This chapter tests stakeholder acceptability and their likely behavior change with respect to innovative solutions for improving urban freight transport efficiency and fostering city sustainability. The proposed solution concerns a new system for integrating direct and reverse logistics in the urban area of Rome with the aim of improving clean waste collection, while also minimizing transport-related CO$_2$ emissions. An *ex ante* behavioral analysis based on a stated preference survey has been conducted to investigate stakeholder preferences for different scenario configurations associated with recycling, so as to boost the success of the initiative and promote sustainable behavior. Results show that an environmentally friendly transport system and a gamification process associated with recycling are the most important attributes for stakeholders. Scenarios including these two elements are the most effective in terms of the amount of recycled materials and potentially saved CO$_2$. Results of the behavioral analysis are useful to plan the functioning of the proposed solution according to stakeholders’ preferences and pave the way for its upscaling and transferability.

1.1. Introduction

The EU’s efforts to develop a sustainable, low carbon, resource efficient and competitive economy rely on a transition to circular economy paradigm, where the
The need to recycle has implications on logistics which negatively affect the environment. In fact, door-to-door systems applied to several types of recycling materials would require a large number of trucks and fragmented collection taking place that negatively impacts service efficiency, while using ad hoc collection points would require costly infrastructure interventions, greater effort and involvement of citizens and additional dedicated trips. Thus, transport management is critical, and additional routes are needed.

Reverse logistics includes all the logistic activities related to the recycling, substituting, reusing and disposing of materials [STO 92]. It involves planning, implementing and controlling an efficient, cost effective flow of raw materials, in-process inventory, finished goods, and pertinent information from consumption to the retrieval or proper disposal of the product [ROG 98]. Efficient reverse logistics systems commonly produce both economic (i.e. recovering the value of goods transported) and environmental benefits (i.e. reuse and recycle waste) without producing additional negative externalities (i.e. congestion and pollutant emissions). Reverse logistics and recycling are therefore strictly related, and different governmental-based strategies can be implemented to foster a broader development of logistic systems for controlling reverse bound flows of recycled materials [WRI 11]. Transport occurs at several stages within the recycling channel and often represents the largest logistical cost [POH 92].

The two fundamental aspects to consider in setting up an efficient reverse logistics process aimed at recycling are as follows:

– Although transport is fundamental to our economy and society, its impacts, in particular at the urban scale, are severe, affecting the livability and sustainability of our cities [EUR 11]. It represents one of the main contributors to greenhouse gas emissions at the global level and is the only economic sector in Europe that has witnessed an increase in emissions by 19.4% over the period since 1990 [EUR 15b]. In this respect, there is a need for a better integration of freight activities in the urban transport system with context-specific measures to improve life quality standards within cities [ALI 15, COM 08].
Consumer involvement in recycling is essential. Consumers are the foremost and decisive link in a reverse logistics chain that aims to recycle household packaging residues. In fact, without consumers’ involvement and continuous collaboration, this system cannot produce the expected results [DOV 09]. A “living lab” (LL) approach is desirable, where cities work as contexts for innovation and implementation processes for public and private measures co-created with stakeholders contributing to an increased efficiency and sustainable urban logistics [ERI 05, QUA 16, GAT 17].

Based on this premise, this chapter describes the case of the Rome LL within the EU CITYLAB project, whose main objective is to develop knowledge and solutions that result in rollout, upscaling and further implementation of cost-effective strategies, measures and tools for emission-free city logistics. The proposed solution in the Rome LL concerns an innovative system for integrating direct and reverse logistics flows in the urban area with the aim of improving clean waste collection, so as to increase the amount of recycled materials while also minimizing the amount of transport-related CO₂ emissions [CIT 16a].

In general, reverse logistics design is maintained separately from direct logistics. Nevertheless, this configuration reveals its weaknesses mostly due to the suboptimality, resulting from the disjoint design of the two logistics systems. Therefore, the goal is to plan a logistics system shared by much of the territorial chain, which reduces losses due to the doubling and overlapping of forward and reverse logistics activities. A reverse logistics network establishes a relationship between the market that releases used products and the market for new products. Using the definition El-Sayed et al. provide [ELS 10], one can say that, “when these two markets coincide, then it is called a closed loop network”.

The main idea behind the Rome LL is to involve the national postal operator, already delivering mails/parcels all around the city, in the pickup, via electric vehicles, of recycled materials during the same transportation route. This will optimize the logistic process by avoiding dedicated trips and increasing load factors, thus reducing congestion and pollution. As a first step, an innovative process of plastic cap collection (clean waste), integrating direct flows (i.e. mail delivery) with reverse flows (i.e. plastic caps), is tested in a small scale implementation involving a University context (i.e. a large attractor). To increase the success probability of the solution proposed, it is fundamental to know the behavioral levers capable of stimulating potential agents’ (i.e. students, administrative personnel and professors) participation in the initiative in advance. Under this respect, a recent and fast-developing trend to engage and promote sustainable behaviors foresees the deployment of gamification techniques, i.e. the use of game dynamics in non-game contexts [DET 11].

1 http://www.citylab-project.eu/.
An *ex ante* behavioral analysis has been performed via stated choice experiments to identify barriers/opportunities and necessary strategic/operational prerequisites for the proposed solution to be accepted and supported. The potential effect of a gamification process applied to plastic cap recycling has been investigated. Results of the behavioral analysis have been used to plan the proposed solution according to stakeholders’ preferences so as to increase their participation and foster sustainable behavior.

The remainder of this chapter is organized as follows: the following section (1.2) describes the aims of the CITYLAB project and the Rome LL case (1.2.1). Besides, the innovative concept of gamification will be introduced as a mean to foster behavior change and participation to recycling initiatives (1.2.2). Section 1.3 on data and methodology illustrates the case study (1.3.1) and the methods used for the *ex ante* behavioral analysis, i.e. stated choice experiments (1.3.2) and discrete choice models (1.3.3). Then, results will be presented (1.4) and policy implications derived, together with further steps of the Rome LL (1.4.1). Finally, a conclusion section (1.5) summarizes the main content and findings of this paper.

### 1.2. CITYLAB: city logistics in living laboratories

The goal of the CITYLAB project is to develop knowledge and solutions for emission-free city logistics. In a set of LL, logistics concepts are tested and evaluated. LL is defined as a dynamic environment built to test project solutions in real-life contexts: the city or city center can typically be such an LL environment where several implementations performed by different stakeholders run in parallel [CIT 16a]. The LL approach allows cities to be used as the contexts where seven innovative solutions identified within the project were tested and fine-tuned. A city logistics LL environment comprises three layers: strategic, practical and *ex-post* result observation. On the strategic layer, LL participants interact with each other with the aim to provide governance of the LL. On the practical layer, the implementations are carried out in order to obtain information and results of the solution proposed; the third layer deals with the results of the implementation cases, enabling a “feedback loop” to decide for new directions and possibilities of the LL [CIT 16b].

Public and private measures, which are promising in terms of the potential impact on traffic, externalities and business profitability, are tested to provide a platform for replication. The project focuses on four main axes:

- highly fragmented last-mile deliveries in city centers;
- large freight attractors and public administrations;
- urban waste, return trips and recycling; and
- logistics facilities and warehouses.
The main objectives of this project involve improving basic knowledge and understanding of urban freight transport/service trips in urban areas and testing and implementing innovative solutions in the cities of Rome, Amsterdam, Brussels, Oslo, London, Southampton and Paris. The Rome LL focuses on the CITYLAB intervention axis on urban waste, return trips and recycling with the aim of reducing trips by integrating direct and reverse flows.

1.2.1. Integrating direct and reverse logistics in a living lab context: the case of Rome

Rome is the most populated city in Italy, and it is in the last positions in the Italian city ranking according to environmental and livability indicators [LEG 15]. Waste management and urban mobility are among the main problems afflicting the city. With a constant presence of about 3.5 million inhabitants, Rome produces more than 1.7 million tons of waste each year, an amount equal to almost 600 kg/inhabitant, and only 37% of the total is recycled [LEG 15, WWF 16]. Using the Scottish Carbon Metric, it has been estimated that recycling can reduce greenhouse gas emissions in Rome of approximately 400,000 tCO2eq [WWF 16]. As far as urban mobility is concerned, Rome also shows significant problems related to traffic congestion and pollution, with 62 cars per 100 inhabitants, resulting in the 53% of total trips made by private vehicles [LEG 15].

The Rome LL aims to facilitate the EU circular economy strategy by providing an efficient city logistics system collecting recycled urban waste, thus minimizing road congestion and polluting emissions while increasing freight vehicle load factors [EUR 15a]. It contributes to the improvement of knowledge and understanding on the impacts of increased waste recycling. It also allows the establishment of a community of multiple actors, working together in the city context, to work together toward shared solutions.

The stakeholders involved in the Rome LL are as follows:

– *Poste Italiane* (PIT), the Italian national postal operator, who is interested in exploring new businesses and discovering the main issues to be tackled when integrating direct and reverse trips in a real-life case;

– *City of Rome* and, in particular, *Roma Servizi per la Mobilità* (RSM), the agency in charge of urban mobility in Rome, representing the main addressee of the LL solutions;

– *University of Roma Tre* (UR3), one of the three main public universities in Rome, providing scientific support to the Rome LL and the testbed for the implementation;
– **Meware (MEWR)**, a software house providing technological support for the LL implementation;

– **Cooperativa Formula Sociale** (CFS), the company providing concierge services to UR3 and UR3’s Mobility Manager, who is actively involved in the implementation process; and

– UR3 students, teaching and administrative staff, representing the demand for recycling in the LL implementation.

The main idea refers to a double role played by PIT which will deliver mails/parcels (direct) and collect recyclable waste directly from the addressees during the same transportation route (reverse). This will optimize the logistic process by avoiding dedicated trips and increasing load factors, thus reducing congestion and pollution. The solution proposed is completely new for PIT, and it has never been tested before. PIT is interested in discovering the organizational, functional, operational, managerial and legal issues to be tackled when integrating direct and reverse trips. PIT sees a business in the expansion of its core activities in a complementary market (potentially profitable) where it can use existing capacity (operated at a marginal cost) to perform reverse logistic activities. Risk and complexity suggest adopting a cautious approach. In fact, a first implementation is proposed on a small scale yet capable of unveiling possible structural problems and relevant upscaling issues. After extensive consultations and meetings, plastic cap collection was chosen as a test case. The choice was mainly motivated by the stringent regulatory/labor legislation constraints that PIT is faced with (e.g. hazardous material regulations and labor union reactions). The already existing and inefficient plastic cap recycling initiative at UR3 was also a complementary motivation.

13% of the total waste in 2012 in Rome consisted of plastic material. Since its unit value is 295 €/t, it has been estimated that this can yield a return of approximately 68 million €. While generic plastic waste management is performed by the local waste collection company (AMA S.p.A.), plastic caps can be collected separately and are more profitable. Plastic caps are composed of polyethylene, which is an easily recyclable-versatile-economic type of plastic, and recycling initiatives have been spreading in local/national contexts in recent years, demonstrating their success with respect to people participation.

The first cycle of the Rome LL therefore aims at setting up a small scale implementation of plastic cap collection in a University context, which is, by definition, a large attractor. Participation in the initiative is fundamental to increase the success probability of the solution proposed. An *ex ante* behavioral analysis has been conducted to investigate the preferences and behavioral levers capable of motivating University agents to take an active role in recycling. In this respect,
gamification has been included as an attribute characterizing variants of recycling initiatives to explore its importance from an agent’s point of view and to estimate its potential impact. The next section briefly describes the fundamental tenets of this innovative approach to engage and promote sustainable behaviors.

1.2.2. The role of gamification to foster sustainable urban freight transport

Gamification consists of “using game design elements in non-gaming contexts” [DET 11]. It is mainly aimed at influencing behaviors, and in the last years, it has been explored and used in many sectors, such as education (e.g. [DEN 13, DOM 13, GÅS 11]) and sustainability (e.g. [GNA 12, BER 13, NEG 15]). Gamification takes advantage of the power of game mechanics for non-entertainment purpose in order to foster sustainable behavior [NEL 12]. Behavior change is the end goal that policy-makers aim for. In fact, a voluntary change in behavior can contribute to the substantial changes needed to ensure a sustainable society [SCH 12]. Inducing behavior changes in the freight industry could help jointly achieve significant reductions in the externalities produced as well as improve economic productivity and efficiency. For this reason, gamification is more progressively used in both passenger [MEL 15, COR 15, HOH 12, KAZ 15, JYL 13] and freight [KLE 14, HEN 14] transport.

Gamification, however, needs to be appropriately conceived, deployed and managed if the expected results are to be achieved. To foster engagement and participation, one has to understand who the potential players are and, above all, what they expect from a gamified experience. Users’ preferences for game types should be directly linked to game elements and mechanics (i.e. rules of the game) so as to maximize the “behavior change potential” the gamification might produce [MAR 16a]. The main game components are (1) point assignment (e.g. by overcoming levels, succeeding in a mission), (2) rewarding mechanisms (e.g. based on badges, external rewards such as discounts) and (3) type of participation (e.g. individual, team).

Since a well-conceived gamification process can increase user participation and contribute to the overall success of the plastic cap initiative, the ex ante behavioral analysis performed investigates the potential impact of a gamification process associated with the plastic cap collection. The aim is to understand if and how much gamification would impact on agents’ behaviors, since the success of the solution under investigation is strictly linked to the participation of the plastic cap recycling initiative: the more the caps are collected, the more the caps are recycled and the less
dedicated the trips are made. This implies a decrease of kilometers traveled and CO₂ emissions emitted. In this respect, stimulating a wider participation in the initiative is important and a gamification process could be potentially crucial. Therefore, it is important to investigate its attractiveness and desirability for UR3 agents.

1.3. Data/methodology

1.3.1. Plastic cap collection at the University of Roma Tre

UR3, which is considered a “green” University according to the UI GreenMetric Ranking,² started a plastic cap recycling initiative 10 years ago. The existing collection process was conceived so that the involved people brought plastic caps to one of the collection points present in several of the 28 buildings scattered around the city. The Mobility Manager was in charge of gathering and consolidating them from the peripheral collection points to the central one (located in the Rectorate). The organization of this process implied detours or ad hoc trips characterized by extremely low load factors. The initiative relied on the voluntary participation of UR3 agents and it was conditioned by the actual availability of participants. In 2015, the plastic cap collection came to an end for various reasons. The presence of indecorous plastic bags filled with caps left next to the bins was one of the reasons that prompted its closure. Old system saturation was basically inducted by its inefficiency in responding to user needs.

An innovative process of cap collection will be tested in four University buildings that accommodate both students’ facilities and offices for professors and administrative staff, integrating direct and reverse flows with the aim of reducing the number of necessary trips and organizing an efficient and sustainable collection system. The implementation site is reported in Figure 1.1. It consists of a small area of about 1 km² located in the southern part of Rome.

The whole system related to caps’ management, from the signaling of full boxes to be picked up, to the distribution from the four buildings to the local PIT distribution center, and then to the UR3 central collection point (Rectorate), will be efficiently and coordinately organized, without ad hoc trips, by taking advantage of the existing trips made by mail carriers.

² http://greenmetric.ui.ac.id/
An *ex ante* behavioral analysis has been performed with the main objective to evaluate the degree of acceptance of the CITYLAB solution in the UR3 social environment. Behavioral analysis is fundamental to elicit stakeholders’ preferences and to investigate their utility, maximizing behavior (e.g. [HOL 13, GAT 16b, MAR 17a, MAR 17b]). First, data were collected (through surveys) from key stakeholders, to understand their behavior and their *ex ante* acceptance of the measures proposed. This process led to the identification of barriers/opportunities and necessary, strategic/operational prerequisites for the proposed solution to be accepted and supported. A questionnaire was subsequently prepared and administered to elicit stakeholders’ general opinions and preferences about alternative scenario configurations. Preferences about hypothetical scenarios were elicited via stated choice experiments (SCEs), while discrete choice models (DCMs) were used to estimate the willingness to pay related to single scenario components [GAT 14].
1.3.2. **Stated choice experiments**

Stated choice experiments (SCEs) are widely used in various areas including marketing, transport, environmental resource economics and public welfare analysis [ALE 16, ALE 17, FEL 07, MAR 11, MAR 12a, ROT 12, STR 07, VAL 16]. They represent one of the most important survey methods used across the world [AIZ 12]. They can be used for forecasting individuals’ preference structures [MAR 16b], estimating robust willingness to pay measures [GAT 15] and calculating scenario simulations [MAR 15]. An SCE consists of several choice sets, each involving two or more alternatives, described by several attributes. Each attribute has two or more levels that are plausible over a reasonable range. Each respondent is asked to choose one of the options presented in the choice set according to his/her preferences. The core part of SCE is characterized by the statistical design to construct hypothetical choice sets. Several types of experimental designs can be created from simple to advanced ones. For instance, Gatta and Marcucci [GAT 16a] propose a stakeholder-specific multistage efficient design for urban freight transport policy behavioral analysis. The idea is to study the relative influence of independent variables (attributes) on a given observed phenomenon (choice).

The *ex ante* behavioral analysis in the Rome LL is based on a questionnaire administered to acquire information on stakeholders’ preferences to customize the proposed solution accordingly. The first section includes general information and opinions about the initiative while the second includes the SCE, aimed at eliciting preferences by proposing different scenario configurations. The choice of the attributes to be included in the SCE has been performed by taking into account the results that emerged from focus groups and, more in general, from the survey with key stakeholders previously conducted. Interviewees were asked to respond to a sequence of tasks where they had to choose one option within a finite and self-excluding choice set. The statistical design adopted in this specific application allows each of the possible level combinations to appear at least once.

The design adopted was divided into five blocks corresponding to five versions of the questionnaire. Each option was characterized by five attributes with two levels each. More in detail, the attributes used are (1) the aim of the initiative (to improve UR3 services/charity), (2) cap-throwing mode (one cap/more caps per time), (3) the transport system used (environmentally/non-environmentally friendly) and (4) the probability to find boxes full (low/high), gamification (yes/no). Besides, for each option, agents were also asked to state (1) if they would have participated in the initiative (yes/no), (2) the expected frequency of participation (e.g. daily, weekly) and (c) the number of caps they would eventually recycle.
1.3.3. Discrete choice models

In choice experiments, it is usually supposed that each interviewee chooses the option with the highest utility among those available [TRA 03]. Random utility models assume that the decision-maker disposes of perfect discriminative capability, while the analyst has incomplete information and, thus, utility is modeled as a random variable [BEN 85]. DCMs are used to analyze data gathered via SCEs where respondents’ decision-making can be modeled using random utility theory. Microeconomics assumes that rational agents maximize utility [LOU 00]. Utility \( U \) is composed of a deterministic \( (V) \) and a stochastic term \( (\varepsilon) \): the former is assumed to be a linear function of attributes while different assumptions about the distribution of the stochastic term lie at the basis of different DCM specifications.

The utility that individual \( i \) associates with alternative \( j \) is given by

\[
U_{ij} = V_{ij} + \varepsilon_{ij} = \beta' X_{ij} + \varepsilon_{ij}
\]  

[1.1]

where \( X_{ij} \) is the vector of attributes as perceived by agent \( i \) for alternative \( j \), and \( \beta' \) is the vector of estimated parameters.

The analysis performed uses multinomial logit models (MNLs). The variables included in the models are effect-coded.\(^3\)

1.4. Results

In total, 597 interviews were administered, mostly consisting of students (90%), professors (5%) and administrative staff (5%), reflecting the different strata of the daily University-going population.

The estimation run over the whole sample is shown in Table 1.1. Three attributes, i.e. the aim of the initiative, cap-throwing mode and the probability to find boxes full, are not significant, meaning that agents are probably indifferent to the levels of that particular attribute or their preferences are not significantly affected by that factor. The attributes that appear to be significant are “Environmentally-friendly transport system” (environ) and “Gamification” (gamif). Both have a positive impact on the overall value of the utility function. The result related to the transport system adopted for the recycling initiative is of great interest for the research. In

\(^3\) Effects coding an attribute imply constraining parameters’ estimates to sum up to zero. One has to take this into account when interpreting the econometric results.
fact, this coefficient is not only significantly different from zero but also seems to have a positive impact on the overall utility function, according to the collected data. On average, interviewees prefer a solution that includes gamification. Econometric analysis testifies the high potential that a gamified plastic cap recycling initiative has, thanks to its engaging capability within a University environment. Other studies too seem to indicate that gamification applied to plastic cap recycling has a positive effect on the final result of the initiative [BER 13].

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T-stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>improve</td>
<td>Improve UR3 services</td>
<td>–0.037</td>
<td>0.022</td>
<td>–0.169</td>
<td>0.866</td>
</tr>
<tr>
<td>onecap</td>
<td>One cap per time</td>
<td>0.012</td>
<td>0.022</td>
<td>0.526</td>
<td>0.599</td>
</tr>
<tr>
<td>environ</td>
<td>Environmentally friendly transport system</td>
<td>0.147</td>
<td>0.022</td>
<td>6.735</td>
<td>0.000</td>
</tr>
<tr>
<td>problow</td>
<td>Low probability to find boxes full</td>
<td>–0.0147</td>
<td>0.022</td>
<td>–0.631</td>
<td>0.528</td>
</tr>
<tr>
<td>gamif</td>
<td>Gamification</td>
<td>0.084</td>
<td>0.218</td>
<td>3.825</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 1.1. MNL results for the whole sample

In order to investigate preference heterogeneity [MAR 12b, MAR 13], estimations were done by dividing the sample according to the different departments. Table 1.2 reports the results for the four departments.

Results obtained by dividing the sample suggest that preferences are quite spatially heterogeneous. However, a wide shared consensus toward the application of an environmentally friendly transport system, which is the main innovation brought by CITYLAB project in Rome, emerges from the estimated models.

Gamification is seen as a positive feature for two out of four departments. During interview sessions, it was possible to experience the reactions of students when faced with gamification. For example, many of those who usually tended to discard this approach used to justify it as ethically unacceptable, while others simply argued that it would be too complex to build a game able to encourage participation in the initiative. A low probability to find full boxes appears to be significant for two out of four departments, while the cap-throwing mode and the aim of the initiative are significant only for one department (Departments 1 and 2, respectively), showing a preference toward throwing more caps per time and improving UR3 services, thanks to the revenue derived from recycled caps.
Another important goal of the research is to estimate the participation of users in the recycling initiative. Since for each scenario configuration, they were asked to state the number of caps that they would eventually throw, it is possible to roughly estimate how many plastic caps could be collected in a scenario analysis. To create a link between the preference toward the alternative systems and the estimated amount of recycled plastic caps per department, a simple measure of the “satisfaction degree” $S$ is adopted:

$$ S_{dep_i}(\%) = \frac{U_{scenario}-U_{min}}{U_{max}-U_{min}} $$

[1.2]

With this simple indicator, it is possible to derive the “satisfaction” with respect to a certain scenario as a percentage of the maximum amount of utility perceived.
Two basic assumptions were made:

– estimations made for departments are extended to the single users; and

– for each user, the maximum amount of caps declared is considered as the amount that they would throw if the utility of the department were maximized.

Starting from these assumptions, the utility assigned to alternative systems is calculated, based on the results of the four MNL models reported earlier. The estimations are then extended to the population attending the four departments, according to internal data available from UR3.\(^4\) Daily estimations are extended to yearly ones by considering an approximate number of the presence at the University.

Starting from the number of caps, it is possible to derive the kilogram of caps collected in a year (considering that 400 caps weigh approximately 1 kg) and the number of full boxes (1 box \(\approx 2\) kg of caps), corresponding to the trips that have to be made to collect caps (1 full box = 1 trip). Then, the total number of kilometers for round trips is estimated for each scenario according to the distance from each department to the collection point, and an estimation of the emitted greenhouse gases (in terms of CO\(_2\)eq) is performed using an average emission factor for cars of 189 gCO\(_2\)eq/vkm ([RIC 14], tab. 33). The amount of CO\(_2\)eq is a measure of the transport impact of the old solution (i.e. the status quo) and, therefore, an estimate of the potentially saved CO\(_2\)eq by combining direct and reverse logistics with the CITYLAB solution.

<table>
<thead>
<tr>
<th>Variable/Scenario</th>
<th>Status quo (worst)</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3 (best)</th>
</tr>
</thead>
<tbody>
<tr>
<td>improve</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>onecap</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>environ</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>problow</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>gamif</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Table 1.3. Scenario analysis

Table 1.3 reports the different scenarios tested. The reference scenario is the status quo situation (i.e. before LL implementation), characterized by a charity aim, a system allowing one thrown cap per time, a non-environmentally friendly transport

\(^4\) Under this respect, data related to the number of students attending classes in the four departments for 6 months of classes are used as the starting point. For a first rough estimate, only a portion of the population is considered (corresponding to 50% of the attendants).
system, a high probability to find boxes full and without gamification. According to the results obtained, this can be considered as the worst option. The other scenarios are built by considering incremental changes to the status quo in line with the preferences expressed by UR3 agents:

– **Scenario 1** improves the status quo by adopting an environmentally friendly transport system (first ranked attribute according to the MNL estimated for the whole sample);

– **Scenario 2** is scenario 1 with, in addition, a gamification process associated with the initiative (second ranked attribute according to the MNL estimated for the whole sample);

– **Scenario 3** also considers improving UR3 services as the aim of the initiative, a system allowing more thrown caps per time and a low probability to find boxes full (as suggested by the results of the MNL per single department). This can be considered as the best option.

Results in terms of expected caps (kilogram per year) and saved CO2 are presented in Table 1.4.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>$S_{dep.1}$ (%)</th>
<th>$S_{dep.2}$ (%)</th>
<th>$S_{dep.3}$ (%)</th>
<th>$S_{dep.4}$ (%)</th>
<th>Expected caps (kg per year)</th>
<th>Expected trips (i.e. boxes per year)</th>
<th>Saved CO2eq (kg per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status quo (worst)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1222.4</td>
<td>611</td>
<td>0</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>36.5</td>
<td>39.1</td>
<td>65.6</td>
<td>100.0</td>
<td>1651.4</td>
<td>826</td>
<td>457.3</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>36.5</td>
<td>77.8</td>
<td>80.0</td>
<td>100.0</td>
<td>1730.3</td>
<td>865</td>
<td>499.3</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>2005.1</td>
<td>1003</td>
<td>556.1</td>
</tr>
</tbody>
</table>

**Table 1.4. Scenario comparison: expected caps and saved CO2eq**

The difference between the status quo solution and scenario 1 is high, with more than 400 kg of additional caps expected to be collected in a year. Since scenario 1 envisages the integration of direct and reverse logistics with no ad hoc trips to carry the caps, it is possible to estimate the saved CO2eq with respect to the status quo, which is of 457 kg per year. By adopting a “gamified” system in scenario 2 and, thus, following the results of the MNL estimated for the whole sample, approximately 80 more kg would be collected compared to scenario 1 with an additional saving in terms of CO2eq emitted (about 40 kg). The “best” scenario (i.e. scenario 3), which encompasses all the heterogeneous preferences of the
departments’ agents, accounts for an additional increase of caps (about 270 kg) and saved \( \text{CO}_2\text{eq} \) (about 50 kg) per year.

These results are helpful to plan the solution to be deployed according to the preferences of stakeholders and the expected impacts in terms of recycled caps and saved greenhouse gas emissions. Clearly, they need to be validated within the implementation to see how much the stated preferences differ from the actual behavior. It is worth noting that the very small scale of the implementation does not allow us to obtain significant results in terms of the overall \( \text{CO}_2\text{eq} \) saved. Nevertheless, by testing the sustainable logistics model and proving its feasibility and effectiveness at a small scale, it would be possible to upscale it and transfer the results to other contexts so as to increase its impact.

1.4.1. Policy implications

Results of the behavioral analysis are useful to plan the functioning of the proposed solution according to stakeholders’ preferences. Assigning a double and correlated task to the postal operator ensures empty trip minimization, thus contributes to the goal of reducing trips by integrating direct and reverse flows. Upscaling the solution proposed will both produce beneficial impacts for the city and contribute to service financial viability. The sustainable logistics model proposed could be applied to (1) other departments within UR3, (2) other Universities/educational institutions, (3) other large attractors (e.g. hospitals), (4) commercial activities and (5) condominiums with a concierge service. Additionally, the logistics solution could also be extended to other types of recycled materials (e.g. exhausted batteries and toners) and to other geographical contexts (i.e. local, national and international). This is particularly relevant for the second cycle of the LL, which will explore the opportunity to (1) extend the implementation in terms of flows involved, sites and alternative waste recycled, and (2) include it in the actual logistics process for urban waste management.

A hybrid waste collection strategy, using large attractors as intermediate locations with dedicated recycling facilities, can (1) reduce the amount of dedicated efforts that agents have to perform while recycling (no specific trips would be required to visit ecological islands), (2) reduce the number of trips that collection firms need to perform in order to increase the amount of materials recycled whilst also avoiding their illegal discharge and (3) optimize load factor capacity by selecting specific waste categories and grouping their collection via appropriately organized and coordinated non-dedicated trips. The Rome LL contributes to the city environment where the recently passed Directives 2016–2021 for the future governance of the city of Rome have set waste collection and management as one of the most relevant issues [ROM 16].
As far as gamification is concerned, we evaluated *ex ante* its potential acceptability and its impact in terms of stakeholder participation in recycling. Future research will consider its implementation as a real opportunity to engage stakeholders and promote sustainable behaviors, and preliminary work is already under way. Apart from the general acceptance of a gamification process, it is necessary to investigate the preferences of the potential (heterogeneous) players and link these preferences to game elements and mechanics so as to increase the probability of success. In this respect, a behavioral analysis based on the stated choice techniques and discrete choice models provides a sound theoretical basis where to ground a user-centered gamification process [MAR 16a]. This complementary measure might have a high impact in fostering financial self-sustainability and upscaling of the solution proposed.

### 1.5. Conclusion

This paper presented the case of the Rome LL within the EU CITYLAB project, where an innovative system for integrating direct and reverse logistic flows in the urban area has been set up with the aim of improving clean waste collection so as to increase the amount of recycled materials while also minimizing the amount of transport-related CO₂ emissions. An *ex ante* behavioral analysis has been conducted via SCEs and DCMs to investigate stakeholder preferences for different scenario configurations and the potential impact of a gamification process associated with the plastic cap collection. Results of the behavioral analysis are useful to plan the functioning of the proposed solution according to stakeholders’ preferences. The scheme proposed represents a solution that can contribute to reach sustainability and efficiency of freight transport at the urban level. The sustainable logistics model proposed has a high potential of upscaling and transferability, e.g. to other departments, Universities or large attractors (e.g. hospitals). Additionally, it could be extended to other types of recycled materials and to other geographical contexts. The scheme proposed contributes to the improvement of knowledge and understanding of the impacts of increased waste recycling and represents a solution that can contribute to reach a circular economy, environment protection, sustainability and efficiency of freight transport at the urban level.

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1.7. Bibliography


