SOMMARIO
Negli ultimi anni il crescente interesse verso i problemi connessi all’incidentalità hanno spinto all’implementazione di azioni specifiche sia in campo urbano che extraurbano. Di contro, gli ultimi dati mettono in luce tendenze alquanto differenti tra le aree urbane e quelle extraurbane. In particolare, la percentuale di veicoli commerciali coinvolti in incidenti urbani a livello europeo è bassa ma significativa (tra il 5% ed il 7%), ed è rimasta pressoché costante negli ultimi anni, dimostrando che le azioni messe in atto per il raggiungimento degli obiettivi comunitari non hanno avuto risultati soddisfacenti e che azioni specifiche devono essere investigate se si vuole raggiungere l’obiettivo di zero vittime nella sicurezza stradale entro il 2050.

La nota propone una analisi del contributo dei veicoli commerciali alla sicurezza stradale urbana con un approfondimento relativo agli incidenti sia mortali che non, in corrispondenza delle intersezioni stradali. Le analisi sono dettagliate per i pedoni e per tre paesi europei, per i quali sono disponibili dati più disaggregati: Germania, Italia e Regno Unito. Viene, quindi, proposta un modello di simulazione che consente di analizzare ed ordinare in modo quantitativo le intersezioni stradali in una area urbana rispetto al rischio di incidente tra veicoli merci e pedoni.

1. INTRODUCTION
Referring to the goals of European Commission, first of all with the White Paper in 2001 [1] (i.e. deaths reduction of 50% by the 2012) and, after, in the White Paper in 2011 [2] (towards the zero-deaths in road safety), in the last years there is a growing interest on problems related to road accidents. This has led to an increased interest of public administrators with the consequent implementation of specific actions in both urban and extra-urban contexts. At the other hand, while the latest statistics reveal the average reduction of accidents and deaths, they reveal quite different trends between the urban and suburban contexts. The same White Paper reports that in 2011, in Europe, 69% of road accidents happening in the city. Besides, referring to the years between 2000 and 2010, in some European countries (including Italy), the rate of road accidents in the national urban average is greater than 50%. In Italy, this percentage was 78%, with an average annual increase of 0.2%. Attention should be paid to deaths and injuries. The annual rate of fatal accidents has remained fairly constant between 2001 and 2010, ranging from 19 % in Spain to 43 %
in Italy. The annual percentage of injuries has remained higher than 60% and only in Spain, however, was slightly lower at 50%.

In this context, special attention should be given to the road accidents involving goods vehicles as they often have serious consequences both for human life and for damage to property.

Although, the percentage of goods vehicles in road accidents in urban European level is low (between 5% and 7%), this has remained fairly constant in recent years, demonstrating that the actions taken to achieve the objectives of the Community did not have satisfactory results. Then, specific actions need to be investigated if the communities want to achieve the goal of zero fatalities in road safety by 2050. Concerning the accidents involving goods vehicles, 70% occur at intersections and a percentage between 6 % and 12% refers to the involvement of pedestrians.

The paper proposes an analysis of the contribution of goods vehicles at urban road safety with an in-depth analysis at road junctions. The analysis is detailed for pedestrians and for three European countries, for which more disaggregated data are available: Germany, Italy and the United Kingdom (section 2). Subsequently, the estimate of road network flows is analyzed and an advanced modelling system for road network flow estimation is recalled (section 3), by means of it is possible: to estimate the commercial vehicle flow at each junction, to estimate a proxy variable of pedestrian flow, to merge with the characteristics infrastructural of the junction, to calculate the risk, and to ordinate the intersection in a list of decreasing risk, to give to the decision maker a quantitative and ordinate sequence to make “road work”. Finally, some conclusions and operative indications to meet the future safety goals are given in section 4.

2. THE CONTRIBUTION OF GOODS VEHICLES TO ROAD ACCIDENTS IN EUROPE AT URBAN LEVEL

Although, the level of detail of the main European safety statistics (e.g. CARE database [3]) is insufficient to provide a fully accurate view with respect to goods vehicles, in the following, some focal analyses based on number of accidents, number of deaths and injuries are provided. The analysis is detailed for some European countries for which data on road accidents were available according to CARE database (e.g. European centralised database on road accidents which result in death or injury across the EU): Germany, Italy and United Kingdom. The available data cover the time between the 1995 and 2010.

Focusing on data available after the 2000 in Italy, Germany and United Kingdom, we can see that the percentage of accidents involving goods vehicles in urban areas is quite constant among the three countries and is higher for United Kingdom (always higher than 6.3%; Table 1). The number of deaths and injuries with respect to number of accidents involving goods vehicles is higher in Italy, while is averagely lower in Germany and United Kingdom (Table 2). Comparing these results with passenger data, we can see that, in the recent years, the many actions proposed by National and European Governments have allowed to reduce the total number of fatalities in road accidents mainly related to passenger vehicles (Figure 1), but fatalities due to goods vehicles is remained quite constant. It is possible to note that the accidents of goods vehicles often have serious consequences on human life and damage to goods.
Table 1 – Trend of the urban accident percentages involving goods vehicles.

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
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<td>5.3%</td>
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<td>4.9%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>4.9%</td>
<td>4.8%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Italy</td>
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<td>5.1%</td>
<td>5.0%</td>
<td>5.1%</td>
<td>5.1%</td>
<td>5.0%</td>
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<td>5.2%</td>
<td>4.8%</td>
<td>4.9%</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6.7%</td>
<td>7.1%</td>
<td>6.8%</td>
<td>7.0%</td>
<td>6.4%</td>
<td>6.9%</td>
<td>6.9%</td>
<td>6.6%</td>
<td>6.4%</td>
<td>6.3%</td>
<td>6.8%</td>
</tr>
</tbody>
</table>

Table 2 - Average number of deaths and injuries in 100 accidents involving goods vehicles.

Deaths

<table>
<thead>
<tr>
<th>Countries</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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<tr>
<td>Germany</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Italy</td>
<td>0.5</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
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<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
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<tr>
<td>United Kingdom</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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<td>0.1</td>
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<tr>
<td>Average</td>
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<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
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<td>0.1</td>
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</table>

Injuries

<table>
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<tr>
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<th>2003</th>
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<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tr>
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<td>21.2</td>
<td>20.4</td>
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<tr>
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<td>26.7</td>
<td>27.4</td>
<td>25.7</td>
<td>25.1</td>
<td>25.5</td>
<td>25.0</td>
<td>25.6</td>
<td>28.2</td>
<td>28.4</td>
<td>27.5</td>
<td>26.4</td>
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<tr>
<td>United Kingdom</td>
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<td>27.8</td>
<td>28.5</td>
<td>27.4</td>
<td>26.8</td>
<td>26.0</td>
<td>26.2</td>
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<td>24.0</td>
<td>26.4</td>
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<tr>
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<td>25.4</td>
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<td>23.3</td>
<td>23.7</td>
<td>24.0</td>
<td>23.9</td>
<td>24.0</td>
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</table>

Figure 1 – Trend of total national road accidents in some European countries.

The location of accidents involving urban goods vehicles and pedestrians in Europe

The following analysis refers to the location of accidents. About 60% involving goods vehicles happens at urban junctions. The number of deaths at these points remains quite high along the years and for the three considered countries, with different percentages among the three countries: the lower values refer to Germany, while the higher one to United Kingdom (Table 3). Although in 2007 in Italy the number of accidents involving goods vehicles is similar to previous and following years (about 30), only 2 accidents occurred at junctions, that means the reported low value. It represents a singular point along the time series reported in the CARE database.
Then, the analysis was detailed in order to estimate the involvement of pedestrians. The results show that the three investigated countries has different trends. United Kingdom has a decreasing trends for number of accidents, number of accidents involving pedestrians and number of pedestrians involved, while in Germany and Italy all these statistics remained quite constant along the investigated years: the German absolute level is higher than Italian one (Figure 2). At the other hand, the average percentage of accidents with pedestrians involved raises for all three countries (Figure 3) with the low absolute values for Italy and higher for United Kingdom.

Table 3 - National ratio between accidents/deaths/injuries at junctions and total urban accidents/deaths/injuries (involving goods vehicles in urban areas).

<table>
<thead>
<tr>
<th>Countries</th>
<th>2000</th>
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<td>Germany</td>
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<tr>
<td>- accidents</td>
<td>60%</td>
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<td>59%</td>
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<tr>
<td>- deaths</td>
<td>28%</td>
<td>19%</td>
<td>27%</td>
<td>15%</td>
<td>39%</td>
<td>22%</td>
<td>24%</td>
<td>20%</td>
<td>16%</td>
<td>26%</td>
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<tr>
<td>- accidents</td>
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<td>53%</td>
<td>52%</td>
<td>52%</td>
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<tr>
<td>- deaths</td>
<td>31%</td>
<td>42%</td>
<td>36%</td>
<td>38%</td>
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<td>32%</td>
<td>39%</td>
<td>7%</td>
<td>39%</td>
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<td>- injuries</td>
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<tr>
<td>United Kingdom</td>
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<tr>
<td>- accidents</td>
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<td>69%</td>
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<td>68%</td>
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<tr>
<td>- deaths</td>
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<td>47%</td>
<td>58%</td>
<td>40%</td>
<td>33%</td>
<td>25%</td>
<td>67%</td>
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<td>- injuries</td>
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</tr>
</tbody>
</table>

Figure 2 – Trend of total national road accidents involving goods vehicles in some European countries.
Finally, the last analyses were performed for investigating the accidents of goods vehicles with the involvement of pedestrians at urban junctions. We have different levels: the low one refers to Italy and the higher one occurs in United Kingdom (Figure 4). Both countries have a revealed heavy traffic counted in 18,000 Millions of tons-kilometers in 2010. We have to note the rising trends for all the three investigated countries, showing the centrality of the problem and more analyses should be carried out in order to implement specific and more performing actions.
3. METHODS TO STUDY ROAD ACCIDENTS

The study of road accidents requires specific data analysis in order to obtain the risk factors and the safety performances. Two different methodological analyses can be used: aggregate or disaggregate. In the following, each of them is briefly described.

3.1 The aggregate analysis

Analysis should be applied to the accidents that occur in an area where the frequency of accidents is higher than the other ones (i.e. black-spots). The black-spots can be relative to a local area (e.g. junction) or a large area (e.g. road network). Their identification derives from predefined accident aggregate indicators.

The aggregate analysis concerns a large area (such as an urban area or a central business district) and estimates the probability of an accident occurring in relation to a set of attributes that generally are macro. These data are often held by public organizations, can be updated through monitoring surveys, and are used to define and to characterize the phenomenon (e.g. type, temporal trend) as well as to locate the black-spots and to define strategies and measures.

The quantification (in terms of absolute value and frequency) and characterization of accidents is based on available data obtained from Institutional Agencies (e.g. Italian National Institute of Statistics, EuroStat). This type of analysis allows to estimate the quantity of accidents in an extended area or in relation to particular type of accidents. In the former, the infrastructural black-spots can be identified, while in the latter it is possible to estimate the weight of accident classes in relation to total number of accidents. Therefore, some indicators can be used in order to identify risk behaviour of users due to no-use of safety passive devices (e.g. seat belts), no-compliance of Highway Code.

The identification of black-spots can be done through the spatialization of different indicators. Examples of possible indicators to be used in an aggregate accident analysis can be classified as follows:

- **general data**, e.g. dimension of study area, inhabitants also aggregated for age classes, type of city (touristic, industrial) or type of area (e.g. cbd);
- **data on mobility**, e.g. network length also classified for type, road flows, pedestrian network length, characteristics of transit, number of veh-km per class of vehicles;
- **data on accidents and involved users**, i.e. total number of accidents per reference time, total number of deaths, number of injured, characteristics of involved users (e.g. age, sex), day of the week, type of vehicle, type of accident (e.g. lateral or frontal crash)

The analysis of these types of data can be done in order to obtain the absolute or the percentage values. The absolute values give us the dimension of phenomenon, in space and time. The percentages allow to identify the relevant characteristics of accidents (e.g. number of deaths with respect to the total number of accidents), to verify the incidence of environmental factors (e.g. type of involved vehicles). The analysis of
these values also provides indications for the existence of black-spots and for comparing different areas.

3.2 The disaggregate analysis

The disaggregate analysis concerns an infrastructural element (such as a road, junction, or parking area) and defines common elements in the accidents in order to identify safety measures to avoid impacts in relation to a set of attributes that are generally micro. With disaggregate analysis the accident scenario can be generated. For disaggregate analysis, different methods have been proposed that can be classified in [4]: collision diagram, cinematic reconstruction, accident scenario.

The collision diagram [5] is a schematic representation of accidents occurred in a specific place and time. Then, they are drawn with schematic conventional signs (segments, lines, circles). Each conventional sign represents a kind of accident or a kind of collision and each accident is defined with the drawing. All the data relative to the accidents are reported and classified in a table in order to select the factors that have produced the accidents. This type of method synthetises the major information referring to accident, such as type and severity of accident, date and time, road conditions and so on.

Another method concerns the cinematic reconstruction [6] of the accident considering as input data the final position of the vehicle after the accident and all the other measured data at the site of the accident. This method allows us to simulate the accident and to verify the effects of implementing various measures that can be applied on the site of the accident.

Based on the statement that accidents could be aggregated in relation to deeper similitudes, some research linked the accidents within the accident scenario approach [7, 8]. Although the accident scenario approach was proposed some years ago in France, it is still in a research phase. Current developments concern the quantitative formalization of the methodology and its application outside France in order to test the transferability of results and increase the number of available scenarios [9, 10].

The analysis through scenario approach consists of aggregating the accidents occurred at a black-spot in groups with similar characteristics such as: accidents involving pedestrians, accidents due to loss of vehicle control and so on.

The methodology is usually articulated as follows:

- each accident is in-depth studied in order to analyse the subsequent phases of guide (before accidents), breaking, emergency (immediately before the accident), choc and crash;
- the accidents are grouped in relation to statistical techniques (e.g. cluster analysis);
- each identified group is associated to each existing accident scenario or a new accident scenario is built that is more general and independent from the analysis procedure

The disaggregate analysis requires ad-hoc surveys and the collecting system can be both on-time and on-the-scene. Where black-spots are, the monitoring should be continuative (on time) with the identification of socio-economic characteristics of areas and storing of traffic data. Besides, a specialist team should be
provided for immediately revealing the accident (on the scene).

4. THE NETWORK ROAD FLOWS FOR SAFETY ANALYSIS

Continuous monitoring and effective understanding are required to afford decision-makers the ability to successfully design and implement transport policies while responding adequately to new challenges [11], especially in the freight transport field. Simulation models play a key-role to evaluate the performance of road network in terms of safety (i.e. number of accidents at nodes and on links) and to calibrate the scenarios from the accidents. A large literature exists on passenger mobility but fewer studies have been done on freight/goods mobility, and, in particular, on joint analyses. In fact, the literature review [12, 13, 14] shows that many urban freight models are not integrated with the models that simulate other components of urban mobility and many of them are only theoretical: they are not used (or usable) for forecasting the impacts of implementing traffic and transportation measures at an urban scale. These models have been developed to simulate some aspects of the restocking process and do not start from the end consumer. Hence, it is difficult to consider the link between these urban models (developed mainly for logistic trips) and end-consumer models (which are those developed for passenger mobility) and to analyse the complexity of urban transport systems with all the components that make up urban mobility.

Besides, the goals to reduce the interferences among the different components of urban mobility (i.e. passenger and goods movements), able to limit the cause of accidents, requires that the measures to be implemented have to be assessed by models that allow to point out each of them. In urban areas, and in particular within the inner areas, shopping trips (and subsequently pedestrian flows) are significant. Surveys focusing on freight mobility carried out in some European cities [15] revealed that about 69% of urban distances (veh-km) covered each day by motorized vehicles consists of shopping trips, 24% of restocking trips and the remaining 7% results from urban management (e.g. building sites, waste collection, network maintenance). At the other hand, in the global urban planning other single urban attractive points have to be studied, such as schools, public offices and so on.

Then, there are models proposing to integrate the previous types of models in a general framework, representing commodity flows as generated by the consumption of the commodity, as a component of the generic urban activity undertaken by consumers. The main characteristic of this general framework is the representation of interacting behaviour of commodity consumers and commodity suppliers/shippers/retailers [16, 17].

Referring to the general modelling system developed by the authors [17] consisting of two levels for a medium-size city, it applies a disaggregated approach for each decision level (Figure 5):

- **commodity level** (first level) concerning estimation of the quantity of Origin-Destination (O-D) flows; at this level the models involve the calculation of
  - O-D flows related to consumption and, then, the end-consumers’ behaviour is investigated and simulated in terms of characteristics of undertaken journey (e.g. origin and destination, dimension of purchases, mode; [18]);
- O-D freight flows related to restocking and then to simulate the restocking process of retail activities located within the urban and metropolitan area (study area) in terms of distribution channels (i.e. to pull or push movements) and the destination areas where freight is to be sold in retail outlets (inside or outside study area);

- **vehicle level** (second level) that allows quantity flows to be converted to vehicle flows [19, 20, 21];
  - at this level the models involve the determination of
    - restocking trip chain in terms of the quantity brought to each stop, the zone and vehicles needed for restocking;
    - time and path chosen for restocking sales outlets.

Therefore, the vehicle level through time and path macro-model allows us to obtain the link road flows (in terms of goods vehicles), while the attraction macro-model gives the end consumer flows according to place where the purchases are done and the origin of trip (i.e. Origin-Destination matrices). These are the input of the assignment models that allows to obtain the link flows and then data for disaggregate analysis of accidents.

The assignment models include path choice models and network loading models for both passenger and freight vehicles. Several models have been developed both for passengers and goods vehicles [19, 22] path choice that can be adapted for this aim. Then, the network loading model simulates how O-D vehicle flows load the paths and the links of the road network, and estimates the link flows, i.e. the number of cars and goods vehicles loading each link. For more details on assignment models for passenger cars refer to [23], while for goods vehicles to [19] and references quoted therein. Therefore, the attracted passenger vehicle flows give us a proxy of the number of pedestrians that move for shopping within the study area.

**Commodity level**

![Commodity level](image)

**Vehicle level**

![Vehicle level](image)

**Figure 5 - Modeling system structure**

### 4.1 The commodity level

The commodity level concerns the estimation of quantity flows. In particular, recalling Figure 5 the main outputs are given by goods quantity flows by family and by retailer (for areas). Referring to goods quantity flows by family, given that goods flows are estimated to support a given end-consumers’ need, the total...
quantity of freight type \( s \) attracted from zone \( d \), \( Q_{s,\text{tot},d} \), can be calculated as:

\[
Q_{s,\text{tot},d} = Q_{s,d} + QE_{s,d} = \sum_{o} Q_{s,od} + QE_{s,d} = \\
= \sum_{\dim} \sum_{o} \text{TRIP}_{s,od}(\dim) \cdot \dim \cdot QE_{s,d} = \sum_{\dim} \sum_{o} \text{TRIP}_{s,o} \cdot p[d/os] \cdot p[\dim/dos] \cdot \dim + QE_{s,d}
\]

where

\( Q_{s,d} \) is the goods quantity bought/sold in \( d \) given by the demand of end-consumers living/working in a zone \( o \) within the study area;

\( QE_{s,d} \) is the goods quantity bought/sold in \( d \) given by the demand of end-consumers living/working in a zone \( z \) external to the study area;

\( Q_{s,od} \) is the goods quantity bought in zone \( d \) by end-consumers living/working in zone \( o \) (sold by retailers of zone \( d \));

\( \text{TRIP}_{s,o} \) is the number of trips for purchase of freight type \( s \) with origin in the inner zone \( o \);

\( \text{TRIP}_{s,od}(\dim) \) is the number of trips for purchases of freight of type \( s \), from \( o \) to \( d \), concluding with a purchase of dimension \( \dim \);

\( p[x/os] \) is the probability for end-consumer \( E \) conditional upon having \( o \) as zone of residence and purchasing freight of type \( s \), of undertaking \( x \) trips in a set time with \( x \) equal to 0, 1, ..., \( n \); it is estimated by a generation model;

\( p[d/os] \) is the probability of trips being undertaken by end-consumer \( E \) going to destination \( d \) conditional upon leaving from \( o \) for purchases of type \( s \); it is estimated by a distribution model;

\( p[\dim/dos] \) is the probability to conclude a trip with a purchase of dimension \( \dim \) (\( 0, \dim_1, \dim_2, \ldots, \dim_n \)) conditional upon undertaking a trip from zone \( o \) to zone \( d \) for a purchase of goods type \( s \); it is estimated by a dimension choice model.

\( \dim \) is the dimension of purchases;

\( n(o) \) is the number of end-consumers (e.g. families) of zone \( o \).

Referring to freight quantity flows by retailer (for areas), let \( Q_{s,\text{tot},d}(c,Y) \) be its generic element. In detail, \( Q_{s,\text{tot},d}(c,Y) \) is the quantity of freight type \( s \) moved between the macro-area \( Y \) and zone \( d \) using the distribution channel \( c \). This quantity can be calculated as:
\[ Q_{s,tot,d}(c,Y) = Q_{s,tot,d} \cdot p[c/Y/ds] = Q_{s,tot,d} \cdot p[c/ds] \cdot p[Y/cds] \]

In a first approximation (Russo and Comi, 2010), this quantity of freight type \( s \) can be detailed for the macro-area within the study area (\( W \)) and for hyper-channel \( c_r \) (i.e. all distribution channels in which the decision-maker can be considered the retailer who chooses how, where and when to go to bring the goods for restocking \( d - pull \) hyper-channel \( . \)).

\[ Q_{s,tot,d}(c_r,W) = Q_{s,tot,d} \cdot p[c_r/W/ds] = Q_{s,tot,d} \cdot p[c_r/ds] \cdot p[W/cds] \]

where

\( Q_{s,tot,d}(c_r,W) \) is the freight quantity of type \( s \) arriving in zone \( d \) from macro-area \( W \) using hyper-channel \( c_r \); \n
\( p[c_r/W/ds] \) is the probability of choosing the distribution channel \( c_r \) and the restocking area \( W \) (i.e. inside the study area); \n
\( p[c_r/ds] \) is the probability of choosing distribution channel \( c_r \) for restocking shops located in zone \( d \) of freight type \( s \); \n
\( p[W/cds] \) is the probability of choosing the restocking area \( W \) having chosen the distribution channel \( c_r \) for restocking shops located in zone \( d \) of freight type \( s \).

### 4.2 The Vehicle level

The vehicle level concerns the estimation of freight vehicle flows. At this level, starting from the outputs of commodity level the quantity flows are converted to vehicle flows. In particular, recalling Figure 5 the main outputs are given by freight vehicle flows by retailer for zones (origin and destination), and path and link freight vehicle flows for target time.

In the considered case, referring to freight vehicle flows by retailer for zones (origin and destination) and under the assumptions \( num(W)=1 \) (i.e. retailer is the restocking decision-maker and she/he undertakes only one round trip); let be \( F_{s,tot,d,c_r}[LGV',w] \) the flow of vehicle type \( LGV' \) to transport freight type \( s \) from \( w \) to attraction zone \( d \), it can be calculated as:

\[ F_{s,tot,d,c_r}[LGV',w] = \frac{Q_{s,tot,d}(c_r,W) \cdot p[LGV'] \cdot p[w]}{q[LGV']} \]

where

\( p[LGV'] \) is the probability that a retailer owns an \( LGV' \) vehicle; \n
\( p[w] \) is the probability of choosing \( w \), the zone inside the study area, in which the retailer purchases the
freight sold in her/his shop;

$\bar{q}_{LGV}$ is the loading capacity of vehicle type $LGV'$.

Finally the vehicle flows at each time on each path can be estimated using the path macro-model. The flow of vehicles from $w$ to attraction zone $d$ with target time $\tau$ on path $k$ $F_{s,tot,d,LGV',w}[\tau,k]$ can be estimated as:

$$F_{s,tot,d,LGV',w}[\tau,k] = F_{s,tot,d,LGV,w}[\tau,LGV'] \cdot p[\tau] \cdot p[k]$$

where

$p[\tau]$ is the probability of having the target time $\tau$ (i.e. Desired Departure/Arrival time from/to zone $d$ and to/from zone $w$);

$p[k]$ is the perceived utility of using path $k$.

4.3 The Modelling system results for disaggregate accident analysis

According to the high level of attention to road safety, there are a range of strategies which may be pursued to reduce the number of goods vehicles involved in road accidents and/or their consequences. It is hence important to identify how the urban network can most appropriately perform the functions required by the area. Therefore, the above described model represents a tool that allows to obtain the data required for the disaggregate accident analysis useful for pursuing the safety goals. The road network should achieve the overall objectives of safety whilst not inhibiting the movement of vehicles and people to any significant extent. Each road and subsequently each junction in the network needs to be examined in terms of its current function and its observed performance of that role. Much of the focus in traffic engineering is on junctions where congestion occurs, where the number of potential conflicts increases with the possible range of vehicle movements, and hence where vehicle to vehicle road crashes concentrate. Besides, pedestrians are channelled to cross roads at junctions.

In this context, the models allow us to estimated the goods vehicle flows at each junction and to investigate the accidents that may result from a combination of factors including conflicting turning movements, speed differentials between motor vehicles and other traffic, pedestrians’ need to cross roads. The models provide a first estimate of probability related to goods vehicles ($p_{\text{goods vehicles}}$) that is required by risk models.

Furthermore, the above models provide the input (as a proxy) for the estimation of probability for pedestrians ($p_{\text{pedestrian}}$) to be used in risk models. The flows interesting junctions are also required by engineer techniques for design and define the characteristics infrastructural in order to have safer crossing points for pedestrians and, in general, for weak road users (e.g. cyclists), and then to improve the whole urban environment.

Finally, the above model results provide data for improving capacity to take passenger vehicles away from goods vehicles, to calculate the risk, and to ordinate the junctions in a list of decreasing risk and then to
give to the decision maker a quantitative and ordinate sequence to make “road work”. In fact, the corresponding provision for walking should begin by identifying the pattern of journeys that people in the area concerned would like to make on foot, and then adapt the road system to create a network of safe and attractive routes for them.

5. CONCLUSIONS

The paper, within the field of city sustainability, analysed the contribution of goods vehicles and pedestrians to the zero-accident goal. Then, the methods to analyse the road accidents are recalled and an integrated modelling framework for disaggregate analysis of road accidents is synthetized. The paper is based on the statements that urban mobility structure in the last decades is changed and the shopping trips are becoming preponderant with respect to commuting ones. Therefore, the analysis of city sustainability can not neglect them. Besides, we have to note that restocking vehicles flows are strictly related to end consumer trips because the shop restocking flows are produced in order support a given end-consumer need. Ignoring these interactions is obviously inappropriate, because traffic impact is an effect shared and generated by both markets, and presumably the decision-makers take the effect into consideration before making a transportation decision. Road accident is politically sensitive issue, and the community expects that policy will continue to be directed towards providing safer roads. Crashes involving goods vehicles are often very dangerous, and goods vehicles are perceived to be over-involved in accidents. Urban policy-makers involved in designing urban measures have to deal with a large number of trucks and vans delivering goods in the urban area whilst preserving the economic viability of city businesses and also ensuring social sustainability. This study pointed out the importance of new approach in analysing road accidents on the urban networks and gives the line for the future developments. In particular, disaggregated models for the analysis of road accidents involving goods vehicles at urban level are being developed because they provides disaggregate outputs that are the base for a focal and more performing analysis.

REFERENCES

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