applied measures been, and so on).

As part of the same discussion, it is expected that UFTI becomes an assessment system linking municipal authorities, academic institutions and planning agencies in Mexico, on the basis of seminars and on-line web-

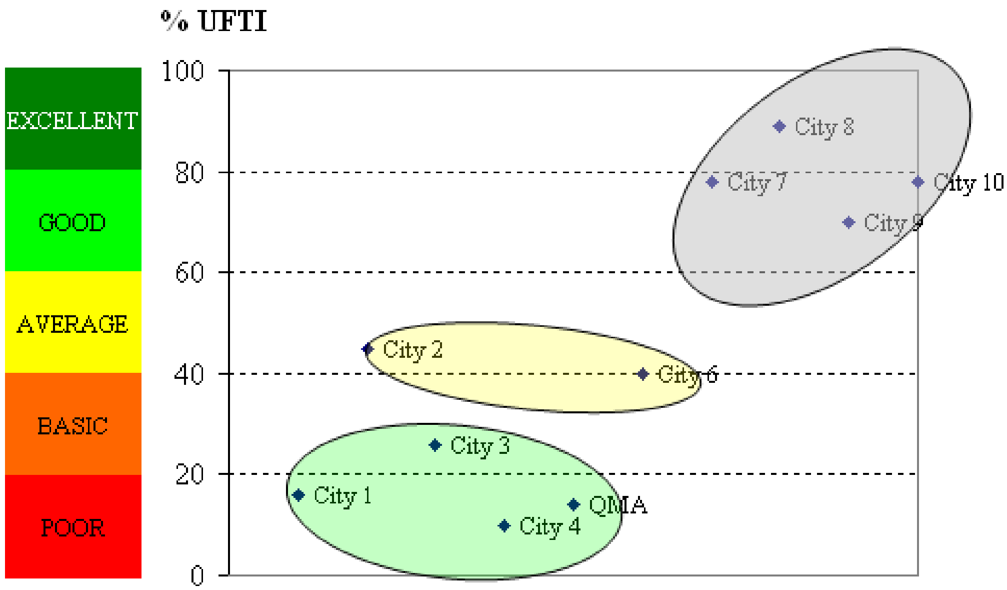

Figure 10. Idealized large scale comparative study in worldwide cities.

based projects. UFTI methodology is expected to be applied simultaneously in a homogeneous set of 55 Mexican metropolitan areas.

Limitations of applying the UFTI tool

1. Inconsistency in UFTI–related decisions.- This inconsistency can occur as a result of poorly selected reagents. However, specific errors in the definition of reagents can be easily debugged, as many other actions are taken into consideration in a staggering process.
2. Incomplete set of reagents.- Future attempts to improve UFTI Version 1.0 consist on adding, reducing or adjusting the number of reagents, that is, fusing reagents in order to pack the indicators.
3. Improve proportionality of indicators and reagents.- Another improvement can introduce a proportionality factor between steps and group of reagents, in order to get a best balance among groups of measures.

Conclusions

While urban freight transport constitutes a basic input to satisfy population needs and economic growth in cities, a large number of impacts affect the way inhabitants live as truck and commercial vehicles generate traffic congestion, pollution in the form of noise and air pollutants, vibration in buildings and physical damages to the infrastructure. Consequently, interest on urban freight results crucial because of its significant environmental sensitivity.

Literature reveals progress in acknowledging the negative effects of urban freight. Recent efforts have been reported about assessing measures and policies adopted and designed to mitigate and promote efficiently urban freight. Sound decisions in evolving systems play a definite role in preventing vicious cycles.

In the perspective of methodological works, an urban freight transport index (UFTI) was proposed as an international standard. The overall view of a freight transport system in a city can be assessed on a comparative basis among other urban agglomerations. UFTI assessments allow identifying five sets of staged measures that can be put into practice in order to mitigate the evolution of urban freight transport effects within a particular area. These assessments enabled us to create performance profiles to specifically identify weak areas that need to be reinforced in order to improve urban freight transport. UFTI numbers can ultimately identify specific actions needed, and what stakeholder should perform the actions.

UFTI evaluation of a Mexican mid-sized urban agglomeration rates the Queretaro Metropolitan Area with 115 out of 807 points corresponding to the ideal situation. That means a general UFTI of 14% of compliance, "*poor*" if compared to developed countries and conscious cities. As a result of this assessment, a variety of measures to alleviate an elementary situation has been established in an integral manner, arranged into four groups and five stages of intervention. Public policies at national and local level need to be placed on top of the priorities and regulations and others forms of traffic control should be applied to reduce traffic congestion, damaged infrastructure and pollution.

Although UFTI results are promising as a new method to assess urban areas, it still needs some complementary improvements to increase the number and quality of objectively verified indicators, as well as other quantitative performance measures. At this stage, UFTI version 1.0 is under experimental observation and represents a promising tool to diagnose and potentially improve urban freight transport.

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