Innovative parking strategies through the application of variable pricing techniques. The case of San Francisco

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Abstract

The goal of this paper is to propose a first methodological approach for the application of the variable parking pricing techniques to Italian medium-sized cities. After some consideration about the need of re-thinking the parking management systems, the pilot project implemented in San Francisco, CA, known as "SFpark", has been analyzed, basing on the results described in a recent final evaluation report. This project represents the first application of variable rates in specific pilot areas for on-street and off-street parking spaces. Its application aimed mainly to optimize the use of existing parking, reducing time to access the city and to search free parking spaces. Starting from this case study, we highlighted the main steps to be implemented in Italian cities to better use the existing parking supply.

1. The parking issue: a general overview

The car ownership increases the need of parking spaces. Over time, the lack of specific actions taken to manage parking led the community to consider free parking as a vested right, generating high parking demand and reducing turnover (The Institution of Highways & Transportation, 2005; Roli, Roli and Medeghini, 2007; Federal Highway Administration, 2012). This approach can potentially generate an increase of "disturbing" traffic, due to the people in search of free parking spaces (a phenomenon known in the American literature as "cruising for parking"). This expectation has a negative impact on roads level of service and on travel times.

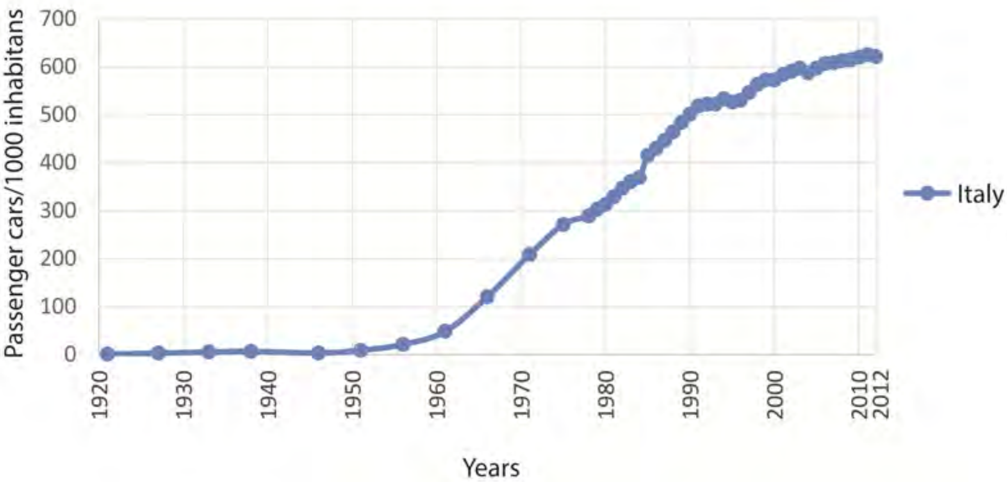

Figure 1 – Italian motorization rate 1921-2012, calculated as ratio between the number of circulating passenger cars (Source: Automobile Club Italia – ACI) and the resident population (Source: National Institute of Statistics – ISTAT).

Despite all, parking demand will change in the near future, mainly as a consequence of the decrease of circulating passenger cars, of the economic crisis, as well as of the improvement of public transport and of non-motorized mobility infrastructures.

Therefore, soon the removal of on-street parking lots will emerge as a significant need, especially in the context of the historical city centers. It will allow the increase of high quality urban spaces reserved for pedestrian and bicycle mobility, as well as for street furniture. The reduction of on-street parking will lead cities to realize parking structures, which need to ensure profit and return on investment, in order to attract potential investors and to be economically affordable. An innovative parking spaces management system could be able to satisfy these requirements.

In order to identify the most appropriate methodology for parking management, we need to consider some boundary conditions, including for example the availability and the level of service of the existing public transport systems (LPT) and the possibility of implementing the intermodality between private cars and LPT (Simićević et al., 2012).

Several studies (for example, Victoria Transport Policy Institute, 2011; Kodransky and Hermann, 2011) suggested, among the possible activities that can be undertaken to manage both parking demand and supply, the application of innovative pricing policies. The number of applicable actions depends on the goal to be achieved: if the innovative parking pricing policies are part of a more general parking management strategy, they act locally on the parking spaces turnover, in relation to the location and the occupancy rate of the considered spaces. If they are applied in presence of congestion pricing, parking pricing should be well integrated in transportation policies, should be applied to a large area and characterized by different fares (Kittelson et al., 2008, Victoria Transport Policy Institute, 2011; Shoup, 2011; Litman, 2010).

2. Variable pricing in parking management

The introduction of variable parking fares mainly aims at improving the occupancy rate and users turnover management. In literature, the variability of parking fares (Victoria Transport Policy Institute, 2011; Shoup, 2011) is generally related to the parking duration, time and day. There are two innovative ways to determine the variable parking fares:

- performance based pricing: the static variability of parking fares depends on the ratio between available spaces and occupied ones. The parking manager can establish the maximum and minimum value of the desired occupancy rate. These values represent the expected performance of parking spaces and fares are regularly calibrated (for example, monthly updated) basing on collected data of spaces occupancy;
- dynamic pricing: based on the principles of performance-based pricing, the fare calibration is dynamic during the day, following the collected data of occupancy rate. This fare variability needs to be carried out also through the implementation of Intelligent Transport System (ITS) technologies, to collect and elaborate parking data and to inform users in real time.

Generally, the application of parking variable fares requires several parameters, such as:

- fee base value, calibrated on the state of art (if parking spaces have been already set, the rate may equal the existing one or be different, according to the current occupancy rate);
- maximum and minimum percentage of occupied spaces (as a matter of fact, in case of too high fares, parking spaces may be occupied below 50%, while in case of too low prices, they may be occupied more than 90%);
- maximum and minimum fee variation during their calibration;
- fee calibration frequency, which includes the communication of the new fares system to the actual and potential users;
- average parking duration.

3. The case study of San Francisco, California

Among several innovative projects involving management parking supply, the case of San Francisco can be considered a good practice well known in literature. The "SF*park*" project aimed at dynamically managing both on and off-street parking supply, through the fees calibration based on actual parking occupancy rate. The main objectives were the minimization of the time spent in search of free parking, as well as the reduction of time to access the city.

3.1. Project roadmap

In November 2008, the "SF*park*" pilot program application guidance was approved, including the pilot area definition and the parking policies. Furthermore, the San Francisco Municipal Transportation Agency (SFMTA) was commissioned to define fees, demand and supply, both for on and off street parking spaces.

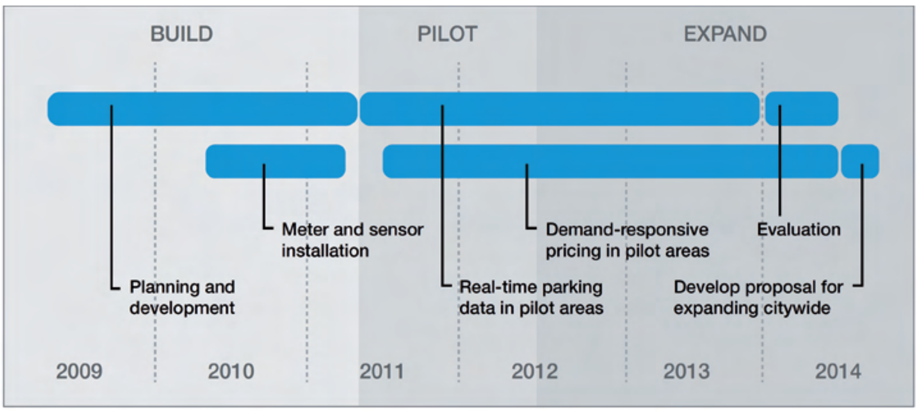

Figure 2 – Summary of the "SFpark" pilot project timeline (Source: San Francisco Municipal Agency, 2011).

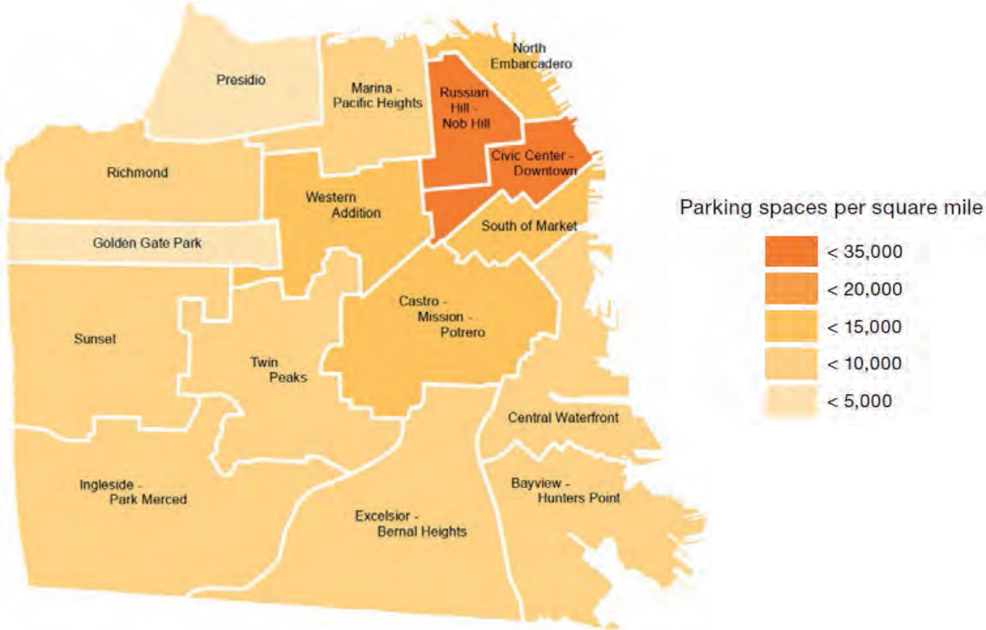

Figure 3 – Publicly-available parking by neighborhood in San Francisco - spaces per square mile (Source: San Francisco Municipal Agency, 2014).

In 2009, the pilot project was developed for seven neighborhood, namely: Marina, Fillmore, Civic Center, Mission, Downtown, South Embarcadero, Fisherman's Wharf. In spring 2010, the required smart park meters and sensors were installed.

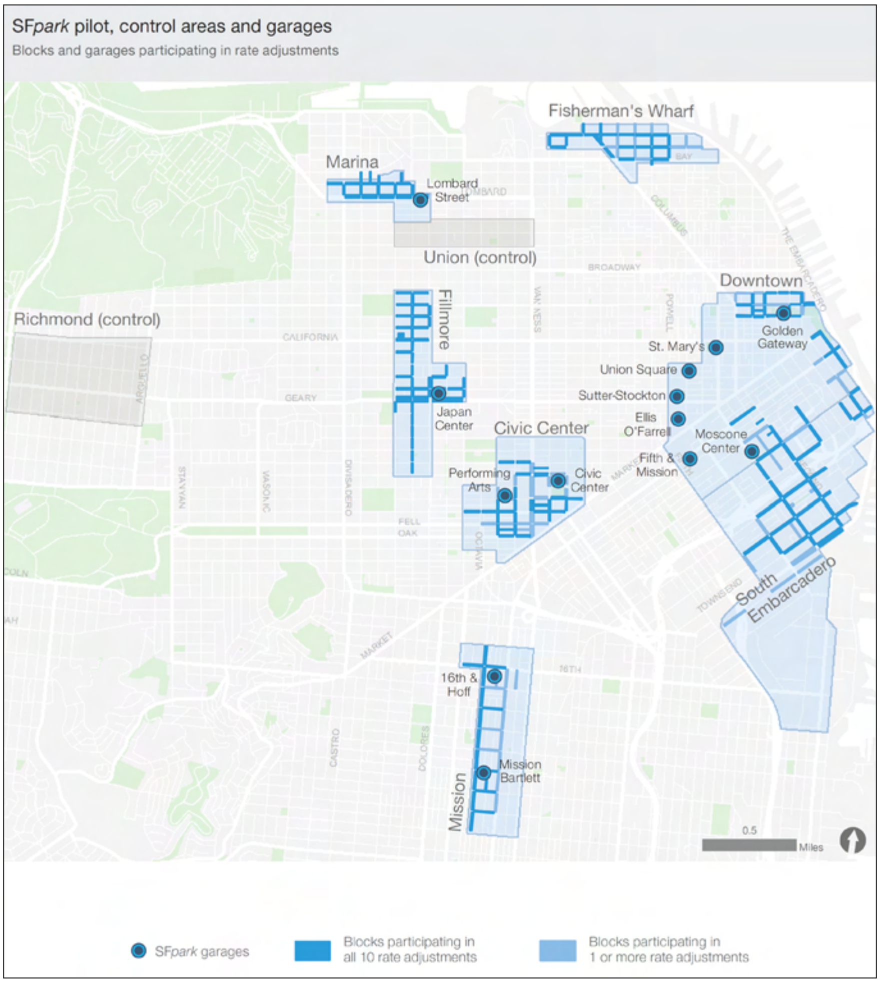

Figure 4 – Pilot and control areas in the "SFpark" project (Source: San Francisco Municipal Agency, 2014).

In April 2011 the "SF*park*" project actually started together with the parking data collection. In August the first park meters calibration was carried out. In this year, also dedicated smartphone applications and "pay by phone" service were launched. In May 2012, the information about parking were also available on "511" phone service. The experimental phase finished in at the end of 2013, sensors were turned off and the evaluation phase started. The first evaluation report was published in August 2011, while the second and last one in June 2014.

3.2. The "SF*park*" project architecture

During the "SF*park*" project, the parking fees gradually and periodically changed (increasing or decreasing) in order to find out the lowest parking price able to get the desired occupancy target, which was set to 60%-80%. Furthermore, the parking duration limits was revised in the pilot areas.
The city renewed also the payment methods, allowing also the use of credit and prepaid cards and of "pay-by-phone" systems. This innovations required to update the existing informative system to give real time information to users about available spaces, preferential routes and parking fees.
The first step consisted in surveying the parking demand, supply and related prices. This phase was useful also to plan the installation of new parking sensors and "smart" park meters. Census data were geo-referenced in GIS environment to make easier their update.
As regards the on-street parking, before the beginning of "SF*park*" project, the hourly fee changed according to the distance between parking lots and the desired destination, as well as to the time and day of the week (distinguishing between working and non-working day). The main actions consisted in dividing the parking fees into five time slots (9-12 or 7-12, 12-15, 15-18 or 15-19) and in their calibration was made as following:

- if the occupancy rate ranged between 80% and 100%, the price increased in the time slot of $ 0,25;
- if the occupancy rate ranged between 60% and 80%, the price was unchanged;
- if the occupancy rate ranged between 30% and 60%, the price decreased in the time slot of $ 0,25;
- if the occupancy rate ranged under 30%, the price decreased in the time slot of $ 0,50.

The periodical update of park meters was carried out by the centralized management system with wireless connection, thanks to the elaboration of the collected data (payment transaction from park meters and occupancy rate from parking sensors). The SFMTA adjusted on-street fees about every eight weeks from August 2011, and hourly rates could not exceed $ 6.00 or go below $ 0.25.

Also for the on-street parking, the parking fees were divided into five time slots (0-9, 9-12, 12-15, 15-18, 18-24) and SFMTA periodically calibrated them as described below:

- if the occupancy rate ranged between 85% and 100%, the price increased in the time slot of $ 0,50;
- if the occupancy rate ranged between 50% and 85%, the price was unchanged;
- if the occupancy rate ranged under 50%, the price decreased in the time slot of $ 0,50.

Alongside variable pricing variable pricing, the pilot project foresaw other initiatives, which indirectly affected peak-hours traffic flows. For example, the price in the peak-hour time slot was calibrated also to stimulate the arrival to the parking spaces in the off-peak hours. Other discounts were available for commuters and for "early birds" (i.e. who arrive at parking before the morning peak hours).

3.3. ITS system

At all the pilot areas, SFMTA installed magnetic sensors in order to monitor on-street parking occupancy: 11700 sensors were installed for about 8000 parking spaces (some spaces needed two sensors). Fees payment within the pilot areas was managed by new smart park meters, replacing the older ones, to allow the payment with credit/debit card and to manage longer parking time limits. Smart park meters are also able to collect payment transactions to update the centralized database. These data were sent by wireless connection, therefore any wired connection was necessary. SFMTA also installed both "single lot" (about 5000 parking spaces) and "multi lot"[1] park meters (covering more than 400 parking space).
As regards off-street parking, the municipal garages were already equipped with access control systems. Furthermore, the payment system was already equipped to allow the use of credit card. SFMTA maintained the existing technology, integrating it with hardware/software and networks able to broadcast the streaming data feed, where necessary.
The "SF*park*" project also included the development of a dedicated website to spread out real time information about the localization of available parking spaces. Furthermore, on the website, documents and reports about results, fees calibration and collected data were periodically published. Furthermore, two smartphone applications were developed replicating website information, as well as adding several static data about suggested itineraries to reach chosen parking spaces. These information were provided in order to reduce the number of vehicles searching of available car parking spaces on the most congested roads.

1. While the "single lot" meter is installed near one specific parking space and allows paying only for its occupation, the "multi lot" one allows paying for a block of spaces, usually for a maximum number of eight.

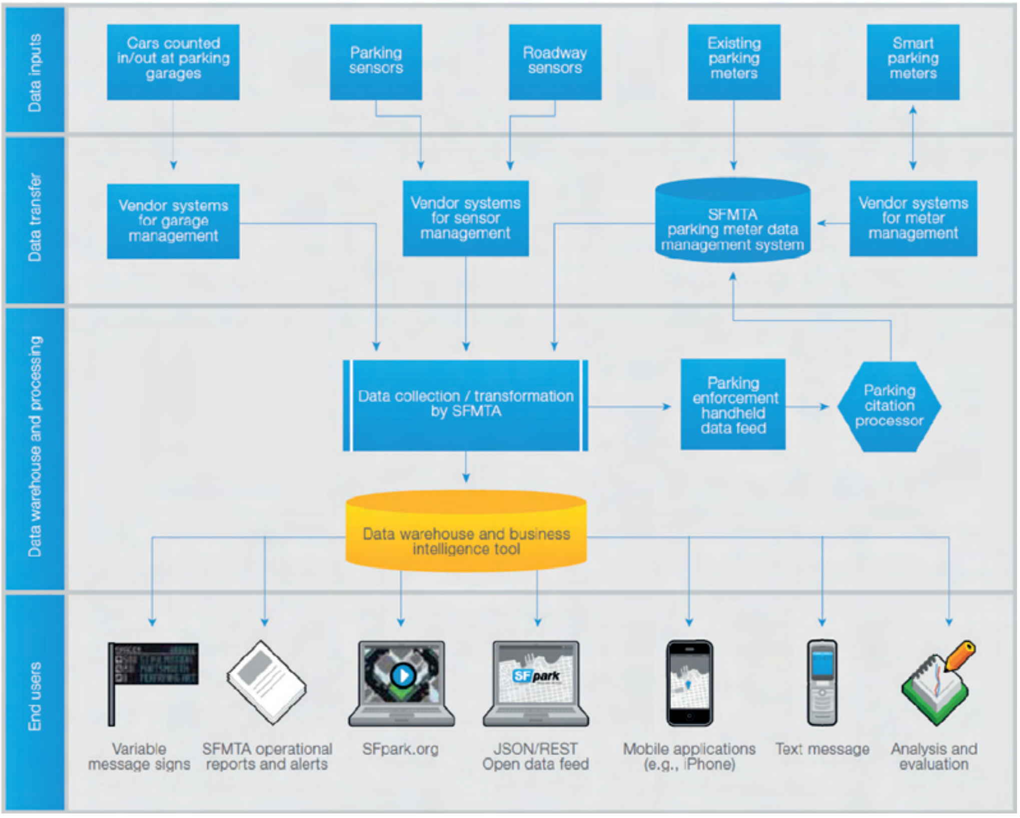

Figure 5 – Architecture of ITS system used in the "SFpark" project (Source: San Francisco Municipal Agency, 2011).

3.4. Project evaluation

The evaluation phase foresaw two independent analysis, one made by the US Department of Transport (USDOT) and other by SFMTA. While USDOT evaluated the urban financed project through the calculation of standard indicators, SFMTA defined two levels of evaluation:

- primary level: the influence of the pilot project on the transport modal choice, as a consequence of the introduction of innovative parking pricing and of the real time information delivery to users;
- secondary level: the possible improvement of public and non-motorized modes of transport due to primary level effect.

SFMTA built up the *ex ante* scenarios through specific parking surveys, while the *ex post* scenario was realized and updated with the following information:

- parking duration and periods of sensor inactivity (on-street parking sensors);
- occupancy rate of motorcycles parking (manual survey *in situ* periodically carried out);
- payment transactions, parking duration, method of payment, paid fees, periods of park meter inactivity (smart park meters);
- hourly use of parking space (off-street public parking);
- parking occupancy of disabled people, its duration and time spent in search of free parking (manual survey *in situ* periodically carried out);
- LPT users (data collected by LPT company);
- traffic flows data at municipal and regional level (surveyed through specific sensors);
- road safety data in pilot areas (given by the municipality);
- exogenous factors, as fuel price, unemployment, weather conditions, etc.

Data collection involved not only the pilot areas, but also some defined "control" areas, where the innovative parking system was not applied. This approach was considered useful to compare the "zero scenario" to "SF*park* scenario". The "before" data are referred to spring 2011, while "after" data to spring 2013.

In June 2014, SFMTA gave the evaluation of the project, showing the effectiveness of demand-response pricing in San Francisco, improving parking availability and utilization. Overall, the parking price decreased for about the 50% of existing parking spaces in the pilot areas.

Furthermore, the project results showed that the amount of time needed to find a free parking space decreased by 43%, compared to a 13% decrease recorded in the control areas.

During the calibration phase, the increase/decrease varied in each area: fares increased more in the Downtown, Marina, Mission neighborhoods and decreased more in the Civic Center, Fisherman's Wharf, and South Embarcadero. In the Fillmore neighborhood fares slightly increased.

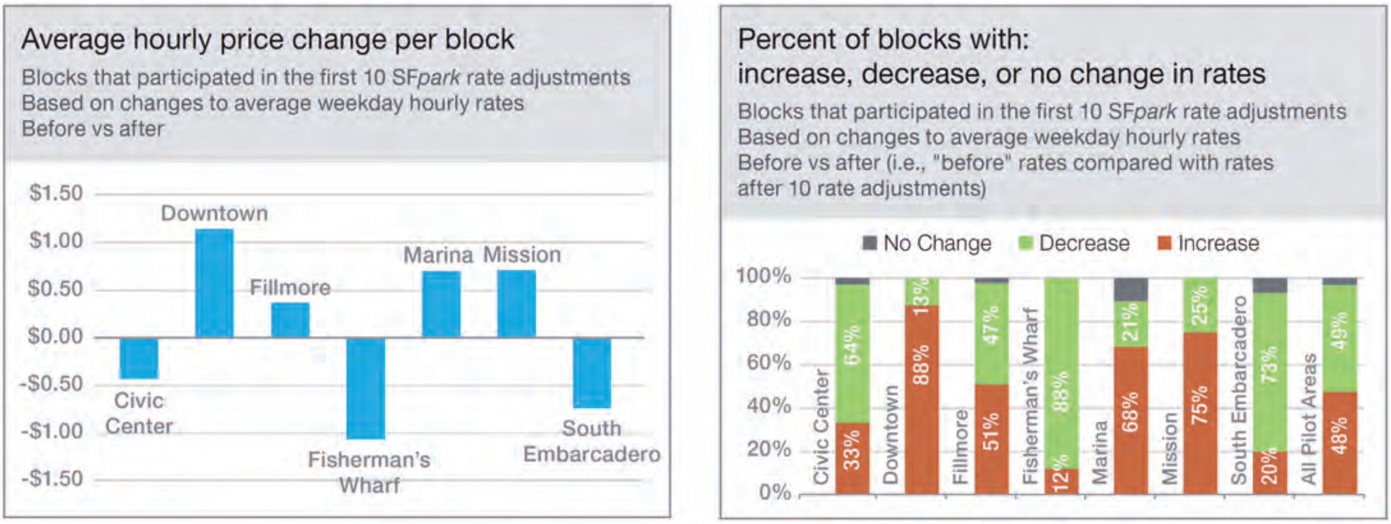

Figure 6 – Summary of pricing variation for on-street parking spaces (Source: San Francisco Municipal Agency, 2014).

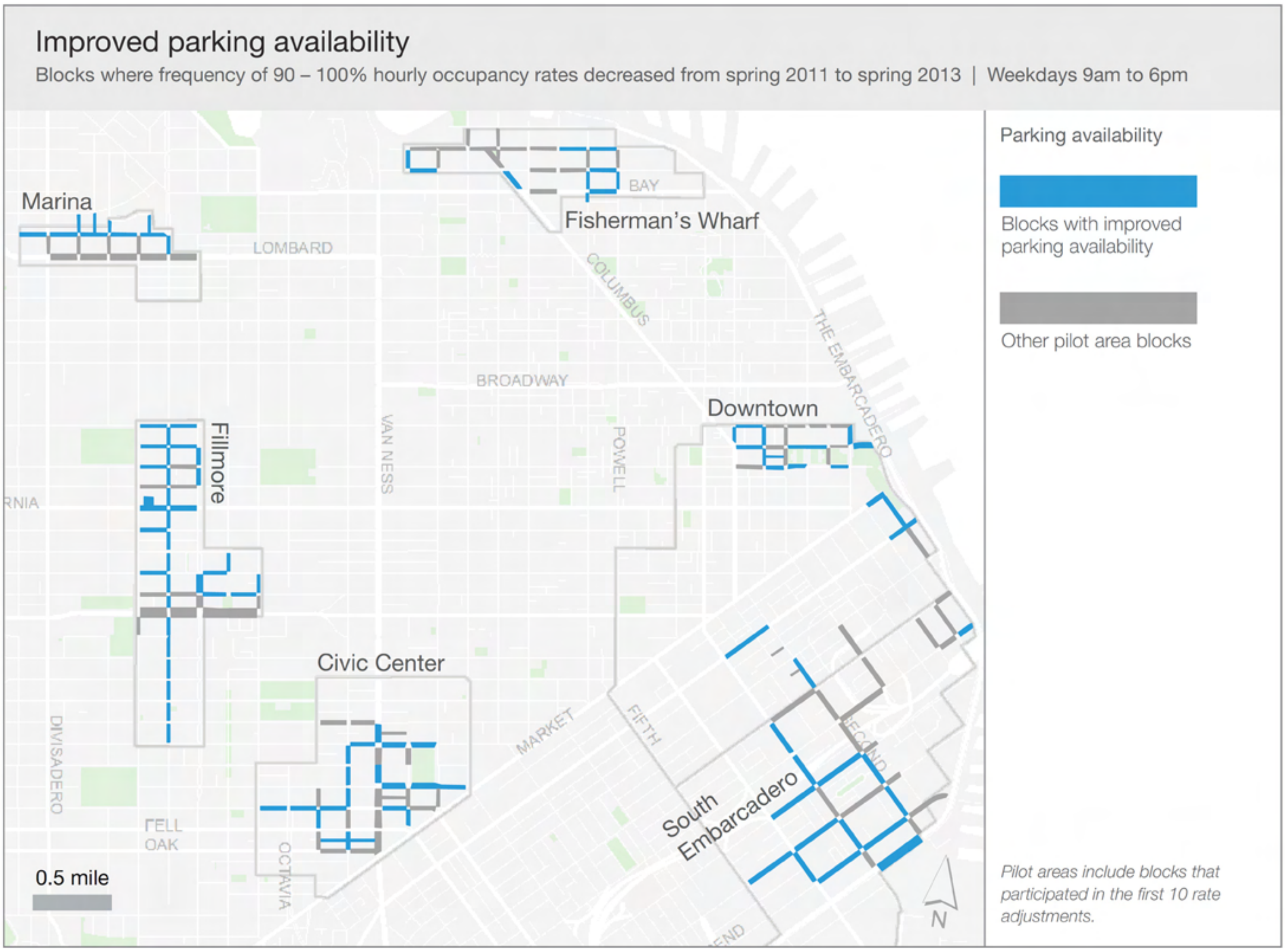

Figure 7 – Parking availability: analysis of variation percentage after "SFpark" implementation (Source: San Francisco Municipal Agency, 2014).

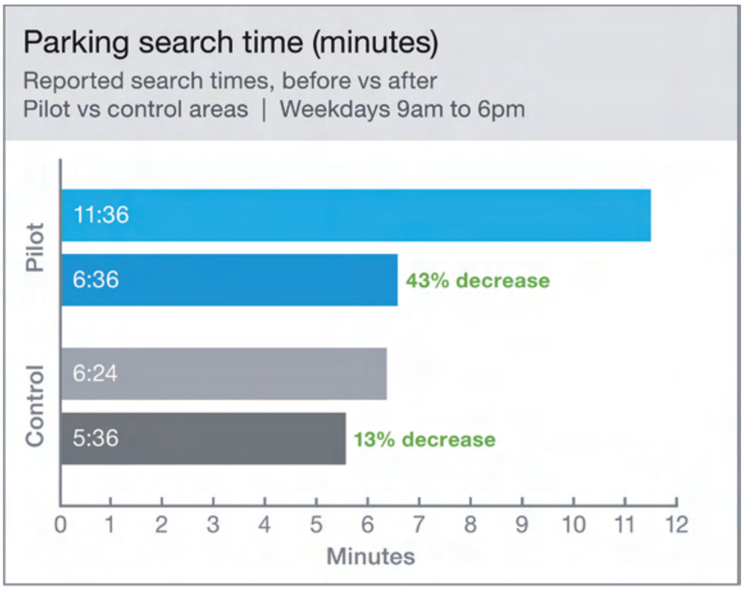

Figure 8 – Parking search time in weekdays: before and after the "SFpark" project implementation (Source: San Francisco Municipal Agency, 2014).

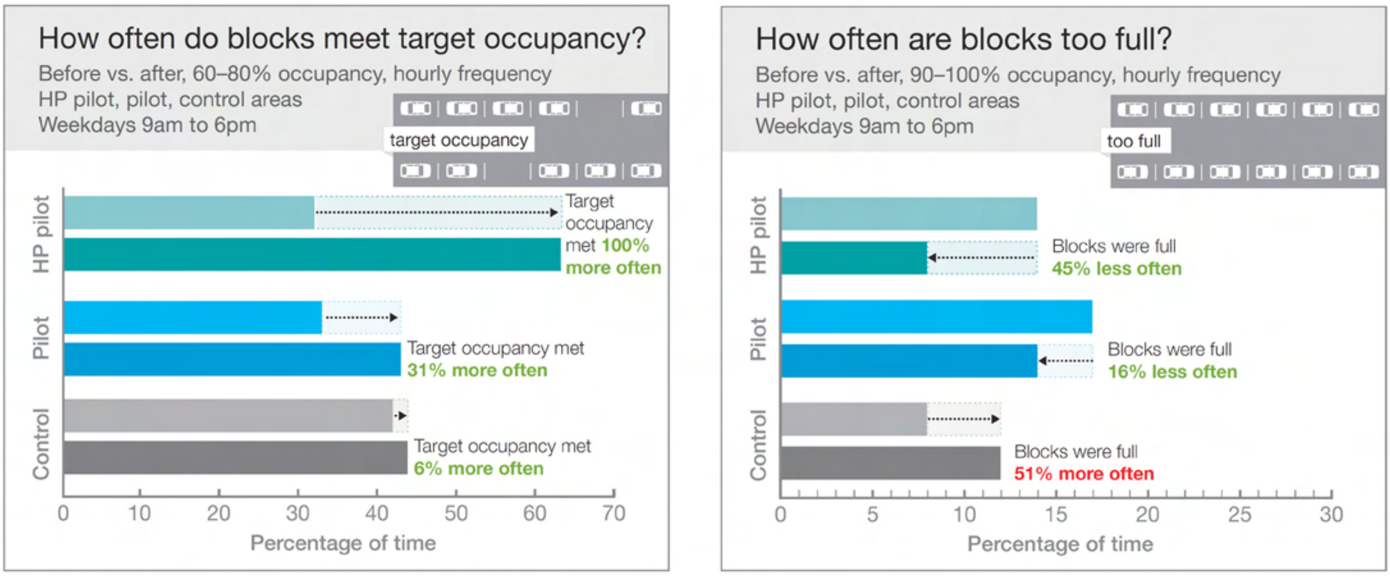

Figure 9 – Summary of parking supply response to actual users demand in the "SFpark" project (Source: San Francisco Municipal Agency, 2014).

The evaluation results showed also that parking pricing could be considered an effective measure for the parking demand management. As SFMTA introduced new park meters in several areas inside and outside of "SF*park*" pilot and control areas in 2011, the parking availability experienced an important improvement, decreasing from 90% to 15% the time of full parking spaces. The natural consequences are the following:

- easiness to find free parking in commercial and mixed-use areas;
- a higher parking turnover;
- increase of the off-street parking use.

Considering the typical underuse of garages in San Francisco, SFMTA tried to increase the use of off-street parking by applying to them lower prices and to reduce the time spent in search of on-street parking, especially for commuters.

Confirming these results (Shoup and Pierce, 2013), the parking elasticity[2] was calculated after the first evaluation period. It was mainly influenced by:

- the localization of the parking spaces: in the pilot areas elasticity was about 0,50 mainly in commercial areas and

2. Usually the elasticity of parking demand is defined as the variation percentage of the use of a specific supply linked with its price changes. The elasticity coefficient represents this kind of variation (J. Simićević, N. Milosavljevi, G. Maletić, S. Kaplanović, 2012). In parking field, the elasticity is calculated as the ratio between the variation percentage of the parking occupancy rate and the variation percentage of parking pricing.

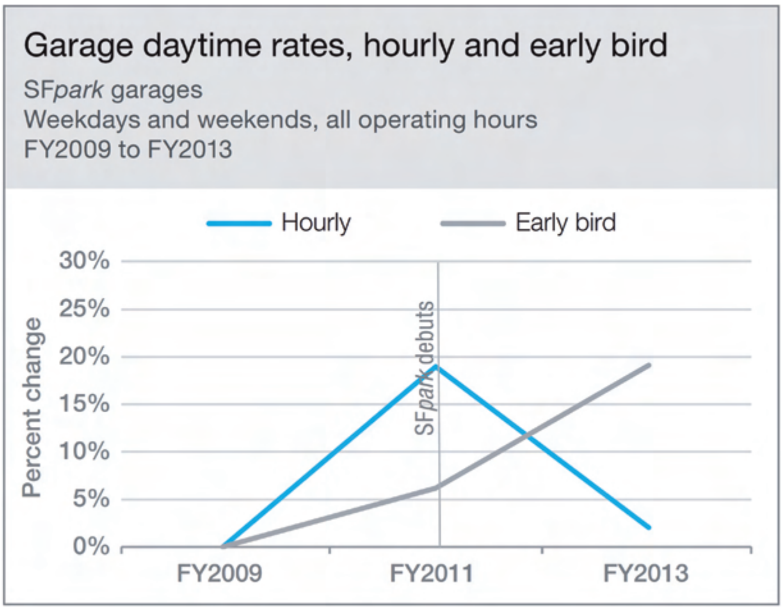

Figure 10 – Garage rates before and after the “SFpark” project implementation (Source: San Francisco Municipal Agency, 2014).

0,21 mainly in residential areas;

- the time of the day: in the morning and in the weekends the parking demand was less elastic than the one registered at noon or in the afternoon;
- the initial price: the elasticity was lower when the initial fares ranged between $ 0,00 and $ 1,00; greater elasticity was detected when fares were already high;
- the amount of price change: greater elasticity was measured after a fee reduction of $ 0,50;
- the amount of fee variation for each specific “block” of parking spaces;
- the specific phase of the pilot project: after the first price calibration, the measured elasticity was limited; it significantly increased after the second fees calibration, while, from the third one on, elasticity reached a stable value. Two factors could justify these results (Shoup and Pierce, 2013): firstly, in August 2011 fees calibration was implemented when “SF*park*” project was not widely known. Secondly, several exogenous factors could affect users’ behavior.

As regards traffic flows, SFMTA declared that within pilot areas daily vehicle miles traveled (V.M.T.) decreased, as shown in the following figures.

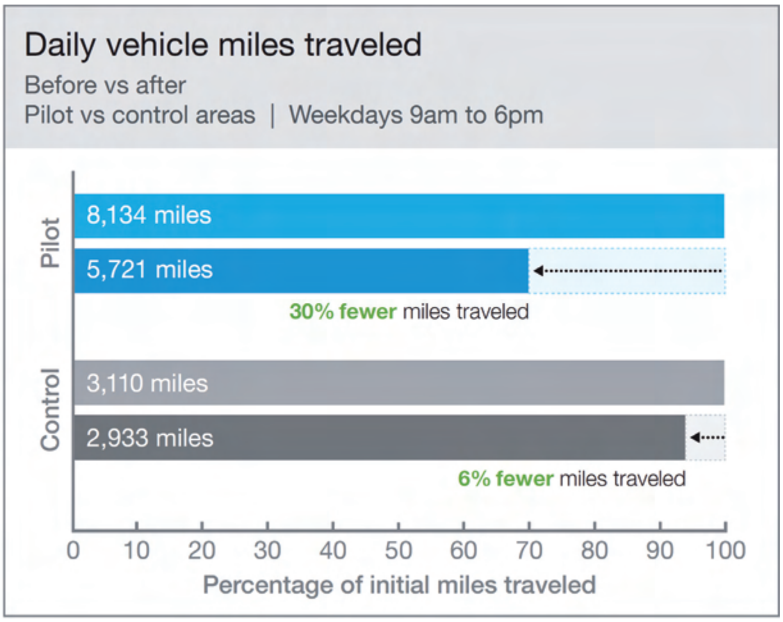

Figure 11 – Vehicle miles traveled (V.M.T.) before and after the “SFpark” project implementation (Source: San Francisco Municipal Agency, 2014).

Traffic data from roadway sensors revealed that areas with improved parking availability experienced a reduction of about 7,7% in traffic flows, while areas where parking availability did not improve or worsened a 4,5% increase in traffic volume was observed. In addition, traffic speed decreased by 6,3% where parking became easily available. SFMTA underlined that traffic flow reduction in pilot areas could not be considered a consequence of a decrease in the local economic activities or of the parking demand, even if parking taxes and sales tax revenues increased. Actually, parking demand and economic activity increased more in these areas than in the control ones.

As regards the payment methods, the results showed that the possibility to use credit cards was really appreciated by actual users. Also the "pay-by-phone" method experienced a continuous growth since its activation.

As regards the implemented ITS systems, SFMTA highlighted the following considerations:

- the electromagnetic interference coming from overhead transit line and other facilities, varied from "block" to "block";
- the sensors battery life was shorter than expected, due to the application of specific software to filter out electromagnetic noise;
- difficulties in coordinating the sensor experimentation with the activities carried out by the San Francisco Department of Public Works, which caused the breaking of several sensors.

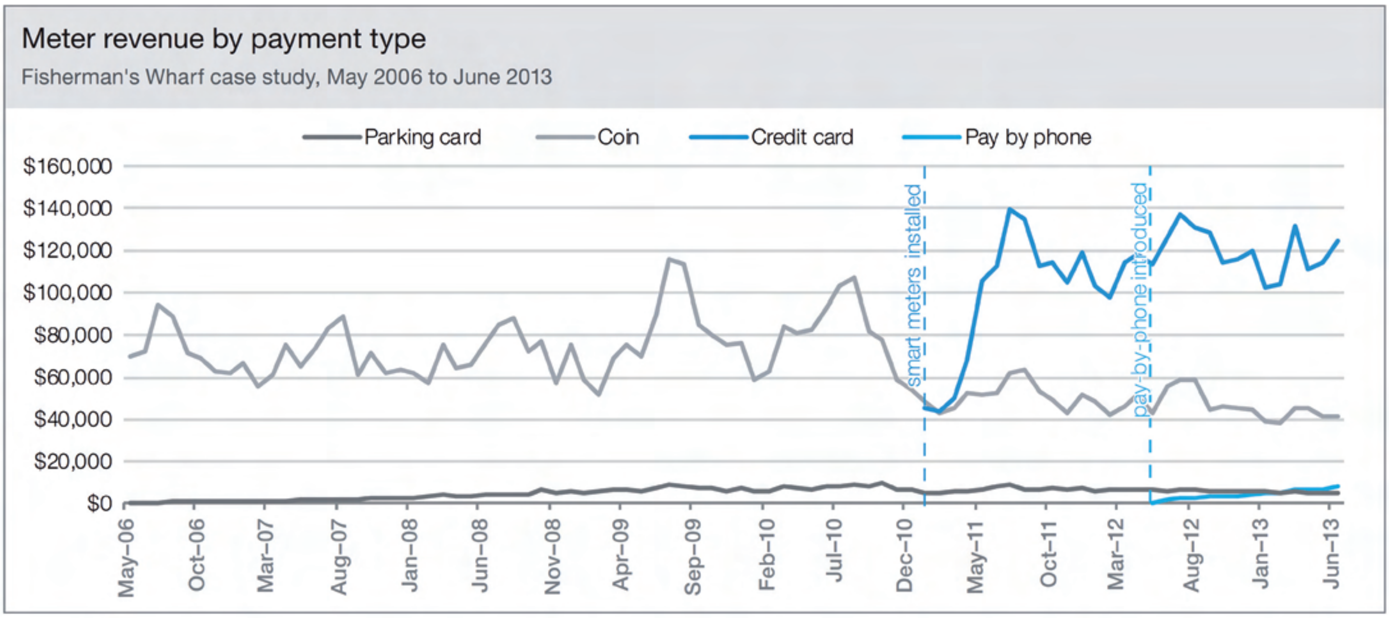

Figure 12 – Trend of different method of payments before and after the "SFpark" project implementation (Source: San Francisco Municipal Agency, 2014).

4. Re-thinking the parking management in italian medium-sized cities

Taking inspiration from some international good practices, a first methodology was developed to re-think the parking management actions in Italian medium-sized cities. The pursued objectives are:

- to incentivize the occupancy of off-street parking spaces, instead of searching for free on-street parking spaces;
- to meet the ever changing demand of mobility;
- to re-generate urban areas in favor of non-motorized mobility and accessibility to public transport.

The first investigated aspect was the applicability of the variable pricing techniques in Italy from a regulation point of view. According to the Italian current set of laws, it is up to the Municipality to define the public parking fares, both in case of direct and indirect management options[3]. The introduction of a new fare usually requires the approval of a special municipal ordinance, as in San Francisco. The possibility, for the parking manager, to apply different variable fares comply with the existing Italian laws but should be regulated by some "limitations" imposed by the Municipality, for example in terms of minimum/maximum applicable fare, the calibration frequency, the entity of the fare variation and the communication channels and timing to users.

3. As stated in the Italian Highway Code (Art. 7, D. Lgs. 30 aprile 1992, n.285 "Nuovo codice della strada").

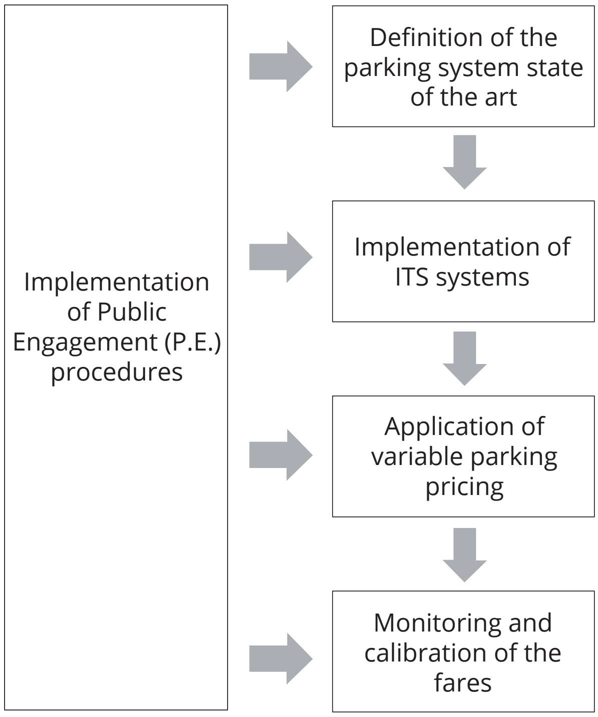

Figure 13 – Methodological proposal for the application of variable parking pricing policies in Italian medium-sized cities. (Source: own elaboration).

The table below highlights the key points, which characterize the proposed methodology.

Table 1 – Methodological proposal for the application of variable parking pricing policies in Italian medium-sized cities (Source: own elaboration).

FIELD	MAIN ACTIVITIES	EXPECTED RESULTS/BENEFITS
Parking spaces state of the art	Surveys on the existing parking supply and demand	Implementation of a parking database (occupancy rate, fees, parking duration, etc.)
	Georeferencing collected data	Implementation of geographical parking database
	Customer care surveys (awareness and acceptance)	Assessment of possible actions
ITS system: state of the art and implementation	Definition of specific characteristics to apply an ITS system (sensors, park meters, connections, *hardware*, *software*, VMP, etc.)	Selection of the most suitable ITS system
	Definition of the responsibilities for the system management and maintenance	More reliability/credibility of the ITS system
Variable pricing for parking management	Definition of the pilot areas where applying variable parking pricing	Evaluation of the project on pilot areas
	Definition of maximum and minimum occupancy rate for on-street and off-street parking	Optimization of the existing parking supply use
	Definition of variable parking fees and their range of calibration	Achievement of the expected performance, reduction of occupancy rate for on-street parking spaces, to favor LPT and non-motorized mobility
	Allocation of revenues from parking fees	Regeneration of urban areas and incentives for non-motorized and LPT mobility
	Organization and implementation of public engagement procedures	Improvement of users' awareness and acceptance about the innovations concerning the parking system and enhancement of the information diffusion
	Monitoring phase (parking data, traffic flows data, parking payment transactions, etc.)	Calibration of the innovative system

As described in the previous table, the first step of the proposed procedure consists in surveying the current parking demand and offer, through the implementation of a parking database. The San Francisco case study highlighted the importance of collecting reliable data in order to obtain a realistic *ex ante* scenario on which basing the following fares

variation. The essential information to be collected are:
- the hourly occupancy rate referred to an entire day and to the peak hour;
- the average parking duration;
- the existence of parking time limitations and fares;
- the traffic flows, distinguishing, if possible, the through from the parking related traffic (including movements to enter/ exit the parking and the disturbing traffic).

Data should be collected for the working and non working days, as the kind of users are generally different. In case of cities characterized by the presence of seasonal touristic traffic, the parking demand seasonal variability should also be taken into consideration.

Collected information should be georeferenced, in order to have a more complete and better evaluation of the parking demand/ offer. This further geo database implementation allows to consider more context information such as for example:
- the presence of different fares/time limitations in the same parking area;
- the localization of the urban traffic generators;
- the presence of parking spaces reserved for special road users categories;
- the presence of transit stops, their level of service[4];
- the level of service of the pedestrian/cycle paths to access the above mentioned urban traffic generators[5].

As regards the ITS implementation, they are considered a fundamental component in the application of innovative fare systems, such as the variable pricing schemes, especially in relation to the information delivery efficiency and management. It is important to make surveys concerning the existing ITS devices in order to assess their functionality. For each of them, the technical features, the maintenance state and the actual use should be investigated. Such data collection is important to define the architecture of the new ITS system, which should be suitable both for the parking manager and users needs, better exploit the existing devices and avoid incompatibility problems between the system components and the technological network. Finally, it would be necessary to establish the responsibility for the ITS system management and maintenance, in order to assure its efficiency and affordability.

The next step consists in defining the pilot areas and the experimentation phase duration, which depends on the parking demand elasticity respect to the fare variation (Shoup, 2011; Victoria Transport Policy Institute, 2011). The expected parking use performance should be set, adopting for example, the range 60 ÷ 80 %, as suggested by the San Francisco case study and by the available literature. Then the variable parking pricing scheme should be set, starting from the definition of different time slots (a minimum of 3 slots is recommended, according to the park meter functioning time and parking demand variation during the day). See the example of San Francisco in the previous paragraph.

Commuters are particularly sensitive to the parking fares modifications. Alongside the introduction of new fare schemes, in order not to penalize commuters and to discourage the use of individual means of transport, favoring the adoption of alternative modal choices, it is important to reinvest part of the parking revenues to improve the non-motorized accessibility to the urban traffic generators.

The monitoring phase is necessary to calibrate the new parking fare system and to find the most suitable parking fees according the desired parking performances. The monitoring process should be accurately planned, as the data collection timing depends on:
- the adopted fare calibration frequency;
- the available measurement systems.

At the end of the experimentation, the final evaluation phase should consider the following aspects:
- the comparison between the *ex ante* and the *ex post* scenarios collected for the pilot areas;
- the ITS effectiveness, possibly administering customer care surveys;
- the most frequent methods of payment, in order to assess their cost effectiveness;
- the economic/financial sustainability of the investment;
- the users acceptance.

The evaluation phase allows to improve the new parking pricing scheme in the pilot areas, in order to scale it at city level.

Of course, during the whole process, the periodic involvement of the interested stakeholders represents a fundamental aspect to increase as much as possible the success of the initiative, as suggested by the well known public engagement procedures developed at European level[6]

6. Some final considerations

Traditionally the increase of the parking demand was faced by enlarging the existing parking spaces supply. However, in the last few years several cities all over the world have set the goal of reducing private traffic and increasing road safety, especially in metropolitan areas. Now, the recent trend is to act on the existing parking supply optimizing its management. The case study of San Francisco shows that

4. For the calculation of the level of service of the waiting areas it is possible to apply the methodology proposed by Maternini and Foini (eds, 2009).

5. For the calculation of the level of service of the non-motorized itineraries, it is possible to apply the methodology proposed by the Highway Capacity Manual (AASHTO, 2010).

6. For example, it is possible to take as reference the procedures developed in France (the so called "Debat public") or in the United Kingdom.

variable parking pricing could be a good innovative system to better manage the existing parking supply. Starting from the experience gained in this city, it is possible to make a first methodological proposal, to calibrate this innovative parking management system to the Italian medium-sized cities.
Thus, variable parking pricing approach could:

- indirectly reduce the "disturbing traffic" component caused by who is looking for parking: ITS systems could suggest the position of available parking spaces to users and the less congested routes to reach them;
- push the use of specific parking spaces (for example, the those off-street ones);
- manage the occupancy rate of on-street and off-street parking spaces, calibrating fees and optimizing use of parking supply;
- control payments, to reinvest the revenues both for parking management and for the improvement of the non-motorized accessibility to the desired destinations.

The analyzed good practices have also demonstrated that variable pricing in parking management would work better if integrated with traffic management activities, such as, for example, the re-organization of the existing on-street parking, the requalification of the non-motorized users itineraries to access the main urban functions and transit nodes.

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